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49. Age, Growth, Sex Composition, and Maturity of White Bass in Bull Shoals Reservoir

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ABSTRACT.--White bass (Roccus chrysops, Rafinesque) in Bull Shoals Reservoir were studied from October 1963 through January 1966 to determine age, growth, sex composition, and maturity. Average calculated total lengths of females at the end of each year of life through 6 years were 193, 338, 400, 427, 441, and 457 mm and of males 185, 320, 344, 397, 413, and 443 mm. Growth in Bull Shoals is similar to that in other southern waters. Growth was faster but lifespan shorter than in northern waters. Females outnumbered males 1.7 to 1. All 2-year-old white bass were sexually mature. Most males but only a few females mature at 1 year. Large fluctuations in year-class strength were evident. The 1961 and 1963 year classes were much stronger than those of 1962 and 1964.

Life history studies are an important part of the research of the South Central Reservoir Investigations to find principles and facts that can be used to improve the management of reservoir fisheries.

This is a report on the age composition, growth rate, and other biological factors in the life history of the white bass, Roccus chrysops (Rafinesque), in Bull Shoals Reservoir, a 45,440-acre impoundment of the White River in Arkansas and Missouri.

White bass are native to the White River in Arkansas. Meek (1894) reported that the species was common near Batesville, Ark., in 1892 and was a favorite with anglers. Black (1940) reported that white bass were common in the channel of the lower reaches of the White River. However, we found no published reports of occurrence of white bass in the river above Batesville before impoundment of Bull Shoals Reservoir in 1951. None were collected in preimpoundment sampling 70 miles above the dam site at Moore's Ferry (now Highway K Boat Dock) by John Funk (personal communication) in the period 1947-51. Records of the Arkansas Game and Fish Commission indicate that 1,376 white bass were transplanted from Norfork Reservoir to Bull Shoals Reservoir in the period 1950 through 1953 (Robert Baker, personal communication). These fish probably provided the stock that produced the present population.

Unpublished creel census summaries for Missouri did not record white bass in the reservoir during 1952, the second year of impoundment, but a small number appeared for the first time in the angler harvest in

1953 (Funk, 1953 and 1954). Burress (1962) reported an increasing harvest of white bass in the Missouri portions of Bull Shoals Reservoir from 1953 through 1959, when fishing success reached a peak. In 1960, the catch dropped drastically.

Bull Shoals Reservoir is the lowermost and largest of four reservoirs on the White River, which flows through the Ozark region of Arkansas and Missouri. A description of the reservoir has been presented by Mullan and Applegate (1966).

METHOD

White bass used in this study were collected from October 1963 through January 1966. Fishing gear consisted of experimental gill nets with mesh sizes ranging from 2 to 6 inches stretch measure, Ederer standard submarine trap nets with 1.5-inch stretch mesh in the crib and tunnel, and a boat-mounted 220-volt a.c. electroshocker. Gill net sampling was conducted at three stations representing upper, middle, and lower regions of the reservoir in each of seven collections. One collection was made in 1963; and starting in October 1964, collections were made at 3-month intervals through January 1966. Gill net collections provided 1,134 white bass, trap nets used in the fall of 1964 provided 271, and one electrofishing collection in October 1965 provided 31.

At time of capture, the date, location, total length, weight, sex, and stage of sexual maturity were recorded for each fish. Scales were removed from the left side, below the lateral line and at the tip of the pectoral fin. Plastic impressions of six scales from each fish using strips of 0.06-inch cellulose acetate were viewed with a standard microprojector at a magnification of 40 diameters. The distance from the focus of the scale to each annulus was measured in millimeters. Fish captured between January 1 and the time of actual annulus formation were assigned an additional annulus at the edge of the scale.

A computer and standardized programs prepared by Dr. James E. Dunn, University of Arkansas, were used to calculate the following:

1. Length-weight relation, expressed as $W = aL^n$ where W is weight in grams, a and n are constants and L is total length in millimeters.

2. Coefficient of condition expressed as $K(TL) = \frac{W}{L^3} 10^5$.

3. Body length - scale length relations were estimated by fitting polynomials of the form

$$L = \theta_o + \theta_1 S + \theta_2 S^2 + \ldots + \theta_k S^k$$

using the technique of stepwise polynomial regression (Graybill, 1961). In this equation L is total length, S is the distance from the focus of a scale to its anterior margin as measured on a microprojector, and θ and K are constants. All computations were made using ungrouped data. For each sex in every sample, a set of equations through the 6th degree polynomial was fitted and tested to determine which would most adequately represent the body length - scale length relation. Because of the volume of computer output from standard analysis of variance techniques, it has been omitted here.

4. Back-calculations of lengths at each annulus for each age group: Average distance to each annulus in each age group by sex was computed. These individual values were substituted in the body length - scale length equation computed earlier, and body lengths obtained were taken to represent lengths attained at the end of each year of life.

RESULTS

Length-weight relation and coefficient of condition

The relation of length to weight was calculated for female white bass in each of seven

collections and for males in four collections. Too few males were captured in the winter of 1963 and spring and summer of 1965 for statistical analysis. The resulting length-weight equations for females, in logarithmic form, are as follows:

October 1963	log W = -5.6630 + 3.3198 log L.
December 1963-January 1964	log W = -5.7305 + 3.3558 log L.
January 1965	log W = -5.5002 + 3.1894 log L.
April 1965	log W = -5.8633 + 3.3790 log L.
July 1965	log W = -4.9667 + 3.0404 log L.
October 1965	log W = -5.3477 + 3.1948 log L.
January 1966	log W = -5.7691 + 3.3656 log L.

Males were represented by the following equations:

October 1963	log W = -5.8821 + 3.4141 log L.
January 1965	log W = -5.6156 + 3.3109 log L.
October 1965	log W = -5.2485 + 3.1554 log L.
January 1966	log W = -5.3577 + 3.1954 log L.

The calculated weight of a 200-mm female was 82 grams in April 1965 but increased to 101 grams in October 1965. Females 300 mm in length varied from a low of 321 grams in April 1962 to a high of 412 grams in January 1965.

The calculated weights for males differed much less between collections than did females. The calculated weight for 240-mm males ranged from 176 grams in October 1963 to 184 grams in January 1965, and at 300 mm the calculated weight ranged from 361 grams in January 1966 to 386 grams in January 1965. The maximum length attained by females was 484 mm and that by males was 448 mm. The maximum weight of a female was 1,907 grams and of a male 1,332 grams.

Coefficients of condition obtained from calculated weights from the length-weight relation equations were used to demonstrate seasonal changes. Females exhibited much higher condition factors in January collections, and the poorest occurred in April, at a time when all but a few individuals in the collection had recently spawned (fig. 1). All but 5 of 52 females in the July collection had spawned. The curve representing their K (TL) exhibited an extremely divergent slope, which apparently reflects an earlier recovery of

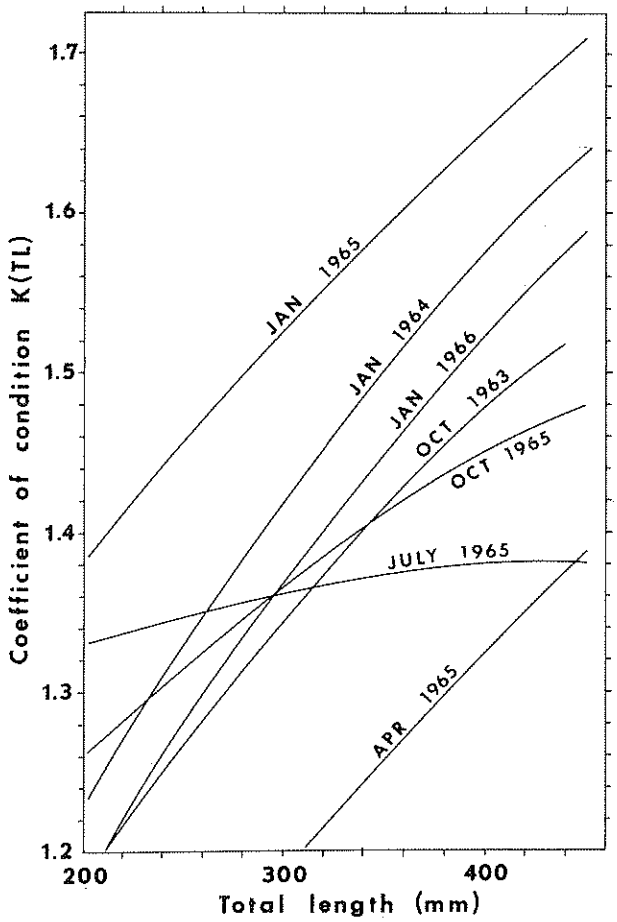

Figure 1.--Comparison of coefficient of condition K(TL) for female white bass in Bull Shoals Reservoir.

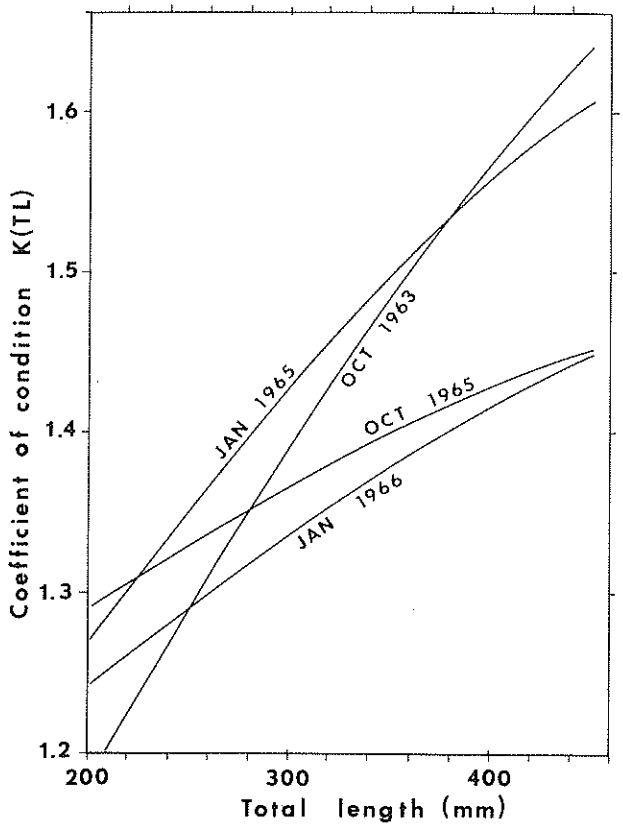

Figure 2.--Comparison of coefficient of condition K(TL) for male white bass in Bull Shoals Reservoir.

weight lost during spawning by younger fish. Since the younger fish probably spawned earlier than older individuals (Webb and Moss, 1967), they would be expected to recover the lost weight sooner. Collections made later in the year showed a steadily improving condition.

The condition of males was not as consistent in seasonal variation. The collection made in January 1965 had the highest coefficient of condition, but it was also high in October 1963 (fig. 2). It was much lower in the January 1966 and October 1965 collections. We found no obvious factor to which these variations can be attributed.

Body length - scale length relation

The relation between standard body length and anterior scale radius for white bass has been shown by Sigler (1949) to be adequately represented by a straight line. However, Weese (1949) and Forney (1963) found the total body length - scale radius relation of white bass to be curvilinear.

The distribution of plotted body-scale measurements for white bass from Bull Shoals Reservoir appeared to follow complex curvilinear paths. We therefore chose to follow the method previously described to obtain equations for back-calculating fish lengths at earlier ages using a computer. Equations obtained for each sample and used to back-calculate growth for female white bass were as follows:

October 1963: 122 fish	$L = 972.96 - 21.435\,S + 0.197\,S^2 - 0.000708\,S^3 + 0.0000009\,S^4$.
January 1964: 58 fish	$L = 30.040 + 1.525\,S$.
December 1964-January 1965: 194 fish	$L = 56.788 + 2.608\,S - 0.003\,S^2$.
April 1965: 82 fish	$L = 287.002 - 3.192\,S + 0.0257\,S^2 - 0.000044\,S^3$.
July 1965: 52 fish	$L = 22.713 + 1.423\,S$.
October 1965: 242 fish	$L = -38.710 + 2.120\,S - 0.00217\,S^2$.
January 1966: 141 fish	$L = 41.046 + 1.317\,S$.

Body - scale length relation equations for males were as follows:

October 1963: 90 fish	$L = 493.034 - 7.317\,S + 0.054\,S^2 - 0.000108\,S^3$.
January 1964: 23 fish	$L = 52.160 + 1.340\,S$.
December 1964-January 1965: 127 fish	$L = -130.309 + 3.367\,S + 0.0050\,S^2$.
April 1965: 127 fish	$L = 30.852 + 1.437\,S$.
July 1965: 27 fish	$L = 36.674 + 1.390\,S$.
October 1965: 174 fish	$L = 161.517 - 0.893\,S + 0.012\,S^2 - 0.000021\,S^3$.
January 1966: 99 fish	$L = 41.224 + 1.296\,S$.

The differences in these equations between sexes and collections from different times of the year reflect a much greater variation than that found in other published studies of age and growth. The technique which utilizes the computer's speed and versatility permitted ready access to equations of higher degree and demonstrated that this relation is often best represented by a curvilinear function.

Age composition

In initial sampling we observed that trap nets captured smaller white bass than gill nets. The samples taken later with gill nets may have been somewhat selective for the larger young fish. If there had been no net selectivity and little difference in year-class strength, 1-year-old fish would have consistently been more numerous than older-age groups (table 1). Although net selectivity may account in part for the 2-year-old fishes' being more numerous, it was evident that trends for numerical difference by age groups were heavily obscured by year-class strength. Except for 1-year-olds, younger fish were usually more numerous. The year classes of 1961 and 1963 clearly were strong while those of 1962 and 1964 were weak.

Sex ratio, age at maturity, and annulus formation

When sex ratios of age groups of white bass in Bull Shoals Reservoir were compared, females outnumbered males in every age group, and survival of females was greater as age increased. From ages 1 through 6, ratios of females to males were 1.2, 1.5, 1.3, 3.4, 3.0, and 4.0 to 1. The sex ratio for all ages combined in the seven collections was 1.7:1. Sigler (1949) reported a ratio of approximately 1.1 females to 1 male in Spirit Lake, Iowa, and Van Oosten (1942) reported a ratio of 1:1 in Lake Erie.

An unusual ratio of 7 females to 1 male occurred in the April 1965 collection. Since this collection was made at spawning time, spent females probably were returning from spawning grounds to the lake proper before the males. Omitting this collection, the other collections exhibited a ratio of 1.6:1.

In a sample of 215 white bass from the January 1966 collection in Bull Shoals Reservoir, all the males 2 years old or older were mature; all but 1 of 15 1-year-old males in the sample were mature. There were 22 1-year-old females in the sample of 142, and only 2 were mature; all 2 years old or older were mature.

White bass in Lake Erie become sexually mature during their third summer (Van Oosten, 1942). In Spirit Lake, Iowa, Sigler (1949) found both sexes maturing during their second and third year and indicated that possibly all females reach maturity by the time they are 2 years old. In TVA reservoirs, Eschmeyer and Manges (1945) and Howell (1945) found that all of both sexes matured during their second year. Webb and Moss (1967) found all 2-year-old and some 1-year-old white bass of both sexes mature in Center Hill Reservoir in Tennessee.

Since none of the 92 white bass collected on April 6, 13, and 28, 1965, had formed an annulus, it seems evident that annulus formation occurs later than April.

TABLE 1.--Composition of catch and frequency of occurrence of age groups

Age	1963 Oct.		1963 Dec. 1964 Jan.		1965								1966 Jan.		Total		Percent frequency in sample	
					Jan.		Apr.		Jul.		Oct.							
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
1 year	23	26	21	16	3	9	5	1	13	3	39	38	22	15	126	108	100	100
2 years	60	34	10	2	118	80	16	5	18	14	76	62	37	26	335	223	100	100
3 years	1	1	20	5	16	17	7		5	4	17	18	30	31	96	76	100	85.7
4 years	5		4		55	20	44	5	15		86	30	10	9	219	64	100	57.1
5 years	2				2	1	8		1		1		40	17	54	18	85.7	25.6
6 years							1				1		2	1	4	1	28.6	14.3
Ratio female to male	1.5		2.4		1.5		7.3		2.5		1.5		1.4		1.7			

Growth history

Rate of growth was calculated for 1,324 white bass, of which 834 were females and 490 males. The weighted average calculated total lengths of females at the end of each year of life through 6 years were 193, 338, 400, 427, 441, and 457 mm and those of males were 185, 320, 344, 397, 413, and 443 mm (tables 2 and 3).

Growth of white bass in Bull Shoals Reservoir was similar to that in other southern waters (table 4) where the growing season is long and large populations of shad are present. Growth was similar to that in Herrington Lake in Kentucky, Fort Gibson Reservoir in Oklahoma, and Center Hill Reservoir in Tennessee, where habitat conditions are generally comparable to Bull Shoals Reservoir. The yearly growth rate in northern lakes is decidedly less.

White bass live longer in more northerly regions. Forney and Taylor (1963) found males 8 years old and females 7 years old in Oneida Lake in New York. Sigler (1949) reported that males in Spirit Lake, Iowa, reach 9 years and females 8 years of age. Webb and Moss (1967) indicated that some white bass reach 8 years in Center Hill Reservoir, Tenn. In Bull Shoals Reservoir we found only 4 females out of 834 that lived to 6 years and only a single male of 490 that reached that age.

TABLE 2.--Calculated lengths and average growth increments of female white bass from Bull Shoals Reservoir

Year class	Number of fish by age groups I through VI	Total length (mm) at annulus--					
		1	2	3	4	5	6
1958	0, 0, 0, 0, 2	187	272	356	402	425	
1959	0, 0, 0, 5, 2	214	338	391	410	442	
1960	0, 0, 1, 4, 12, 2	202	318	396	422	442	450
1961	0, 60, 20, 236, 2, 2	192	316	399	428	447	463
1962	23, 10, 45, 10	183	352	403	434		
1963	21, 228, 30	184	360	406			
1964	60, 37	217	368				
1965	22	253					
Weighted mean		193	338	400	427	441	457
Annual increment		193	145	62	27	14	16
Number of fish		834	708	373	277	22	4

TABLE 3.--Calculated lengths and average growth increments of male white bass from Bull Shoals Reservoir

Year class	Number of fish by age groups	Total length at each annulus (mm.)					
		1	2	3	4	5	6
1960	0, 0, 1, 0, 1, 1	233	330	380	399	414	443
1961	0, 34, 5, 55, 17	186	279	366	396	413	
1962	26, 2, 39, 9	179	326	383	403		
1963	16, 161, 31	170	338	382			
1964	51, 26	219	349				
1965	15	249					
Weighted mean		185	320	344	397	413	443
Annual increment		185	135	54	23	18	30
Number of fish		490	382	159	83	18	1

Changes in growth and abundance

Although Bull Shoals Reservoir has been renowned for its largemouth bass, Micropterus salmoides (Lacepede), fishery since impoundment, white bass became the principal species in the Missouri sport fish harvest in 1959 when the population reached its greatest size (Hanson, 1962). Hanson concluded that keen competition developed between predatory species in the reservoir during 1958 and suggested that the increase in the white bass population may have been responsible for the decline in the largemouth bass population which occurred after a peak harvest in 1958. The gizzard shad, Dorosoma cepedianum (LeSueur), was the primary forage species at that time. When the large white bass population developed in the presence of an already high largemouth bass population, he hypothesized that a serious shortage of food developed and that the largemouth bass population began to decrease.

TABLE 4.--Calculated growth of white bass in selected U.S. waters

[Arranged by length at end of fourth year of life]

Body of water	Reference	Total length at end of year of life			
		1	2	3	4
Center Hill Reservoir, Tenn.	Webb and Moss, 1967	212	364	401	426
BULL SHOALS RESERVOIR	This study	190	332	382	420
Oklahoma reservoirs	Jenkins and Elkin, 1957	203	320	376	409
Herrington Lake, Ky.	Tompkins and Peters, 1951	210	338	376	389
Fort Gibson Reservoir, Okla.	Houser, 1958	170	287	363	416
Lake Catherine, Ark.	Hulsey and Stevenson, 1958	224	305	333	368
Wheeler Reservoir, Ala.	Howell, 1945	165	267		
Oneida Lake, N.Y.	Forney and Taylor, 1963	140	254	310	335
Spirit Lake, Iowa	Sigler, 1949	101	192	250	282
Lake Erie, Mich.	Van Oosten, 1942	96	166	221	252

In an attempt to provide additional forage, the Arkansas Game and Fish Commission introduced threadfin shad, Dorosoma petenense (Gunther), in Bull Shoals Reservoir in 1961. Robert Baker, fishery biologist of the Arkansas Game and Fish Commission has conducted annual fish population sampling with rotenone on Bull Shoals Reservoir from initial impoundment to the present. His unpublished summaries indicate that the threadfin shad population increased from 1962 through 1965 and declined in 1966. Exploratory otter trawling during initial studies in 1963 showed that a large population of threadfin shad was present. Since then, despite some rather large fluctuations, there has been an abundance of forage fish in the reservoir (Houser and Bryant, 1967). It appeared that the forage fish shortage observed by Hanson (1962) from 1958 through 1960 was alleviated.

When threadfin shad became abundant, the average rate of growth of white bass improved greatly (figs. 3 and 4). First-year growth in both sexes increased in 1964 and in 1965. An increase was also seen in the second year, but 3-year-old and older fish exhibited little or no change.

The creel census reported by Burress (1962) showed a peak white bass harvest in 1959, followed by a major decline in 1960. The rotenone samples taken by Baker showed highest abundance in 1958 but a decrease in 1959. In our annual gill net samples taken in January the white bass catch dropped from 11.4 fish per net day in 1965 to 4.4 in 1966. In 4 years of gill net sampling (1963-66) white bass have consistently been the most numerous species in the catch. The peaks of abundance in 1958-59 and in 1965 suggest that large cyclic fluctuations occur in the white bass population of Bull Shoals Reservoir.

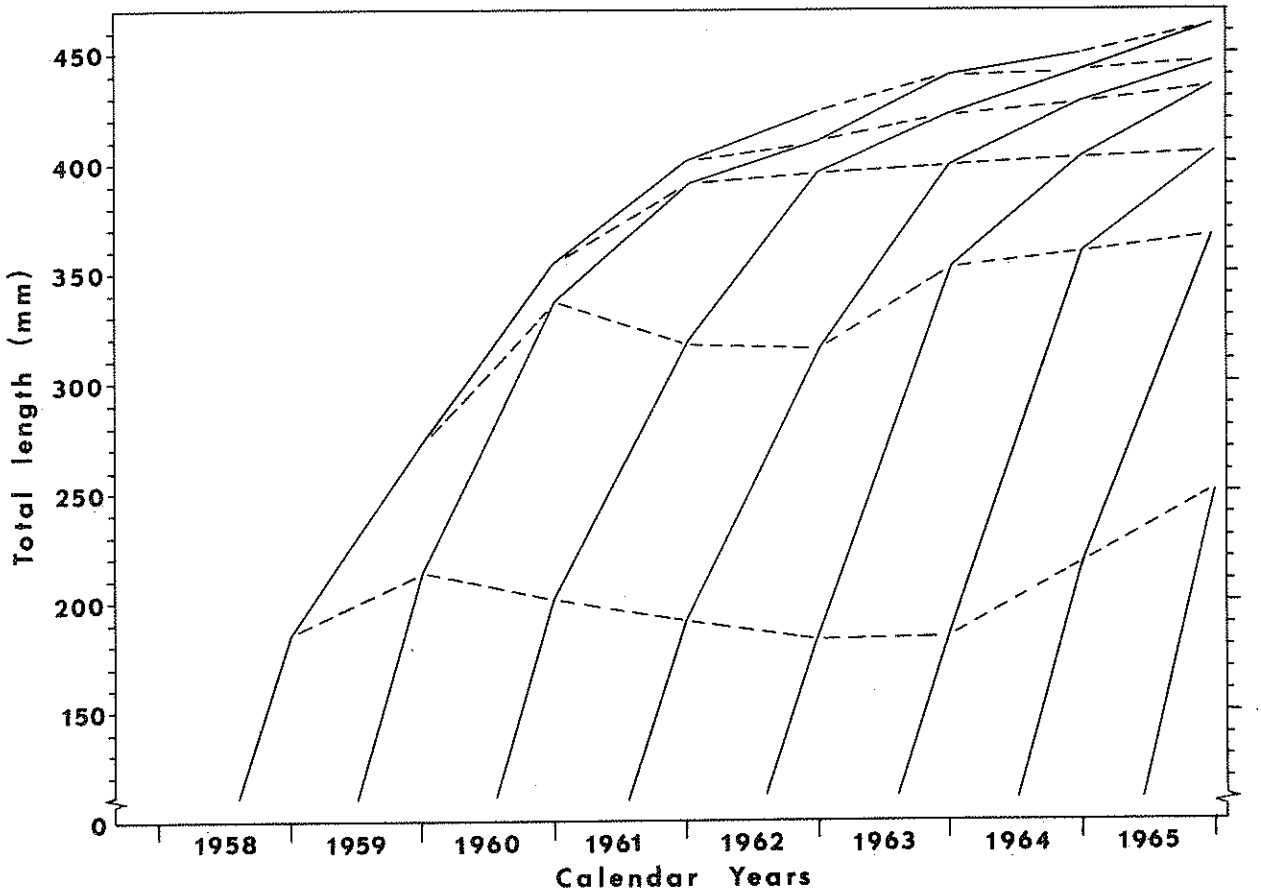

Figure 3.--Growth history of female white bass from Bull Shoals Reservoir.

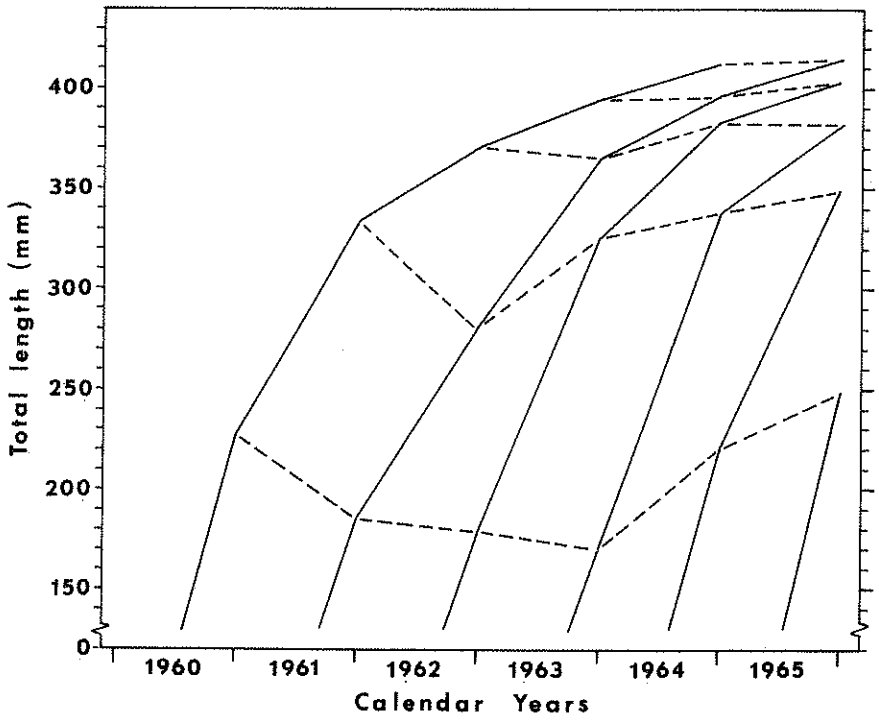

Figure 4.--Growth history of male white bass from Bull Shoals Reservoir.

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