Effects of Angling on Largemouth Bass Population Structure in a Previously Unfished Mississippi Lake.[1]

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Abstract: Fishery data were collected from February to August 1984 for Bluff Lake, Noxubee County, Mississippi, to evaluate the effect of refuge areas and size and creel limits in reducing possible overharvest of largemouth bass (*Micropterus salmoides*) from previously unfished waters. During the study, 1,779 bass were marked and 150 were recaptured. The pre-fishing bass population was estimated at 7,657. Fishing mortality during opening weekend was 10%, 525 parties who fished a total of 3,292 hours caught 361 bass (255 kg). Over the 6-month period, anglers fished a total of 48,796 hours and harvested 3,080 kg of bass. Largemouth bass accounted for 24% of the total weight of fish creeled; catch per hour was 0.04 kg. Although refuge areas and size and creel limits may have reduced the initial overharvest of bass during opening weekend, more than 40% of the bass population had been harvested by the end of the study and few legal-sized bass (≥254 mm) remained.

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The initial overharvest of largemouth bass (hereafter referred to as bass) from previously unfished waters is well documented (Bowers and Martin 1956, Turner 1963, Hoey and Redmond 1974, Rasmussen and Michaelson 1974, Goedde and

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Coble 1981). Harvest of bass by angling can be so severe that reproduction and recruitment rates declined as well as fishing quality (Ming 1974). The factors most frequently thought to cause overharvest are heavy initial fishing pressure (Bowers and Martin 1956, Turner 1963, Schneider 1973, Hoey and Redmond 1974, Rasmussen and Michaelson 1974, Redmond 1974) and a fish population not previously exposed to fishing (Aldrich 1938, Bowers and Martin 1956, Anderson and Heman 1969, Bennett 1974).

Various management techniques have been used in attempts to reduce the initial harvest of bass from new impoundments. Redmond (1974) advocated stocking forage fish, adding reduced numbers of bass periodically, imposing a minimum length limit, and prohibiting fishing from certain areas of the lake.

We report on the initial harvest of bass from a previously unfished lake under regulations with minimum length (254 mm) and maximum daily creel limit of 5 bass per person and in which patches of floating and emergent vegetation and areas of standing timber effectively reduced the fishable portion of the lake by about 25% (Royce Huber, Asst. Manager Noxubee Wildl. Refuge, pers. commun.). The 3 objectives of the study were to 1) estimate the size and characteristics of the prefishing bass population, 2) document changes in these population characteristics through time as they related to fishing pressure, and 3) assess the refuge area concept in combination with size and creel limits as a management strategy for reducing the heavy initial harvest of bass.

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Methods

Study Area

The study was conducted on Bluff Lake a 404-ha impoundment on the Noxubee National Wildlife Refuge in east-central Mississippi. After a portion of the dam was washed out by heavy spring floods in 1979, the lake was drained, the dam was repaired, the basin was refilled, and largemouth bass were stocked: 42,000 fingerlings in spring 1982 and 2,400 bass (102–152 mm long) in October 1983. Length and creel limits were imposed when the lake was opened to fishing on 1 March 1984.

Capture and Sampling

Sampling was conducted from February through August 1984. A boom-type electrofisher powered by a 240-volt portable generator and mounted in a boat was used to collect bass. Initially, the lake was divided into 404 1-ha cells, from which 30 cells (sampling stations) were randomly selected. Daytime sampling in each cell was conducted along 3 100-m transects marked with buoys. The starting point and direction of travel were selected by the flip of a coin. This sampling strategy was following until 8 June. Thereafter, sampling was conducted at night because daytime success had diminished considerably. Night sampling was conducted by electrofishing along 100 m of shoreline. Locations of shoreline transects were estimated relative to the location of known cells and transects buoys. A sampling occasion was the time required (usually 2–3 days) to sample all of the 30 stations on the lake; there were 23 sampling occasions.

All captured bass were marked, weighed to the nearest gram, measured to the nearest millimeter (total length), and then released. Bass ≥175 mm long were marked at the posterior base of the soft dorsal fin with a serially numbered Floy[3] FD-68B anchor tag. Bass <175 mm long were marked by removing the anal fin. All lengths, weights, and tag numbers (when applicable) were recorded. Anglers were asked to place tags from harvested bass in any 1 of 3 locked boxes located at accessible points around the lake. These angler-collected tags were used to estimate fishing mortality. Scales taken from bass captured at the beginning and at the end of the study were used to determine age and growth, following methods given by Frie (1982).

Creel Surveys

During the first 4 days of fishing, a complete creel census was conducted. Thereafter, a roving creel survey with nonuniform probability sampling (Malvestuto et al. 1978) was used. The survey was conducted 7 days per month. Creel survey data were recorded on standardized creel forms provided by the Mississippi Department of Wildlife Conservation.

Data Analysis

The Jolly-Seber (Jolly 1965, Seber 1965) and Modified Schnabel models (Ricker 1975) were used to estimate the size of the bass population from mark-recapture data. Catch and effort statistics were developed from the nonuniform probability creel data, which were analyzed with a processed computer program following Malvestuto et al. (1978). Monthly fishing mortality was estimated to be the proportion of the total number of tags available for harvest (i.e., tagged bass of harvestable size) that were returned by anglers. Tag loss was estimated from the proportion of the total bass recaptured that showed signs of having been previously tagged. A scar or an open wound at the tagging site was interpreted as indicating a lost tag. Sampling intensities (proportion of population sampled) were calculated according to Hightower and Gilbert (1984). Confidence intervals (95%) for recapture frequencies were obtained from a table of binomial confidence limits.

Results

Capture-Recapture and Population Estimates

During the study, we marked 991 bass ≥175 mm long with Floy anchor tags, and clipped anal fins of 789 bass <175 mm long. We captured 74 of the tagged bass and 76 of the fin-clipped bass during electrofishing. Recapture frequencies of 9.6% for fin-clipped and 7.5% for tagged bass were not significantly different (P >0.05). Tag loss was estimated at less than 3%. Sampling intensities for the portion of the bass population composed of fish ≥175 mm long ranged from <1 to 4.3%.

The Jolly-Seber estimate of the pre-fishing population of bass ≥175 mm long was 4,784 ±11,014 (95% confidence limit). Post-fishing Jolly-Seber estimates of the bass population ≥175 mm long fluctuated widely during the study (Table 1). The Modified Schnabel estimate of the pre-fishing bass population in the lake was 7,657 ±2,849. Modified Schnabel estimates made after fishing fluctuated initially, but stabilized at about 10,000 bass during the latter part of the study (Table 1).

Proportional Stock Density

The pre-fishing proportional stock density (PSD) value for bass in Bluff Lake was 45%. The value had declined to 22% 2 months after fishing began and to 17% by the end of the third month, and remained below 20% for the rest of the study (Fig. 1).

Fishing Mortality

Seventy-one tags returned by anglers from bass harvested during the study were the basis for the monthly and cumulative fishing mortality rates (Table 2).

Table 1. Population estimates (*N*) of largemouth bass 175 mm long by Jolly-Seber and all sizes by Modified Schnabel methods in Bluff Lake, Mississippi, from February through July 1984.

	Jolly-Seber estimate		Modified Schnabel estimate (95% confidence)	
Date	*N*	SE	*N*	range
25 Feb	4,784	5,507	7,657	4,808–15,538
21 May	76	0[a]	12,348	7,753–25,054
10 Jun	10,868	13,325	13,546	8,858–25,032
17 Jun	4,495	3,575	11,406	8,802–15,799
26 Jun	2,213	1,785	10,126	8,239–12,761
10 Jul	1,380	1,233	10,337	8,450–12,953
17 Jul	759	549	10,375	8,528–12,912
Jul 25	1,608	1,589	10,800	9,156–12,943

[a]No recaptures during this sampling period; hence SE = 0.

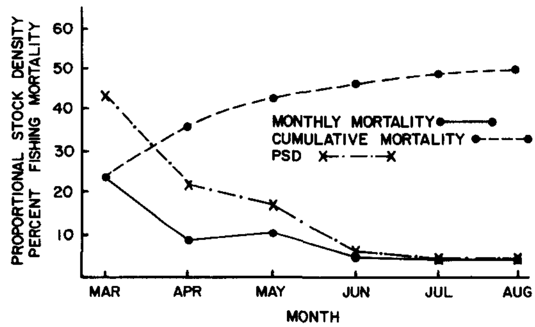

Figure 1. Monthly proportional stock density (PSD) values and monthly and cumulative fishing mortality of largemouth bass in Bluff Lake, Mississippi, from March through August 1984.

Table 2. Monthly totals for numbers of tagged bass, 245 mm long, available for harvest, number tags returned, and estimated fishing mortality rates.

Month	Tagged bass at large (*N*)	New bass tags released (*N*)	Total tagged bass (*N*)	Tags returned by month's end (*N*)	Estimated monthly fishing mortality (%)	Estimated cumulative fishing mortality (%)
1–4 Mar[a]	153	0	153	15	9.80	9.80
5–31 Mar	138	0	138	19	13.77	23.57
Apr	119	15	134	12	8.95	32.52
May	122	11	133	14	10.52	43.04
Jun	119	60	179	5	2.79	45.83
Jul	174	18	192	3	1.56	47.39
Aug	189	1	190	3	1.57	48.96

[a]Opening weekend statistics

Bass fishing mortality rate for the first month was estimated at 24% with the opening weekend (1–4 March) accounting for 42% of the opening month's total fishing mortality. The rate remained high during April (9%) and May (11%), then fell below 3% for the rest of the study. Cumulative fishing mortality for the study period was 49% (Fig. 1).

Age- and Length-Frequency Distributions

The pre-fishing length-frequency distribution of bass in the lake ranged from 60 to 510 mm (Fig. 2). Analyis of scale data indicated that these bass were of ages I to V. The average back-calculated lengths ($\bar{x} \pm$ SE) for ages I–V were 118.1 ± 4.3 mm, 214.4 ± 6.8 mm, 302.5 ± 12.6 mm, 351.6 ± 12.5 mm, and 413.8 ± 13.4 mm, respectively. Near the end of the study, no 4- and 5-year-old fish were taken by electrofishing, and the length-frequency distribution indicated a population with mainly sublegal bass (<254 mm) (Fig. 2)—although seasonal distribution may be a contributing factor.

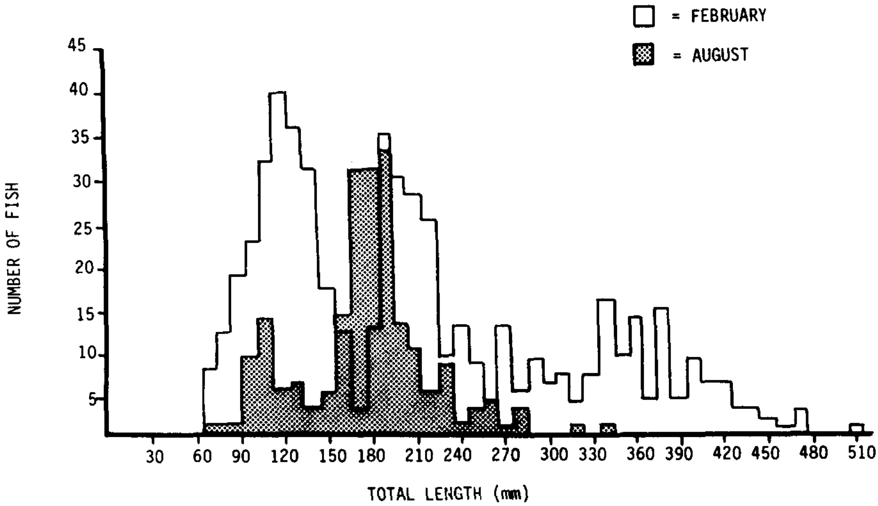

Figure 2. Length-frequency distributions of largemouth bass in electrofishing samples taken from Bluff Lake, Mississippi, before to the opening of the 1984 fishing season (February) and at the end of the season (August).

Effort and Harvest

During the first 4 days of the fishing season, the complete census showed that 525 parties fished a total of 3,292 hours; 71% of all anglers fished for bass. These anglers caught 463 bass and released 102 of them. The 361 harvested bass weighed an estimated 255 kg. During the opening weekend, the harvest was 0.63 kg/ha and the rate of catch was 0.08 kg/hr. Tagged bass accounted for 4.0% (15 of 361) of the bass caught and 1.9% (2 of 102) of the bass released. Although opening weekend accounted for only 23.7% of the estimated effort for March, it accounted for 62.8% of the total estimated weight of bass harvested during the month. The estimated bass harvest dropped form 1.0 kg/ha in March to 0.4 kg/ha in April and remained low for the rest of the study.

From 5 March to 31 August we interviewed 398 fishing parties (808 anglers) during 41 creel surveys. Creel survey estimates indicated that anglers fished a total of 48,796 hours and harvested 12,699 kg of fish for an average yield of 0.26 kg/ha. Estimated fishing effort remained above 25 hours/ha for the first 3 months of the season and then fell below 16 hours/ha for the rest of the study. Bluegill (*Lepomis macrochirus*) suppported the highest average catch per unit effort (0.11 kg/h, SD = .05) and accounted for more than 53% by weight of all fish harvested (Table 3).

March had the highest monthly fishing effort (34.4 hours/ha) and the greatest monthly bass harvest (1.0 kg/ha). Although opening weekend accounted for only 23.7% of the estimated effort for March, it accounted for 62.8% of the total estimated bass harvest for the month. Estimated fishing effort remained above 25 hours

Table 3. Average weight, percentage composition by weight, and average catch per unit of effort for various species in the creel from Bluff Lake, March through August 1984. Standard deviations are shown in parentheses.

Species	Mean weight (kg)	Percent composition by weight	Catch-per-unit-effort (kg/hr)
Largemouth bass	0.59 (.08)	24.25	0.005 (.013)
White crappie (*Pomoxis annularis*)	0.18 (.10)	5.16	0.033 (.059)
Black crappie (*P. nigromaculatus*)	0.22 (.05)	3.89	0.036 (.027)
Bluegill	0.10 (.01)	53.26	0.110 (.054)
Redear (*Lepomis microlophus*)	0.10 (.02)	3.82	0.009 (.013)
Other sunfish (*Centrarchidae*)	0.08 (0.02)	0.24	0.001 (.0004)
Channel catfish (*Ictalurus punctatus*)	0.49 (0.20)	3.75	0.009 (.005)
Blue catfish (*I. furcatus*)	0.23 (.00)[a]	0.05	0.009 (–0–)[a]
Bullhead catfish (*I. spp.*)	0.32 (0.27)	1.44	0.005 (.005)
Other	1.30 (0.40)	4.14	0.009 (.005)

[a]Only 1 individual was encountered in the creel.

for the first 3 months of the season, then fell below 16 hours/ha for the rest of the study. The estimated bass harvest dropped from 1.0 kg/ha in March to 0.4 kg/ha in April and remained low for the rest of the study. Bass accounted for 24.25% (3,080 kg of 12,699 kg) of the total weight of fish creeled.

Discussion

Population Estimates

The population estimtes we obtained with the modified Schnabel model indicated a largemouth bass population that increased during the first 7 to 9 weeks of the season, but then stabilized about 12 weeks after fishing began and remained fairly uniform for the rest of the study. The apparent increase in the size of the population could have been the result of the small number of recaptures or an initial population estimate that was too low. The stability in estimates of population size 12 or more weeks after the season began could relate to the remaining mainly sub-legal bass (<254 mm long) not being harvested.

Population estimates produced by the modified Schnabel model were relatively precise; whereas, population estimates produced by the Jolly-Seber Model were too imprecise to be useful. The coefficient of variation (CV) for 75% of the Jolly-Seber estimates exceeded 1.0. Population estimates with CV greater than 100% are considered useless (Arnason and Mills 1981). Our recapture frequencies generally fell below the minimum of at least 5 per interval that Arnason and Mills (1981) considered necessary to insure a negligibly small sample bias. Our low recapture frequency was the likely cause of the high variability and low precision associated with Jolly-Seber estimates. Hightower and Gilbert (1984) also reported that use of the Jolly-Seber Model yielded low precision. The low recapture frequencies in our study were the result of low (<5%) sampling intensities. Hightower and Gilbert (1984) suggested that sampling intensities greater than 10% are necessary to obtain reliable estimates with the Jolly-Seber Model, whereas Schnabel methods require 4 or more recaptures (Ricker 1975).

Proportional Stock Density

Anderson (1978) reported that balanced bass populations have PSD values of 40% to 60%, and that PSD values below 20% usually indicate excessive reproduction or high mortality of stock-size fish, and values above 80% indicate little or no reproduction and low annual mortality (Anderson 1980). The PSD for bass in our study lake during the pre-fishing period was within the target values. With the advent of fishing, however, value dropped below the suggested balance range. The abrupt drop values indicated that the structure of the bass population had changed. The short time over which this change occurred, as well as the season, suggested that fishing mortality was the probable cause of the change. Carline et al. (1984) reported that seasonable distributions of large bass in large waters sometimes affect PSD values. The effects of excessive fishing mortality were not evident in the initial population estimates because not enough bass had been tagged to produce a reliable estimate. Fish were continually tagged throughout the study. By the time reliable estimates were available, the population shift had already occurred. The PSD values for bluegill also declined from 33% to 11%.

Fishing Mortality

The initial harvest rate of bass from Bluff Lake was lower than rates reported for the opening of many other new lakes (e.g., Bowers and Martin 1956, Turner 1963, Schneider 1973, Hoey and Redmond 1974, Rasmussen and Michaelson 1974, Redmond 1974, Goedde and Coble 1981). This lower mortality rate could have been the result of the extensive surface vegetation and flooded timber that covered about 25% of the lake's surface and unseasonably cool weather during the opening weekend.

Except for a slight (1.6%) increase from April to May, bass mortality declined steadily during the course of the study. This decline may have resulted more from a reduction in the numbers of fish of harvestable size, as evidenced by declining PSD values, than from reduction in the catchability of the bass. Although we may have underestimated the actual fishing mortality for bass because we were unable to determine tag loss or the incidence of anglers not returning tags, the known cumulative fishing mortality (Fig. 2) had exceeded 40% by the end of the study. Graham (1974) has suggested that a bass population cannot withstand a fishing mortality that exceeds 40% and continue to support a fishery. Thus, even though the refuge effect appears to have reduced the initial harvest, over 40% of the legal-sized bass had been harvested within 6 months.

Age- and Length-Frequency Distributions

Pre-fishing age-frequency distributions of bass in the lake indicated the presence of 4- and 5-year-old fish even though stocking records for the lake included no fish of those ages. Our back calculations of age suggested that three growing seasons were necessary for the average stocked bass to be large enough (≥254 mm) to be recruited into the fishery. This slow growth rate could have been due to an inadequate supply of essential nutrients in the lake. Because Bluff Lake had been stocked for only 2 years, only the fastest growing bass of the 1982 and 1983 stockings or individuals that immigrated into the lake would have been available for harvest. The presence of 4- and 5-year-old bass in electrofishing samples as well as other species before fishing began (Table 3) and the time required for stocked bass to reach those ages suggested that the older bass were immigrants from adjacent systems that became joined with Bluff Lake during periods of flooding.

Even though the initial harvest of bass was low, the PSD vaues were quickly reduced, probably because few harvestable-size bass were available when the lake opened. Pre- and post-fishing length-frequency distributions of bass in the lake showed that the initial population had shifted and was dominated by sublegal bass at the end of the study. The "stockpiling" of bass below the minimum length limit was reported by Farabee (1974), Rasmussen and Michaelson (1974), and Paragamian (1982). This stockpiling of sublegal bass results from the harvest of the faster-growing bass as soon as they reach the minimum length limit (Paragamian 1982). The absence of age groups 4 and 5 bass from our electrofishing samples taken in August probably was a direct result of fishing mortality.

Effort and Harvest

Although opening day was unseasonably cool (air temperature − 1° C), many anglers were present. Most were fishing for bass, and fishing effort was high; however, the catch rate and harvest were low. Other workers investigating the opening of new lakes have reported similar amounts of effort but greater harvests and higher catch rates (Bowers and Martin 1956, Schneider 1973, Redmond 1974, Hoey and Redmond 1974). After Bluff Lake opened, no really satisfactory bass fishery developed. The amount of fishing effort and the size of the harvest gradually declined during the course of the study. Many of the anglers we interviewed during the creel survey expressed dissatisfaction with the quality of bass fishing. We did identify a small group of anglers who regularly fished the lake successfully. Familiarity with the lake and superior skill may be the reasons why the "regulars" were consistently better than the other anglers. The low-quality bass fishing on Bluff Lake and the subsequent reduction in fishing effort and harvest were most likely due to the scarcity of harvestable-size bass. The refuge effect created by dense patches of vegetation and the unseasonably cool weather may also have helped to reduce the initial harvest of bass from the lake.

Our attempts to evaluate the effectiveness of a refuge area on a lake as a management strategy was inconclusive. The weather during opening weekend was unseasonably cool and was undoubtedly a factor in the lower fishing mortality and harvest rate that occurred on Bluff Lake than in other waters that have been studied. Even though the combination of refuge areas and size and creel limits may have reduced the initial overharvest of bass, continued fishing pressure eventually overharvested the bass population well before the end of the first fishing season.

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