extended for another year on the Little North Fork Arm to evaluate reports by dock owners and anglers that bass fishing declined markedly in 1959. However, there is good reason to believe that increasing populations of white bass and crappie offered strong competition as they did on the White River Arm, with much the same result.

Creel limits were varied rather widely by regulation changes during the study period, with the general trend being toward liberalization. However, no effect could be discerned on the harvest as a result of the regulation changes. A far greater effect on harvest was brought about by the drought of 1954, when greatly reduced lake levels caused the pressure per acre to go up markedly, and by the influence of Table Rock Reservoir when bass fishing there became good and caused a 50 percent reduction in pressure on Bull Shoals.

ACKNOWLEDGMENTS

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DYNAMICS OF THE LARGEMOUTH BASS POPULATION IN BULL SHOALS RESERVOIR, MISSOURI

By Willis D. Hanson

ABSTRACT

Black bass fishing in the White River Arm of Bull Shoals Reservoir, Missouri, was regarded as sensational for several years following its impoundment in 1952. In 1958, just after a tagging program was added to test netting and creel census programs, an unpredicted decline in black bass fishing began.

Only largemouth bass nine inches or longer were tagged so population estimates include only that portion of the population. In 1958, black bass numbers reached an all-time high, but late that year the population began a decline which continued throughout the study. The average length of bass captured by electro-fishing increased each succeeding year, indicating a population of larger bass fewer in number.

According to various measurements, 1958 began with a high predator population and a low forage population. Few schools of shad were seen, and largemouth bass scales showed poor growth. The percentage of yearlings each spring, a good indication of the success of the future fishery, was high in early 1958 but dropped sharply in 1959 and 1960.

Low tag return rates indicated that angling did not seriously exploit the bass fishery.

Information collected suggests the possibility of strong competition between white and black bass for forage. It suggests that white bass should not be stocked in new impoundments without careful consideration.

INTRODUCTION

In the White River Arm of Bull Shoals Reservoir, Missouri, black bass fishing was excellent after impoundment in 1952, reaching a peak in 1957 and early 1958. In spring, 1958, a tagging study was initiated and continued in 1959 and 1960, when an unpredicted decline in the fishery took place. Results of this study, when integrated with those of other research conducted on Bull Shoals, provide reliable documentation of the decline of the fishery and suggest some of the causes.

This study was financed in part with federal-aid in fish restoration funds under Missouri's Dingell-Johnson Project F-1-R.

PROCEDURES

Bass were captured with a boat-mounted electric boom shocker similar to that described by Larimore *et al.* (1950) powered by a 110 volt, 2500 watt single phase AC generator. They were tagged around the premaxillary just to one side of the frenum with monel metal butt-end tags, which were found to be much superior to the monel metal strap tags formerly used.

Tagged bass were released as randomly as possible within the creel census area, because creel information was used in estimating populations. Since recoveries were dependent upon angling returns, the entire area was posted with signs asking anglers to cooperate. A creel census clerk regularly picked up returns from anglers and dock operators. A few were returned by conservation agents and by mail.

The formula $P = \frac{T \times C}{Y}$, a modification of the Petersen Method, was used to calculate the population in the census area; T is the total number of tagged fish in the census area at a given date, C is the total estimated number of fish caught in a 30-day period following the date of T, and Y is the number of tag returns in the 30-day period.

Only the tags returned during the 30-day period immediately following tagging are required in this estimation procedure which minimizes the biasing effects of tag loss, bass mortality, and recruitment. Kimsey (1956) found flat and rounded jaw tag losses to be too high to give information useful in longer term studies. However, Tebo (1957) found 7 out of 10 number 3 metal strap tags remaining after a one-year period. Tags of three sizes used in this study were large enough to allow for considerable fish growth. They were applied according to the sizes of the bass.

Spotted bass were not included in estimates because they made up only about five percent of the black bass taken. Largemouth bass nine inches or more in total length were tagged, so population estimates refer only to that portion of the black bass population.

FINDINGS

The estimated population of largemouth bass in the creel census area for three years is shown in Table I. The population declined about 80 percent between 1958 and 1960; the estimated creel, about two-thirds in the same period. This is considered significant even though the two estimates are interdependent. The decline in the numbers of catchable-size bass per acre is perhaps the most striking information in the table. When the population estimates are reduced to terms of bass nine inches or larger per acre, the 1959 and 1960 estimates seem quite low.

TABLE I

ESTIMATED NUMBER OF LARGEMOUTH BASS IN THE POPULATION AND IN THE CREEL IN WHITE RIVER ARM OF BULL SHOALS RESERVOIR, MISSOURI, 1958–1960. BASS NINE INCHES AND OVER IN LENGTH WERE CONSIDERED CATCHABLE SIZE

Item	*1958*	*1959*	*1960*
Estimated population	111,258	22,236	19,560
Estimated creel	19,091	7,662	6,191
Estimated number of catchable size bass per acre	46.7	11.2	8.4
Average creel census area in acres	2,382	1,900	2,325

However, by comparison, Maloney *et al.* (1962) estimated 23 and 12 bass over six inches long per acre in 1957 and 1958, respectively in Gladstone Lake, Minnesota. Considering the Bull Shoals estimate to be for largemouth bass nine inches and larger and the spotted bass not included, the figure seems to be plausible. Mraz and Threinen (1957) measured 55.5 largemouth bass six inches or longer per acre in a population they considered "abundant".

The question arises as to what happened within the fish population to cause this decline in the bass fishery. The following direct and circumstantial evidence is presented in an attempt to answer this question.

The average length of all bass taken with electro-fishing gear increased markedly each succeeding year as the population declined (Table II). This suggests a population of progressively fewer, older, and larger bass. Table II also shows a decline in the percent of the tagged bass reaching the creel A drop of about 50 percent in the catch of bass is indicated.

TABLE II

AVERAGE LENGTH IN INCHES OF LARGEMOUTH BASS TAKEN WITH ELECTRIC SEINE AND THE PERCENTAGE OF TAGS RETURNED FROM THE WHITE RIVER ARM OF BULL SHOALS RESERVOIR, MISSOURI, 1958–1960

	1958	*1959*	*1960*
Average length of bass	9.5	11.2	14.6
Percent of tag returns	11.1	7.8	5.5

Figure 1 presents a three-year summary of all largemouth bass tagged and the number of tags returned. Under ordinary conditions in a comparison of this kind, it could be expected that the proportions of returns would be relatively constant for all sizes of bass. Actually, it wouldn't be unreasonable to expect a proportionately higher return for the smaller bass. Maloney *et al.* (1962) found that largemouth bass one to three pounds in weight were taken more frequently than larger bass. Mraz and Threinen (1957) found that most of the bass creeled fell into the 9-14 inch range. However, the information in Figure 1 shows a higher relative number of tag returns for the larger bass. This leads to the question why these tagged bass, 9-14 inches in length, made such a poor showing in the creel.

Numbers of Age Group I black bass captured while electro-fishing during the spring yield valuable information about the success of the spawn and survival through the first winter. These young bass frequented the shallows in spring and seemed particularly vulnerable to capture by this method. Scale reading during and prior to this study has shown that largemouth bass less than 8.5 inches and spotted bass less than 6.0 inches total length by May usually are yearlings. Table III is a record of the capture of yearling bass for 1958, 1959 and 1960. Both largemouth bass and spotted bass are included in the table, and both show the same downward trend. The total number of yearlings of each species captured annually declined over 80 percent between 1958 and 1960.

Three years of study showed variations in growth increments made each year by largemouth bass. Table IV lists these increments. Those for 1958 were quite low, but showed some recovery in 1959. However, scales taken that year showed resorption of scale material in the 1958 growth areas, suggesting malnutrition.

In the 1958 creel there was an all-time high in the total numbers of black bass, white bass, and crappie, the principal predator species (Table V). The catch of largemouth bass had increased gradually from 1956 to 1958, but the

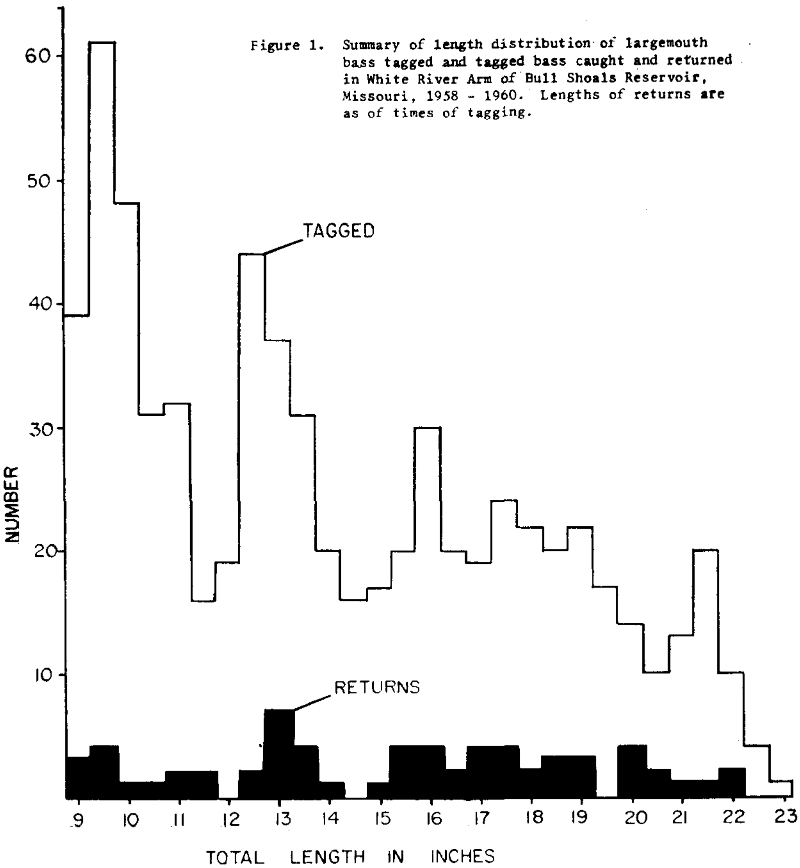

Figure 1. Summary of length distribution of largemouth bass tagged and tagged bass caught and returned in White River Arm of Bull Shoals Reservoir, Missouri, 1958 - 1960. Lengths of returns are as of times of tagging.

TABLE III

PERCENT OF YEARLING LARGEMOUTH BASS AND SPOTTED BASS IN THE TOTAL ELECTRIC SEINE CATCH IN THE WHITE RIVER ARM OF BULL SHOALS RESERVOIR, MISSOURI, 1958–1960

	1958	*1959*	*1960*
Largemouth bass (less than 8.5 inches long)	54.9	30.1	7.3
Spotted bass (less than 6 inches long)	55.5	28.5	9.8

TABLE IV

GROWTH INCREMENTS IN INCHES OF LARGEMOUTH BASS FROM BULL SHOALS RESERVOIR, MISSOURI, WHITE RIVER ARM FOR YEARS 1957–1959. INCREMENTS ARE GROWTH INTERVALS MADE DURING INDICATED YEARS, NUMBERS IN PARENTHESES ARE SAMPLE SIZES

Year of Life	*1957*	*1958*	*1959*
1	8.4 (171)	6.1 (45)	6.5 (15)
2	6.6 (44)	3.0 (74)	4.6 (34)
3	4.0 (13)	0.9 (21)	3.1 (53)
4	2.5 (26)	0.5 (20)	1.1 (19)
5	1.5 (14)	0.7 (8)	0.8 (16)
6	1.0 (4)	0.5 (16)	0.7 (21)
7	..	..	0.5 (9)
8	..	..	0.4 (1)

build-up of white bass and black and white crappie was explosive by comparison. The white bass catch increased over 275 percent between 1957 and 1958; the crappie catch, over 160 percent.

TABLE V

ESTIMATED CREEL OF PRINCIPAL PREDATOR SPECIES IN THE WHITE RIVER ARM OF BULL SHOALS RESERVOIR, MISSOURI, FOR 1956–1960

Species	*1956*	*1957*	*1958*	*1959*	*1960*
Largemouth bass	14,574	18,623	19,001	7,662	6,191
Spotted bass	1,228	428	1,025	192	204
White bass	14,319	25,745	71,293	75,991	17,785
Crappie	70,587	93,028	153,323	63,691	76,540
TOTAL	100,708	138,725	244,732	147,737	100,720
Predator fish/hour in the creel	.54	.65	.90	.66	.81
Largemouth bass/hour in the creel	.08	.09	.07	.03	.05

These changes in the creel do not necessarily parallel changes in the fish population, but apparently predatory species were very abundant in Bull Shoals in the spring of 1958. Looking further at the data in Table V, the white bass numbers held up in 1959 after the black bass numbers had already dropped. The predator fish-per-hour figures show only minor fluctuation, while the largemouth bass-per-hour figures show a marked drop in 1959 This data shows that when the predator population was high and foraging became difficult, the black bass were among the first to succumb. The crappie numbers also showed a drop in 1959. Many of the 1958 crappie were large and represented a strong year class that was about due to drop out of the fishery normally. The forage shortage no doubt hastened the decline.

The net catch for the fall of 1957 and 1958 (Table VI) corroborates this opinion. Table VI shows a very rapid increase in the white bass catch. Also, during the fall of 1957, crappie numbers (as shown by netting) were at their peak. Many of these crappie were entering the creel that fall and during the spring of 1958. Their numbers, as well as those of the black bass, were very low by the fall of 1958.

TABLE VI

THE COMBINED CATCH IN FISH PER NET DAY FOR ALL NETS FISHED IN THE WHITE RIVER ARM OF BULL SHOALS RESERVOIR, MISSOURI, IN THE FALL OF 1955 THROUGH 1960

Species	*1955*	*1956*	*1957*	*1958*	*1959*	*1960*
White bass	0.4	13.3	17.5	24.2	7.2	18.9
White crappie	5.7	11.1	17.4	16.5	14.2	3.4
Black crappie	0.9	1.2	2.4	2.4	3.8	0.2

Table VII shows the annual creel of bass in the fall quarter as observed by the census clerk. The highest creel of black bass always occurred in the spring quarter with the fall quarter in second place. It is noteworthy in Table VII that the fall creel for 1958 drops sharply from that of previous years. This again indicates that something happened to the black bass in 1958.

TABLE VII

THE OBSERVED FALL CREEL (SEPTEMBER, OCTOBER, AND NOVEMBER) OF LARGEMOUTH BASS FROM THE WHITE RIVER ARM OF BULL SHOALS RESERVOIR, MISSOURI, FOR THE YEARS 1955 THROUGH 1960

Year	*1955*	*1956*	*1957*	*1958*	*1959*	*1960*
No. of largemouth bass censused	262	342	449	131	102	119
Largemouth bass/hour	.10	.09	.30	.04	.06	.06

There was an excellent spawn of black bass in the three years previous to 1958 (Table VIII). Under the usual growth conditions in this impoundment, many bass enter the catch their second summer, and three- and four-year-olds are the mainstay of the bass creels (Mraz and Threinen, 1957). However, Table I shows a marked reduction in the creel for 1959 and 1960. It would seem that even after making ample allowance for normal mortality, the excellent bass spawns of 1955, 1956 and 1957 should have provided more younger bass for the 1959 and 1960 creel than actually were caught.

TABLE VIII

NUMBERS OF YOUNG-OF-THE-YEAR LARGEMOUTH AND SPOTTED BASS TAKEN PER SEINE HAUL DURING THE SUMMERS OF 1955–1959 IN BULL SHOALS RESERVOIR, MISSOURI

Species	*1955*	*1956*	*1957*	*1958*	*1959*
Largemouth bass	69.5	26.3	10.4	0.8	5.6
Spotted bass	10.1	48.7	24.1	0.9	0.5
TOTAL	79.6	75.0	34.5	1.7	6.1

Referring again to Figure 1, it can be seen that there were relatively fewer tag returns from 9-14 inch bass than for larger sizes. These smaller size bass usually have provided the greatest number of bass in the creel. In this study, however, the tag returns indicate proportionately more 15-inch and over bass were caught. Table III shows a substantial proportion (54.9 percent) of surviving, yearling largemouth bass in the spring of 1958. These young fish should have provided a larger bass creel in the fall of 1958 and 1959 than the creel census data in Table I indicates.

DISCUSSION

The decreased growth rates and resorption of part of the 1958 growth areas on largemouth bass scales, a drastically reduced bass creel in 1959, a much reduced fall bass creel in 1958, an all-time high in the predator population in 1958, and a low return of tags from largemouth bass less than 14 inches total length all point to the posibility that many bass in 1958 probably perished from starvation or predation. There can be little doubt that competition for forage was keen in 1958. Several emaciated, fungused black bass were found along the shoreline late in the summer and during early fall of that year. These may have been victims of malnutrition.

Bull Shoals Reservoir has been subjected to intermittent water level fluctuations. Wiebe (1940) found that drawdowns in Norris Reservoir precluded the establishment of a zone of aquatic vegetation and the associated fish food organisms. It would follow that there must exist in the fish population complex a primary consumer adapted to feeding upon other food sources; namely, plankton and deeper benthic organisms. The gizzard shad fills this role in Bull Shoals Reservoir. Dendy (1945) found that the chief food for Norris Reservoir game fish was the gizzard shad. Schneidermeyer and Lewis (1956) found that Crab Orchard Lake largemouth subsisted largely upon gizzard shad and exhibited "above average" growth. Dubets (1954) in doing a gastroscopic study of largemouth bass food habits found gizzard shad to be heavily utilized.

The only weak link in the chain of evidence is lack of an adequate measurement of the abundance of young-of-the-year of the principal forage species, the gizzard shad. However, circumstantial evidence is available. During the summer fishermen try to locate schools of small shad, which are a fruitful place to fish for white bass. The creel clerk and dock operators were unable, during the summer of 1958, to find surfacing shad schools. Direct evidence of poor foraging is reflected in the condition of factor (C) (Thompson and Bennett, 1939) of the white bass, which reached its lowest ebb in the fall of 1958 (Table IX).

TABLE IX

THE CONDITION FACTOR (C) OF WHITE BASS IN THE WHITE RIVER ARM OF BULL SHOALS RESERVOIR, MISSOURI, IN THE FALL, 1956–1960

	1956	*1957*	*1958*	*1959*	*1960*
"C" Factor	5.43	5.42	4.71	4.73	5.18

This study began in 1958 when there was an all-time high in black bass numbers, and continued as bass numbers were dastically reduced. Tag returns indicate that angling probably had but minor influence upon this decline. In 1958, the year of heaviest angling for black bass, the tag return rate was only 11.1 percent. Patriarche (1956)[1] found a 31 percent harvest of largemouth bass in Lake Taneycomo in 1955, and that in the face of this much exploitation, the largemouth bass continued to provide good fishing. Even if the returns from Bull Shoals Reservoir reported here represent only half the tagged bass caught, the angling still should have had no deleterious effects on the catchable portion of the largemouth bass population.

It seems likely that factors other than angling were responsible for the marked decline in largemouth bass numbers. The tagging results coupled with other information suggests strong interspecific competition between black and white bass in Bull Shoals. White bass are suspect in this instance because of their almost explosive expansion just prior to the drop in black bass numbers. The effect of this great increase in predators was aggravated, of course, by a shortage of forage. Competition may not be noticeable when forage is abundant, or when white bass numbers are low. White bass, because of their tremendous reproductive capacity, may pose a potential threat to the black bass.

Admittedly, white bass do produce excellent fishing and are highly desirable game fish under favorable conditions. However, until additional research either further verifies the thesis advanced here or provides reliable information to the contrary, the possible undesirable consequences of deliberate introduction of white bass into a fishery containing black bass should be carefully weighed.

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HARVEST OF FISH FROM TAILWATERS OF THREE LARGE IMPOUNDMENTS IN MISSOURI[1]

By James P. Fry

ABSTRACT

Quantitative creel census techniques were employed on Missouri tailwaters for the fist time during 1961. Specific areas below Table Rock and Taneycomo Reservoirs on White River and below Clearwater Reservoir on Black River were censused using a stratified sampling technique throughout the year.

Estimated fishing pressure on Table Rock tailwater was 608 hours per acre and the rate of catch amounted to 0.62 fish per hour. The yield per acre was about 380 fish, weighing 192 pounds. Hatchery reared rainbow trout comprised nearly 90 percent of the yield by number.

Taneycomo tailwater supported an estimated 609 hours of fishing per acre. Rate of catch amounted to 0.55 fish per hour; the yield per acre was 343 fish weighing 408 pounds. White bass made up more than 37 percent of the total creel, followed by drum, crappie, channel catfish, and bluegill.

Estimated fishing pressure on Clearwater tailwater was 1,607 hours per acre, with a catch rate of 0.55 per hour. The yield per acre was 930 fish weighing 845 pounds. Numerically, crappie comprised about 35 percent of the total catch, followed by carp, bluegill, channel catfish, and buffalo. Carp provided about one-third of the total weight.

The tailwaters of Table Rock, Taneycomo and Clearwater reservoirs received 7, 10 and 16 times more fishing pressure per acre than the reservoirs themselves. Taneycomo tailwater had more fishermen than Lake Taneycomo. Taneycomo and Clearwater tailwaters provided greater total harvests by weight than did their respective reservoirs.

INTRODUCTION

Although the tailwaters of large impoundments in Missouri vary greatly in physical character, all are used extensively by sport fishermen. Heavy angler use of tailwaters has been reported in several other states. Miller and Chance (1954) reported that 35 percent of the estimated 2 million fishing trips and 52 percent of the estimated 7-million pound harvest from all TVA waters may be attributed to tailwater fishing. Unpublished reports[2] indicate that some TVA tailwaters now support as many as 735 fishing trips per acre per year, yielding fish at an average annual rate of 1,152 pounds per acre.

This study was undertaken to quantitatively measure the fishing pressure and catch in tailwaters of Missouri reservoirs. The tailwaters selected were Table Rock and Taneycomo on White River in southwestern Missouri, and Clearwater on Black River in southeastern Missouri.

METHODS

Two job-trained creel census clerks conducted the tailwater censuses in conjunction with censuses on the associated reservoirs. Each worked 25 days a month with days off scheduled on a stratified basis. One clerk rotated his work days among Table Rock tailwater, Lake Taneycomo, and Taneycomo tailwater, while the other alternated his work days on Clearwater Lake and Clearwater tailwater. The clerks' principal duties were to count, twice daily, the number of boat and bank fishermen and to interview fishermen. Counts were made by boat on Table Rock and Taneycomo tailwaters and by automobile on Clearwater tailwater. The counts were begun at opposite ends of the census area each work day, and the starting point of the afternoon count was reversed from that of the morning count. Counting times were stratified so that each workable hour would be sampled an equal number of times in a season.

Fishermen were interviewed at fishing docks, by boat, and on shore. Information obtained included: the date; number, residence and sex of fishermen; hours fished; boat or shore fishing; fishing method and bait; number successful

1 This work was financed in part with federal-aid in fish restoration funds under Missouri's Dingell-Johnson Project F-1-R

2 Sport Fishing Institute Bulletin No. 116 (July 1961).