COMPARISONS BETWEEN OZARK AND OUACHITA STREAM FISHERIES IN EASTERN OKLAHOMA

By

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CHAPTER I

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, "Use of the bus-route and roving creel survey on two eastern Oklahoma streams," and Chapter III, "Comparisons between Ozark and Ouachita stream fisheries in eastern Oklahoma."

CHAPTER II.

AN EVALUATION OF THE BUS-ROUTE AND ROVING CREEL SURVEY TECHNIQUES ON TWO REGIONALLY DISTINCT EASTERN OKLAHOMA STREAM FISHERIES

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Abstract.-- We implemented roving and bus-route creel surveys to determine their efficacy and efficiency on two low fishing intensity stream fisheries in geomorphically distinct regions of Oklahoma. Based on pilot creel surveys and fishery and environmental characteristics, we used a roving creel survey on Baron Fork Creek and estimated fishing pressure from progressive instantaneous counts. In the Glover River, we used the bus-route survey technique and estimated fishing pressure from vehicle counts. We used relative standard errors as a measure of precision to compare monthly and annual estimates of fishing pressure, catch and yield obtained from both methods. Precision was generally greatest for months with highest fishing intensities; however, all monthly estimates were relatively imprecise. Annual fishing pressure and catch estimates, however, were relatively precise. Based on our sampling effort, we did not obtain monthly precision estimates within the recommended range of 15-20% for creel survey estimates primarily because of small sample size, the environmental variability of the streams and the inconsistent angling pressure in these low fishing intensity fisheries. Selection of a stream creel survey technique requires careful consideration of a stream's geomorphic, hydrologic and fishery characteristics, and the survey's ability to allow one to accurately and precisely synthesize data needed to describe angler effort and success.

Traditionally, intercept surveys have been used to measure fishing pressure and catch by enumerating anglers from access sites or by roving through the fishery (Malvestuto et al. 1978). A creel clerk in the act of enumerating and/or interviewing anglers while traveling through a fishery is conducting a roving creel survey (Robson 1991). Roving creel surveys have historically been used for fisheries exhibiting diffuse and/or private access (Pollock et al. 1994). The statistical validity of the roving creel survey is contingent on several assumptions (Robson 1961). First, the probability of a rover's chance to intercept an angler is not predetermined, but is a function of the density and distribution of anglers fishing a body of water (Malvestuto 1983, Robson 1991, Wade et al. 1991). Secondly, angler catch and harvest per unit of fishing effort (CPUE & HPUE) does not differ for incomplete and completed fishing trips or between short and long trips (Malvestuto et al. 1978, Malvestuto 1983). Third, the rover follows a representative and systematic route through a fishery (Robson 1991). Fourth, the rate of speed of travel for the clerk exceeds that of the anglers (Hoenig et al. 1993). Finally, the probability of a rover intercepting an angler is a function of the length of the angler's trip (Robson 1991).

Access point surveys are typically conducted by creel agents who interview departing anglers to determine time spent fishing and catch and harvest information from completed trips (Malvestuto 1983, Van Den Avyle 1986, Hayne 1991, Pollock et al. 1994). Although these surveys can be used on any body of water, they are most commonly used on reservoirs and large rivers with high concentrations of anglers who disperse throughout a fishery by entering and exiting through limited, well-defined access areas (Hayne 1991). During randomly chosen work periods, a creel clerk counts the number of anglers exiting a fishery and interviews them about the length of time fished to estimate total fishing effort. For many fisheries, individual anglers cannot be enumerated, and although angler counts are preferred, fishing party counts can be used to estimate fishing pressure in these situations (Lambou 1961). Robson and Jones (1989) furthered this survey innovation by theorizing that a count of cars parked at known fishing access sites can be used to estimate fishing pressure. This method is unique because daily fishing estimates are calculated over the entire route instead of estimating individual site values (Pollock et al. 1994). For this reason, the bus-route was recommended for fisheries exhibiting numerous but well-defined access areas along a broad geographic area (Robson and Jones 1989).

Creel surveys have been used infrequently on remote and inaccessible streams and small rivers (Heggenes 1987). Selection of a creel survey technique requires careful consideration of how well it allows one to accurately and precisely obtain and synthesize data needed to describe angler effort and success for a particular fishery (Weithman and Haverland 1991). Accordingly, specialized creel survey techniques are needed for fisheries exhibiting extreme spatial or temporal variations in effort and success (Van Den Avyle 1986). Labor requirements, travel, and other associated costs need to be considered while maintaining the procedural and statistical integrity of the design. The objectives of this study were to (1) describe modifications we made to roving and bus-route survey techniques used to evaluate the black bass Micropterus spp. fisheries in two eastern Oklahoma streams with different geomorphic, hydrologic and fishery characteristics, (2) define the advantages and disadvantages of these techniques for use in low intensity stream fisheries, (3) compare the efficacy of the techniques by analyzing the precision of survey estimates, and (4) evaluate their usefulness for providing baseline information from which management recommendations can be formulated that will benefit anglers and the stream fishery resources.

Methods

Study area.--Baron Fork Creek and Glover River are free-flowing, wild and scenic rivers in eastern Oklahoma with similar-sized drainages, but different topographies. Baron Fork Creek is in the Ozark Highlands and has drainage area of 795 km^2 at the USGS stream gauge located within our study site. Baron Fork Creek, a tributary of the Illinois River, originates in northwestern Arkansas and flows easterly for 56.9 km through Adair and Cherokee Counties, Oklahoma (OKWRB 1990, Blazs et al. 1992). Glover River is in the Ouachita Highlands and has a drainage area of 816 km^2 near its mouth. It originates in Leflore and Pushmataha Counties, Oklahoma and flows south through McCurtain County, OK for 54.2 km before entering Little River (OKWRB 1990, Blazs et al. 1992).

Baron Fork Creek flows almost entirely through private land except for the lower four kilometers which is held by the U.S. Army Corps of Engineers as flood control for Lake Tenkiller. A large percentage of anglers fishing Baron Fork Creek 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 the private land holdings of the Weyerhaeuser Company. Due to state tax easements, Weyerhaeuser allows unlimited access to their land for fishing, hunting and other recreational uses. Because the topography of Glover River is mainly sharp ridges and steep slopes (Orth and Maughan 1984), most of the fishing access is limited to low-water bridge crossings and logging roads abutting the stream. Low flows in summer preclude canoeing on the river.

Stream flows in Baron Fork Creek were more stable than those in Glover River. During the creel year on Baron Fork Creek (1 April - 30 September 1994), mean stream discharge was 7.1 m^3/s and ranged from 55.2 m^3/s in April to 1.2 m^3/s in July. In Glover River during the creel year (16 March - 15 September 1994), mean discharge was 10.0 m^3/s and ranged from 240.6 m^3/s in May to 0.1 m^3/s in August. In Baron Fork Creek, minimum flows were greater and maximum flows were less than those in Glover River. Estimates of the coefficient of variation in discharge, based on a mean square successive difference variance estimator (Hayne 1991), indicated that total Glover River flow (CV=12%) was about four times more variable than total flow on Baron Fork Creek (CV=3%) during the creel year.

Substrate in Glover River was dominated by boulders and emergent bedrock. During low flows, these instream structures made canoeing for roving creel surveys difficult and impractical. Baron Fork Creek did not have this limitation because higher summer baseflows and a pebble and gravel dominated substrate made canoeing possible throughout the year.

Roving creel survey procedures.--We evaluated the recreational fishery for black bass on Baron Fork Creek with a roving creel survey (Robson 1960, 1961, 1991). On Baron Fork Creek, a 16.71 km section was delineated and three sub-sections of 8.28 km, 5.52 km and 2.91 km were defined (Figure 1). Surveys were conducted monthly (time blocks) from 1 April to 30 September 1994 and stratified by weekdays and weekend days. Randomized sub-sections were floated each creel day. Wade et al. (1991) showed that interception probability shadows occur because of clerk detainment along his/her travel trajectory through a fishery. As the length of interviews and/or the number of anglers encountered increases, the likelihood of a clerk encountering a fishing party decreases. To minimize the bias of interception probability shadows, the 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. To decrease the time of each interview, only angling parties were interviewed. When the number of anglers fishing exceeded the creel clerks' ability to interview all parties and stay on schedule, fishing parties were systematically skipped (every other fishing party) to ensure time schedule commitments (Malvestuto 1983, Hayne 1991, Wade et al. 1991). Stream sections were traveled by floating down stream in a canoe and shuttling between sub-sections by a motorized mini-bike. A progressive instantaneous count was made while floating down stream, and all anglers who were in the process of fishing were included in the pressure count and interviewed (Fleener 1975, Van Den Avyle 1986, Hoenig et al. 1993). Persons considered to be actively fishing included those who were in the act of fishing, moving between fishing sites, changing fishing tackle, or moving in to or out of the fishery. This definition for active fishing was chosen because Phippen and Bergersen (1987, 1991) demonstrated that a liberal definition of fishing provided the least biased estimate of catch during a roving creel survey. To ensure creel clerk safety, sub-section floats were not started during inclement weather. Inclement weather was defined as climatic conditions (e.g., severe rainstorms) that were potentially dangerous to creel clerks. It was assumed that most anglers would choose not to fish under these conditions and, therefore, zero angler hours would be accumulated during that sampling period. Catch cards were distributed to anglers who had not completed their fishing trips to obtain complete trip information and additional catch information (Appendix A). Entry into a US$100 cash drawing was offered to increase response rates.

Each primary sampling unit (day) was split into two secondary sampling units (time periods), and early or late creel surveys were chosen for each creel day. Six creel combinations were possible because of randomization of sub-sections. Each combination was unique in the time it took to complete the survey. Maximum, minimum and mean creel times were 8.08, 6.08 and 7.11 hours, respectively. Under certain creel combinations and during certain times of the year, creel lengths exceeded or were less than one-half the length of the fishing day. This problem is common of roving creel surveys, and under ideal situations, Hoenig et al. (1993) suggested that the length of the survey be modified to account for non-overlapping time periods. Modifying the length of the survey was not logistically possible on Baron Fork Creek because the length of time to shuttle between sub-sections and float down-stream could not be adjusted. For this reason, if time periods were greater than one-half the length of the fishing day, over-lapping periods were ignored. Conversely, if time periods were less than one-half the length of the fishing day, survey starting times were randomized using continuous uniform probabilities within time periods. With this method, randomizing work periods within time periods biases estimates towards the middle of the time period (Hoenig et al. 1993). This bias, however, was unavoidable. 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 2). Mean of the ratios were used to calculate CPUE and HPUE estimates (Pollock et al. 1994).

We gathered information from catch cards and interviews on: angling starting and ending times, number of fish caught and kept, length of fish being harvested, number in party, state/zipcode of trip origination, species sought, angling method (rod & reel, fly fishing, trot-line or gigging), type of fishing (bank & wading, boat/canoe, or float tube), bait (artificial, natural or combination), and angling satisfaction. A Wilcoxon signed rank test was used to test for differences between CPUE and HPUE from incomplete (interviews) and completed (catch cards) fishing trips.

Bus-route creel survey procedures.--We used the bus-route survey on Glover River (Robson and Jones 1989). On Glover River, two stream sections (24.31 and 3.69 km) were delineated, 11 access points were defined, and a circuitous creel route was mapped along the river (Figure 3). Surveys were conducted monthly from 16 March to 15 September 1994. Monthly sampling periods were stratified into weekday and weekend primary sampling units (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 (time periods) were defined for each day. Early or late starting times, locations, and direction of travel were randomly chosen for each survey (Robson and Jones 1989, Pollock et al. 1994). Waiting times were partitioned among access sites proportional to their probability of being fished

(Robson and Jones 1989, Pollock et al. 1994). Schedules were used to keep clerks on specified arrival and departure times. At each access site, creel clerks counted the number of vehicles, interviewed anglers, and placed postage-paid self-addressed recreational survey cards on all parked vehicles (Appendix B). Entry into a $100 cash drawing was offered to survey card consignees to increase response rates. Survey card consignees were asked to record when they arrived and departed from the stream, and the number of hours spent fishing. Also, an information flyer explaining the purpose of the project and the importance of returning recreational survey cards was distributed to all vehicles. Information gathered from recreational survey cards and from interviews included the parties' arrival time, number of hours spent fishing, number of anglers in party fishing, number of vehicles in party, number of fish caught and kept, length of fish being harvested, state/zipcode of trip origination, species sought, angling method (rod & reel, fly fishing, trot-line or gigging), type of fishing (bank & wading, boat/canoe, or float tube), bait (artificial, natural or combination), and angling satisfaction.

Estimated total party hours (ETPH) were derived from instantaneous arrival and departure counts of parked vehicles at access sites (Figure 2). 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). Means of the ratios were used to calculate catch per unit effort (CPUE) and harvest per unit effort (HPUE) estimates (Pollock et al. 1994).

Based on 1993 pilot creel surveys, stream flows greater than 70.78 m^3/s on Baron Fork and Glover River were designated as non-fishable. Stream flows were monitored through the U.S. Geological Survey Automated Data Processing System, which transmits near real-time stream flows via satellite and is accessible through remote computer access. This process decreased the number of potential creeling days when angling was limited by extreme high flows (Fleener 1975, Spiller et al. 1988). Monthly strata estimates were adjusted to reflect the number of "fishable" days.

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

<u>Survey Implements</u>.--On-site catch cards have been used when low

fishing pressure and other fishery dependent characteristics limit catch information (Essig and Holiday 1991). Although both of the on-site survey cards (recreational survey cards for the bus-route creel and catch cards for the roving creel; Appendix A, B) served as a means for obtaining additional catch and harvest information, one important distinction between these two survey implements needs further clarification. One objective of the recreational survey card on the bus-route creel survey was to calculate fishing ratios and the number of anglers per vehicle. To satisfy this objective, a benign survey implement was used. 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 sending the survey card in. For this reason, each stream user was able to answer all questions on the survey card except the last one on the number of fish caught and harvested. We included this question on the card to gather catch and harvest data during the 1994 surveys, which was limited during the 1993 pilot creel surveys.

In addition to a benign survey implement, information signs were posted at all access sites explaining the recreational aspect of the project, and expressing the need for cooperation (Appendix C). Secondly, a $100 cash drawing was offered to survey card consignees to increase response rates from all stream users.

Bus-route verification.--To ensure the bus-route was sampling the majority of stream anglers in Glover River, we verified it with a roving creel survey. In June 1994, five roving creel surveys were conducted concurrently with bus-route surveys. Six sections were defined on Glover River and four were randomly chosen with uniform probabilities for each verification survey. Procedures described above were used for the roving creel surveys. Paired t-tests were used to compare estimates of effort, catch, and yield from both methods.

Results

Thirty-five creel surveys and 128 interviews were conducted on Baron Fork Creek between 1 April and 30 September 1994 (Table 1). On average, 3.7 (± 3.2 SD) anglers were contacted during each survey. Anglers were contacted while in the process of fishing; therefore, most were incomplete trips. In order to obtain complete trip information, 96 catch cards were distributed to those anglers who had not completed their fishing. Thirty-two catch cards were returned for a 30.0 % response rate (Table 1). No attempt was made to ascertain whether catch and harvest rates differed between anglers who returned catch cards and those who did not. Interviews where anglers had not accumulated 0.75 hours of fishing were omitted from analyses. Catch per unit effort (df=23; Z=1.2075; P=0.2273) and HPUE (df=23; Z=-0.9496; P=0.3515) did not significantly differ between interviewed anglers and those completing catch cards.

Thirty-eight creel surveys and 102 interviews were conducted on Glover

River between 16 March 1994 and 15 September 1994 (Table 1). Each interview, on average, represented 2.7 (± 0.20 SE) anglers. On the bus-route survey, anglers and other stream users were interviewed, and in order to obtain complete trip information, 193 recreational survey cards were distributed. Fifty-five recreational survey cards were returned for a 28.5 % response rate (Table 1). No attempt was made to ascertain whether catch and harvest rates differed between anglers who returned recreational survey cards and those who did not. Interviews where anglers had not accumulated 0.75 hours of fishing were omitted from analyses. Catch per unit effort (df=14; Z=1.0327; $\underline{P}$=0.3017) and HPUE (df=14; Z=1.0335; p=0.3014) did not differ between interviewed anglers and those completing recreational survey cards.

Fishing pressure estimates on Baron Fork Creek were generally greater and more precise than those on Glover River (Table 2). Annual fishing pressure per hectare on Baron Fork Creek was 317 h/ha and ranged from 94 h/ha in June to 17 h/ha in September. Annual fishing pressure on Glover River was 234 h/ha and ranged from 76 h/ha in May to 3 h/ha in August (Table 2). In general, precision was greatest during months of highest fishing pressure (i.e., May - August on Baron Fork Creek and April - May on Glover River).

Catch per hectare was nearly five times greater and estimates were generally more precise on Baron Fork Creek than on Glover River (Table 3). Total catch In Baron Fork Creek was 333 fish/ha and ranged from 2 fish/ha in April to 114 fish/ha in June. Total catch in Glover River was 64 fish/ha and varied monthly ranging 0 fish/ha in September to 20 fish/ha in April. Annual catch on Baron Fork Creek was more precise than that on Glover River (Table 3).

Annual yield of fish from Baron Fork Creek was nearly two times greater than that from Glover River (Table 4), and estimates were relatively imprecise for both streams. Annual yield on Baron Fork was 22.5 kg/ha and ranged from 0.9 kg/ha in April to 8.8 kg/ha in August. On Glover River, annual yield was 11.1 kg/ha and ranged from 0.0 kg/ha in September to 3.4 kg/ha in April. In both streams, estimates of yield were relatively imprecise; however, precision of annual yield was 33% greater in Glover River (Table 4).

Estimates of fishing pressure, catch, and harvest did not differ between bus-route and roving verification estimates in Glover River (Table 5). Ninety percent (18 of 20) anglers encountered during roving verifications were using bus-route creel access areas.

Discussion

Because many anglers on Baron Fork Creek used private access sites, we found during pilot studies in 1993 that it was not amenable to the bus-route technique. Foremost among these were privately-owned access (private clubs and private land), church camps, and public areas not suitable to access site surveys. Furthermore, from May to August public access sites were heavily used by non-angling recreationalists. We coined this phenomena the "beach effect" as it made conducting access site surveys extremely difficult during the 1993 pilot year. Changing to roving creel surveys in 1994 enabled us to select and interview only those stream users who fit our definition of anglers in the process of fishing.

Although Robson's (1961) theoretical formulation of the roving creel survey requires that direction of travel be randomly selected, in practice this assumption can not always be met (Malvestuto 1983). Others who have used roving creel surveys on streams have met this assumption either by traveling the fishery on foot (Heggenes 1987) or by air boat (J.S. Stanovick, personal communication). On Baron Fork Creek, the length of the stream section and clerk safety were the primary deterrents for traveling the fishery on foot. Air boats were not considered an option because in-stream structure (e.g., log jams) and impassable channel formations precluded such travel during low flow periods along many of the reaches on the creel route, and they were not available to us. An additional assumption of the roving creel survey requires that CPUE estimates not differ between complete and incomplete fishing trips (Malvestuto et al. 1978, Malvestuto 1983). Our paired comparisons of anglers who were interviewed and responded to catch cards indicated that CPUE and HPUE for incomplete and complete trips were similar.

We were not able to meet several assumptions of the roving creel survey on Baron Fork Creek because of logistical constraints. First, direction of travel was unidirectional. Secondly, even though random starting points (one of three) were chosen for each creel day, theoretically, unique starting points along the entire reach should be used (Pollock et al. 1994). Even though other violations and assumptions (i.e., stopping progressive counts for interviews and ensuring catch and harvest rates do not differ between short and long trips or between incomplete and completed trips) have been tested by others (Malvestuto et al. 1978, Wade et al. 1991), additional studies and verifications may be warranted.

The majority of stream users in Glover River were anglers (89 %), but trips were often combined with camping (42 %) and other activities (15 %). Turn-over rates of anglers (anglers entering and leaving the fishery) among sites were extremely low and several sites precluded use by multiple fishing parties (e.g. single camp sites). The bus-route was designed to record the time of all arriving and departing vehicles. On Glover River we found this to be unmanageable and possible at only the most "restrictive of access sites". Many of the access sites extended parallel to the stream channel with multiple entry and exit points. For this reason we took arrival and departure instantaneous counts of parked vehicles (Figure 2). If waiting periods at access sites were appreciable and/or if turn-over rates were high, a more appropriate method would have been to randomly schedule one or more instantaneous counts during wait periods.

Total harvest per unit effort significantly differed ($df=48$; $t=3.8072$; $\underline{P}=0.0004$) for all Centrarchid species (sunfish and black bass) on Glover River between interviewed anglers who did not send recreational survey cards and non-interviewed anglers who did respond to survey cards. This trend may be a result of bias due to survey techniques or incomplete responses by survey card consignees. Nearly one-third of the anglers on Glover River fished with trot-lines and used sunfish to bait their lines. During interviews, anglers were encouraged to list all species that were caught and kept. Non-interviewed anglers may not have recorded non-memorable catches (species used to bait trot-lines) thereby underestimating harvest. Secondly, in an effort to increase the number of interviews, all stream parties that could be reached by walking up and down the stream channel or those located at access sites were interviewed. If stream users who frequent access site areas were significantly different than those who did not, our estimates would be biased towards the former stream user. This potential source of bias could be avoided only if arriving and departing parties were interviewed.

Verification of the bus-route was conducted on Glover River to ensure comparability and compatibility between this and other creel survey techniques, and to test the assumptions of an access point survey. The bus-route assumes that the majority of anglers fishing a stream gain access to the water from readily accessible locations (e.g., bridge crossings, parks, etc.). Anglers who gain access from remote and secluded locations (e.g., private land, camps etc.) not covered by the bus-route will not be enumerated. If non-coverage of remote anglers is prodigious, angler effort, catch, and harvest statistics will be underestimated with an access site survey (Hayne 1991). Based on roving verifications, 90% of anglers were using creel access points. Two of the 20 anglers encountered during verifications gained access to Glover River from private access (Boy-scout camp). Additionally, of few other public access areas could not be included along the route because of their inaccessibility. These roads were washed-out unimproved roads that were difficult to locate, used infrequently, and required four-wheel drive or all terrain vehicles to reach. In an effort to maximize the efficiency of the bus-route design (i.e., maximize waiting periods at access sites) and for safety considerations, these sites were not included on the survey. Non-coverage of these sites could have potentially caused a downward trend in pressure estimates.

We believe the roving creel survey best suited Baron Fork Creek and the bus-route for Glover River; however, each method had its limitations. One disadvantage of the bus-route based on vehicle counts was the number of different iterations needed to estimate actual fishing pressure (Figure 2). However, if users of a resource are almost exclusively anglers and fishing is the only activity undertaken while parked at the stream, then one would expect the precision of bus-route survey estimates based on vehicle counts to increase. Secondly, locating and including all access sites along a stream can be difficult. We recommend contacting local landowners, anglers, and natural resource personnel (e.g., conservation officers) during the initial stages of survey implementation to identify frequently used access sites. It may, however, be necessary to conduct periodic roving verifications of the bus-route survey to ensure complete coverage of the fishery.

Two advantages of the bus-route technique over the roving creel technique was increased safety and lower salary appropriation. Other researchers have conducted roving stream surveys with one creel clerk (Fleener 1975, Rohrer 1986); however, we used two person creel teams to increase their safety, and allocated greater budgetary resources for salaries. Bus-route surveys do not have similar safety limitations and can be conducted effectively and safely with one creel clerk thereby reducing budgetary needs.

Estimating hectares within the study area was subjective because calculations based on the wetted perimeter vary with stream flow (Heggenes 1987). To compare yield estimates objectively with those from the literature, standardized calculations need to be made. For this study, the stream system was mapped using Geographic Information Systems (GIS) during summer base flows.

The effects of climatic variables on the precision of creel estimates have been well documented. Malvestuto et al. (1979) showed that 83 % of the variation in creel estimates on West Point Lake, Georgia-Alabama was explained by climatic variables, including ambient temperature and rainfall. Lake and reservoir fisheries (in terms of angling and environmental characteristics) are relatively static when compared to stream and small river fisheries. Although, inclement weather may limit fishing activities in both types of water, spates in rivers and streams may persist for days decreasing stream angling opportunities.

Monthly creel estimates were relatively imprecise and rarely within the recommended range (15-20%) of precision due to the capricious nature of these fisheries. Without increasing sample sizes substantially, it may be unreasonable to expect relative standard errors to be within 15-20% of monthly estimates (Malvestuto 1983, Hayne 1991). Conversely, annual fishing pressure on Baron Fork Creek and Glover River, and annual catch on Baron Fork Creek were within this recommended range of precision (Table 2). Studies whose objective is to quantify total annual estimates should appropriate greater sampling effort to time blocks with higher expected fishing intensities. Although this will potentially decrease precision among months, precision among annual estimates will most likely increase (Dent and Wagner 1991).

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References

Blazs, R. L., D. M. Walters, T. E. Coffey, D. K. White, D. L. Boyle, and J. F. Kerestes. 1992. Water resources Data, Oklahoma, water year 1992. U. S. Geological Survey Water-Data Report OK-92-1, Oklahoma City.

Dent, R. J. and Wagner, B. 1991. Changes in sampling design to reduce variability in selected estimates from a roving creel survey conducted on Ponne de Terre Lake. American Fisheries Society Symposium 12:88-96.

Essig, R. J. and M. C. Holliday. 1991. Development of a recreational fishing survey: the marine recreational fishery statistics survey case study. American Fisheries Society Symposium 12:245-254.

Fleener, G. G. 1975. Harvest of smallmouth bass and associated species in Courtois Creek. Pages 250-256 in Black Bass Biology and Management, R. H. Stroud and H. Clepper, Ed. Sport Fishing Institute, Washington, D. C.

Hayne, D. W. 1991. The access point creel survey: procedures and comparison with the roving-clerk creel survey. American Fisheries Society Symposium 12:51-60.

Heggenes, J. 1987. Random, stratified creel surveys in three Norwegian rivers with low fishing intensities. North American Journal of Fisheries Management 7:363-368.

Hoenig, J .M., D. S. Robson, C. M. Jones, and K. H. Pollock. 1993. Scheduling counts in the instantaneous and progressive count methods for estimating sportfishing effort. North American Journal of Fisheries Management 13:723-736.

Lambou, V. W. 1961. Determination of fishing pressure from fishermen or party counts with a discussion of sampling problems. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 15:380-401.

Malvestuto, S. P., W. D. Davies, and W. L. Shelton. 1978. An evaluation of the roving creel survey with nonuniform probability sampling. Transactions of the American Fisheries Society 107:255-262.

Malvestuto, S. P., W. D. Davies, and W. L. Shelton. 1979. Predicting the precision of creel survey estimates of fishing effort by use of climatic variables. Transactions of the American Fisheries Society 108:43-45.

Malvestuto, S. P. 1983. Sampling the recreational fishery. Pages 397-419 in L. A. Nielsen and D. L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

OKWRB (Oklahoma Water Resources Board). 1990. Oklahoma water atlas. University of Oklahoma Press, Norman.

Orth, D. J. and O. E. Maughan. 1984. Community structure and seasonal changes in standing stocks of fish in a warm-water stream. American Midland Naturalist 112(2):369-378.

Phippen, K. W. and E. P. Bergersen. 1987. Angling definitions and their effects on the accuracy of count-interview creel survey harvest estimates. North

American Journal of Fisheries Management 7:488-492.

Phippen, K. W. and E. P. Bergersen. 1991. Accuracy of a roving creel survey's harvest estimate and evaluation of possible sources of bias. American Fisheries Society Symposium 12:51-60.

Pollock, K. H., C. M. Jones, and T. L. Brown. 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society Special Publication 25.

Robson, D.S. 1960. An unbiased sampling and estimation procedure for creel censuses of fishermen. Biometrics 16:261-277.

Robson, D.S. 1961. On the statistical theory of a roving creel census of fishermen. Biometrics 17:415-437.

Robson, D. S. 1991. The roving creel survey. American Fisheries Society Symposium 12:19-24.

Robson, D. S. and C. M. Jones. 1989. The theoretical basis of an access site angler survey design. Biometrics 45:83-98.

Rohrer, R. L. 1986. Creel surveys from a kayak on the Henry's Fork of the Snake River, Idaho. North American Journal of Fisheries Management 6:294-295.

Spiller, K. W., A. W. Green, H. R. Osburn. 1988. Increasing the efficiency of angler surveys by canceling sampling during inclement weather. North American Journal of Fisheries Management 8:132-138.

Van den Avyle, M. J. 1986. Measuring angler effort, success and harvest.

Pages 57-64 in G. E. Hall and M. J. Van den Avyle, editors. Reservoir fisheries management: Strategies for the 80's. American Fisheries Society, Bethesda, Maryland.

Wade, D. L., C. M. Jones, D. S. Robson, and K. H. Pollock. 1991. Computer simulation techniques to assess bias in the roving-creel-survey estimator. American Fisheries Society Symposium 12:40-46.

Weithman, S. A., and P. Haverland. 1991. Comparability of data collected by telephone and roving creel surveys. American Fisheries Society Symposium 12:67-73.

Table 1.--Number of creels per month, interviews and catch cards on Baron Fork Creek, and recreational survey cards on Glover River distributed and returned.

	Number of creel surveys conducted							Number of interviews conducted	Number of cards distributed	Number of cards returned
	Mar	Apr	May	Jun	Jul	Aug	Sep			
Baron Fork	...	6	6	6	5	6	6	128	96	32
Glover River	4	6	6	6	6	6	4	102	193	55

Table 2. Estimated weekend, weekday, monthly, and annual fishing pressure (h/ha) on Baron Fork Creek and Glover River. Relative standard error (100 × SE/mean) estimates given in parentheses.

Stream	Mar	Apr	May	Jun	Jul	Aug	Sep	Totals
				Weekend				
Baron Fork	-	12.4	27.8	34.0	51.7	24.8	7.7	158.5
		(20)	(52)	(4)	(18)	(25)	(84)	(12)
Glover River	7.1	36.4	43.3	22.9	20.6	3.6	0.0	133.9
	(63)	(43)	(44)	(65)	(37)	(36)	(0)	(22)
				Weekday				
Baron Fork	-	8.1	33.7	60.1	14.2	32.5	9.5	158.2
		(100)	(42)	(38)	(1)	(20)	(53)	(19)
Glover River	2.9	23.2	33.1	28.8	9.5	0.0	2.8	100.3
	(62)	(34)	(27)	(51)	(100)	(0)	(100)	(21)
				Monthly				
Baron Fork	-	20.5	61.5	94.1	66.0	57.4	17.2	316.7
		(41)	(33)	(24)	(14)	(16)	(47)	(11)
Glover River	10.0	59.6	76.4	51.7	30.1	3.6	2.8	234.3
	(48)	(29)	(27)	(40)	(40)	(36)	(100)	(16)

Table 3.--Estimated monthly and annual catch per hectare (no/ha) on Baron Fork Creek and Glover River. Relative standard error (100 × SE/mean) estimates are in parentheses.

Stream	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Baron Fork	–	2.0	36.2	70.7	78.8	113.9	31.7	333.3
		(100)	(49)	(15)	(18)	(44)	(78)	(19)
Glover River	4.8	20.1	7.7	16.0	14.3	1.1	0.0	64.0
	(10)	(38)	(51)	(55)	(83)	(100)	(0)	(27)

Table 4.--Estimated monthly and annual yield (kg/ha) on Baron Fork Creek and Glover River. Relative standard error (100 × SE/mean) estimates are in parentheses.

Stream	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Baron Fork	-	0.9	2.3	4.2	3.5	8.8	2.9	22.5
		(100)	(68)	(56)	(53)	(72)	(71)	(33)
Glover River	1.9	3.4	2.9	1.5	1.4	<0.1	0.0	11.1
	(42)	(38)	(48)	(45)	(87)	(100)	(0)	(22)

Table 5.--Mean effort (h/ha), catch (no/ha) and yield (kg/ha) of fish from five concurrent bus-route and roving creel surveys on Glover River, June 1994.

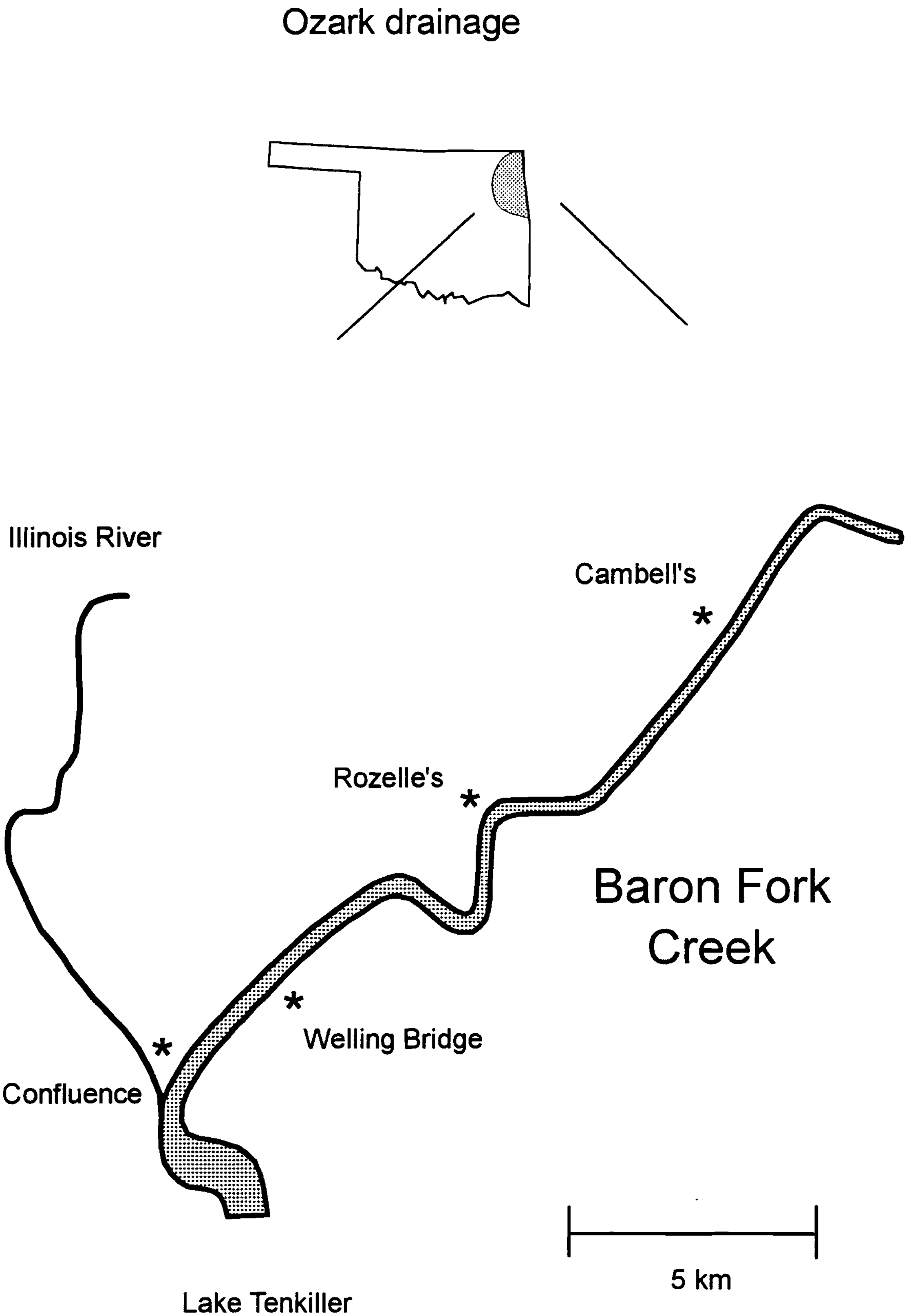
Parameter	Effort (h/ha)	Catch (no/ha)	Harvest (no/ha)
Bus-route			
mean ± (SD)	27.6 ± (25.3)	3.6 ± (5.2)	1.0 ± (1.5)
Roving			
mean ± (SD)	14.8 ± (10.9)	4.3 ± (6.5)	0.0 ± (0.0)
$\underline{P} > t$	0.2013	0.8149	0.2232

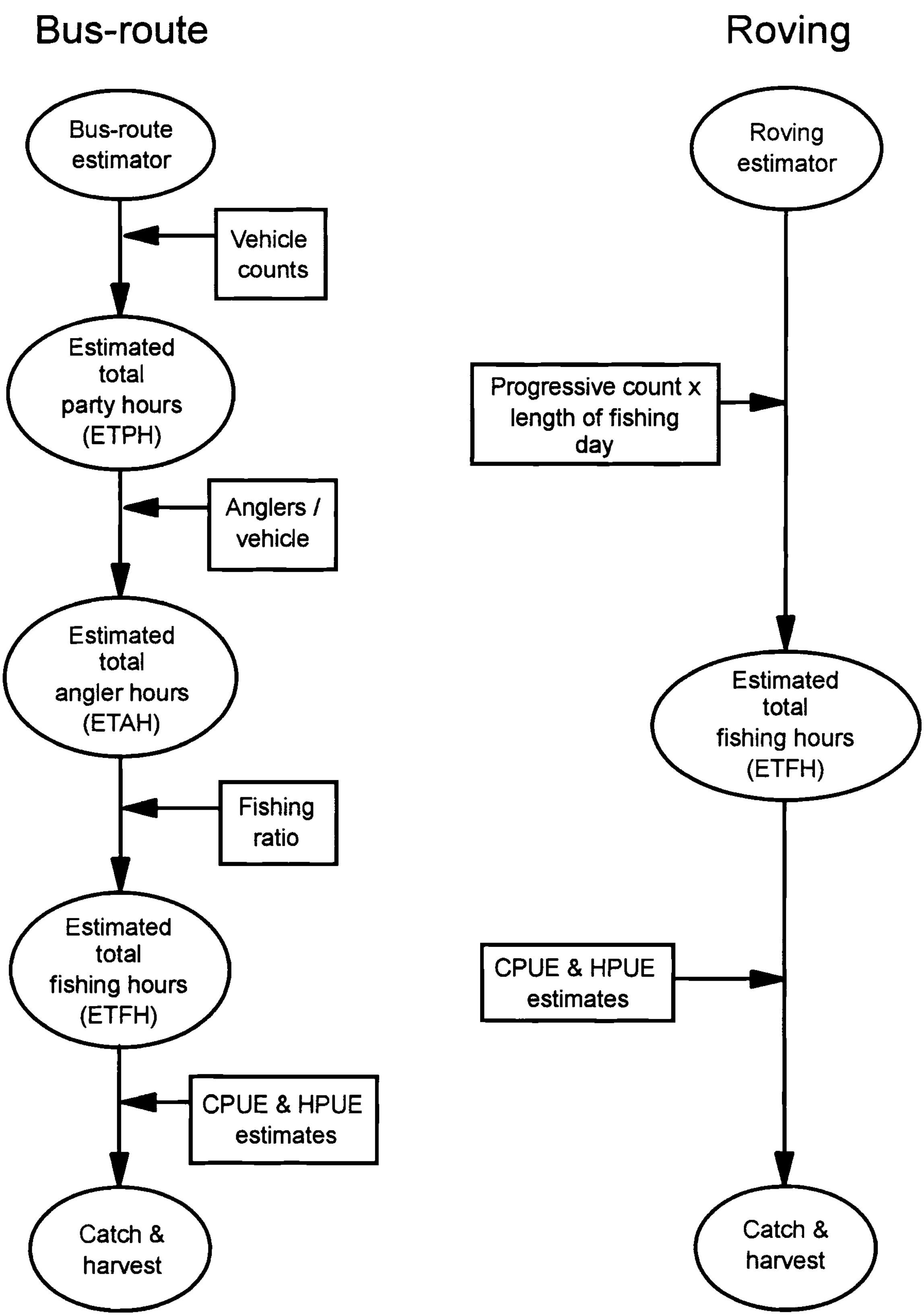
Figure Captions

1. Study area on Baron Fork Creek in northeastern Oklahoma. Stars denote end points of stream sub-sections.

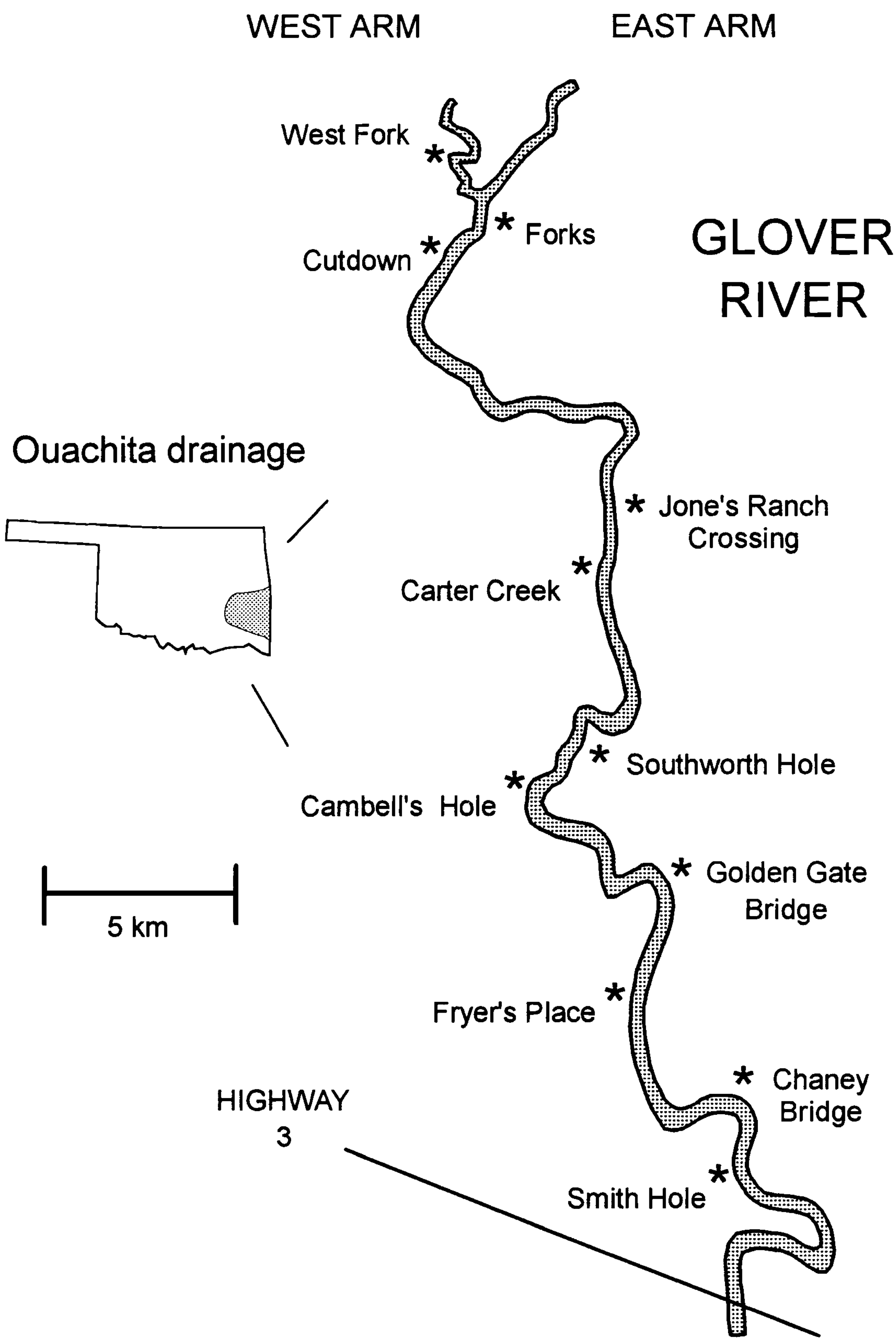
2. Flow chart depicting bus-route and roving creel survey estimation of fishing pressure, catch and harvest.

3. Study area on Glover River in southeastern Oklahoma. Stars denote creel access sites.


Ozark drainage
Illinois River
Cambell's
Rozelle's
Baron Fork Creek
Welling Bridge
Confluence
Lake Tenkiller
5 km



Bus-route
Roving
Bus-route estimator
Vehicle counts
Estimated total party hours (ETPH)
Anglers / vehicle
Estimated total angler hours (ETAH)
Fishing ratio
Estimated total fishing hours (ETFH)
CPUE & HPUE estimates
Catch & harvest
Roving estimator
Progressive count x length of fishing day
Estimated total fishing hours (ETFH)
CPUE & HPUE estimates
Catch & harvest


WEST ARM
EAST ARM
West Fork
Forks
Cutdown
GLOVER RIVER
Ouachita drainage
Jone's Ranch Crossing
Carter Creek
Southworth Hole
Cambell's Hole
Golden Gate Bridge
5 km
Fryer's Place
Chaney Bridge
HIGHWAY 3
Smith Hole

Appendixes

Appendix A

Catch card questionnaire used with the roving creel survey on Baron Fork Creek.

$ $ 100 DRAWING 100 $ $ **CATCH CARD** $ $ 100 DRAWING 100 $ $

STREAM ______________________ DATE ______________________ INTERVIEW NO ______________

NUMBER IN PARTY FISHING ____________ SPECIES SOUGHT ______________________________________

TIME FISHING STARTED ______________________ TIME FISHING ENDED ______________________

<u>AVERAGE</u> NUMBER OF <u>HOURS</u> FISHED <u>PER</u> <u>PERSON</u> (to the nearest 1/2 hour) ______________ (hrs)

FISH CAUGHT......YES or NO FISH NAME	NUMBER CAUGHT	NUMBER KEPT	NUMBER AND LENGTHS OF FISH KEPT (in inches) number kept length of fish kept (for example...										

YOUR COOPERATION WILL HELP STREAM FISHING IN OKLAHOMA, **PLEASE SEND IN ! !**

Returned cards will be entered into a **$$$ 100 cash drawing** just include your return address on the opposite side

Appendix B

Recreational survey questionnaire card used with bus-route survey on Glover River.

$$$100 DRAWING 100$$$ **STREAM RECREATIONAL USE QUESTIONNAIRE** $$$100 DRAWING 100$$$

DATE ____________ STREAM ____________________ ACCESS SITE ________________ INTERVIEW NO. ________

Oklahoma State University is conducting a RESEARCH PROJECT SURVEY to evaluate the recreational usage of eastern Oklahoma streams. Please answer the following questions and send the questionnaire, it has pre-paid postage and is already addressed to OSU. Thank you!

1) WHAT ACTIVITIES DID YOU PARTICIPATE IN **TODAY** ( ) (please circle ALL that apply)

a). Canoeing b). Swimming/Sun bathing c). Fishing d). Picnicking f). Other ________________________

2) TODAY'S ARRIVAL TIME (record sunrise if camped over-night) ____________ TODAY'S DEPARTURE TIME (record sunset if camping over-night) ____________

3) ESTIMATE THE AVERAGE NUMBER OF HOURS (nearest 1/2 hour) YOUR PARTY PARTICIPATED IN THE FOLLOWING ACTIVITIES TODAY (from sunrise to sunset)

Canoeing __________hrs Swimming/Sun Bathing ________hrs Fishing________hrs Picnicking ________hrs doing other activities ________hrs

4) WHAT WAS YOUR PRIMARY REASON FOR BEING AT THE STREAM TODAY? (please fill in): ________________________________

5) HOW MANY VEHICLES WERE IN YOUR PARTY TODAY? (please circle one): a). 1 b). 2 d). 3 e). 4 f). 5 g). other ________

6) HOW MANY PEOPLE FISHED IN YOUR PARTY TODAY? (please circle one): a). none b). 1 c). 2 d). 3 e). 4 f). 5 h).other _____

If you were fishing, please record **FOR TODAY** the total number of fish your **PARTY** caught, and number and lengths of fish being kept.

FISH CAUGHT... **YES** or **NO** / FISH NAME	NUMBER CAUGHT	NUMBER KEPT	NUMBER AND LENGTHS OF FISH KEPT (in inches) number kept length of fish kept (for example....									

IT IS IMPORTANT FOR ALL PEOPLE RECEIVING THIS CARD TO SEND IT IN !!!

Returned cards will be entered into a $$$ 100 CASH DRAWING - just include your return address on the opposite side

Appendix C

Information sign at all access sites on Glover River. Signs stressed the need for cooperation and explained the purpose of the project as a recreational use survey.

RESEARCH PROJECT

OKLAHOMA STATE UNIVERSITY is conducting a Recreational Use Research Project. We are interested in obtaining information on the recreational usage of Glover River. OSU students will periodically conduct surveys (6 random days per month) and occasionally ask to interview you. Participation is voluntary.

In addition to interviews, students will periodically leave pre-addressed stamped survey cards on your vehicles. Please fill out and send to OSU (postage is already paid for). Your time and cooperation is appreciated. For more information, call Craig Martin, Paul Balkenbush, or Dr. William Fisher at (405)744-6342.

PLEASE PARTICIPATE IN THE SURVEY

THANK YOU ! !

CHAPTER III

COMPARISONS BETWEEN OZARK AND OUACHITA SMALLMOUTH BASS FISHERIES IN TWO EASTERN OKLAHOMA STREAMS

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Abstract.--To gain information on the recreational fishery for native stream stocks of smallmouth bass Micropterus dolomieu in eastern Oklahoma streams, creel and tagging exploitation studies were conducted on Baron Fork Creek in northeastern Oklahoma and Glover River in southeastern Oklahoma. We evaluated the recreational fishery of Baron Fork Creek with a roving creel survey and that of Glover River with the bus-route creel survey. Exploitation rates for black bass Micropterus spp. were analyzed by tagging fish in two consecutive years. During the exploitation studies in 1993 and 1994, 412 and 194 black bass were tagged with abdominal anchor tags, and exploitation was estimated to be between 6-15% on Baron Fork Creek and 3-11% on Glover River. Fishery characteristics of Baron Fork Creek and Glover River were indicative of quality smallmouth bass fisheries. Catch and harvest per unit effort, fishing pressure, yield and exploitation on Baron Fork Creek exceeded those of Glover River. The smallmouth bass fishery in Baron Fork Creek was characterized by high catch and harvest rates, and even though the creel was made up of relatively small individuals, 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. Assuming these fisheries are representative of others in their region, then different management schemes may be needed for smallmouth bass streams in northeastern and southeastern Oklahoma.

Angling for smallmouth bass Micropterus dolomieu in Oklahoma increased dramatically during the 1980s (Summers 1990). Results from a 1989 Oklahoma annual angler survey indicated that 34% of all Oklahoma anglers fished for smallmouth bass, and that this species had become the sixth most sought after sport fish. Although this increase in popularity can be partly attributed to the successful introduction of Tennessee lake strain smallmouth bass into Oklahoma reservoirs (Summers 1990), a traditional smallmouth bass fishery occurs in northeast (Ozark Highlands) and southeast (Ouachita Highlands) Oklahoma streams (Leonard and Jenkins 1952, Finnell et al. 1956, Andrews et al. 1974, Smith 1982, Orth et al. 1983).

Smallmouth bass reach their most southwestern native range in eastern Oklahoma (MacCrimmon and Robbins 1975). Hubbs and Bailey (1940) described native smallmouth bass in Oklahoma as the Neosho smallmouth bass Micropterus dolomieu velox, a sub-species distinct from the northern smallmouth bass Micropterus dolomieu dolomieu. In addition to Hubbs and Bailey's (1940) designation, genetically distinct stocks of smallmouth bass occur in northeast and southeast Oklahoma (Stark et al. 1995), abundance, size, and age structure (Stark and Zale 1991). Stark and Zale (1991) recommended different management strategies for northeast and southeast smallmouth bass populations to ensure quality fisheries. However, harvest and exploitation estimates, and fishery characteristics were needed for smallmouth bass before the Oklahoma Department of Wildlife Conservation (ODWC) could implement angling and harvest regulations on these native stream populations.

Ozark streams in eastern Oklahoma have not been as intensively studied as their counterparts in Missouri, and at present, a paucity of information exists for Oklahoma's Ouachita stream fisheries. In the early 1950's, researchers were concerned over the general lack of quality size (≥ 254 mm) smallmouth bass in the Illinois River drainage even though stock size (< 254 mm) appeared to be abundant (Leonard and Jenkins 1952). Smith (1982) sampled throughout the upper Illinois River drainage (i.e., Baron Fork Creek and Flint Creek) and found that it supported abundant fish populations, even though the relative abundance of smallmouth bass had declined from previous estimates. He found smallmouth bass were widely distributed and abundant; however, large adults (≥ 305mm) were not well represented in the samples, and he concluded that overharvest of large smallmouth bass may be occurring.

Orth et al. (1983) documented age, growth, and relative condition of smallmouth bass in Glover River, southeast Oklahoma. Although these population characteristics indicated that exploitation was similar to that in other streams, 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 source.

Stark and Zale (1991) surveyed 62 sites in 21 streams in eastern Oklahoma and documented differences in bass abundance, year class-strengths and congeneric populations densities. They recommended a 229 - 305 mm slot regulation on smallmouth bass in northeastern streams to minimize intraspecific competition, which they postulated was occurring because of the high relative abundance and the slow growth rates of 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 congeners in southeastern Oklahoma streams. The length limit would promote survival of younger individuals while allowing harvest of trophy fish. The generous bag limits would concentrate angler exploitation on spotted bass Micropterus punctulatus and would subsequently allow smallmouth bass population size to increase in response to the absence of this congener (Stark and Zale 1991).

Information on fishing effort, catch and harvest, survival, mortality, and exploitation are crucial biological parameters required for formulating management policies (Paragamian 1984a). Management regulations may be beneficial for one system but deleterious to another. For this reason, it is imperative that individual systems be evaluated before implementing regulations (Fox 1975, Smith and Kauffman 1991). The objectives of this study were to (1) evaluate and compare smallmouth bass fisheries in a northeastern (Ozark) and southeastern (Ouachita) Oklahoma stream and (2) use this information in developing drainage-wide management recommendations that will benefit both anglers and the stream fishery resources.

Methods

Study Areas.--Baron Fork Creek and Glover River are free-flowing streams in eastern Oklahoma that are designated as wild and scenic rivers (Figure 1). Baron Fork Creek, a tributary of the Illinois River, originates in the Ozark Highlands of northwestern Arkansas and flows easterly for 56.9 km through Adair and Cherokee Counties, Oklahoma (OKWRB 1990, Blazs et al. 1992). It has drainage area of 795 km^2 at the United States Geological Survey (USGS) stream gauge located within our survey area. Glover River originates in Ouachita Highlands of Leflore and Pushmataha Counties, Oklahoma and flows south through McCurtain County, OK for 54.2 km before entering Little River (OKWRB 1990, Blazs et al. 1992), and has a drainage area of 816 km^2 near its mouth.

These two streams are indicative of the high quality streams of eastern Oklahoma and provide for comparisons between these two drainages from which management recommendations can be made for each region. Additional site descriptions can be found in Chapter II.

Creel survey techniques.--We evaluated the recreational fishery of Baron Fork Creek with a roving creel survey (Robson 1960, 1961, 1991) and that of Glover River with the bus-route creel survey (Robson and Jones 1989).

On Baron Fork Creek, a 16.71 km section was delineated and three sub-sections of 8.28 km, 5.52 km and 2.91 km were defined. Surveys were conducted monthly (time blocks) from 1 April to 30 September 1994 and stratified by weekdays and weekend days. Stream sections were traveled by floating down-stream in a canoe and shuttling between sub-sections by a motorized mini-bike. A progressive instantaneous count with interviews was kept while floating down stream, and all anglers who were in the process of fishing were included in the pressure count (Fleener 1975, Van Den Avyle 1986, Hoenig et al. 1993). Catch cards were distributed to anglers who had not completed their fishing trips to obtain complete trip information and additional catch information.

In Glover River two stream sections (24.31 and 3.69 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 1994. Monthly sampling periods were stratified into weekday and weekend primary sampling units (days). Six randomly-chosen days, 3 weekdays and 3 weekend days were surveyed each month (Table 1, Chapter II). Early or late starting times, locations, and direction of travel were randomly chosen for each survey (Robson and Jones 1989, Pollock et al. 1994). At each access site, creel clerks counted the number of vehicles, interviewed anglers, and placed postage-paid self-addressed recreational survey cards on all parked vehicles.

Information gathered during surveys included the parties' arrival time, number of hours spent fishing, number of anglers in party fishing, number of vehicles in party, number of fish caught and kept, length of fish being harvested, state/zipcode of trip origination, species sought, angling method (rod & reel, fly fishing, trot-line or gigging), type of fishing (bank & wading, boat/canoe, or float tube), bait (artificial, natural or combination) and angling satisfaction. Weight-length relationships obtained from fish sampled during tagging exploitation studies and population sampling were used to estimate weights from lengths of fish entered into the creel (Appendix A, Appendix B). For further description of creel survey methods, see Chapter II.

We used Chi-Square analysis to test for probability differences in angler characteristics and species proportions, and the Wilcoxon test for two random samples testing catch and harvest per unit effort estimates. Statistical tests were considered significant at $\underline{P} \leq 0.05$.

Exploitation and mortality rates.--To evaluate catch and exploitation rates, black bass Micropterus spp. greater than 180 mm were collected by electrofishing and angling (Figure 2 and 3). Fish were tagged abdominally with 16 mm X 6 mm disk and 65 mm streamer Floy Tag FM-94 internal anchor tags (Floy Tag & Manufacturing, Inc.) and released into the stream section where they were captured. We attempted to distribute tagged fish evenly throughout the study reach. Tags were implanted by making an incision slightly larger than the base of the tag, 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). Dorsal anchor tags were not used because internal anchor tags have been shown to have superior retention rates over extended periods of time (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 convenient food marts. These signs instructed anglers catching tagged fish to send them to Oklahoma State University, and to indicate whether they kept or released the fish, where they caught it, the date of capture and whether they used artificial or natural baits. A limited edition stream angler cap and entry into a US$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 and survival rates, and exploitation. Exploitation and survival for black bass were examined by marking fish in two consecutive years (Ricker 1975). Estimates were derived assuming 100% and 64% tag return rates (Weathers and Bain 1992).

Results

Recreational fishery analyses.--Thirty-five creel surveys were conducted on Baron Fork Creek and 38 creel surveys on Glover River. During the creel year, an average of 3.7 (± 3.2 SD) interviews were conducted on Baron Fork and 2.7 (± 2.4 SD) interviews on Glover River. About one-third of the distributed catch cards were returned by Baron Fork Creek 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.

Anglers overwhelmingly indicated that stream angling was very important to them (Table 1). Nearly 96% of Baron Fork Creek and Glover River anglers rated stream fishing as important or more important than other fishing activities they participated in. However, anglers were generally dissatisfied with their fishing success. When asked to rate their fishing, three of four anglers rated their fishing as either fair or poor (Table 1).

On Baron Fork Creek and Glover River, the majority of anglers fished with rod & reel, and a small percentage of anglers fly fished; however, one in four anglers fished with trot-lines on Glover River whereas no trot-line angling was encountered on Baron Fork Creek (Table 1). On Baron Fork Creek, nearly two-thirds of anglers fished with artificial baits, whereas Glover River anglers used natural and artificial baits with nearly equal frequencies. Bank and wade fishing were the most popular types of fishing on both streams, but a higher proportion of anglers float-fished on Glover River. Black bass were the most sought after sport fish in both streams. However, more anglers (14%) fished for black bass on Baron Fork Creek than on Glover River, primarily because of the higher proportion of sunfish and catfish fishing on Glover River. Over 90% of anglers on both streams were Oklahoma residents. Non-Oklahoma residents using Glover River were predominately from Texas, whereas no consistent trend was apparent on Baron Fork Creek.

Although total catch rates were similar between Baron Fork Creek and Glover River, catch and harvest rates differed for sunfish, black bass, and smallmouth bass (Table 2). Catch rates for smallmouth bass were nearly three times greater in Baron Fork Creek than Glover River, whereas sunfish catch and harvest rates were two to three times greater on Glover River than Baron Fork Creek (Table 2).

Fishing pressure was variable throughout the year and was distributed normally among months on both streams (Figure 4). Highest months of fishing pressure occurred later in the season on Baron Fork Creek (May, June, July and August) than on Glover River (April, May and June). Annual fishing pressure was nearly 75% greater on Baron Fork Creek (317 h/ha) than on Glover River (234 h/ha; Table 3). This same trend was apparent in total catch, but the species composition was different. Catfish made up a small portion of catch in both streams, but was four times greater in Glover River (4 no/ha) than in Baron Fork Creek (1 no/ha; Table 3). Sunfish species dominated the catch in Glover River (86%) and made up a smaller proportion of the catch in Baron Fork Creek (41%). Black bass made up a larger proportion of catch in Baron Fork Creek (55%) than in Glover River (14%). Smallmouth bass were the dominate black bass species caught in both streams but spotted and largemouth bass made up a larger proportion of catch in Glover River than in Baron Fork Creek (Table 3).

Total annual harvest (no/ha) was similar between Baron Fork Creek and

Glover River (Table 4). However, catfish and sunfish harvest was nearly three times greater in Glover River, whereas black bass harvest was four times greater in Baron Fork Creek (Table 4). Black bass harvest was dominated by smallmouth bass in both streams, but congeners made up a higher percentage of total bass harvest in Glover River (23%) than in Baron Fork Creek (15%). Total annual black bass and smallmouth bass yields were three times greater in Baron Fork Creek than in Glover River; spotted bass and largemouth bass yield were similar in both streams (Table 5).

Exploitation.--In Baron Fork Creek and Glover River 412 and 194 black bass were tagged with abdominal anchor tags in each system respectively. In 1993, 144 smallmouth, 12 spotted and 11 largemouth bass, and in 1994, 202 smallmouth, 15 spotted and 28 largemouth bass were tagged in Baron Fork Creek (Appendix C). In Glover River, 35 smallmouth, 20 spotted and 8 largemouth bass, and, 88 smallmouth, 29 spotted bass, and 14 largemouth bass were tagged in 1993 and 1994, respectively (Appendix D). Mean length of tagged fish was 261 mm (± 54 SD) and 279 mm (± 62 SD) on Baron Fork Creek and Glover River, respectively. The mean number of days tagged fish were at large before being caught by anglers was 78.5 d (± 96.4 SD) on Baron Fork Creek and 115.2 d (± 113.6 SD) on Glover River. The maximum number of days tagged fish were at large before being caught was 563 d on Baron Fork Creek and 332 d on Glover River. Although exploitation estimates were calculated using 100% and 64% tag return rates (Table 6; Table 7), subsequent discussions are based upon the 64% response rates. Annual smallmouth bass exploitation on Baron Fork Creek (mean=0.13) was nearly twice that of Glover River (mean=0.07; Table 6). Catch rates were higher than exploitation rates on both streams indicating that a large proportion of the bass caught were released (Table 6).

Comparisons of Baron Fork Creek and Glover River stream fisheries with those reported in the literature, indicated that both of these streams sustain quality fisheries (Table 8). Mean fishing pressure on Baron Fork Creek and Glover River was similar to that of other smallmouth bass streams in North America. Both catch and harvest rates on Baron Fork Creek were among the highest reported in the literature; however, CPUE on Glover River was among the lowest, whereas HPUE was intermediate (Table 8). Smallmouth bass yields on Baron Fork Creek were among the highest reported in the literature.

Discussion

Nearly one-half of interviewed anglers rated their stream fishing experience as extremely important, indicating that eastern Oklahoma stream fisheries are an integral part of the state's fishery resources for anglers who use them. Interestingly, the majority of these same anglers felt their fishing was either fair or poor indicating these eastern Oklahoma streams provide a quality fishing experience beyond catching fish.

Lake Tenkiller, which is located down-stream from the confluence of

Baron Fork Creek and Illinois River and during extreme flood periods backs up into the Baron Fork Creek, had a minor influence on the stream fishery in Baron Fork Creek. Three returned tags were from fish who had migrated into Lake Tenkiller and were caught in the reservoir. Not surprisingly these tagged fish were either spotted bass (N=2) or largemouth bass (N=1). There was no indication that smallmouth bass exhibited seasonal or yearly migrations into the reservoir, supporting the conclusion of Gerking (1950), Larimore (1952, 1954), Funk (1957), and Todd and Rabeni (1989) that most stream-dwelling smallmouth bass populations exhibit high site fidelity.

Stark and Zale (1991) found abundances of black bass were nearly five times greater in northeastern (mean=48 kg/ha) than southeastern (mean=9 kg/ha) Oklahoma streams. In the two streams we creeled, Stark and Zale (1991) estimated abundance by numbers and weight to be 656 no/ha and 96 kg/ha in Baron Fork Creek and 12 no/ha and 2 kg/ha in Glover River. Differences in growth rates were also documented between northeastern and southeastern Oklahoma streams. Smallmouth bass grew rapidly in the northeast until age 3 when growth rates steadily declined. Conversely, smallmouth bass in the southeast grew rapidly throughout all year classes which resulted in a greater proportion of larger individuals in the population even though abundances of these individuals were far less than in northeastern Oklahoma streams (Stark and Zale 1991). They concluded that smallmouth abundance in Baron Fork Creek was indicative of a high quality fishery, whereas Glover River was representative of a marginal fishery. Except for this last observation, similar trends were apparent from this study. In Baron Fork Creek, the fishery was dominated by a large number of catchable individuals, but a smaller percentage of the catch was harvestable as indicated by the high release rates (81%) and small length at harvest (270mm). Contrastingly, the smallmouth bass fishery in Glover River was typified by lower catch rates, greater lengths at harvest (315mm), and lower release rates (65%). Comparisons with those in the literature, however, indicate that both fisheries sustain quality smallmouth bass fisheries (Table 8).

Comparing Stark and Zale's (1991) mean estimates for standing stock with harvest estimates from our survey, indicated that angler harvest exceeded the average standing stock for smallmouth bass in Glover River. This disparity occurred during similar studies in Courtois Creek, and Funk (1975) speculated that migration of substantial numbers of catchable-size bass from lower fishing pressure or higher production areas may be occurring. Access to Glover River is limited because of geomorphic, geographic and hydrologic characteristics of the system. During low flows (June, July, August and September), fishing was limited (especially float fishing) to access areas and steadily declined away from these sites. It is probable that a gradual shift or influx of smallmouth bass individuals occurred in response to gradual changes in standing crops at or near access areas. Funk (1975) speculated that 25 - 50% of annual catch in Courtois Creek may have been directly due to immigration of smallmouth bass into their study area. Additionally, characteristics that limit fishing pressure to access areas, also limits sampling equipment. Estimates of smallmouth bass populations at or near areas of heavy exploitation (3 of 5 samples were taken adjacent to low-water bridge crossings; Stark and Zale 1991), may underestimate standing crops when compared to moderately fished areas.

Catch from Glover River consisted of a larger proportion of spotted bass and largemouth bass than did Baron Fork Creek; however, this trend was not as great as differences in standing stock estimates (Stark and Zale 1991). Standing stocks of black bass in Glover River indicated that spotted and largemouth bass were nearly three times (77%) more abundant than congeneric species (23%; Stark and Zale 1991), whereas anglers on Glover River caught predominately smallmouth bass (76%) and to a lesser extent spotted bass and largemouth bass (24%). Several factors may have caused this enigma. First, anglers may have been selectively fishing for smallmouth over spotted and largemouth bass; however, tag return rates for 71 spotted and largemouth bass (N=11; 15%) and 121 smallmouth bass (N=12; 10%) does not support this conclusion. Secondly, anglers occasionally identified spotted bass as smallmouth bass. Misidentification typically occurred for smaller fish and by younger and/or uninformed anglers. Finally, geomorphic, geographic and hydrologic characteristics, as previously discussed, limits the efficiency of electrofishing in Glover River. Areas of highest smallmouth bass abundance are often times in remote non-accessible locations, and these areas may have been sampled less frequently by Stark and Zale (1991) than those dominated by spotted bass and largemouth bass. Furthermore, conductivity in Glover River is at or near the lower range of electrofishing efficiency. These problems may account for some of the discrepancies between the two data sets. Similar results, however, were obtained between population and creel survey studies for species proportions in Baron Fork Creek (Stark and Zale 1991) and Glover River and tributaries of the Little River (Finnell 1955, Finnell et al. 1956). On Baron Fork Creek standing stock and angler catch estimates indicated that smallmouth bass were 80 - 90% more abundant than other black bass species. Secondly, angler catch on Glover River and abundance of black bass congeners as reported by Finnell (1955) were similar. Finnell (1955) estimated that about 70% of black bass abundance was smallmouth bass which was similar to the catch by anglers in this study. This trend indicates that spotted bass may not be replacing smallmouth bass in Glover River, as suggested for streams in Oklahoma (Stark and Zale 1991) and Missouri (Fajen 1991), and supports others' findings for spotted bass trends in the Little River drainage (Rutherford et al. 1987).

We estimated that nearly one-fourth 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 Creek and Glover River when compared to estimates from the literature (Table 8). However, if these studies did not account for anglers releasing fish, then the proportion of anglers catching tagged fish were similar to exploitation rates reported by others (Table 8). Secondly, 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. Lesions causing fish mortality or tag shedding would have caused a downward trend in our exploitation estimates. Additional studies over extended periods of time may be needed to evaluate the effects of abdominal anchor tags on fish mortality and shedding rates over extended periods of time.

Orth et al. (1983) estimated total annual mortality for smallmouth bass to be 61%. Fishing mortality estimated from this study on Glover River ranged from 3 - 11% (5 - 18% of total annual mortality). It appears that smallmouth bass population in Glover River is characterized by high mortality rates with only a small percentage occurring from angler harvest. Finnell (1955) aged 161 smallmouth bass in the Little River and Mountain Fork drainage and found no bass over six years and only 18 (11%) greater than 3. Similarly, Orth et al. (1983) found no bass older than 6 years and 12% to be greater than 3. 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.

One of the contrasting differences between the two fisheries was the number of trot-line anglers on Glover River; however, differences in survey techniques may have been one contributing factor. Trot-lines are fished passively, and with the roving creel survey, trot-line anglers would only be enumerated if anglers were in the process of checking, baiting, or setting their lines. Even though roving creel surveys do not adequately enumerate passively fished gear and, therefore, may have contributed to this difference, the proportion of anglers fishing for catfish was significantly greater on Glover River. Secondly, catfish anglers were partly responsible for the high harvest of sunfish species on Glover River, because sunfish were used to bait trot-lines.

Glover River sustains a quality sunfish and catfish fishery. Sunfish species made up 89% of total harvest on Glover River compared to 39% of harvest on Baron Fork Creek. Length limit implementation can have beneficial and detrimental effects on species other than those being directly targeted by a management regulation (Fajen 1975, Kauffman 1983). After implementation of a 305-mm minimum length limit on bass in Huzzah Creek, Missouri, smallmouth bass catch rates doubled and the number and average size of rock bass increased (Fajen 1975). Kauffman (1983) found a similar increase in the sunfish yields, but documented a steady decline in channel catfish harvest after implementation of bass minimum size regulations. These affects should be considered when implementing management regulations on Baron Fork Creek and Glover River. Clearly, however, the fishery in Glover River is more dependent on species other than black basses and the potential effects on fish not being directly targeted by a management schemes should be considered before implementation (Smith and Kauffman1991).

Clapp and Clark (1989) documented higher mortality rates for bass caught on natural than artificial baits. With a high proportion of the smallmouth bass population being caught each year, catch and release mortality may contribute significantly to fishing mortality. Even though most anglers who caught tagged fish were using artificial baits in Baron Fork Creek and Glover River, many anglers used soft-plastic lures. During creel surveys, several anglers were encountered who kept injured bass because of deep hooking. Assuming 5.5% hooking mortality (mean mortality rate for bass caught on artificial (0%) and natural (11%) baits; Clapp and Clark 1989), mortality from fishing may be underestimated by nearly 10% on Baron Fork Creek and Glover River. Additional studies may be warranted to evaluate the effect of hooking mortality on smallmouth bass populations where a high proportion of the standing stock is caught but not harvested each year.

Management Implications

Baron Fork Creek and Glover River have unique smallmouth bass fisheries in terms of angler use, fishing effort, catch and harvest, and population and genetic characteristics. Assuming these fisheries are representative of others in their region, then different management schemes will be needed for smallmouth bass streams located in the Ozark and Ouachita Highlands of eastern Oklahoma. Stark and Zale (1991) recommended slot-length regulations for smallmouth bass in Ozark streams and minimum length limits for smallmouth bass in Ouachita streams. These recommendations are supported by findings from this study. Slot-length limits on Baron Fork Creek would concentrate angler harvest on individuals below the slot thereby reducing abundances and enhancing growth rates. However, for this regulation to be effective, anglers must be willing to harvest fish below the slot. Judging from the relatively small length at harvest (mean=270mm) for smallmouth bass on Baron Fork Creek, it seems reasonable to assume that anglers would be willing to comply with a slot-length regulation. Stark and Zale (1991) also recommended limiting daily harvest above the slot to one or two fish to encourage harvest of smaller fish.

Imposition of a minimum size restriction on Glover River would decrease harvest of smallmouth bass below the minimum size restriction. However, with high annual mortality (61%) and angler harvest accounting for only a small percentage of total mortality (5 - 18%), it is likely that many fish would be released only to die from natural causes. it does appear, however, that this fishery is unable to sustain yields similar to Baron Fork Creek. Proportional Stock Density for Glover River was among the lowest reported in the literature

(Orth et al. 1983); however, mean length at harvest (315mm) was intermediate to high when compared to others (Table 8). It seems that two factors are contributing to low PSD. First, high natural mortality seems to be limiting the abundance of larger fish. Finnell (1955) and Orth et al. (1983) did not sample smallmouth bass greater than 6 years old. Low exploitation rates indicate that many fish are dying from natural causes; however, mean length at harvest (315mm) for smallmouth bass indicates that anglers are primarily harvesting 5 and 6 year old fish. It seems that a high minimum length regulation (e.g., 305mm) would increase smallmouth bass PSD and protect this vulnerable fishery.

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References

Andrews, A. K., G. A. Earls, and R. C. Summerfelt. 1974. Recreational use of an Oklahoma scenic River. Oklahoma Department of Wildlife Conservation, Federal Aid in Sportfish Restoration F-31-R-2, Final Report, Oklahoma City.

Austen, D. J., and D. J. Orth. 1984. Angler catches from New River, Virginia and West Virginia, in relation to minimum length limit regulations. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 38:520-531.

Blazs, R. L., D. M. Walters, T. E. Coffey, D. K. White, D. L. Boyle, and J. F. Kerestes. 1992. Water resources data, Oklahoma, water year 1992. U. S. Geological Survey Water-Data Report OK-92-1, Oklahoma City.

Clapp, D. F., and R. D. Clark. 1989. Hooking mortality of smallmouth bass caught on live minnows and artificial spinners. North American Journal of Fisheries Management 9:81-85.

Fajen, O. F. 1975. Population dynamics of bass in rivers and streams. Pages 195-203 in R. H. Stroud and H. Clepper, editors. Black bass biology and management. Sport Fishing Institute, Washington D.C.

Fajen, O. F. 1991. Recent changes in the distribution and relative abundance of smallmouth bass and spotted bass in Missouri streams. Pages 3-4 in D. C. Jackson, editor. The first international smallmouth bass symposium. American Fisheries Society, Bethesda, Maryland.

Finnell, J. C. 1955. Growth of fishes in cutoff lakes and streams of the Little River System, McCurtain County, Oklahoma. Proceedings of the Oklahoma Academy of Science 36:61-66.

Finnell, J. C., R. M. Jenkins, and G. E. Hall. 1956. The fishery resources of the Little River system, McCurtain County, Oklahoma. Oklahoma Fisheries Research Laboratory Report No. 55, Norman.

Fleener, G. G. 1975. Harvest of smallmouth bass and associated species in Courtois Creek. Pages 250-256 in Black bass biology and management, R. H. Stroud and H. Clepper, editors. Sport Fishing Institute, Washington, D. C.

Forbes, A. 1989. Population dynamics of smallmouth bass (Micropterus dolomeiui) in the Galena (Fever) River and one of its tributaries. Wisconsin Department of Natural Resources, Technical Bulletin 165.

Fox, A. C. 1975. Effects of traditional harvest regulations on bass populations and fishing. Pages 392-398 in R. H. Stroud and H. Clepper, editors. Black bass biology and management. Sport Fishing Institute, Washington D.C.

Funk, J. L. 1957. Movement of stream fishes in Missouri. Transactions of the American Fisheries Society 85:39-57.

Funk, J. L. 1975. Evaluation of the smallmouth bass population and fishery in Courtois Creek. Pages 257-269 in R. H. Stroud and H. Clepper, editors. Black bass biology and management. Sport Fishing Institute, Washington

D. C.

Garner, K. E., F. A. Harris, and S. L. Van Horn. 1984. Catch/release bias in reward tag exploitation studies. Proceedings from the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 38:579-582.

Gerking, S. D. 1950. Stability of a stream fish population. Journal of Wildlife Management 14:193-202.

Hoenig, J. M., D. S. Robson, C. M. Jones, and K. H. Pollock. 1993. Scheduling counts in the instantaneous and progressive count methods for estimating sportfishing effort. North American Journal of Fisheries Management 13:723-736.

Hubbs, C. L., and R. M. Bailey. 1940. A revision of the black basses (Micropterus and Huro) with descriptions of four new forms. University of Michigan Museum, Zoology Miscellaneous Publication No. 48., Ann Arbor.

Kauffman, J. 1983. Effects of a smallmouth bass minimum size limit on the Shenandoah River sport fishery. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 37:459-467.

Larimore, R. W. 1952. Home pools and homing behavior of smallmouth black bass in Jordan Creek. Illinois Natural History Survey, Biological Notes No. 28:1-12.

Larimore, R. W. 1954. Dispersal, growth, and influence of smallmouth bass stocked in a warm-water stream. Journal of Wildlife Management 18:207-

216.

Leonard, E. M., and R. M. Jenkins. 1952. Growth of the basses of the Illinois River, Oklahoma. Proceedings of the Oklahoma Academy of Science 33:21-30.

MacCrimmon, H. R., and W. H. Robbins. 1975. Distribution of the black basses in North America. Pages 56-66 in R. H. Stroud and H. Clepper, editors. Black bass biology and management. Sport Fishing Institute, Washington D.C.

OKWRB (Oklahoma Water Resources Board). 1990. Oklahoma water atlas. University of Oklahoma Press, Norman.

Orth, D. J., D. D. Oakey, and O. E. Maughan. 1983. Population characteristics of smallmouth bass in Glover Creek, south-east Oklahoma. Proceedings of the Oklahoma Academy of Science 63:37-41.

Paragamian, V. L. and D. W. Coble. 1975. Vital statistics of smallmouth bass in two Wisconsin rivers, and other waters. The Journal of Wildlife Management 39:201-210.

Paragamian, V. L. 1984a. Population characteristics of smallmouth bass in five Iowa streams and management recommendations. North American Journal of Fisheries Management 4:497-506.

Paragamian, V. L. 1984b. Evaluation of a 12.0-inch minimum length limit on smallmouth bass in the Maquoketa River, Iowa. North American Journal of Fisheries Management 4:507-513.

Pollock, K. H., C. M. Jones, and T. L. Brown. 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society Special Publication 25.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Robson, D.S. 1960. An unbiased sampling and estimation procedure for creel censuses of fishermen. Biometrics 16:261-277.

Robson, D.S. 1961. On the statistical theory of a roving creel census of fishermen. Biometrics 17:415-437.

Robson, D. S. 1991. The roving creel survey. American Fisheries Society Symposium 12:19-24.

Robson, D. S. and C. M. Jones. 1989. The theoretical basis of an access site angler survey design. Biometrics 45:83-98.

Rutherford, D. A., A. A. Echelle, and O. E. Maughan. 1987. Changes in the fauna of the Little River Drainage, southeastern Oklahoma, 1948-1955 to 1981-1982: A test of the hypothesis of environmental degradation. Pages 178-183 in W. J. Matthews and D. C. Heins editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman.

Sanderson, A. E., Jr. 1958. Smallmouth bass management in the Potomac River basin. Transactions of the North American Wildlife Conference 23:248-262.

Smith, J. 1982. A 1982 Illinois River fisheries survey compared to previous Illinois River fisheries surveys. Oklahoma Department of Wildlife Conservation. Northeast Regional Office, Porter.

Smith, P. P., and J. W. Kauffman. 1991. The effects of a slot size limit regulation on smallmouth bass in the Shenandoah River, Virginia. Pages 112-117 in D. C. Jackson, editor. First international smallmouth bass symposium. American Fisheries Society, Bethesda, Maryland.

Stark, W. J., A. A. Echelle, and W. L. Fisher. 1995. Genetic structure of stream populations of smallmouth bass in eastern Oklahoma. Oklahoma Department of Wildlife Conservation, Federal Aid in Sportfish Restoration F-41-R, Final Report, Oklahoma City.

Stark, W. J. and A. V. Zale. 1991. Status of smallmouth bass populations in eastern Oklahoma. Oklahoma Department of Wildlife Conservation, Federal Aid in Sportfish Restoration F-41-R, Final Report, Oklahoma City.

Summers, G. L. 1990. Oklahoma anglers opinion survey. Oklahoma Department of Wildlife Conservation, Federal Aid in Sportfish Restoration F-37-R-18, Final Report, Oklahoma City.

Surber, E. W. 1969. Effects of a 12-inch size limit on smallmouth bass populations and fishing pressure in the Shenandoah River, Virginia. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 22:300-311.

Todd, B. L., and C. F. Rabeni. 1989. Movement and habitat use by stream-dwelling smallmouth bass. Transactions of the American Fisheries Society 118:229-242.

Van den Avyle, M. J. 1986. Measuring angler effort, success and harvest. Pages 57-64 in G. E. Hall and M. J. Van den Avyle, editors. Reservoir fisheries management: Strategies for the 80's. American Fisheries Society.

Weathers, K. C., S. L. Morse, M. B. Bain, and W. D. Davies. 1990. Effects of abdominally implanted internal anchor tags largemouth bass. American Fisheries Society Symposium 7:117-120.

Weathers, K. C., and M. B. Bain. 1992. Smallmouth bass in the Shoals Reach of the Tennessee River: population characteristics and sport fishery. North American Journal of Fisheries Management 12:528-537.

Table 1.--Attitudes, preferences, and characteristics of Baron Fork Creek and Glover River anglers (1994). Chi-square analyses (2 x 2 contingency table) used to test for differences between anglers.

	Percent of responses		
Characteristics	Baron Fork	Glover River	P [a]
Importance of stream fishing compared to all other fishing activities.			
Extremely important	43	51	NS
Above average	27	26	NS
Average	27	20	NS
Below average	2	3	-
Not important	2	0	-
Rating present fishing experience.			
Excellent	5	2	-
Good	19	16	NS
Fair	42	20	0.003
Poor	35	62	0.000
Bait type			
Artificial	64	41	0.001
Natural	28	42	0.037
Combination	8	17	0.032
Fishing method			
Rod & Reel	95	97	NS
Fly fishing	7	5	NS
Trot-line	0	25	0.000
Gigging	0	0	-
Type of fishing			
Bank & wading	89	64	0.000
Boat / Canoe / Tube	9	24	0.000
Combination	2	13	0.003
Species sought			
Black bass	55	41	0.047
Sunfish	9	23	0.007
Catfish	5	30	0.000
No preference	37	26	NS
State of residence			
Oklahoma residence:	95	93	NS
Non-residents:	5	7	-

[a] NS=not statistically significant; - = insufficient data for test.

Table 2.--Catch per unit effort (CPUE) and harvest per unit effort (HPUE) estimates (± SE) from Baron Fork Creek and Glover River (1994).

		Total [a]		Sunfish [b]		Black bass [c]		Smallmouth bass	
Stream	n	CPUE	HPUE	CPUE	HPUE	CPUE	HPUE	CPUE	HPUE
Baron Fork Creek	103	1.91 ± .20	0.57 ± .12	0.81 ± .12	0.23 ± .07	1.02 ± .14	0.30 ± .08	0.87 ± .13	0.27 ± .07
Glover River	89	1.76 ± .25	0.72 ± .13	1.42 ± .21	0.60 ± .13	0.36 ± .10	0.13 ± .04	0.25 ± .09	0.10 ± .03
P [d]		NS	0.0259	0.0084	0.0001	0.0001	NS	0.0001	NS

[a] Excluding set line estimates.
[b] Includes longear sunfish *Lepomis megalotis*, green sunfish *Lepomis cyanellus*, bluegill sunfish *Lepomis macrochirus*, and rockbass *Ambloplites rupestris*.
[c] Includes smallmouth bass *Micropterus dolomieu*, spotted bass *Micropterus punctulatus*, and largemouth bass *Micropterus salmoides*.
[d] NS = not statistically significant.

Table 3.--Fishing pressure (h/ha) and catch (no/ha) estimates from Baron Fork Creek and Glover River (1994). Relative standard error (100 x SE/mean) estimates for annual catch given in parentheses.

					Black bass			
Time block	Fishing pressure (h/ha)	Total catch (no/ha)	Catfish (no/ha)	Sunfish (no/ha)	All species (no/ha)	Smallmouth bass (no/ha)	Spotted bass (no/ha)	Largemouth bass (no/ha)
				Baron Fork Creek				
Apr	20.5	4.5	0	2.1	2.0	1.6	0.4	0
May	61.5	98.1	0.1	58.7	36.2	33.3	0	3.0
Jun	94.1	183.6	0	98.6	70.7	67.2	0.6	2.9
Jul	66.0	123.2	1.3	41.8	78.8	67.9	4.1	6.8
Aug	57.4	167.7	0	49.8	113.9	106.3	0	7.6
Sep	17.2	34.0	0	2.3	31.7	30.7	0	1.1
Annual	317 ± (11)	611 ± (18)	1 ± (66)	253 ± (28)	333 ± (19)	307	5	21
				Glover River				
Mar [a]	10.0	13.6	< 0.1	10.1	4.8	3.1	0.3	1.4
Apr	59.6	59.5	2.8	38.9	20.1	15.1	3.8	1.3
May	76.4	162.8	0.2	155.2	7.7	5.6	0.6	1.5
Jun	51.7	88.2	0.1	72.2	16.0	12.7	0	3.3
Jul	30.1	109.9	0.5	95.6	14.3	11.1	0	3.2
Aug	3.6	5.6	0	4.5	1.1	1.1	0	0
Sep [b]	2.8	15.5	0.1	15.5	0	0	0	0
Annual	234 ± (16)	455 ± (27)	4 ± (41)	392 ± (30)	64 ± (27)	49	5	11

[a] 16 March - 31 March 1994

[b] 1 September - 15 September 1994

Table 4.--Monthly and annual harvest (no/ha) estimates on Baron Fork Creek and Glover River (1994). Relative standard error (100 x SE/mean) estimates for annual harvest given in parentheses.

				Black bass			
Time block	Total harvest (no/ha)	Catfish (no/ha)	Sunfish (no/ha)	Total fish (no/ha)	Smallmouth bass (no/ha)	Spotted bass (no/ha)	Largemouth bass (no/ha)
			Baron Fork Creek				
Apr	2.0	0	0	2.0	1.6	0.4	0
May	41.5	0.1	28.2	10.3	10.3	0	0
Jun	36.5	0	16.0	16.1	12.6	1.1	2.3
Jul	30.8	1.3	9.2	19.7	16.8	1.4	1.4
Aug	54.8	0	15.1	36.5	31.7	0	4.8
Sep	10.6	0	0.8	9.8	9.2	0	0.7
Annual	176 ± (25)	1 ± (66)	69 ± (34)	94 ± (33)	82 ± (33)	3 ± (36)	9 ± (42)
			Glover River				
Mar [a]	10.6	< 0.1	8.1	3.7	2.2	0.3	1.3
Apr	27.6	2.3	18.4	8.7	6.7	2.0	0
May	95.4	0	95.0	0.4	0.3	0	0.1
Jun	22.6	0.1	20.1	2.5	2.4	0	0.1
Jul	28.7	0.5	23.1	5.6	3.7	0	1.9
Aug	2.2	0	1.1	1.1	1.1	0	0
Sep [b]	15.5	0	15.5	0	0	0	0
Annual	203 ± (32)	3 ± (47)	181 ± (35)	22 ± (28)	16 ± (27)	2 ± (34)	3 ± (51)

[a] 16 March 1994 - 31 March 1994
[b] 1 September 1994 - 15 September 1994

Table 5.--Monthly and annual yield (kg/ha) estimates on Baron Fork Creek and Glover River (1994). Relative standard error estimates (100 x SE/mean) for annual yield given in parentheses.

Time period	Total Black bass (kg/ha)	Smallmouth bass (kg/ha)	Spotted bass (kg/ha)	Largemouth bass (kg/ha)
		Baron Fork Creek		
Apr	0.9	0.6	0.3	0.0
May	2.3	2.3	0.0	0.0
Jun	4.2	3.5	<0.1	0.5
Jul	3.5	2.9	0.3	0.3
Aug	8.8	7.6	0.0	1.1
Sep	2.9	2.6	0.0	0.3
Annual	22.5 ± (33)	19.5 ± (34)	0.6 ± (55)	2.2 ± (40)
		Glover River		
Mar [a]	1.9	1.1	<0.1	0.7
Apr	3.4	2.6	0.8	0.0
May	0.2	0.1	0.0	0.1
Jun	1.5	1.4	0.0	0.1
Jul	1.4	1.0	0.0	0.3
Aug	<0.1	<0.1	0.0	0.0
Sep [b]	0.0	0.0	0.0	0.0
Annual	8.4 ± (24)	6.2 ± (24)	0.8 ± (36)	1.2 ± (35)

[a] 16 March 1994 - 31 March 1994
[b] 1 September 1994 - 15 September 1994

Table 6.--Catch and exploitation rates for tagged smallmouth bass Micropterus dolomieu in Baron Fork Creek and Glover River in 1993 and 1994. Estimates derived assuming 100% and 64% tag return rates for tagged bass.

	Baron Fork Creek			Glover River	
	100%	64%		100%	64%
			1993		
Catch rates	0.15	0.23		0.20	0.31
Fishing mortality (u_1)	0.06	0.10		0.07	0.11
			1994		
Catch rates	0.23	0.36		0.06	0.09
Fishing mortality (u_2)	0.10	0.15		0.02	0.03

Table 7.--Mortality estimates for tagged black bass Micropterus spp. in Baron Fork Creek and Glover River (1993-1994).

	Baron Fork		Glover River	
Parameter	100% return	64% return	100% return	64% return
1993 total mortality (A)	0.95	0.95	1.00	1.00
1993 fishing mortality (u_1)	0.06	0.09	0.10	0.16
1993 natural mortality (v)	0.89	0.86	0.94	0.84
1994 fishing mortality (u_2)	0.10	0.15	0.04	0.07
Instantaneous mortality (Z)	1.6094	1.6094	0	0
Instantaneous fishing mortality (F)	0.0969	0.1515	.	.
Instantaneous natural mortality (M)	1.5125	1.4579	.	.

Table 8. Length regulations, catch, harvest and release rates, average 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 are made by the authors where appropriate.

Stream and 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 no/ha	U^c	Source
Baron Fork Creek, OK	None	0.87	0.27	81	317	270	19.5	82	.06 - .15[d]	This study
Glover River, OK	None	0.25	0.10	65	234	315	6.2	16	.02 - .11[d]	This study
Tennessee R., AL	None	0.51[a]	0.16[a]	68	26	360	6.7	9	.35 - .55[d]	Weathers and Bain 1992
New River, WV	None	1.05	0.40	62	-	242	-	-	-	Austen and Orth 1984
Shenandoah River, VA	None	0.19	-	44	182 - 290	<300	-	24	-	Surber 1969; Kauffman 1983
Galena River, WI	None	0.32	0.14	57	185 - 257	<290	8.2	24-38	.34	Forbes 1989
Red Cedar River, WI	None	0.07	-	N[b]	318	260	5.1	-	.16 - .29[e]	Paragamian and Coble 1975
Maquoketa River, IA	None	0.05	0.5	N[b]	628 - 1,082	260	1.7-20.1	-	.17 - .55	Paragamian 1984a
Courtois Creek, MO	None	0.10	-	U[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	-	.14 - .23[f]	Paragamian 1984b
New River, VA	305	1.33	0.06	95	-	322	-	-	-	Austen and Orth 1984
Shenandoah River, VA	305	0.54	-	95	196 - 223	330	-	4-10	-	Kauffman 1983
Potomac River, MD	254	0.51	0.06	88	98	<300	3.6	-	.12	Sanderson 1958
Potomac River, MD	229	0.37	0.13	65	74	<300	5.7	-	.12	Sanderson 1958
Shenandoa River, VA	279-356	0.53	-	70	233 - 247	-	-	4-72	-	Smith and Kaufman 1991

[a] CPUE and HPUE estimates based on anglers fishing specifically for smallmouth bass.
[b] N = Negligible, U=Unknown
[c] U = annual fishing mortality. Mean estimate reported for multiple year studies.
[d] Estimates derived from 100% and 64% response rates
[e] Estimates derived from 100% and corrected for nonresponse and tag shedding (64%).
[f] Estimates for smallmouth bass > than 200 mm.

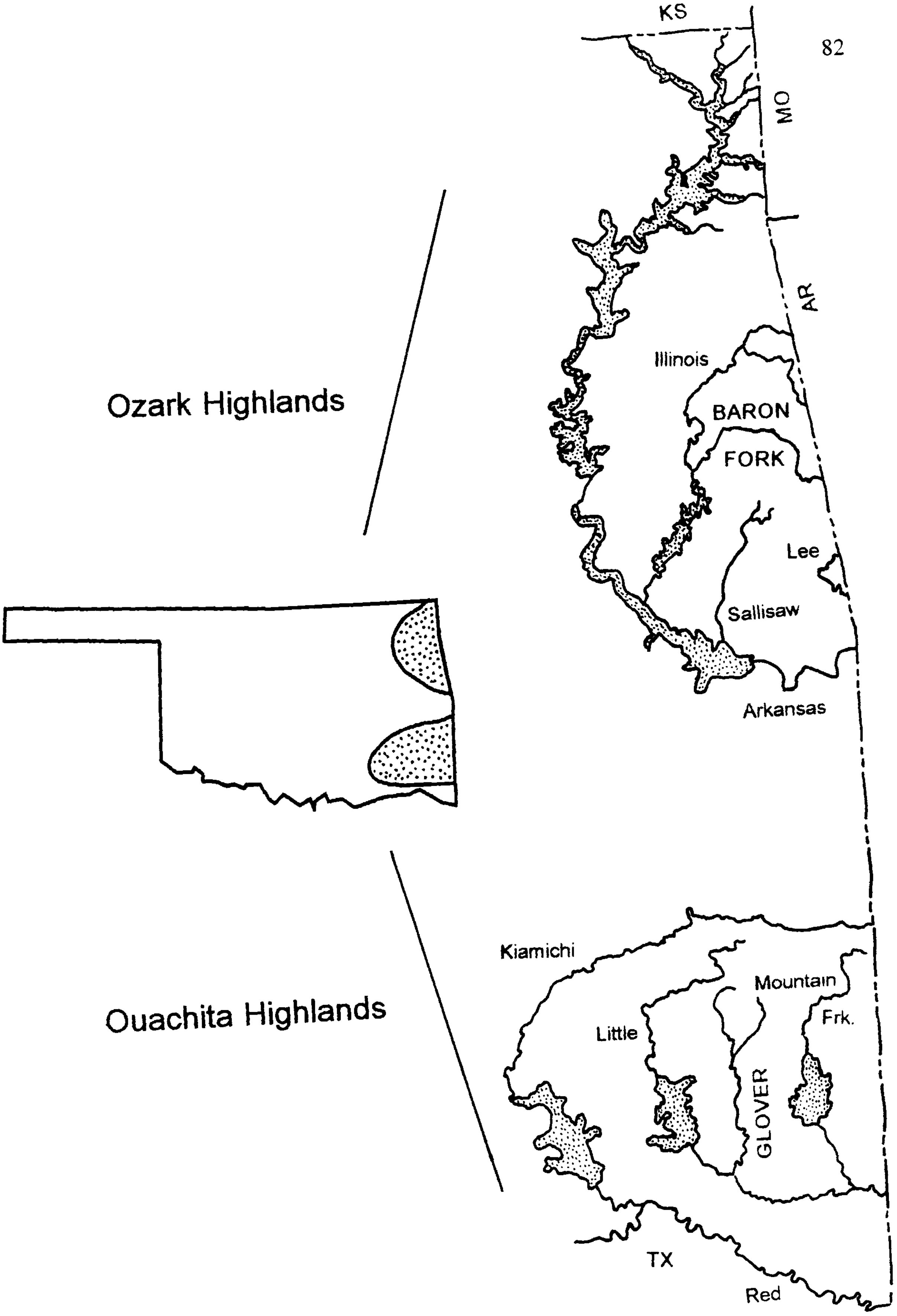
Figure Captions

1. Baron Fork Creek and Glover River study streams in Ozark and Ouachita Highlands in eastern Oklahoma.

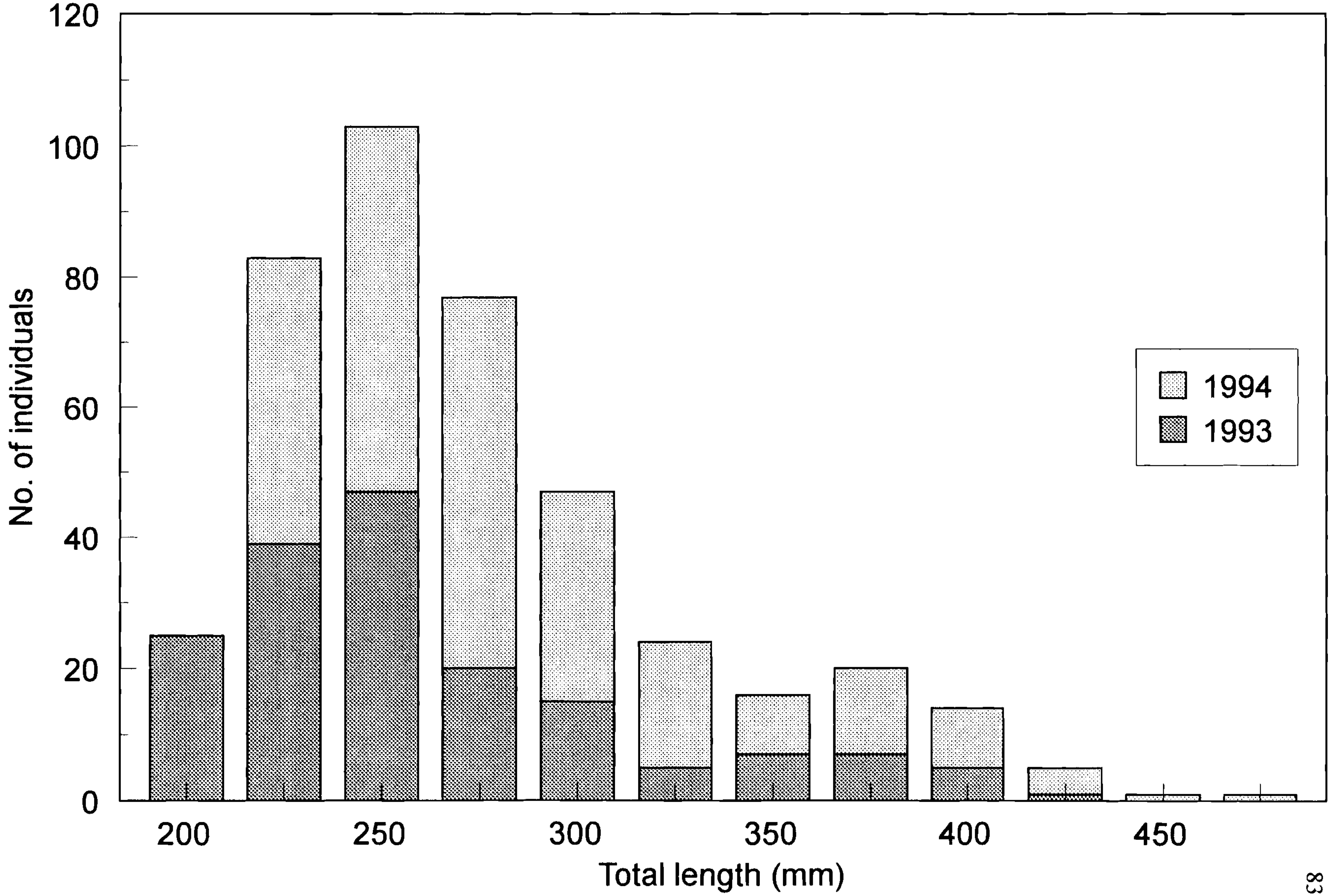
2. Length / frequency of black bass Micropterus spp. tagged with internal abdominal anchor tags in Baron Fork Creek, 1993 and 1994.

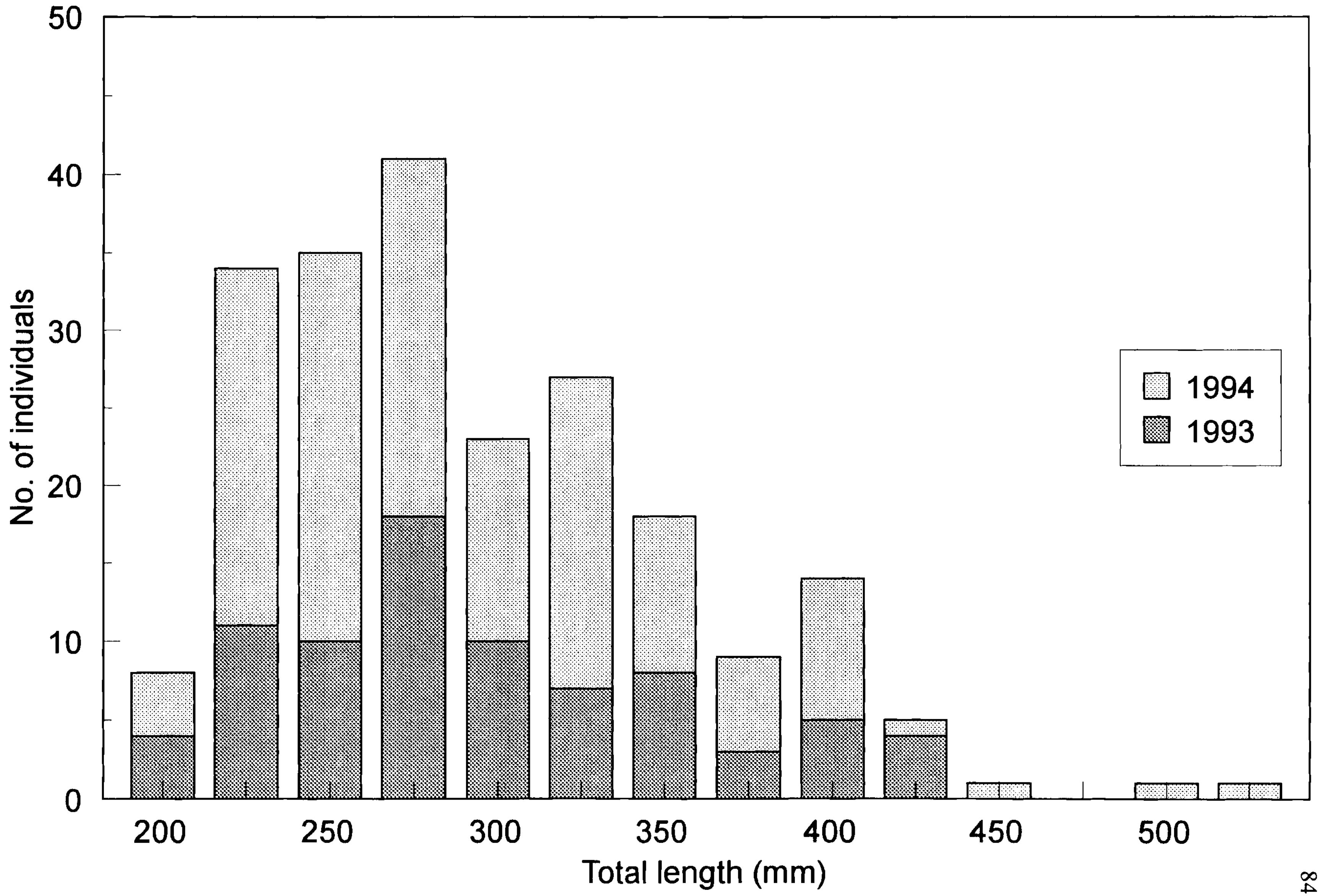
3. Length / frequency of black bass Micropterus spp. tagged with internal abdominal anchor tags in Glover River, 1993 and 1994.

4. Monthly fishing pressure (hr/ha) on Baron Fork Creek and Glover River (1994).



KS
MO
AR
Illinois
BARON
FORK
Lee
Sallisaw
Arkansas
Ozark Highlands
Ouachita Highlands
Kiamichi
Mountain
Frk.
Little
GLOVER
TX
Red


120
100
80
60
40
20
0
No. of individuals
200
250
300
350
400
450
Total length (mm)
1994
1993


No. of individuals
0
10
20
30
40
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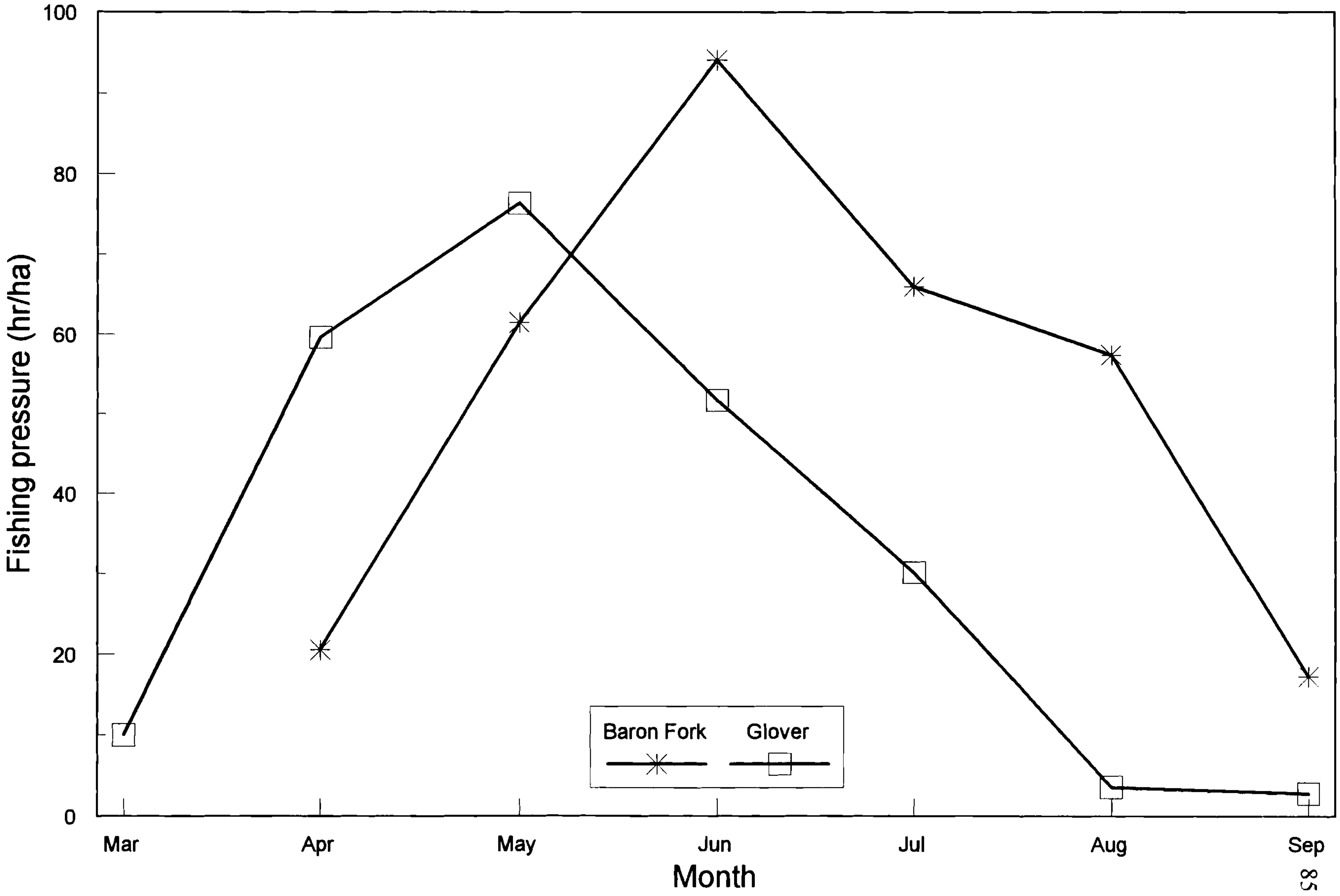
200
250
300
350
400
450
500
Total length (mm)
1994
1993


Fishing pressure (hr/ha)
100
80
60
40
20
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Month
Baron Fork
Glover

Appendixes

Appendix A.--Weight-length relationships ($w = al^b$) for sportfish species in Baron Fork Creek and Glover River. Estimates derived from fish sampled during tagging exploitation and population studies, 1993 and 1994.

Appendix A. Weight-length relationships ($w = al^{b}$) for sportfish species in Baron Fork Creek. Estimates derived from fish sampled during tagging exploitation and population studies, 1993 and 1994.

SPECIES	N	INTERCEPT (a)	SLOPE (b)	r^2	t	p < t
Bluegill Sunfish	87	-4.4999	2.8866	0.9459	38.567	0.0001
Green sunfish	26	-4.7961	3.0298	0.9249	17.195	0.0001
Longear sunfish	234	-4.9418	3.1202	0.9233	52.860	0.0001
Rock bass	68	-2.3636	1.9236	0.3843	6.419	0.0001
Redear sunfish	13	-5.2867	3.2532	0.9662	17.736	0.0001
Warmouth	4	-6.1424	3.6620	0.9989	42.215	0.0006
Sunfish	432	-4.3926	2.8434	0.9038	63.553	0.0001
White crappie	.	.	.	.	.	.
Smallmouth bass	338	-4.5243	2.8395	0.9426	74.309	0.0001
Spotted bass	31	-4.9552	3.0190	0.7461	9.232	0.0001
Largemouth bass	73	-5.3914	3.2029	0.8463	19.769	0.0001
Black bass	442	-4.6267	2.8838	0.9276	75.071	0.0001
Channel catfish	11	-6.3049	3.4952	0.9597	14.643	0.0001
Flathead catfish	.	.	.	.	.	.
Catfish	11	-6.3049	3.4952	0.9597	14.643	0.0001

Appendix A. Weight-length relationships ($w = al^b$) for sportfish species in Glover River. Estimates derived from fish sampled during tagging exploitation or population studies, 1993 and 1994.

SPECIES	N	INTERCEPT (a)	SLOPE (b)	r^2	t	p < t
Bluegill Sunfish	26	-4.9216	3.0615	0.9701	27.915	0.0001
Green sunfish	291	-4.4112	2.8144	0.8656	43.140	0.0001
Longear sunfish	871	-4.7256	2.9702	0.8619	73.641	0.0000
Rock bass	.	.	.	.	.	.
Redear sunfish	2	-20.6903	11.0930	1.0000	.	.
Warmouth	5	-5.8617	3.5241	0.9887	16.207	0.0005
Sunfish	1195	-4.5937	2.9024	0.8901	98.288	0.0000
White crappie	.	.	.	.	.	.
Smallmouth bass	70	-5.2108	3.1197	0.9260	29.173	0.0001
Spotted bass	75	-5.7356	3.3398	0.9585	41.039	0.0001
Largemouth bass	24	-5.3519	3.1618	0.9795	32.441	0.0001
Black bass	169	-5.3669	3.1835	0.9485	55.466	0.0001
Channel catfish	2	-6.1131	3.4288	1.0000	.	.
Flathead catfish	12	-5.6873	3.2801	0.9900	31.422	0.0001
Catfish	14	-5.6814	3.2737	0.9899	34.291	0.0001

Appendix B.--Summary data from black bass *Micropterus* spp. tagging studies in Baron Fork Creek and Glover River from 1993 to 1994.

Appendix B. Summary data from black bass tagging studies in Baron Fork Creek from 1993 to 1994.

Year Tagged	No. Tagged	Number and percentage (cumulative) of tagged fish reported by anglers by year			
		1993 [a]		1994 [a]	
		No.	%	No.	%
			1993		
Black bass	167	22	13.2	2	14.4
Smallmouth bass	144	21	14.6	2	16.0
Spotted bass	12	1	8.3	0	8.3
Largemouth bass	11	0	0.0	0	0.0
			1994		
Black bass	245			54	22.0
Smallmouth bass	202			46	22.8
Spotted bass	15			2	13.3
Largemouth bass	28			6	21.4

[a] 05/15/93 - 05/14/94
[b] 05/15/94 - 05/14/95

Appendix B. Summary data from black bass tagging studies in Glover River from 1993 to 1994.

Year Tagged	No. Tagged	Number and percentage (cumulative) of tagged fish reported by anglers by year			
		1993 [a]		1994 [b]	
		No.	%	No.	%
1993					
Black bass	63	12	19.0	0	19.0
Smallmouth bass	35	7	20.0	0	20.0
Spotted bass	20	2	10.0	0	10.0
Largemouth bass	8	3	37.5	0	37.5
1994					
Black bass	131			11	8.3
Smallmouth bass	88			5	5.7
Spotted bass	29			3	10.3
Largemouth bass	14			3	21.4

[a] 06/01/93 - 05/31/94
[b] 06/01/94 - 05/31/94

Appendix C.--Estimated number of fish caught and harvested per hectare on Baron Fork Creek and Glover River. Estimates derived by group (black bass, sunfish, catfish, rough fish, and other species).

Appendix C. Angler use and estimated number of fish caught per hectare on Baron Fork Creek, 1994. Estimates derived by group (black bass, sunfish, catfish, rough fish, other).

	Parameter [± relative standard error] or (% of catch by group)					
CHARACTERISTIC	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Fishing pressure (hr/ha)	20.5 [± 41]	61.5 [± 33]	94.1 [24]	66.0 [14]	57.4 [16]	17.2 47]
Total catch	4.5 [± 100]	98.1 [± 55]	183.6 [± 39]	123.2 [± 24]	167.7 [± 31]	34.0 [± 72]
Black bass	2.0 [± 100]	36.2 [± 49]	70.7 [± 15]	78.8 [± 18]	113.9 [± 44]	31.7 [± 78]
Smallmouth bass	1.6 (82)	33.3 (92)	67.2 (95)	67.9 (86)	106.3 (93)	30.7 (97)
Spotted bass	0.4 (18)	.	0.6 (1)	4.1 (5)	.	.
Largemouth bass	.	3.0 (8)	2.9 (4)	6.8 (9)	7.6 (7)	1.1 (3)
Sunfish	2.1 [± 100]	58.7 [± 60]	98.6 [± 56]	41.8 [± 49]	49.8 [± 29]	2.3 [± 51]
Catfish	.	0.1 [± 100]	.	1.3 [± 71]	.	.
Rough fish	.	.	4.4 [± 100]	0.6 [± 100]	3.7 [± 73]	.
Freshwater drum	.	.	4.4 (100)	0.6 (100)	1.8 (50)	.
Catostomatidae	.	.	.	.	1.8 (50)	.
Other	0.4 [± 100]	0.2 [100]	.	0.7 [100]	0.3 [100]	.
White bass	.	0.2 (100)	.	0.7 (100)	0.3 (100)	.
Walleye	0.4 (100)	.	.	.	.	.

Appendix C. Estimated number of fish harvested per hectare on Baron Fork Creek, 1994. Estimates derived by group (black bass, sunfish, catfish, rough fish, other).

Group Species	Parameter [± relative standard error] or (% of harvest by group)					
	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Total harvest	2.0 [± 100]	41.5 [± 67]	36.5 [± 25]	30.8 [± 41]	54.8 [± 54]	10.6 [± 67]
Black bass	2.0 [± 100]	10.3 [± 68]	16.1 [± 56]	19.7 [± 53]	36.5 [± 72]	9.8 [± 71]
Smallmouth bass	1.6 (82)	10.3 (100)	12.6 (79)	16.9 (86)	31.7 (87)	9.2 (93)
Spotted bass	0.4 (18)	.	1.1 (7)	1.4 (7)	.	.
Largemouth bass	.	.	2.3 (14)	1.4 (7)	4.8 (13)	0.7 (7)
Sunfish	.	28.2 [± 74]	16.0 [± 40]	9.2 [± 37]	15.1 [± 58]	0.8 [± 50]
Longear sunfish	.	1.5 (5)	0.8 (5)	6.1 (67)	6.5 (43)	0.8 (100)
Rockbass	.	11.9 (42)	5.9 (37)	3.1 (33)	.	.
Green sunfish	.	4.5 (16)	5.1 (32)	.	5.9 (39)	.
Bluegill sunfish	.	10.4 (37)	4.2 (26)	.	.	.
Redear sunfish	.	.	.	.	2.7 (18)	.
Catfish	.	0.1 [± 100]	.	1.3 [± 71]	.	.
Channel catfish	.	.	.	1.3 (100)	.	.
Rough fish	.	.	4.4 [± 100]	.	3.2 [± 84]	.
Freshwater drum	.	.	4.4 (100)	.	1.6 (50)	.
Catostomatidae	.	.	.	.	1.6 (50)	.
Other	.	.	.	0.7 [100]	.	.
White bass	.	.	.	0.7 (100)	.	.

Appendix C. Angler use and estimated number of fish caught per hectare on Glover River, 1994. Estimates derived by group (black bass, sunfish, catfish, rough fish, and other).

	Parameter [± relative standard error] or (% of catch by group)						
CHARACTERISTIC	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Fishing pressure (hr/ha)	10.0 [± 48]	59.6 [± 29]	76.4 [± 27]	51.7 [± 40]	30.1 [± 40]	3.6 [± 36]	2.8 [± 100]
Total catch	13.6 [± 43]	59.5 [± 39]	162.8 [± 58]	88.2 [± 39]	109.9 [± 60]	5.6 [± 95]	15.5 [± 100]
Black bass	4.8 [10]	20.1 [± 38]	7.7 [± 51]	16.0 [± 55]	14.3 [± 83]	1.1 [± 100]	.
Smallmouth bass	3.1 (65)	15.1 (75)	5.6 (73)	12.7 (80)	11.1 (78)	1.1 (100)	.
Spotted bass	0.3 (6)	3.8 (19)	0.6 (8)	.	.	.	.
Largemouth bass	1.4 (29)	1.3 (6)	1.5 (20)	3.3 (20)	3.2 (22)	.	.
Sunfish	10.1 [± 64]	38.9 [± 54]	155.2 [± 61]	72.2 [± 40]	95.6 [± 58]	4.5 [± 93]	15.5 [± 100]
Rough fish [a]	.	0.5 [± 100]	.	.	.	.	.
Trot-line pressure	3.8 [± 12]	10.8 [± 35]	9.9 [± 56]	9.6 [± 72]	2.5 [± 100]	1.0 [± 100]	1.2 [± 100]
Catfish [b]	0.04 [± 100]	2.45 [± 51]	0.14 [± 100]	0.08 [± 100]	0.42 [± 100]	.	0.09 [± 100]
Rough fish [c]	.	1.28 [± 100]	.	.	.	.	.

[a] Including Lepisosteus spp., Catostomotidae, and Aplodinotus grunniens caught with rod and reel.
[b] Including Ictalurus punctatus, Pylodictis olivaris, Ictalurus furcatus caught with trot-lines.
[c] Including Lepisosteus spp., Catostomotidae, and Aplodinotus grunniens caught with trot-lines.

Appendix C. Estimated number of fish harvested per hectare on Glover River, 1994. Estimates derived by group (total species, black bass, sunfish, catfish, rough fish, and other).

	Parameter [± relative standard error] or (% of harvest by group)						
CHARACTERISTIC	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Total harvest	10.6 [± 49]	27.6 [± 47]	95.4 [± 59]	22.6 [± 59]	28.7 [± 76]	2.2 [± 100]	15.5 [± 100]
Black bass	3.7 [± 42]	8.7 [± 38]	0.4 [± 64]	2.5 [± 45]	5.6 [± 87]	1.1 [± 100]	.
Smallmouth bass	2.2 (59)	6.7 (77)	0.3 (75)	2.4 (96)	3.7 (67)	1.1 (100)	.
Spotted bass	0.3 (7)	2.0 (23)	.	.	.	.	.
Largemouth bass	1.3 (34)	.	0.1 (25)	0.1 (4)	1.9 (33)	.	.
Sunfish	8.1 [± 61]	18.4 [± 75]	95.0 [± 60]	20.1 [± 65]	23.1 [± 74]	1.1 [± 100]	15.5 [± 100]
Longear sunfish	7.8 (95)	1.0 (6)	9.0 (10)	5.0 (25)	1.5 (7)	.	.
Rockbass	.	.	.	0.7 (2)	.	.	.
Green sunfish	0.4 (5)	17.4 (94)	58.8 (62)	14.6 (73)	21.6 (93)	1.1 (100)	.
Rough fish [a]	.	0.5 [± 100]	.	.	.	.	.
Catfish [b]	< 0.1 [± 100]	2.3 [± 55]	.	0.1 [±100]	0.5 [± 100]	.	.
Rough fish [c]	.	1.3 [± 100]	.	.	.	.	.

[a] Including Lepisosteus spp., Catostomotidae, and Aplodinotus grunniens harvested with rod and reel.

[b] Including Ictalurus punctatus, Pylodictis olivaris, Ictalurus furcatus harvested with trot-lines.

[c] Including Lepisosteus spp., Catostomotidae, and Aplodinotus grunniens harvested with trot-lines.

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