Angler Exploitation and Angling Mortality of Largemouth Bass and Spotted Bass at Norris Reservoir, Tennessee

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Abstract: Angler exploitation, sex and size selection, temporal and spatial capture patterns, and angling mortality were determined in 1996 and 1997 for largemouth bass *(Micropterus salmoides)*, spotted bass *(M. punctulatus)* in Norris Reservoir, Tennessee. Adjusted annual angler exploitation was 20% (± 4) for 1996-tagged largemouth bass and 14% (±4) for 1997-tagged largemouth bass. Adjusted annual angler catch was 47% (±8) for 1996-tagged fish and 34% (±7) for 1997-tagged fish. No significant differences (P >0.05) were detected between years for either exploitation or catch. No significant differences (P>0.10) by sex or size were detected for largemouth bass in either year. Anglers caught the majority of largemouth bass in the spring and 86% were captured within the embayment of tagging. Total angling mortality was estimated at 23% (±1) in 1996 and 16% (±1) in 1997 for largemouth bass. Mortality attributed to harvest represented approximately 85% of total angling mortality in 1996 and 86% in 1997. Spotted bass were subjected to annual angler exploitation rates of 22% (+11) in 1996 in 1996 and 17% (±9) in 1997. No significant differences (P>0.05) were observed between years. Adjusted annual angler catch was 48% (±19) in 1996 and 38% (±16) in 1997. No significant differences (P>0.10) by size were detected for spotted ass, but a significance difference (P≤0.10) was detected for sex. Spotted bass were primarily captured by anglers in the late spring and displayed a strong tendency to remain in their embayment of tagging. Spotted bass had a slightly elevated total angling mortality in both years with total angling mortality estimated at 25% (±1) and in 1997 20% (±1). Harvested related mortality represented approximately 87% of total angling mortality.

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Angler exploitation and movement of selected species, important considerations when developing a fishery management plan, are often overlooked because of the time and expense of conducting such research. Angler exploitation traditionally has been assessed by mark and recapture techniques. These involved implanting a sportfish with a tag and the reporting of harvested individuals by anglers (Wydoski and Emery 1983). Adjustments accounting for tag retention, tagging-induced mortality, and nonreporting are often required to provide a better understanding of angler exploitation. Numerous studies have evaluated tag retention, growth, and tagging-related mortality (see McFarlane et al. 1990 for a review), as well as nonreporting by anglers (Zale and Bain 1994) and promoting tag returns (MacRitchie and Armstrong 1984).

The black bass fishery in most southeastern reservoirs is composed primarily of largemouth bass *(Micropterus salmoides),* spotted bass *(M. punctulatus),* and smallmouth bass *(M. dolomieu).* Annual angler exploitation for largemouth bass has been reported to range from 13% to 35%. Rates of 15% on Conway chain of lakes and 13% on Winter Park chain of lakes in Florida (Renfro et al. 1995), 8%–15% on Sam Rayburn Lake, Texas (Parks and Seidensticker 1992), and 16%–35% on Lake Walter F. George, Georgia (Keefer and Wilson 1993), are fairly consistent with several other studies. Spotted bass annual angler exploitation rates have been reported to range from 29% for Center Hill Reservoir, Tennessee (Yeager and Van den Avyle (1978), to 31% for Allatoona Lake, Georgia (Kirkland 1963).

Anglers have expressed concerns about the quality of angling on Norris Reservoir, Tennessee, for several years (Peterson et al. 1993). Although considerable attention has been given to the influence of striped bass *(Morone saxatilis)* on other endemic fish species, the influence of angling on sportfish populations also has been a concern. Previous studies on angler exploitation have been conducted on largemouth bass and spotted bass on Norris Reservoir. Eschmeyer (1942) reported annual angler exploitation of 19% for largemouth bass and 19% for spotted bass. Manges (1950) reported rates ranging from 5% to 21% for largemouth bass and 30% to 40% for spotted bass. In these studies, no definitive information was available on tag retention, tagging-related mortality, or angler nonreporting.

This study was conducted to obtain information about the influence of angling on largemouth bass and spotted bass. Specific objectives were: 1) to determine the annual angler exploitation of largemouth bass and spotted bass, 2) to determine angler selection based on sex and size, 3) to ascertain both temporal and spatial capture patterns, and 4) to determine angling related mortality on these sportfish.

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Methods

Norris Reservoir is a 13,840-ha impoundment in eastern Tennessee. The Clinch River was impounded in 1936 by the Tennessee Valley Authority (TVA) to provide downstream navigation, flood control, and hydropower. The dam is located at Clinch River Kilometer 128.4 in Campbell and Anderson counties. Norris Reservoir is a thermally stratified, oligotrophic system with an extremely limited littoral zone.

The Norris Reservoir recreational fishery is primarily comprised of black bass, black crappie *(Pomoxis nigromaculatus),* striped bass, and walleye *(Stizostedion vitreum)* (O'Bara 1997). Black bass are the most sought-after species group with approximately 35% of angling effort expended on this group. Striped bass (24%), walleye (13%), and crappie (6%) also are important components of the fishery (O'Bara 1997). In March 1993, new angling regulations were imposed on the black bass fisheries of Norris Reservoir. Harvest of largemouth bass and smallmouth bass was restricted by a size limit (356 mm), but 2 largemouth bass <356 mm could be harvested. No size limit was imposed on spotted bass. A daily creel limit of 5 fish per day of all black bass (largemouth bass, spotted bass, and smallmouth bass) also was imposed in 1997 as part of a statewide regulation.

Largemouth bass and spotted bass were collected using boat-mounted electrofishing gear (220-V 2–4 A, DC) during April and early May 1996 and 1997. Individuals were collected and tagged from 11 areas of Norris Reservoir (Fig. 1). After collection, all fish were kept in aerated live wells for at least 10 minutes prior to measuring and tagging. Fish were individually measured and sexed, and only individuals >250mm were tagged.

Two types of tags were used. All spotted bass and a subset of largemouth bass were tagged with T-Bar anchor tags (Model T-104, Hallprint, Ltd.). The remaining largemouth bass were tagged with internal anchor dart tags (Hallprint, Ltd.). The TWRA mailing address and a reward announcement were printed on each tag. T-bar

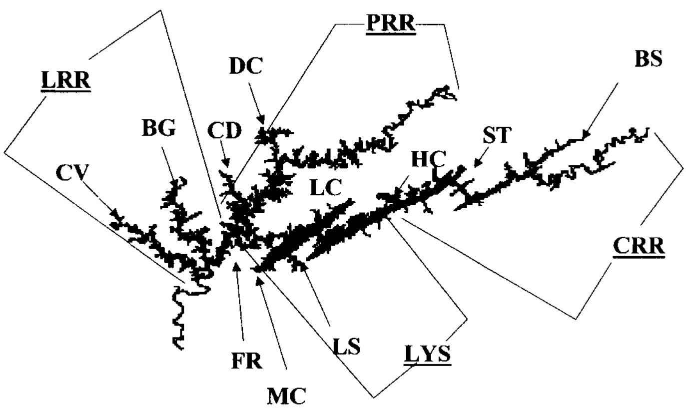

Figure 1. Tagging and recover embayments and regions on Norris Reservoir, Tennessee, 1996 and 1997. Regions are noted by underline.

tags were placed between the pterygiophores immediately anterior to the soft dorsal fin with the aid of a Floy Mark II tagging gun. Dart tags were placed in the lower abdomen with a sterile 16-gauge needle. Prior to release, individual fish were retained for a minimum of 10 minutes to insure recovery. Visibly stressed fish were not released.

Several methods were employed to encourage tag returns. A $5 reward was offered for each returned tag. Posters were placed at all commercial boat docks on Norris Reservoir and area sporting good stores. Articles were published in local newspapers and public service radio announcements were broadcast. In all media, anglers were encouraged to return tags with information about capture location, date of capture, and whether the fish was released or harvested.

All tags and information were initially returned to the TWRA Region IV Office, and once logged, information was sent to TTU-WC. If anglers did not provide the necessary information, they were contacted by mail in an attempt to complete the survey.

Estimates for tag retention, tagging-related mortality, and nonreporting were determined and are reported in O'Bara et al. (1999). Tag retention was estimated at 100%, tagging-related mortality was estimated at 12%, and angler nonreporting was estimated at 35%.

Annual angler exploitation (exploitation) was defined as a percent of tags returned from harvested black basses during a 12-month period following tagging, adjusted for percent of release, tag loss, total tagging-related mortality, and nonreporting (Jagielo 1991). Annual angler catch (catch) also was determined and defined as the percent of all tags returned, adjusted for tag loss, total tagging-related mortality, and nonreporting by anglers. Confidence limits (95%) were determined using a binomial distribution for annual angler exploitation and catch, and unless otherwise indicated were the measurement of variability. Statistically, differences were determined using a Student *t*-test with statistical differences declared at $P \leq 0.05$.

Angler selectivity by sex and size (total length) was determined by comparing tagged and returned sex ratio. Length frequency distributions (25mm size class) of tagged and caught, as well as harvested and released individuals were also examined. Statistical differences were tested using Kolmogorov-Smirnov 2-sample test with statistical differences declared at $P \leq 0.10$.

Capture period was determined from angler accounts and segregated into months. Annual frequency of capture based on monthly data was determined using this data set. This frequency was compared to creel survey effort data for black bass anglers (O'Bara 1997) using the Kolmogorov-Smirnov 2-sample test with statistical differences declared at $P \leq 0.10$.

The deviation from tagging location to angler capture location was ascertained based only on complete angler accounts. The deviation was defined from the tagging location (region) to the embayment of angler capture because exact locations were difficult to determine from angler accounts. In addition, exploitation and catch were determined for the four regions of the reservoir only for largemouth bass. Statistically differences were determined using a Student *t*-test with statistical differences declared at $P \leq 0.05$.

Total angling-related mortality (harvest and delayed) was determined for both species. Delayed mortality was determined using the model of Wilde (1998), which predicts mortality based on water temperature. This model was developed for tournament-associated delayed mortality. It was assumed that because anglers could potentially harvest 2 individuals of any size, they would keep the first caught-fish in a live-well until the end of the angling day, then either cull smaller fish or release all fish if an appropriate number of larger fish were not caught. This would be a similar strategy implemented by competitive anglers. Seasonal angler catch and harvest data for Norris Reservoir was obtained by an annual roving creel survey conducted by TWRA (O'Bara 1997). Water temperature data from Norris Reservoir were obtained from TVA (TVA 1997 and 1998). These data sets were integrated with study-derived angler exploitation data (harvest-associated mortality) and model-derived mortality data (delayed-associated mortality) developed by Wilde (1998). Annual angling-mortality was determined by a weighted mean of monthly angling mortality. All measurements of variations are 95% confidence limits unless noted.

Results

Annual Exploitation and Catch

Anglers reported harvesting 42% of caught-largemouth bass in the 1996-tagged group and 41% in 1997-tagged group. As reported by anglers, spotted bass were harvested at a 45% rate in both 1996-tagged and 1997-tagged groups.

Five hundred and eighty-four largemouth bass were tagged in 1996 and 921 in 1997 (Table 1). Anglers returned 158 tags from 1996-tagged largemouth bass and 178 from the 1997-tagged largemouth bass within 12 months of tagging (Table 1). Exploitation was 20% (±4) for 1996-tagged fish and 14% (±4) for 1997-tagged fish. Catch was 47% (±8) for 1996-tagged fish and 34% (±7) for 1997-tagged fish. No significant differences ($P>0.05$) were detected between years for either exploitation or catch.

In 1996, 102 spotted bass were tagged, and 164 were tagged in 1997. Anglers returned 28 tags from 1996-tagged fish and 36 from 1997-tagged fish (Table 1).

Table 1. Actual and adjusted of tagged individuals and returned tags, and actual percent of tags returned for largemouth bass and spotted bass on Norris Reservoir, 1996 and 1997.

	N Tagged		*N* Returned tags			
Year	Actual	Adjusted	Actual	Adjusted harvest	Adjusted catch	Actual % returned
Largemouth Bass						
1996	584	514	158	102	243	27
1997	921	810	178	115	273	19
Spotted Bass						
1996	102	90	28	19	43	27
1997	164	144	36	25	55	22

Exploitation was 22% (±11) in 1996 and 17% (±9) in 1997. No significant differences (P>0.05) were observed between years. Catch was 48% (±19) in 1996 and 38% (±16) in 1997. Again, no significant differences (P>0.05) were observed between years.

Angling Selection

Length frequencies and sex ratios of fish tagged and caught were compared to determine if anglers were selecting by either size and/or sex. Significant difference (P≤0.10) by sex were found for spotted bass. Anglers caught spotted bass females at a greater rate than were tagged. No significant differences (P>0.10) by sex were detected for largemouth bass.

Size differences (total length) were examined for harvested vs. released individuals, as well as caught vs. tagged individuals. No significant differences (P>0.10) were detected for harvested vs. released, or caught vs. tagged individuals for largemouth bass and spotted bass. Both angler-caught and investigator-tagged largemouth bass were primarily in the 325–400 mm size classes, and spotted bass were primarily in the 250–300mm size classes.

Temporal and Spatial Characteristics

Both species were primarily caught in the spring. Largemouth bass were caught primarily during April through June with most tag returns in May and June (Fig. 2). Percent of the catch increased slightly in November. Spotted bass displayed similar trends to largemouth bass, but with more concentrated activity in June (Fig. 2). The remainder of the catch was evenly divided throughout the year. No significant differences (P>0.10) were detected between monthly percent tag returns and monthly-directed angling effort (black bass) for either species.

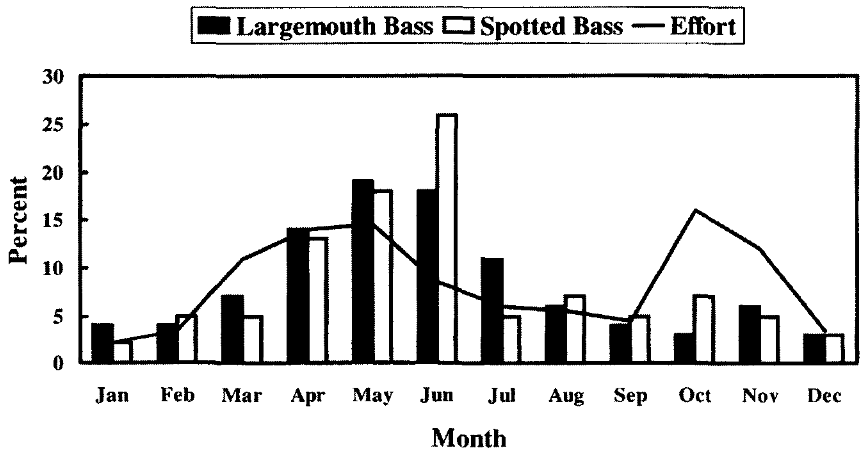

Figure 2. Percent of tagged largemouth bass and spotted bass caught within a given month for Norris Reservoir, Tennessee, 1996 and 1997.

Anglers reported exact capture locations for 307 largemouth bass and 60 spotted bass. Eighty-six percent (264 of 307) of largemouth bass were caught in the embayment of tagging. Of the remaining 43 largemouth bass, 8% (24) were caught in the river channel adjacent to the embayment, and 6% (19) were caught in another embayment. Only 1 largemouth bass was reported caught outside of the reservoir region it was tagged. Eighty-seven percent (52 of 60) of spotted bass were caught within the embayment of tagging, 12% (7) were caught in the river channel adjacent to the embayment, and 1% (1) was reported caught in another embayment. No spotted bass were caught outside the reservoir region of tagging. Maximum distance between the location of tagging to location of capture was approximately 11 km for largemouth bass and 2km for spotted bass. The majority of both largemouth bass and spotted bass were captured within 1 km of the location of tagging.

Estimates of exploitation and catch for largemouth bass were determined for 4 regions of the reservoir in both 1996 and 1997. Exploitation was not significantly different among the lower reservoir region (LRR), Clinch River region (CRR), Power River region (PRR), or the Loyston Sea region (LYS) in 1996 (Fig. 3). Exploitation for largemouth bass tagged in the LYS was significantly different in 1997 than for other regions (Fig. 3). Exploitation ranged from 24% (±8) for the PRR in 1996 to 9% (±5) for the LYS in 1997. Exploitation was generally higher in the upper regions of the reservoir. Estimates of catch followed similar trends with values ranging from

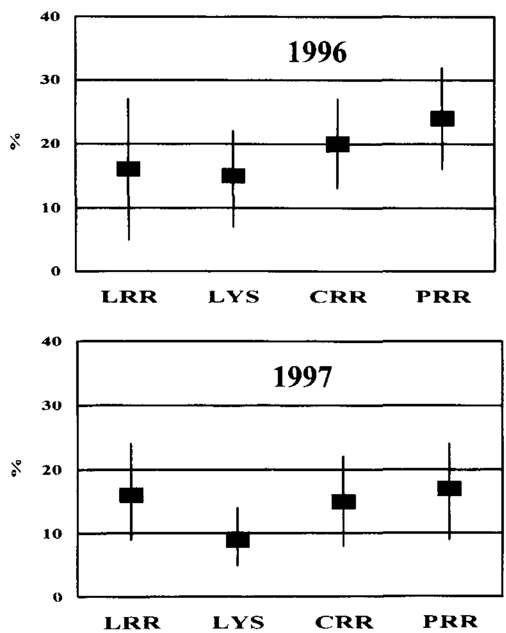

Figure 3. Annual exploitation estimators with 95% confidence intervals for largemouth bass within 4 regions of Norris Reservoir, 1996 and 1997.

51% (±14) for the CRR in 1996 to 31% (±13) for the LYS in 1997 (Fig. 3). No significant differences (P>0.05) were detected.

Total Angling Mortality

Total angling mortality was estimated at 23% (±1) in 1996 and 16% (±1) in 1997 for largemouth bass. Harvested-associated mortality was estimated at 20% (±4) in 1996 and 14% (±3) in 1997. Delayed mortality was estimated as 4% (±1) in 1996 and 2% (±1) in 1997. Mortality attributed to harvest represented approximately 85% of total angling mortality in 1996 and 86% in 1997. Spotted bass had a slightly elevated total angling mortality in both years. In 1996, total angling mortality was 25% (±1) and in 1997 20% (±1). Delayed mortality was 3% (±1) in 1996 and 3% (±1) in 1997, representing approximately 13% of total angling mortality.

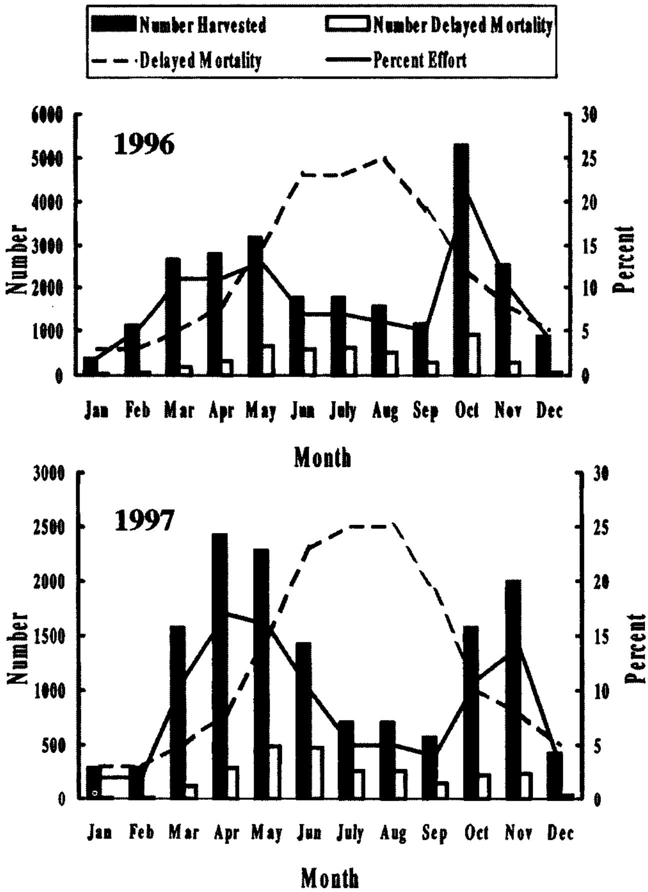

Figure 4. Estimated number of largemouth bass harvested and delayed mortality as well as percent delayed mortality and angling effort on Norris Reservoir, Tennessee, 1996 and 1997.

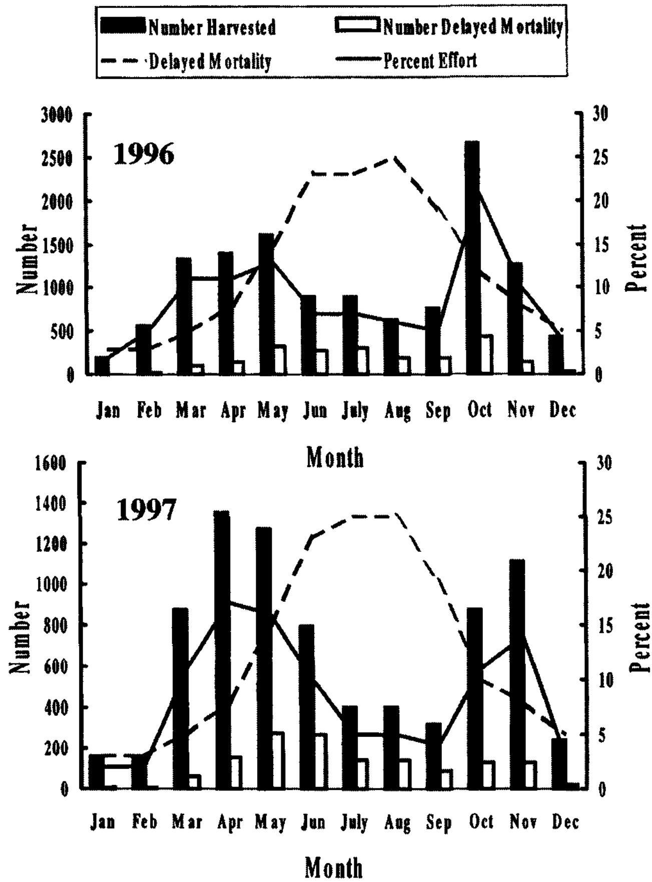

Figure 5. Estimated number of spotted bass harvested and delayed mortality as well as percent delayed mortality and angling effort on Norris Reservoir, Tennessee, 1996 and 1997.

Total estimated catch (standard error) of largemouth bass in 1996 was 60,254 (±16,480) and in 1997 total estimated catch was 34,771 (±6,812). If estimated adjusted exploitation (harvest-associated mortality) and delayed mortality are applied, total estimated harvest (standard error) would be 25,176 (±380) in 1996 and 14,268 (±226) in 1997. In addition, an estimated 4,488 (±80) in 1996 and 2,568 (±46) in 1997 largemouth bass would die because of delayed mortality. Consequently, 29,664 (±442); (2.1/ha) in 1996 and 16,836 (±260); (1.2/ha) in 1997 largemouth bass would not have survived because of angling.

Total estimated catch (standard error) of spotted bass was 30,274 (±13,938) in 1996 and 19,421 (±4,628) in 1997. Estimated number (standard error) of spotted bass lost because of delayed mortality was 2,244 (±36) in 1996 and 1,428 (±24) in 1997. Overall, 14,904 (±221) (1.1/ha) in 1996 and 9,396 (±145) (0.7/ha) spotted bass were either harvested or died as a result of delayed mortality.

Monthly delayed mortality ranged from less than 3% in the winter months to greater than 25% in summer months for largemouth bass and spotted bass (Figs. 4, 5). Total number of harvested largemouth bass and spotted bass peaked in the spring and fall months when angling effort was greatest (Figs. 4, 5). Overall, delayed mortality contributed more to the total number of both largemouth bass and spotted bass lost because of angling in the summer months.

Discussion

Exploitation by recreational and commercial anglers plays an important role in the quality of angling experiences and population stability of sportfish. Excessive exploitation may reduce population size and abundance of desirable-size fish (Smith 1988) or promote growth and well-being of overabundant populations (Schramm et al. 1985). In either scenario, it is important to have an understanding of angler exploitation in the management of any fishery.

Annual angler exploitation of largemouth bass was 20% (±4) for 1996-tagged fish and 14% (±4) for 1997 tagged-fish. Adjusted catch was 47% (±8) for 1996-tagged fish and 34% (±7) for 1997-tagged fish. Historically, angler exploitation for largemouth bass in Norris Reservoir has ranged from 5% to 19% (Eschmeyer 1942, Manges 1950). Renfro et al. (1995) reported annual exploitation rates of 15% on Conway chain of lakes, and 13% on Winter Park chain of lakes in Florida. Annual catch was 50% and 46% for each lake system. Annual angler exploitation on Sam Rayburn Lake, Texas, was 8.5% and 15.1% and was considered not to be detrimental to the largemouth bass population (Parks and Seidensticker 1992). In Lake Walter F. George, Georgia, annual exploitation ranged from 16% to 35% for the period 1987 through 1991, and annual catch ranged from 40% to 68% (Keefer and Wilson 1993). Annual exploitation for Norris Reservoir exceeded that reported for Florida and Texas systems, but was similar to Lake Walter F. George. Annual catch was similar to that reported for Florida and Georgia lakes, indicating a greater tendency of Norris Reservoir black bass anglers to harvest largemouth bass.

Angling-related mortality is often difficult to estimate because of the diversity of mortality-causing factors. The majority of evaluations have been conducted in the competitive angling arena, primarily because of the concerns expressed by the non-competitive angling public. Water temperature (Schramm et al. 1987), fish size (Weathers and Newman 1997), tournament size and procedures (Schramm et al. 1987, Kwak and Henry 1995), and live-well conditions (Kwak and Henry 1995) have all been suggested as contributory factors. In the non-competitive arena, harvest also must be considered since many anglers at least in part fish for food.

Annual angling mortality of largemouth bass ranged from 16% to 27% depending on water temperature and adjusted exploitation and catch in Norris Reservoir. Mortality attributed to harvest represented approximately 85% of total angling mortality for largemouth bass and 87% for spotted bass. Keefer and Wilson (1993) reported 41% to 68% of the largemouth bass caught were released in a Georgia reservoir. In Florida, release rates exceeding 70% were reported by Renfro et al. (1995).

Parks and Seidensticker (1992) reported 52% to 57% of the largemouth bass >356mm were voluntarily released. Release rates in Norris Reservoir were 58% (largemouth bass >250 mm), similar to that reported by Keefer and Wilson (1993) and Parks and Seidensticker (1992), but considerably less than that reported by Renfro et al. (1995). If water temperature were consistent, Norris Reservoir angling-related mortality would be similar to that of Lake Walter F. George, but it most likely exceeds both Sam Rayburn Lake and the Conway and Winter Park chains of lakes in Florida.

Spotted bass annual adjusted exploitation was 22% (±11) in 1996 and 17% (±9) in 1997. Annual angler catch was 48% (±19) in 1996 and 38% (±16) in 1997. Eschmeyer (1942) reported annual angler exploitation of 19%, and Manges (1950) reported rates of 30% to 40% from Norris Reservoir. Annual angler unadjusted exploitation for spotted bass in Center Hill Reservoir, Tennessee, was 15% and adjusted was 29% (Yeager and Van den Avyle 1978). Spotted bass annual angler exploitation was reported as 31% for Allatoona Lake, Georgia (Kirkland 1963). Annual angler exploitation for Norris Reservoir was similar to that reported for Center Hill Reservoir and Allatoona Lake, but was slightly less than that reported by Manges (1950) for Norris Reservoir.

Examination of sex and size related factors suggest that anglers were not selecting either largemouth bass or spotted bass based primarily on size. Angling techniques or angler bias may have contributed to this factor. Regulations allowed for the harvesting of 2 largemouth bass of any size. It appears that anglers did not catch or harvest these smaller fish (<356mm) at a greater rate than larger fish. No regulations were in effect on spotted bass, thus anglers appear to be catching and harvesting this species in similar proportions to the population structure.

Angler capture locations strongly suggest that minimal movement occurred for largemouth bass and spotted bass. Greater than 85% of largemouth bass and spotted bass were captured within the tagging embayment. Intra-reservoir management of these centrarchids may be biologically possible if information of embayment-specific exploitation were to be considered. Potentially different size and bag limits within large areas of the reservoir appear to be biologically defendable, although difficult to enforce. Significant differences in exploitation among reservoir regions also suggest that largemouth bass populations were not being equally exploited, so some intra-reservoir management strategies may be warranted.

Angler exploitation is one of many factors that must be addressed if a biologically sound management plan is to be developed and implemented for any sportfish species. If managers are to truly manage black bass species to provide both increased and new angling opportunities, and maintain the integrity of these populations, the influence of angling must be addressed.

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