# A FIELD TEST OF THE USE OF SCALE SIZE AT THE FORMATION OF THE FIRST ANNULUS TO PERMANENTLY MASS-MARK SMALLMOUTH BASS, Micropterus dolomieui LACEPEDE

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## ABSTRACT

This study, using smallmouth bass, *Micropterus dolomieui* Lacépède, was a field test of a new method of permanently mass-marking fishes. This method consists of producing fish by means of rapid or prolonged growth whose scales have a significantly larger focus to first annulus distance than fish native to a stream chosen for stocking. In October, 1965, 322 young-of-the-year bass, that had been raised either in laboratory aquaria or a hatchery pond, were stocked in three headwater streams of Northwest Arkansas. Recapture attempts in June, 1966, yielded seven scale-marked bass from two of the three streams stocked, indicating the feasibility of this marking technique for certain types of field use.

## INTRODUCTION

Methods of mass-marking fishes frequently have proven unsatisfactory because the tags, dyes, and markers used are seldom permanent, or else the marking method itself renders the fish less suited for growth and survival than its unmarked competitors (Jensen, 1967, and Latapie, 1967). This paper reports on a field test of an apparently harmless, yet efficient, method for permanently mass-marking smallmouth bass, *Micropterus dolomieui* Lacépède. This method, based on studies by Castro (1963) and Peek (1965a), consists of producing fish by means of rapid or prolonged growth whose scales have a larger focus to first annulus distance than fish native to a stream chosen for stocking.

## METHODS

Recently hatched smallmouth bass fry were collected in late May and early June, 1965, from the Middle Fork of the White River and from Fall Creek of the Arkansas River drainage. Five hundred bass fry from Fall Creek were transported to the state fish hatchery at Centerton, Arkansas, where they were released into a one-tenth acre rearing pond containing a large supply of mosquitofish, *Gambusia affinis* (Baird and Girard). Seven hundred smallmouth bass fry from Middle Fork were taken to a laboratory on the University of Arkansas campus and were evenly distributed among five 40-gallon tanks containing aged tap water. Each tank had a plastic bottom filter covered with approximately 5 centimeters of sand. Tank water was also pumped through filters containing bone carbon covered with a layer of glass wool, and constant illumination was provided by fluorescent lights. Water temperature was maintained at 28°C, because Peek (1965a) found the maximum growth rate of smallmouth bass occurred at 28 and 29°C.

For the first three weeks, the young bass were fed brine shrimp twice daily. Then mosquito wigglers and daphnia were fed in large quantities to the bass. By the end of July chopped earthworms were provided three times a day, because sufficient numbers of mosquito wigglers and daphnia could not be obtained to insure maximum growth. Periodically, debris was siphoned from the bottoms of all tanks and fresh tap water was added.

The occurrence of monogenetic trematodes, a gill parasite, was discovered in mid-July and a 3-minute dip in a 1:4000 formalin solution proved to be temporarily effective in controlling the infection. However, the trematode again appeared in September causing some mortality and necessitating another treatment.

Four locations on three headwater streams in Northwest Arkansas were selected for the stocking experiments. These streams were chosen for this study, because the small mouth bass in them were known to have slow rates of growth (Castro, 1963; and Peek, 1965a). The locations exhibited the typical pool-riffle pattern characteristic of the smallmouth bass habitat in Arkansas, but they varied with respect to degree of development and other features. Briefly, each study area can be described as follows:

(1) *Spavinaw Creek upstream from Highway 59 South of Gravette, Benton County*

This location was characterized by small pools, usually about 20 meters long and rarely over 1 meter deep in any part. Other features of this location were clear water cool enough to support stocked rainbow trout, an absence of large boulders in the stream, rapid flow of water with little fluctuation of level, many logs and undercut banks, and exceptional stability of pool and riffle configuration from year to year. The stream bottom was composed of gravel and was generally without rubble or silt.

(2) *White River at Riverside Cemetery upstream from St. Paul, Madison County*

Most of the pools were long (some up to 70 meters), but varied in depth (1 to 2 meters deep). The water was slightly turbid at this location and had low conductivity. The stream bottom was composed of rock, rubble, and gravel in the riffle areas and shallow pools, and considerable amounts of silt in the deeper pools. Variation in water temperature occurred in response to changing air temperatures. This stream was intermittent during periods of low rainfall.

(3) *Fall Creek below waterfall at Strickler, Washington County*

This headwater area contained small, shallow pools (10 to 20 meters long and up to 1 meter deep) with stream bottoms composed of bedrock, rock, rubble, gravel, and silt in various proportions. The water was slightly turbid and its temperature fluctuated with air temperature. This section of the stream bed had a very high gradient, and water became intermittent early in June.

(4) *Fall Creek above low-water bridge one-fourth mile upstream from its confluence with Lees Creek, Crawford County*

The pools at this location varied greatly in size. Some were wide and shallow (approximately 25 meters wide and ½ to 1 meter deep) with bedrock, rock, rubble, and gravel bottoms. Other pools were narrow and deep (10 to 15 meters wide and 1 to 2 meters deep) with bedrock, gravel bottoms. Most pools contained large boulders. The water was generally clear, and cool water flowing into the pools at their upstream ends provided a variety of temperatures for smallmouth bass during the summer. This section of the stream also became intermittent in dry weather, and was approximately 10 miles downstream from location 3.

Collections were made with electric-shocking equipment September 13, 1965, at Spavinaw Creek, September 26, at the two locations on Fall Creek, and September 28, on the White River at St. Paul to obtain samples of smallmouth bass and to remove possible predators and competitors prior to stocking.

Miller (1958) found that survival of stocked trout was severely reduced by competition with an established population of the same or similar species. For this reason, electrofishing equipment was used to rid some pools of centrarchids, as completely as practical; other pools were left untouched to serve as controls.

Spotted bass, *Micropterus punctulatus* (Rafinesque), occurred at location 4, but not at the others. The rock bass, *Ambloplites rupestris* (Rafinesque), was common at study areas 1 and 2, but was not taken at the other locations. Green sunfish, *Lepomis cyanellus* Rafinesque, and longear sunfish, *L. megalotis* (Rafinesque), were present at all study areas and were common at 2, 3, and 4. Bluegills, *L. macrochirus* Rafinesque were rare at all locations.

The pools that were cleared of centrarchids were examined until further collecting yielded practically no centrarchids. The entire area of most of these pools was swept at least four times with an electric field of sufficient strength to stun fishes. The majority of the fishes were collected during the first sweep of the pool. Granulated NaCl was dissolved in the White River to increase conductivity to a level needed for successful electrofishing.

The smallmouth bass taken in the electrofishing collections were used to determine, by direct measurement of scales of young-of-the-year (YOY) and by measurement of focus to first annulus distance of older bass, the size scale a laboratory—or hatchery-raised bass should have for stocking at the various locations. The bass suitable for stocking should possess a first year scale length significantly larger at the 0.05 level of probability than smallmouth bass of the same age which were native to the stream. Therefore, the stocked bass could be identified upon recapture.

Scales were sampled from 70 laboratory-raised fish of diverse standard lengths which died before stocking and from 12 hatchery-raised bass which had been preserved. Scale lengths (magnified 57X), standard lengths (Figure 1), and size of fish were least for the YOY smallmouth bass taken from Fall Creek near the end of the growing season on September 26, 1965, intermediate for the laboratory-raised fish, and greatest for the hatchery-raised fish. No YOY bass were collected at Spavinaw Creek or the White River, although two were seen at the latter location swimming in the shallow water, and were noted to be much smaller than the laboratory-raised fish. All scale samples were taken from native, laboratory- and hatchery-raised bass from an area at the tip of the extended right pectoral fin, five scale rows below the lateral line (by the Lagler method, 1956).

The size scale required for stocked fish (Table 1) was determined in the following manner: From the stream collections, the scale lengths of all YOY smallmouth bass were obtained. In streams where no YOY were taken, focus to first annulus length was measured on scales from all older bass collected. Using these measurements, the standard deviation, s, of the scale lengths was calculated independently for each stream. Applying the statistical concept that the mean scale length, $\overline{X}$, of the bass of each stream plus two times the standard deviation will include over 95% of the small mouth bass in the stream (Steel and Torrie, 1960), it follows that unless a one in 20 chance has occurred, a laboratory- or hatchery-raised fish with a scale length $\geq \overline{X} + 2s$ can be identified upon recapture.

Because the scale length-body length relationships were known for the laboratory- and hatchery-raised bass (Figure 1), the approximate size fish possessing the minimum size scale required for stocking at each location could be determined (Table 1).

On the basis of the number of proper-sized smallmouth bass available (a few were considered too small to stock), 60 laboratory-raised bass were released in one pool in the White River on October 5, 1965. Eighty were stocked, 20 per pool, in four pools at Spavinaw Creek on October 7. Eight fish were stocked in one pool and 25 in another in Fall Creek at Strickler on October 9. One hundred and seventeen bass were distributed as even as possible, among three pools at the downstream location in Fall Creek on October 9. Thirty-two hatchery-raised fish were also released the same day in one pool at the downstream location on Fall Creek.

In natural fish populations, annuli, or year-marks, are formed by cessation of scale growth in the fall because of cold water temperatures, along with subsequent renewal of growth in the spring which delimits the annual mark. The smallmouth bass were stocked at the four locations under the assumptions that: (1) these abnormally large fish would continue to grow at the same rate as the fish already in the stream, thus maintaining the size differential between them and the fish native to the stream; (2) the following spring the stocked bass would form their first annuli along with the stream fish; and (3) the distance from the focus to the first annulus would be significantly larger on the stocked fish than on the native stream fish.

In June, 1966, electrofishing trips were made to the locations stocked in an attempt to recapture as many of the marked bass as possible in the immediate area of their release.

## RESULTS

No native or scale-marked smallmouth bass were taken from Spavinaw Creek or from Fall Creek at Strickler during the recapture attempts. At Fall Creek ¼ mile upstream from its confluence with Lees Creek, 27 bass with appropriate standard lengths for laboratory- or hatchery-raised fish (80 to 182 mm.) were captured. When the scales were checked, eight of these fish were found to have a single annulus each, with focus to annulus distances of 26, 33, 35, 48, 52, 65, 70, and 75 mm. (X57), and standard lengths of 55, 69, 70, 86, 96, 106, 113, and 119 mm., respectively. The three smallest of these fish had standard lengths, including growth made in the spring of 1966, that were less than those of the smallest scale-marked bass (Table 1) stocked in Fall Creek, demonstrating that they were native fish. The two next smallest fish were either laboratory-raised, because their first annulus distances were too small to be from the hatchery, or exceptionally large one-year-old fish native to the stream (Figure 2). It is unlikely that these two fish were native, because 1965 was apparently a year of slow growth. Six YOY smallmouth caught September 26, 1965, near the end of the growing season, had standard lengths of 35, 40, 42, 44, 48, and 61 mm. (Figure 1). The three largest bass with one annulus each had too great focus to first annulus lengths to be native fish, and could have been either laboratory or hatchery raised. The rest of the smallmouth bass taken at this location, which were of an appropriate size to be scale-marked fish, had from two to four annuli.

Four bass captured on June 21, 1966, in the White River near St. Paul were of a size which indicated that they could have been stocked at this location. One fish considered native because its standard length was less than any of the laboratory-raised fish when stocked (Table 1), had a focus to first annulus distance of 28 mm. (X57) and a standard length of 69 mm. Two of the fish with standard lengths of 91 and 106 mm. and focus to first annulus distances of 50 and 53 mm. (X57), respectively, were considered to be stocked fish, because they had significantly larger (P 0.05) focus to first annulus lengths than those of native fish in various years (Figure 2). The fourth smallmouth bass had a standard length of 129 mm., and was in its fourth year.

Three of the bass recaptured from Fall Creek were taken from pools where the centrarchids had been removed prior to stocking. The other two recaptures at this location were from pools that had not been previously cleared with the electrofishing equipment.

One of the bass recaptured from the White River was collected from a pool from which the centrarchids had been eliminated, while the other recaptured fish was from a previously uncleared pool.

## DISCUSSION

There are three possible explanations for the sparse number of recaptures from the four locations stocked with smallmouth bass: (1)

extremely high mortality resulting from predation, competition, angling, disease, or other causes; (2) movement of the fish either upstream or downstream or both, away from the stocking areas; and (3) failure to capture marked bass that were present.

*Mortality*

The occurrence of high mortality was a distinct possibility, because the laboratory-raised bass had experienced severe infection with monogenetic trematodes. Although corrective measures had been taken, the fish were weak when stocked. Wickliff (1933) had only 10 returns from 717 smallmouth bass released, and attributed this small return to high mortality.

Fall Creek at Strickler was considered poor smallmouth bass habitat, because bass (either native or stocked) were never collected in this area of the stream. It is believed that the shallow pools at this location did not permit overwinter survival of the stocked bass.

Predation plays an important part in any natural environment. This is of special concern to the smaller, younger organisms. Even though native fish of a size capable of eating the laboratory-raised bass had been eliminated from many of the pools stocked, there were still birds, snakes and other piscivorous organisms for the stocked bass to contend with.

Our removal of centrarchids from certain pools prior to stocking the bass should have increased the survival rate of stocked bass in these pools (Miller, 1958). However, by the time of recapture, pools that had been cleared were repopulated by very few smallmouth and spotted bass, and by rock bass and green and longear sunfish in numbers approaching those found prior to removal of the centrarchids.

Some fish could have been lost to angling. The number of fishermen on most Ozarkian streams is small, but a skilled fisherman can remove within an hour or less a large percentage of the smallmouth bass living in a warm-water pool similar to those stocked in the White River and Fall Creek. Only the hatchery-raised fish were large enough to be attractive to fishermen, and the presence of paths along the edge of the pool in which they were stocked indicated angling.

*Fish Movement*

Brown (1961) studied the movements of native and hatchery-reared smallmouth bass released in a headwater tributary of the Little Miami River of Ohio. He found that more than 91% of the marked native fish were recaptured within ½ mile of the release points. This is in close agreement with the findings of other workers Larimore, 1952; Gerking, 1953; and Forney, (1961) that appreciable numbers of native smallmouth bass remain within limited areas (home ranges) of one to several pools. Brown also found a tendency for large numbers of the hatchery-raised fish to move downstream considerable distances from the point of release.

Larimore (1954) released four groups of pond-raised (mostly yearling) smallmouth bass in Jordan Creek, Illinois, and found that 75% of them remained within ½ mile of the point of release.

At our White River locality, all bass were released in a single pool. One recaptured fish had remained in the pool, and the other fish was captured 200 yards downstream. Recapture attempts in all streams extended little beyond areas in which the fish were stocked. Therefore, we can only speculate about the movement of the stocked bass to other areas.

High rainfall during the winter and spring of 1965-66, caused flooding in all of the headwater streams studied, and was probably conducive to fish movement. In the two streams where smallmouth bass were recaptured, the water level was so low at the time of stocking that the bass could not have moved out of the pools in which they were stocked until the first heavy rain. The first general rainfall of approximately ½ inch fell around 26 days after stocking, with another occurring 16 days later. After that heavy rain came again in mid-December. Therefore, the bass which were recaptured at their points of release could have established territories while confined to pools where stocked, and remained there until captured.

The smallmouth bass stocked in Spavinaw Creek, where none were recaptured, were free to move upstream or downstream from their points of release at any time, because of the continual flow of water.

### *Failure to Capture Marked Bass*

The shortcomings of the electric shocker have been attested to by several workers (Gerking, 1953; and Lewis, *et al.*, 1962). It is known that larger fish are more easily collected than smaller ones, and that factors such as turbidity, conductivity of the water, and competence of the collecting crew affect its performance. The electric shocking equipment was operated efficiently in the smaller pools of all locations, but some fish could have been missed in one deep pool at the downstream locality on Fall Creek and in two deep pools near St. Paul on the White River.

### *Practicality of this Marking Method for Field Use*

The present study demonstrates that the scale method of permanently marking fishes is practical for certain types of field use. Various precautions must be employed when using this technique, depending upon the type of stocking study to be undertaken. The size fish required for stocking at a particular location may vary from year to year, because the native stream fish often exhibit different first year growth rates each year (Figure 2). Differences in first year growth rates among locations within a stream should be considered when using scalemarked fish to study long-distance movements. Purkett (1958) and Peek (1965b) found that the growth of smallmouth bass often varied more between different locations on the same stream than between different streams. Peek found that a gradient in the growth rates of bass occurred from slow at the headwaters to fast near the mouths of streams.

Although our method of permanently marking fishes has been developed using the smallmouth bass, its application to many other species is apparent. For locations where distinct annuli are not formed, an identification mark equivalent to an annulus can be placed on the scales of fishes by exposing them to refrigerated water for a few weeks prior to stocking (Peek, 1965a).

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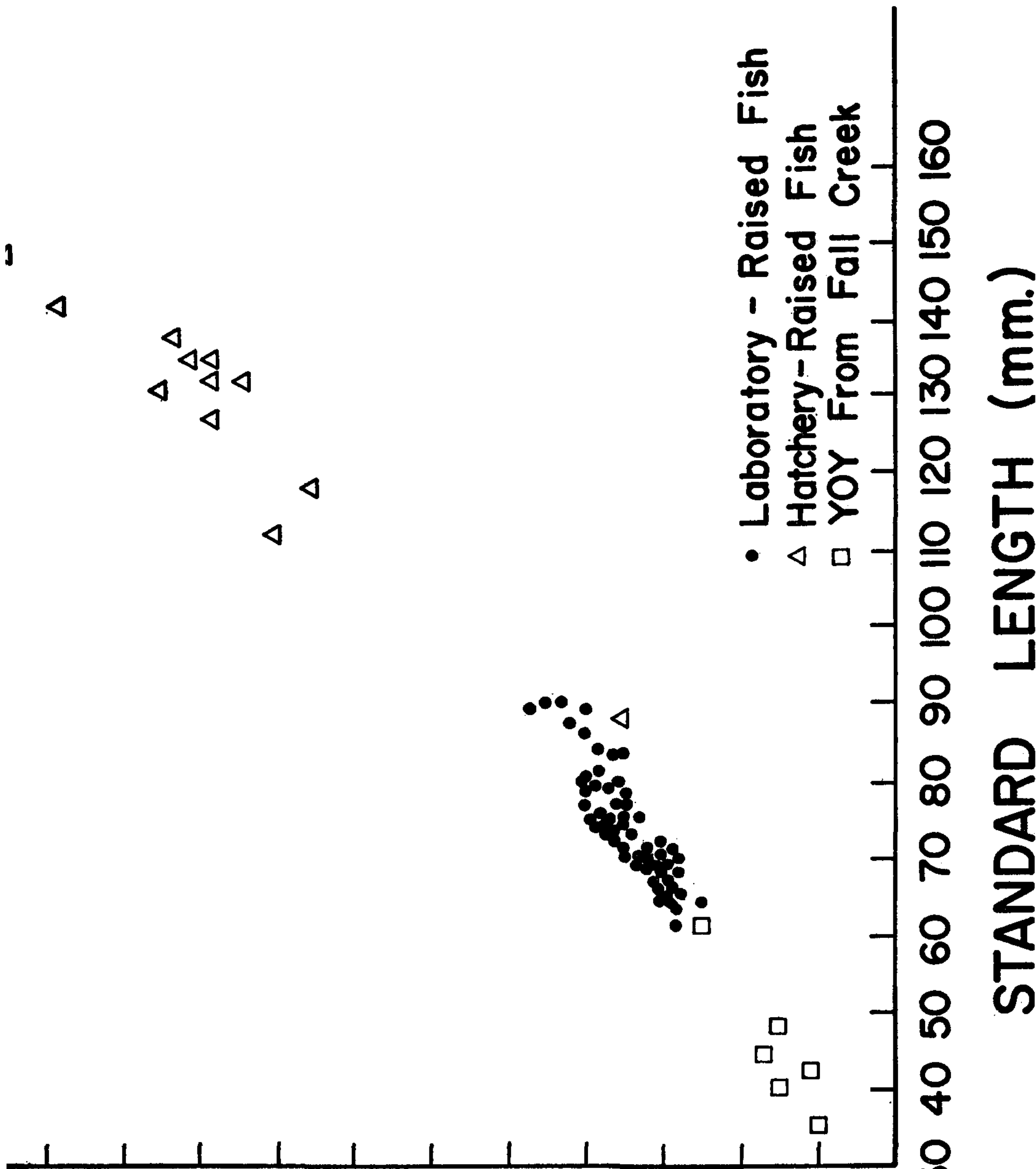
TABLE 1. Scale lengths and standard lengths required of smallmouth bass for stocking at the various locations, with means and ranges of the standard lengths of fish stocked at each location.

| Location | Mean scale length of stream-raised bass after first year's growth [1] | Standard deviation | Distance from focus to first annulus required for stocking ( $\bar{x}+2s$ ) | Minimum standard length of fish suitable for stocking | Mean standard length of stocked bass | Range of standard lengths of stocked bass |
|---|---|---|---|---|---|---|
| Spavinaw Creek | 34.8 | 6.9 | 48.6 | 75 | 77.8 | 75-92 |
| White River | 34.0 | 5.5 | 45.0 | 75 | 81.8 | 75-97 |
| Fall Creek | 25.5 [2] | 5.4 | 36.3 | 68 | 82.0 | 73-110 |
| | | | | | 128.4 | 97-150 [3] |

1 All measurements presented in mm.; all scale measurements are magnified 57 ×.

2 Calculated from YOY captured September 26, 1965; other means in this column were calculated from older bass captured over a period of several years.

3 Measurements for hatchery-raised bass; all above figures in last two columns are for laboratory-raised bass.



SCALE LENGTH (mm. x 57)
120
110
100
90
80
70
60
50
40
30
20
STANDARD LENGTH (mm.)
30
40
50
60
70
80
90
100
110
120
130
140
150
160
• Laboratory - Raised Fish
△ Hatchery- Raised Fish
□ YOY From Fall Creek

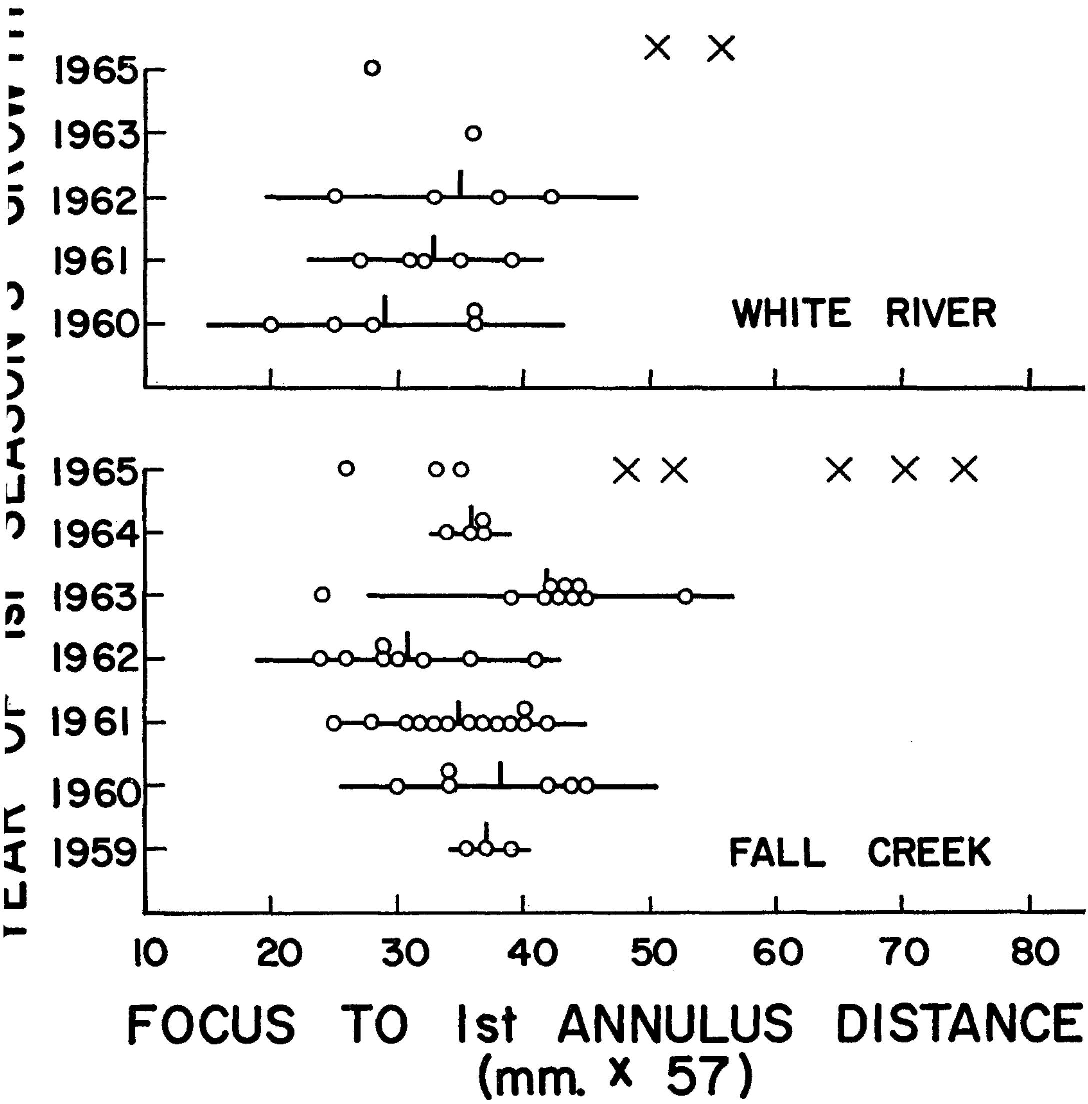



FIGURE 2. A comparison of first year scale growth of recaptured bass from Fall Creek and the White River (X=one fish) with first year scale growth of native bass (O= one fish) from these streams over a period of several years. Vertical lines represent mean first year scale growth, horizontal lines represent the mean two standard deviations for the years there were at least three native fish available.