ESTIMATING LARGEMOUTH BASS POPULATIONS IN RESERVOIRS FROM CATCHES IN ANGLING TOURNAMENTS

by
LARRY R. AGGUS and WILLIAM C. RAINWATER
South Central Reservoir Investigations
U. S. Fish and Wildlife Service
Fayetteville, Arkansas

ABSTRACT

We estimated populations of largemouth bass (*Micropterus salmoides*) 12 inches long or longer in total length by mark and recapture, using angling tournament catches on 28,200-acre Beaver Lake in 1974, and tournament catches and a supplemental creel census on 45,440-acre Bull Shoals Lake in 1975. Population estimates were 55,450 in Beaver Lake and 30,800 in Bull Shoals Lake. These estimates were in good agreement with those based on mark-recapture samples taken each spring by electrofishing near shore, and were correlated with harvest when applied to the lower reaches of each lake. Lakewide estimates of anglers' catches indicated that the largemouth bass populations may have been 2-2.5 times larger than those based on tournament catches in both lakes. Probable sources of bias in these estimates include nonrandomization of marks and recaptures, and an exceptionally high tag return during the 1-month creel census on Bull Shoals Lake. Tournaments during periods of peak springtime fishing afford biologists a potential tool for efficiently estimating black bass populations in large impoundments. Under favorable conditions, tournament catches can provide 20-40% of the total fish required for a realistic population estimate.

INTRODUCTION

One of the most formidable tasks facing reservoir biologists is accurate estimation of the size of major sport fish populations. Biologists need to develop economical procedures for obtaining this information in order to assess the potential ability of a body of water to produce sport fishes and to evaluate the effectiveness of such management procedures as harvest regulation, water level fluctuation, or predator introductions.

The largemouth bass (*Micropterus salmoides*) is the principal predaceous sport fish in the southern United States, and one of the most difficult to sample. Mark and recapture of fish caught near shore by electrofishing currently offers the most practical approach to estimating the abundance of largemouth bass in large impoundments (Bryant and Houser 1971; Houser and Rainwater in press; Zweiacker and Brown 1971). Although manpower and equipment constraints usually limit estimates to small areas of major impoundments, biologists need estimates for entire lakes to test the accuracy of shoreline sampling.

Grinstead and Wright (1973) marked bass and later examined bass caught during a fishing tournament in 101,000-acre Eufaula Reservoir, Oklahoma, while exploring potential sampling approaches for estimating total population size. They considered this technique among the most valid in terms of sampling design. However, the problem of handling sufficient numbers of fish proved insurmountable in this lake, and has been considered the most serious deterrent to use of fishing tournaments for population estimation elsewhere.

Three-day bass tournaments with as many as 200 participants potentially provide the numbers of fish necessary for estimating populations in large waters. Tournaments sponsored by the Bass Anglers Sportsman Society (B.A.S.S.) on Beaver Lake in 1974 and Bull Shoals Lake in 1975 provided opportunities to study the feasibility of using tournament catches to estimate black bass populations in large impoundments. Ongoing estimates based on recoveries of marked fish during electrofishing and annual estimates of angling harvest on both reservoirs provided comparative data for evaluation. We present here the results of using these tournament catches and compare the results with existing methods of indexing black bass populations in the two impoundments.

ACKNOWLEDGMENTS

The studies on Beaver and Bull Shoals Lakes were conducted under the auspices of the Reservoir Committee, Southern Division, American Fisheries Society. The following organizations and agencies participated in various facets of the studies: Bass Anglers Sportsman Society, Bass Research Foundation, Arkansas Game and Fish Commission, Missouri Conservation Commission, Mississippi State University, Tennessee Valley Authority, and the National Reservoir Research Program. To the many individuals involved, we extend our sincere appreciation

METHODS AND MATERIALS

The Beaver Lake tournament was held April 3-5, 1974, and was headquartered near the middle of the reservoir. Surface area of Beaver Lake at the time was 29,000 acres, compared with 28,200 acres at conservation pool level. Turbid water in the uplake portion of the reservoir probably limited both electrofishing and angling success. The Bull Shoals tournament was held April 2-4, 1975. Surface area was approximately 49,000 acres compared with a normal area of 45,400 acres. The event was headquartered at the lower end of the lake. Turbidity was not considered a limiting factor. Inasmuch as minimum size limits of 12 inches were imposed in both tournaments, population estimates were, therefore, limited only to the portion of the black bass population that was 12 inches long or longer.

Bass tagged before the tournaments were captured by electroshocking near shore in both lakes. We planned total effort to produce 2,000 to 3,000 fish for marking, based on previous electroshocking experience. In an attempt to randomize marking, we divided the entire shoreline of each lake into a number of units on the basis of available manpower and equipment. Each field crew marked fish within a designated area, so that electroshocking effort was spread over the entire lake. Both AC and DC electroshocking units were used, but we made no effort to compare efficiencies of the two types of gear. The length of a man-day of shocking was designed to be 6 hours of actual shocking. However, this was subject to variation as a result of weather or equipment problems.

Shocking crews did not begin collecting and tagging fish until 7 to 10 days before the start of each tournament, to minimize tag losses resulting from shedding, or recovery of marked fish by fishermen before the tournament. Tagging was conducted from March 25 to April 1, 1974 at Beaver Lake, and from March 24 to April 2, 1975 at Bull Shoals Lake. From 3 to 8 crews, usually of 2 to 3 men each (depending on availability of manpower) participated in shocking at any given time; most of it was done at night. Forms were provided to boat dock concessionaires requesting that tags recovered before the tournaments be reported.

Black bass 12 inches (305mm) long or longer were tagged with anchor tags (Dell 1968) applied below the posterior margin of the soft dorsal fin. Fish were measured to the nearest 1mm, or sometimes to the nearest 0.1 inch. Total length, species, and tag number and color were recorded.

Bass caught during the tournaments were censused at each daily "weigh-in." The fish were placed in a large aerated tank to which an antiseptic (acriflavin) had been added. Before being released, all fish were identified to species, measured to the nearest 1mm (total length), and checked for the presence of a tag or tag wound.

The catch at the Bull Shoals tournament was extremely low because weather conditions were adverse. In an attempt to increase the number of bass examined, we conducted a creel census during the month immediately following the tournament by hiring local residents or concessionaires to examine and measure as many black bass as possible brought in by anglers to major access points.

Population estimates of the single-census type were employed, and involved use of Bailey's modification of the Petersen estimate (Ricker 1958). Confidence limits were calculated from Chapman's (1948) Poisson approximation of the hypergeometric distribution, since tag-return ratios were expected to be low.

Population estimates based on recaptures of black bass marked after collection by electrofishing near shore have been conducted each spring in cove areas of Beaver and Bull Shoals Lakes since 1969. The methodology was described by Bryant and Houser (1971) and Houser and Rainwater (in press). Stratified random sampling estimates of angler use and harvest were conducted on both lakes from 1971 through 1974. These estimates of bass populations and harvest were used to help evaluate the population estimates derived from tournament catches.

ELECTROSHOCKING EFFORT AND SAMPLE SIZE

Total tagging effort preceding the tournaments was 52 man-days at Beaver Lake and 92 man-days at Bull Shoals (Table 1). Adverse weather and equipment failure reduced the amount of effort planned for both lakes. The number of fish tagged per man-day was low, 17.3 in Beaver Lake and 11.8 in Bull Shoals Lake.

Shocking before the Beaver Lake bass tournament yielded 897 fish for tagging; 833 largemouth bass, and 64 spotted bass *(Micropterus punctulatus)*; and 1,082 fish in Bull Shoals; including 1,048 largemouth, 21 spotted, and 13 smallmouth bass, *(Micropterus dolomieui)*. Fourteen tagged largemouth and one spotted bass were caught before the tournament in Beaver Lake.

Total catch of black bass in the Beaver Lake tournament was 1,476 of which 1,150 were largemouth and 326 were spotted bass. This number slightly exceeded the average of 1,231 black bass caught in 22 B.A.S.S. tournaments conducted in various lakes in 1972-74 (Anonymous, 1975). The Bull Shoals

Table 1. Effort expended in tagging black bass 12 inches long or longer, before fishing tournaments in Beaver and Bull Shoals Lakes; number of bass tagged; number of bass examined in anglers' catches; and number of tagged bass recovered in the catches.

Item	*Beaver Lake 1974*[1]	*Bull Shoals Lake 1975*[2]	
Tagging effort and results			
Man-days of tagging effort	52	92	
Man-hours of tagging effort	260	386	
Fish tagged per man-hour	3.5	2.8	
Fish tagged per man-day	17.3	11.8	
Number of bass tagged			
Largemouth	833	1,048	
Spotted	64	21	
Smallmouth	0	13	
Total	897	1,082	
Number of bass examined in angler catches			
Largemouth	1,150	1,881	(283)
Spotted	326	375	(97)
Smallmouth	0	508	(24)
Total	1,476	2,764	(404)
Number of tagged bass in catches			
Largemouth	16	63	(2)
Spotted	3	0	(0)
Smallmouth	0	2	(0)
Total	19	65	(2)

[1] Includes 14 tagged largemouth and 1 tagged spotted bass which were returned by anglers before the start of the tournament on Beaver Lake.
[2] Numbers in parentheses indicate catch and recaptures during the tournament, in Bull Shoals Lake, April 2-4, 1975.

Table 2. Comparison of population estimates of largemouth bass 12 inches long or longer in Beaver Lake in 1974 and Bull Shoals Lake in 1975, as estimated from B.A.S.S. tournament catches, the tournament plus a supplemental creel census, and electroshocking near shore in spring.

Lake, and source of data	*Estimated total number of bass*	*95% confidence interval*	*Estimated number of bass per acre*
Beaver Lake			
B.A.S.S. Tournament	55,450	31,700-89,100	1.9
Spring Electroshocking	60,720	41,370-114,092	2.1
Bull Shoals Lake			
B.A.S.S. Tournament	99,200	— —	1.9
B.A.S.S. Tournament, plus supplemental creel census	30,800	24,810-40,240	0.6
Spring electroshocking	29,500	20,200-54,500	0.6

tournament yielded a catch of only 404 black bass, of which 283 were largemouth. The supplemental creel census conducted immediately after the tournament increased the number of bass 12 inches long or longer captured and examined for tags to 2,764. Of the combined catch examined, 1,881 were largemouth, 375 spotted, and 508 smallmouth bass. Percentages of tagged largemouth bass in the tournament catches were 1.4 in Beaver Lake and 0.7 in Bull Shoals. In the supplemental creel census at Bull Shoals, 3.8% of the largemouth bass examined were tagged.

POPULATION ESTIMATES

Of the three species, only largemouth bass were captured in sufficient numbers to permit population estimates. Using a single census approach, we estimated entire lake populations of largemouth bass 12 inches long or longer from tournament catches of 55,400 for Beaver Lake and 99,200 for Bull Shoals Lake (Table 2). The Bull Shoals estimate was based on the return of only two marked fish. The estimate based on the combined catches during the tournament and the later creel census in Bull Shoals was 30,800. These population values show good agreement with estimates based on spring shocking in downlake areas of both lakes, on a number-per-acre basis (Table 2).

We compared frequency distributions of tagged and recaptured largemouth bass from both lakes (Figs. 1 and 2), using a Kolmogorov-Smirnoff non-parametric two-sample test (Siegel 1956). Length-frequency distributions of tagged and recaptured fish did not differ significantly ($P = 0.01$) in either sample. Similar comparisons of recaptured fish with those used in estimations based on electrofishing in the spring also showed no difference in size distribution for 12-inch and longer bass in each lake.

Estimates based on recapture of fish collected by electrofishing in the spring included all sizes of largemouth bass. We used these estimates to establish ratios between the number of largemouth bass less than 12 inches, and those 12 inches and longer, although Houser and Rainwater (in press) indicated that estimates of yearlings may be conservative. Our results showed that 36% of the largemouth bass population was 12 inches long or longer in Beaver Lake during spring 1974, and 12% in Bull Shoals during spring 1975. We used these ratios and frequency distributions to expand estimates on both lakes to include all sizes of largemouth (Fig. 3). Estimates for total largemouth bass were 153,400 in Beaver Lake in 1974, and 261,400 in Bull Shoals in 1975, or 5.2 and 5.3 bass per acre, respectively. Corresponding biomass estimates were 137,000 pounds (4.7 pounds per acre) in Beaver Lake and 187,200 pounds (3.7 pounds per acre) in Bull Shoals Lake. The percentage of the total largemouth bass biomass consisting of fish 12 inches long or longer was 69 in Beaver Lake but only 32 in Bull Shoals. The largemouth bass population in Bull Shoals Lake was dominated by age II fish produced in 1973, when water levels in the spring and summer were exceptionally high (Aggus and Elliott, in press). The pattern of recruitment in Beaver Lake in recent years has been more stable.

COMPARISON OF ANGLERS' HARVEST AND POPULATION ESTIMATES

Inasmuch as it is not possible to directly enumerate an entire population of given fish species in a large impoundment, particular sampling methods must be evaluated indirectly. Comparisons between estimates of yearling and older largemouth bass based on electroshocking in the spring and on long-term creel census studies show reasonable agreement for downlake regions (lower one-third) of each lake (Table 3). Harvest of largemouth bass has consistently been much higher in the upper than in the lower reaches of both impoundments. For the period 1971-74, average ratios of entire lake to downlake harvest were 2.45:1 in Beaver Lake and 2.48:1 in Bull Shoals Lake. Assuming that these ratios represent true differences in abundance rather than variations in harvest efficiency, the total largemouth bass population was 375,800 fish weighing 385,700 pounds (13 fish or 13.3 pounds per acre) in Beaver Lake in 1974, and 648,300 fish weighing 463,000 pounds (13.3 fish or 9.5 pounds per acre) in Bull Shoals in 1975.

DISCUSSION

These tests established that it is possible to mark and recapture a sufficient number of adult largemouth bass to estimate population size in large impoundments. The total numbers of largemouth bass handled in both Beaver (1,983) and Bull Shoals (2,929) Lakes were sufficient to meet the minimum requirements set forth by Robson and Regier (1964) for estimating the populations within 50% of the true values, at the 95% confidence level. Length-frequency distributions of largemouth bass caught by electrofishing, in fishing tournaments, or in post-tournament fishing were in close agreement, suggesting that lengths obtained during tournament "weigh-ins" are indicative of size structure of the adult populations. As suggested by Holbrook et al. (1972), the examination of fish

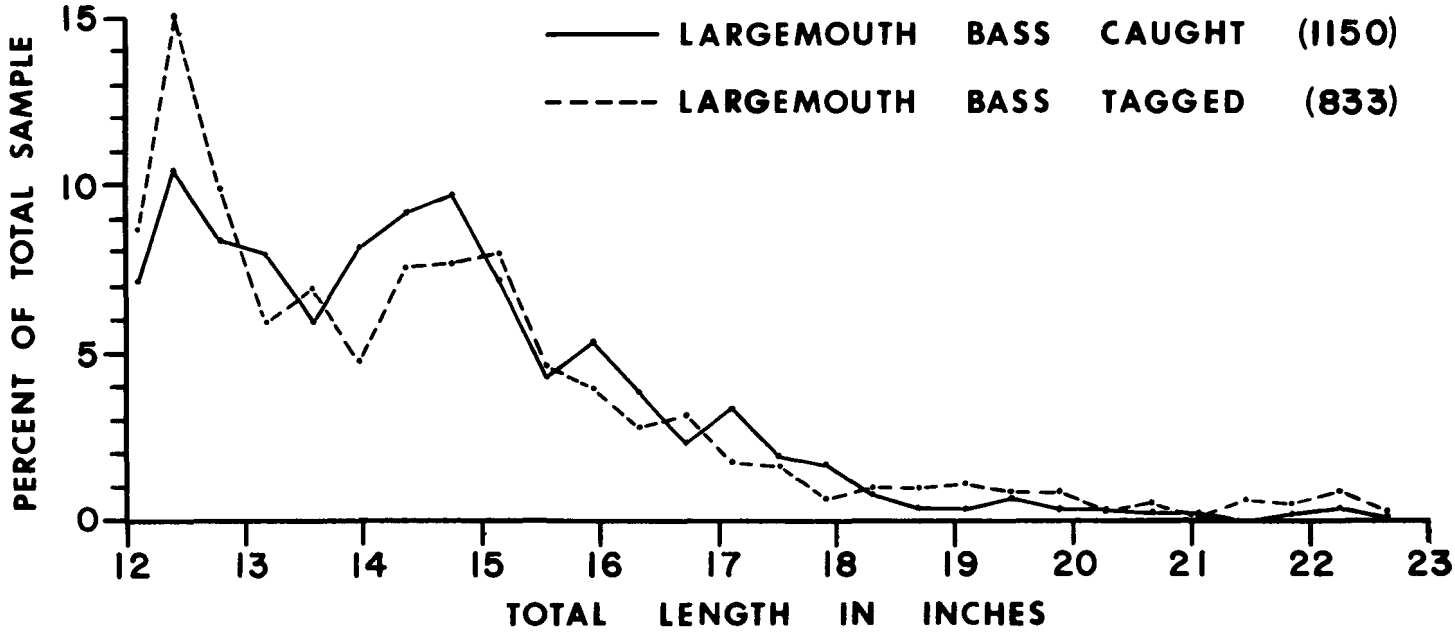

Figure 1. Length-frequency distribution (by 1-inch length classes) as percent of total sample of largemouth bass tagged (March 25—April 1) and caught in tournament (April 3-5, 1974), Beaver Lake, Arkansas.

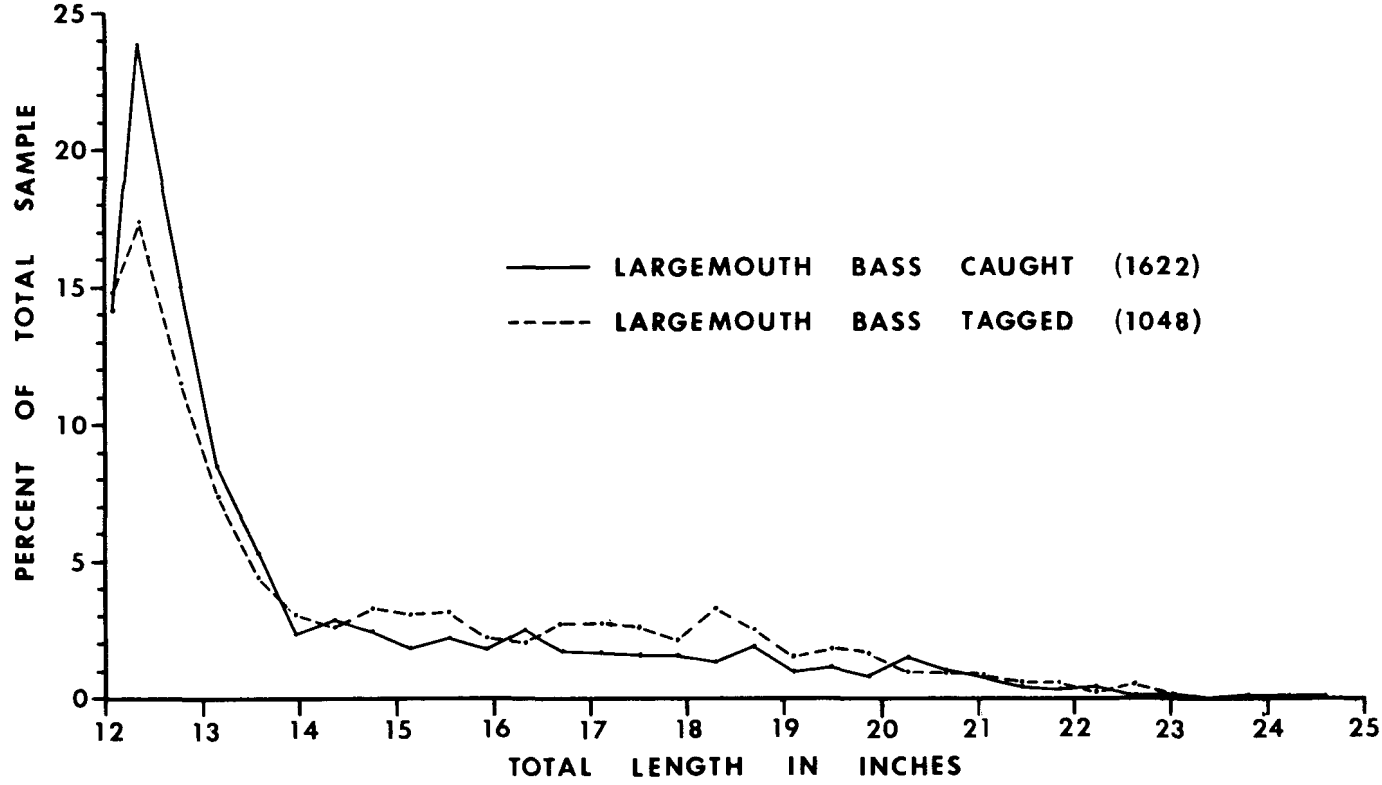

Figure 2. Length-frequency distribution (by 1-inch length classes) as percent of total sample of largemouth bass tagged (March 24—April 1) and caught in fishing tournament or recorded during a 1-month creel census (total period, April 2—May 10, 1975), in Bull Shoals Lake.

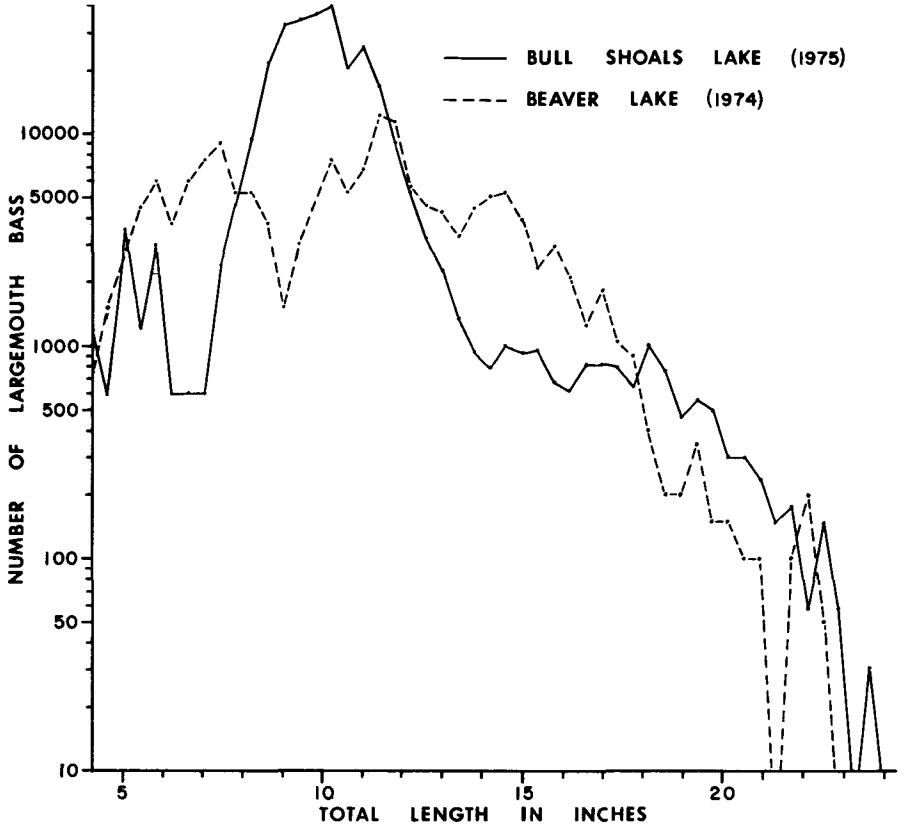

Figure 3. Length-frequency distribution of yearling or older largemouth bass in Beaver Lake in spring 1974 and in Bull Shoals Lake in spring 1975, estimated from fish 12 inches long or longer taken during the fishing tournaments and creel census on Bull Shoals, and ratios, between fish less than 12 inches long and those 12 inches long or longer, from estimates based on electrofishing near shore in spring.

Table 3. Estimated standing crop and anglers' harvest of yearling or older largemouth bass (in numbers per acre) from downlake areas of Beaver and Bull Shoals Lakes, compared with entire lake estimates of anglers' harvest, 1971-75.

Lake and year	Downlake area (number per acre)		Lakewide harvest (Number per acre)	Ratio of lakewide to downlake harvest
	Standing crop*	Anglers' harvest		
Beaver				
1971	4.01	3.20	6.8	2.13
1972	4.22	1.03	2.5	2.38
1973	3.45	1.39	3.9	2.83
1974	5.67 (5.2)	1.26	3.1	2.47
1975	5.24	—	—	Mean = 2.45
Bull Shoals				
1971	1.69	0.92	2.2	2.34
1972	0.85	0.49	0.9	1.86
1973	0.88	0.35	1.6	4.45
1974	16.49	3.50	4.5	1.28
1975	5.10 (5.3)	—	—	Mean = 2.48

* Number of largemouth bass from expanded tournament estimates in parentheses.

caught during tournaments can offer the management biologist a rapid insight into a number of attributes of adult black bass populations in large impoundments.

The largemouth bass population estimates from tournament catches, from the expanded spring shoreline mark-recapture studies, and harvest estimates for the lower one-third of the lake were in excellent agreement on Beaver Lake. However, creel census data indicated that lakewide abundance was more than twice that estimated on the basis of catch during the tournament and suggested a significant bias. The most probable source of error in the tournament estimate was non-random distribution of both tagged and recaptured fish. Marking effort was designed to insure coverage of the entire lake, and it was assumed that areas of high bass density would produce a high rate of capture of fish for marking. However, areas of turbid water in the upper reaches of the lake resulted in decreased captures of fish by electrofishing where sport fishing data indicated high bass densities. A redistribution of marking effort, as described by Zweiacker and Brown (1971), offers one method of improving randomization of marked fish within the population. It was also assumed that the fishing effort of tournament fishermen would be randomly distributed. This assumption proved invalid because water turbidity and weather influenced the choice of fishing localities. The responsibility for randomizing should, therefore, rest on the biologist who distributes the tagged bass.

The estimate of the population size of largemouth bass in Bull Shoals from fish caught during the tournament was probably closer to the true population than that developed from the combined tournament and supplemental creel census. Although the latter estimate agreed well with the estimate based on shocking in the spring in the lower reaches of the lake, and harvest data from the same area, comparison with lakewide harvest data also suggested serious bias.

Our attempts to examine as many bass as possible immediately after the low tournament catch in Bull Shoals Lake showed that a short-term, intensive effort can result in the examination of a large number of fish. A serious bias was encountered, however, because a disproportionally high number of tags were returned. A comparison of ratios of tag returns from boat dock concessionaries and local residents showed that concessionaires reported a ratio of tagged to untagged fish 4.3 times that of the local residents. It appeared that fishermen tended to bring tagged fish directly to boat docks for identification, but tended to depart from public boat ramps if they had caught only untagged fish. The use of trained creel census clerks with randomly distributed effort at both floating boat docks and public launching ramps could overcome much of this apparent bias.

Proper timing is essential for maximizing rates of marking and recapturing fish in the present type of study. In electrofishing in the spring we have found that adults of all black bass species become much more vulnerable to electrofishing gear as water temperatures exceed 50°F and approach 60°F. In northern Arkansas this temperature range usually occurs over about a 2-week period in mid-April. Water temperatures during shocking efforts before both of the present tournaments were less than 50°F and cooled slightly during the tagging period, severely reducing capture efficiency. Adverse weather also posed a serious problem to tournament fishermen in early April. Bass harvest usually peaks 3 to 4 weeks after the dates of the 1974 and 1975 tournaments, and the pattern of daily harvest becomes much more consistent.

Spawning of the black basses in White River impoundments begins when water temperatures are near 57°F or about April 15 in most years (South Central Reservoir Investigations, unpublished). Grinstead and Wright (1973) suggested that black bass become territorial during spawning, and because some fish may be in closer proximity to the shoreline these individuals could become more vulnerable to capture. By selecting a tournament time during the peak period of harvest, and tagging before the onset of spawning, biologists should be able to increase severalfold the number of bass that are marked and recaptured without introducing serious bias. The marking of fish by one method (electrofishing) and recapturing them by another (angling) offers further protection against bias (Ricker 1958).

Properly timed bass tournaments should provide the means of handling 20-40% of the number necessary to develop a valid estimate of fish 12 inches long or longer. Tournament catches represent a substantial contribution of manpower, and offer a major reduction in the cost of estimating bass populations in large impoundments.

LITERATURE CITED

Aggus, Larry R., and George V. Elliott. (In press.) Effects of cover and food on year-class strength of largemouth bass. *In* Henry Clepper, ed. Black bass biology and management, Sport Fishing Institute, Washington, D. C.

Anonymous. 1975. Catch'n release B.A.S.S. tournament facts, figures. Bass Master Magazine 8(2): 46.

Bryant, Horace E., and Alfred Houser. 1971. Population estimates and growth of largemouth bass in Beaver and Bull Shoals Reservoirs. Pages 349-357. *In* Gordon E. Hall, ed. Reservoir fisheries and limnology, Am. Fish. Soc. Spec. Publ. No. 8.

Chapman, D. C. 1948. A mathematical study of confidence limits of salmon populations calculated from sample tag ratios. Int. Pac. Salmon Fish. Comm. Bull. 2: 69-85.

Dell, M. B. 1968. A new fish tag and rapid cartridge fed applicator. Trans. Am. Fish. Soc. 97: 57-59.

Grinstead, Bobby G., and Garland L. Wright. 1973. Estimation of black bass, *Micropterus* spp., population in Eufaula Reservoir, Oklahoma with discussion of techniques. Proc. Okla. Acad. Sci. 53: 48-52.

Holbrook, John A., II, Don Johnson, and Joseph P. Strzemienski. 1972. Management implications of bass fishing tournaments. Proc. 26 Annu. Conf., Southeast. Assoc. Game and Fish Comm. 26: 320-324.

Houser, Alfred, and William C. Rainwater. (*In* press.) Production of largemouth bass in Beaver and Bull Shoals Lakes. *In* Henry Clepper, ed. Black bass biology and management, Sport Fishing Institute, Washington, D. C.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Bull. Fish. Res. Board. Cana. No. 119. 300 pp.

Robson, D. S., and H. A. Regier. 1964. Sample size in mark-recapture experiments. Trans. Am. Fish. Soc. 93(3): 215-226.

Siegel, Sidney. 1956. Nonparametric statistics for the behavioral science. McGraw-Hill, New York. 312 pp.

Zweiacker, Paul L., and Bradford E. Brown. 1971. Production of a minimal largemouth bass population in a 3000-acre turbid Oklahoma reservoir. Pages 481-493. *In* Gordon E. Hall ed., Reservoir fisheries and limnology, Am. Fish. Soc. Spec. Publ. No. 8.