AGE AND GROWTH OF THE WHITE CRAPPIE (POMOXIS ANNULARIS RAFINESQUE) IN LAKE TEXOMA, OKLAHOMA, 1949[1]

CLAY WILSON Jr., Oklahoma Game and Fish Department, Oklahoma City

INTRODUCTION. Lake Texoma is impounded by the Denison Dam. The dam is located on the Red River in Grayson County, Texas, and Bryan County, Oklahoma.

The maximum power pool at elevation 617.0 inundates approximately 95,000 acres. Bottom lands were cleared up to the limits of the permanent power pool. The lake itself is divided into two main portions, the Red River and Washita River arms, which approximately correspond with the positions of the old channels of these two rivers. Various creeks also empty into the lake, contributing to its total volume and area and causing its dendritic shape.

The white crappie, *Pomoxis annularis* Rafinesque, has been widely propagated. In Oklahoma it is highly regarded both as a game fish and as a food fish. It is probably more widely and more intensively fished for than any other Oklahoma fish. The habit of aggregating around brush piles, off steep banks, around bridge piers, etc., facilitates its capture. White crappie reproduce rapidly, resulting in overpopulation of this species in many Oklahoma lakes. A legal length of six inches was imposed on the white crappie until April 3, 1950, at which time the Oklahoma Game and Fish Department removed both length and creel limits.

METHODS AND MATERIALS

GENERAL. With the exception of six young-of-the-year fish collected with a 25' ¼" bar mesh bag seine and twelve fish collected by hook and line, all fish used in this study were taken by means of 1", 1½", 2", and experimental gill nets, and a fyke net. All nets employed, with the exception of one 2" gill net, which was used infrequently, were in excellent condition at the beginning of the investigation, but were somewhat worn at the end of the two month period. The following is a description of the nets used:

NET	DESCRIPTION
1" gill net	1" bar mesh 150'/8'.
1½" gill net	1½" bar mesh 200'/8'.
2" gill net	2" bar mesh 200'/8'.
Experimental gill net	5 sections with the following bar mesh: ¾", 1", 1¼", 1½", 2". Each section was 25' long; total net measurement was 125'/6'.
Fyke net	Double throat, ¼" bar mesh, 7 hoops, 4' front hoop, 12½' wings, 100' lead of 1" bar mesh.

Collections were made at eight stations on the lake. Data for the locations, dates, number of net collections, and number of fish taken are shown in Table I.

The metric system was used for measurements of both length and weight. Length measurements, both total (from anterior tip of head to posterior end

---

[1]This is part of a thesis submitted to the Graduate College, University of Oklahoma, in partial fulfillment of the requirements for the Master of Science degree. The research was under the direction of Prof. Carl D. Riggs and Dr. A. O. Weese. Appreciation is expressed to Mr. Gordon E. Hall, Oklahoma Game and Fish Department, for suggestions and aid in age and growth techniques. The University of Oklahoma, the Oklahoma Game and Fish Department, and the U. S. Army Engineers provided the funds and equipment to make the collections.

of the depressed caudal fin) and standard (from anterior tip of head to crease in caudal peduncle formed by flexing caudal fin) were taken to the nearest millimeter on a standard fish-measuring board. Fish of 500 grams or less were weighed to the nearest gram on a direct reading spring platform balance of 500 grams capacity; fish weighing more than 500 grams were weighed to the nearest 5 grams on a similar balance of 5 kilograms capacity. All measurements were taken from living or freshly killed specimens.

TABLE I

Date, Location, Number of Net Collections, and Number of Fish Captured at Each Station.

STATION	DATE	LOCATION	NUMBER OF NET COLLECTIONS	NUMBER OF FISH TAKEN
1	6/12-6/20	Rock Creek	20	348
2	6/20-6/25	Newberry Creek	12	95
3	6/25-6/30	Big Glasses Creek	14	95
4	6/30-7/8	Cold Springs Creek	15	6
5	7/8 -7/15	Hickory Creek	18	119
6	7/15-7/22	Buncombe Creek	16	74*
7	7/22-7/29	The Islands	13	57
8	7/29-8/4	Caney Creek	9	55
			TOTAL	850

* Six young-of-the-year fish collected in a 25", ¼" bar mesh bag seine not included.

Sex was determined whenever possible. Stomachs (and in some cases intestines and gills) were taken for food and parasite studies. The food habits and parasite studies have not been completed.

A small number of scales to be used for age determination and growth calculation were removed from below the lateral line from the left side of each fish. Key scales were not selected, but scales were consistently removed from the same area of each fish.

PREPARATION OF SCALES. For the first 100 samples, scales were soaked in water and cleaned with small, wooden skewers. Subsequently, it was found that scales could be cleaned faster and easier after they had been soaked for 5 to 10 minutes in a 5 percent solution of sodium hydroxide. Four scales of average size from each sample were cleaned and mounted on a microscope slide in a glycerin-gelatin medium prepared according to a formula presented by Van Oosten (18). No misshapen or obviously regenerated scales were mounted. Scales were studied with a projection apparatus similar to that described by Van Oosten, Deason, and Jobes (19) and pictured by Lagler (10). A magnification of X45 was used. All growth calculations were made from total length measurements in millimeters. Conversion factors based on 862 fish were determined as follows: total length to standard length—.774; standard length to total length—1.20. A total of 868 fish were collected. Six of these were young-of-the-year fish and were not used in growth calculations. Twelve fish were taken by hook and line.

RESULTS

NET SELECTIVITY. The problems involved in collecting a representative sample of fish for use in age and growth studies are generally recognized. Extensive use of gill nets has resulted in conflicting ideas as to their influence on age and growth data. Hile (6) presented an adequate survey of previous work and concluded that "... each species and each locality offers its own special problem of gear selection." As a result of his own investigations, he concludes that: "The action of a net of specified mesh depends first upon the range of length and abundance of the fish within the population and second upon those morphological characteristics that determine in what manner the fish is held captive."

Table II presents the frequency distribution for all fish taken with nets. No attempt will be made to evaluate accurately the relative abundance of year classes. Table II was compiled only to present evidence of the adequacy of the sample. No one net collects an unbiased sample of the population, and each is selective within a relatively narrow size group.

AGE AND GROWTH. Determination of the age of all individuals was made on the basis of the year of life completed as indicated by the number of annuli on the scales. Despite extensive seining, only six fish were taken which belong in the 0 age-group. This should not be regarded as indicative of the relative abundance of young-of-the-year fish.

SEX RATIOS. A greater number of females than males were taken. The data were examined for departure from the hypothesis that in any population 50 percent of the fish should be males and 50 percent females. Utilizing the Chi-square test, a significant difference was found. The data were then subjected to the test for homogeneity. The results of this test revealed that the abundance to males in proportion to that of females may be described by a 9:11 ratio. Exhaustive search of the literature reveals no data on the sex ratio of this species.

TABLE II

Length Frequency Distribution in 10 Millimeter Intervals of Empirical Total Length of Lake Texoma White Crappie Taken in Different Sized Nets in 1949.

LENGTH INTERVAL (MILLIMETER)	GILL NET MESH (BAR MESH) EXPERIMENTAL	1"	1½"	2"	FYKE NET	TOTAL
100-109	1					1
110-119						0
120-129	23		1		21	45
130-139	33			1	46	80
140-149	16		1	1	51	69
150-159	6	1			22	29
160-169	44	26	4		8	82
170-179	59	84	1	1		145
180-189	31	44	6		5	86
190-199	22	21	4	1	4	52
200-209	13	8	4	2	2	29
210-219	5	1	25	1	2	34
220-229	2	1	50	3	2	58
230-239	3		27	1	1	32
240-249	4	2	9	1	1	17
250-259	4	1	7			12
260-269	3		6	2		11
270-279			5	9		14
280-289	6	1	3	12		22
290-299	2		2	17		21
300-309	1		1	6		8
310-319			1			1
320-329						0
330-339			1			1
340-349		1				1
TOTAL	278	191	158	58	165	850
NUMBER TIMES NET SET	56	17	78	59	8	218

EMPIRICAL LENGTH-FREQUENCY DISTRIBUTION. Table III gives length-frequency distribution of fish at the time of capture. No significant difference was found between males and females; therefore, the data for both sexes were combined. It is believed that because of the errors involved in growth calculation, such measurable data are of greater value in evaluating the environmental adaptation of the species than are the results of calculated growth. In practice, relatively small samples collected at a comparable time could be compared with such data and thus indicate the growth trend. This is not meant to imply that length is a good index of age. On the contrary, length is a rather poor index of age. The amount of overlap among the IV, V, and VI age-groups is so extensive that an individual of a given length might readily belong to any of the three age-groups (Table III). In contrast, the small amount of overlap in age-groups I, II, and III is further indication of the diversified reaction of older individuals to cumulative environmental action.

AGE DETERMINATION. Hansen (5) and Ricker and Lagler (13) have reported the presence of accessory checks (false annuli) in the scales of white crappie. The latter authors report "considerable confusion" in determining the first annulus in the scale. They found accessory checks only rarely in succeeding inter-annular areas. Although false annuli were found in Lake Texoma white crappie scales, they did not present a serious difficulty. Some regenerated scales were discarded, but in no instance was it necessary to discard a specimen because of doubtful age determination.

TABLE III

Length Frequency Distribution in 10 Millimeter Intervals of Empirical Total Length in Each Age-group of Lake Texoma White Crappie Collected in 1949.

MEAN LENGTH (MILLIMETERS)	O	I	II	III	IV	V	VI
45	1						
55	1						
65	3						
75	1						
85							
95							
105		1					
115							
125		45					
135		80					
145		69	4				
155		13	19				
165		20	61	1	1		
175		10	108	21	5	1	
185			59	25	2	1	
195			34	14	5		
205			10	16	4		
215			4	25	4	1	
225			5	44	8	1	
235				17	9	6	
245				6	7	4	
255				2	6	2	2
265					11		
275					10	4	
285				3	15	5	
295					10	11	
305					1	5	2
315						1	
325							
335						1	
345						1	
TOTAL NUMBER OF FISH	6	238	304	174	98	44	4
AVERAGE LENGTH (MILLIMETERS)	62	141	178	210	249	273	280

TIME OF ANNULUS FORMATION. No attempt has been made to determine either length of growing season of time of annulus formation. Weekly collections over a two or three year period would be necessary for an accurate determination of the average time of annulus formation. Ricker and Lagler (13) found that no fish taken in early July, 1940, from Foots Pond, Indiana, lacked new growth. Johnson (9) reports that in Greenwood Lake the annulus was definitely formed prior to June 16. In the present study all of 348 fish taken between June 16 and 20 possessed a new annulus. The last annulus of the older fish appeared to be of recent formation. This observation tends to substantiate the conclusions of previous investigators (5, 9) that the younger fish form their annuli sooner than the older individuals.

BODY-SCALE RELATIONSHIP. The data were grouped (Table IV) in 10 millimeter intervals of total fish length and 10 millimeter intervals of scale length (X45). When the data are so grouped and the calculated means of body length

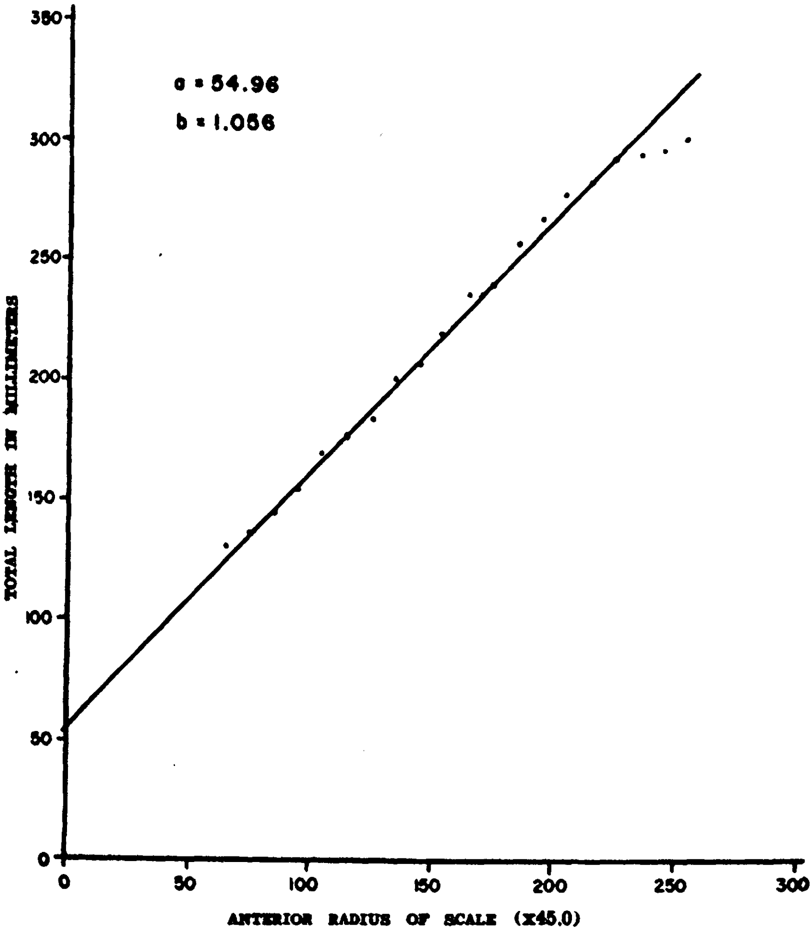

FIGURE 1

TABLE IV

Correlation Table Showing the Distribution of X and Y Values Where X Is Scale Length (X45) and Y Is Total Length

	45	65	68	65	71	107	115	68	52	47	34	30	24	13	25	11	12	6	2	2	862
y																					f
105	1																				1
115																					
125	21	21	21	3																	45
135	21	26	24	8	1																80
145	2	17	30	23			1														73
155		1	2	13	11	5															32
165			6	13	25	24	13	2													83
175			2	7	25	49	44	14	1	2						1					145
185				1	7	23	27	17	11	1											87
195			1		2	1	20	16	9	4											53
205						5	7	6	6	3	1			1	1						30
215							1	4	10	12	3	4									34
225							1	7	12	15	14	8	1								58
235							1	1	3	7	6	7	4	2	1						32
245											6	3	6		2						17
255										2		4	3	2	1						12
265										1	1	1	4		3		1				11
275											2	1	1	3	1	2	2	2			14
285								1				2	4	3	10		1	2			23
295													1	1	3	7	5	1	2	1	21
305											1			1	2	1	2			1	8
315																	1				1
325																					
335															1						1
345																		1			1
x	65	75	85	95	105	115	125	135	145	155	165	175	185	195	205	215	225	235	245	255	

are plotted on a graph, the points in Fig. 1 result. The two variates (fish length and scale length) may be considered as having a bivariate normal distribution in the general population. In any case, two regression lines may be drawn. Some confusion seems to exist among fishery investigators in regard to which regression line should be used for determining the constants to be used in calculating growth. Since the ultimate aim in all methods is the estimation of body length (y) from known scale length (x), it is the regression of y on x which should be used in the determination of the intercept (a) and the slope of the the regression line (b) (21).

Since the computation of the coefficient of correlation is dependent upon the total variation, calculations must be made from independent data, i.e., not from totals calculated by grouping the values of y in arrays of x or *vice versa*. The author desired to find the coefficient of correlation between scale length and body length, and a correlation table was used (Table IV). Data from this table were employed in the determination of the values of a and b. However, if the coefficient of correlation had not been desired, the proper regression line could have been obtained by grouping y (fish length) values in arrays of x (scale length) and the values of the constants a and b determined by the least squares method.

The calculated value of the intercept (a) is 54.96 millimeters of fish length and for the slope (b) is 1.056. The coefficient of correlation is 0.937. . This high coefficient of correlation indicates that the relationship between total length and scale length of Lake Texoma white crappie is essentially linear, in which case either regression line would have given proximate results. Fig. 1 illustrates the regression line of y on x. Slightly different results would have been obtained if the regression of x on y had been computed. The difference would have been greater had the coefficient or correlation been lower.

ANNUAL GROWTH. Utilizing the formula $L = a + bS$, total length in millimeters was calculated for each individual fish of each year class. The data were then averaged to find the average growth for each year of life. Total length was calculated separately for males and females, but there was no significant difference, so data for both were combined (Table V).

TABLE V

Average Empirical Total Length and Average Calculated Total Length in Millimeters at the End of Each Year of Life for Each Age-group of Lake Texoma White Crappie Collected in 1949.

Year Class	Age Group	No. Fish	Average Calculated Total Length at End of Year of Life: 1	2	3	4	5	6	Empirical T. L. at Time of Capture
1948	I	238	98						141
1947	II	304	95	144					178
1946	III	174	96	145	186				210
1945	IV	98	97	140	192	231			249
1944	V	44	97	135	174	221	255		273
1943	VI	4	92	131	164	203	239	259	280
Grand average calculated total length			96	143	186	227	254	259	
Average increments of calculated length				47	43	41	27	5	
Equivalent total length in inches			3.8	5.6	7.3	8.9	10.0	10.2	
Number of fish used in calculation			862	624	320	146	48	4	

COMPARISON OF ANNUAL GROWTHS. The growth in length of Lake Texoma white crappie was compared with the growth in other waters (Table V). In general the growth of Lake Texoma white crappie compares favorably with that in other localities. Comparison of the results of the present study with those of Sneed and Thompson (15) would seem to indicate that the rate of growth is diminishing in Lake Texoma; however, 80 per cent of their fish were taken from creels of fishermen, a method of sampling which tends to select larger fish and, perhaps, the faster-growing ones. It will be shown later that conditions existing at Station 1 have contributed significantly to these results. In addition, it should be remembered that the present study was based on one summer's collection; thus the results may not be considered conclusive.

LENGTH-WEIGHT RELATIONSHIP. The length-weight relationship was determined, according to the method of Hile (6), for all fish taken and for males and females separately. No significant difference was found between the averages thus obtained. Table VI presents the data for the entire sample. The equation $\log w = -5.15279 + 3.11180 \text{ Log } L$ was determined to apply in calculating weights.

TABLE VI

Comparison of Growth in Inches of Total Length of White Crappie in Lake Texoma and in Other Waters.

WORKER	LOCATION	AVERAGE TOTAL LENGTH IN INCHES AT END OF YEAR OF LIFE				
		1	2	3	4	5
Wilson 1950	Lake Texoma	3.8	5.6	7.3	8.9	10.0
Sneed and Thompson 1950	Lake Texoma	3.6	5.9	9.3	10.0	12.5
Johnson 1945	Greenwood Lake, Ind.	4.8	7.2	8.2		
Stroud 1949	Cherokee, Tenn.	1.5	8.7	11.6		
	Douglas, Tenn.	2.9	7.3	9.2		
	Hiwasse, N. C.	2.4	6.8	9.5	9.5	
Ricker and Lagler 1942	Foots Pond, Ind.	2.8	5.8	8.6	10.2	11.5
Roach and Evans 1948	Ohio Lakes	2.6	5.5	7.6	9.2	10.4
Unpublished	Grand Lake, Okla.	3.5	5.4	7.9	10.7	14.1

LOCAL STUNTING. At the beginning of this investigation it was hoped that the data obtained might reveal some information pertinent to the theory that local stunting of white crappie occures in the reservoir. Growth was calculated for fish taken at each station (Table VIII). The data indicate that at Station 1 there had been a significant retardation of growth. Twenty-five per cent (348/862) of all fish were collected from Station 1. This large number has a major influence on average lengths calculated from the entire sample. In age-groups III, IV, and V the differences are most pronounced. This could account for the lower average total lengths calculated for these three age-groups from those calculated for the same age-groups by Sneed and Thompson (15). Fig. 2 illustrates the difference in growth between the average of Stations 2 through 8 combined, and that at Station 1. For a proper evaluation of the difference indicated, in the development of the scale-fish formula, the fish from Station 1 should be treated as a population separate from that of the combined fish from the other stations. Such a splitting would seriously decrease the relative size of the samples. The specimens used were collected in one season over a relatively short period of time. For these reasons it is not deemed advisable at the present time to attempt further explanation.

TABLE VII

Length-weight Relationship of Lake Texoma White Crappie Collected in 1949.

Total length in millimeters	Total length in inches	Weight in grams	Calculated Weight in grams	Calculated Weight in ounces
105	4.1	17	13.7	.6
115	4.5			
125	4.9	22	23.6	.8
135	.53	28	29.2	1.0
145	5.7	36	37.4	1.3
155	6.1	45	46.0	1.6
165	6.5	58	55.9	2.0
175	6.9	65	67.2	2.3
185	7.3	79	79.8	2.8
195	7.7	92	94.0	3.2
205	8.1	113	109.8	4.0
215	8.5	132	127.4	4.7
225	8.9	144	146.8	5.1
235	9.3	156	168.1	5.5
245	9.6	169	191.3	6.0
255	10.0	209	216.7	7.4
265	10.4	240	244.6	8.5
275	10.8	278	274.1	9.8
285	11.2	308	306.3	10.9
295	11.6	339	341.0	12.0
305	12.0	363	378.2	12.8
315	12.4	424	418.3	15.0
325	12.8			
335	13.2	640	506.5	22.6
345	13.6	555	550.0	29.6

TABLE VIII

*Calculated Average Total Length in Millimeters to the end of Each Year of Life for All Fish Taken at Each Station.**

Station	Number of fish	Length at end of year of life 1	2	3	4	5	6
1	348	95	140	176	207	236	250**
2	95	95	146	191	233		
3	96	95	147	209	248		
4	6	96	134	163	231	272	
5	119	103	152	194	243	273	287**
6	74	100	144	197	233	265	
7	57	100	148	187	252		
8	55	97	141	176	242	261	
Grand average total length		96	143	186	227	254	259**

*Grand average total lengths are weighted for number of fish used in calculation.
**Not significant; only 4 fish in group.

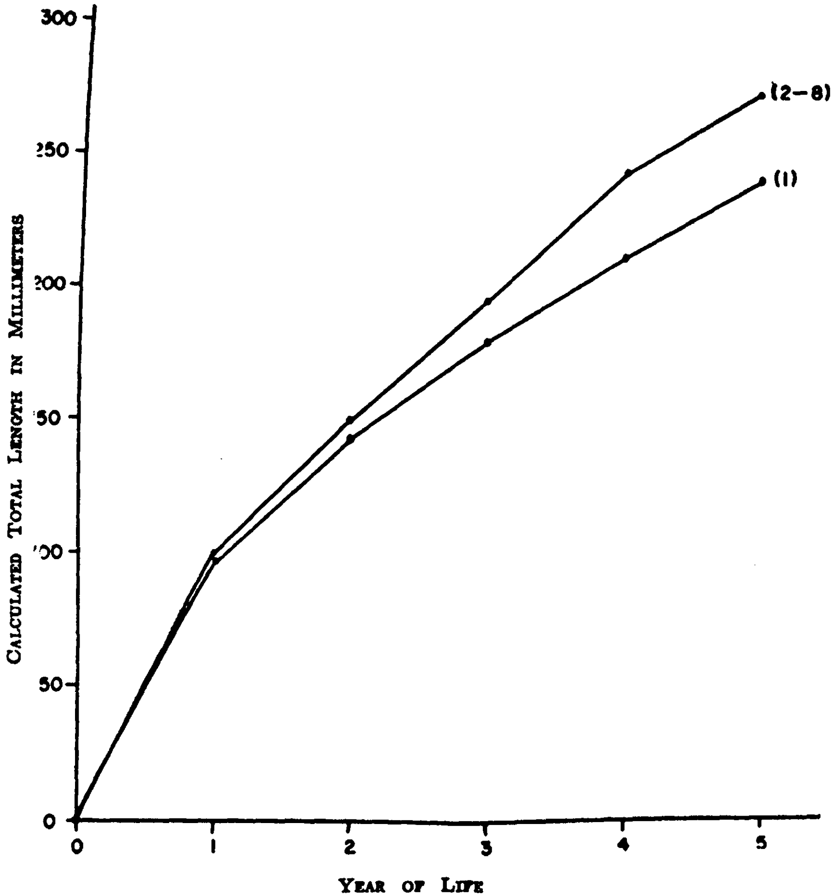

FIGURE 2

Summary

1. This study of the age and growth of the white crappie *(Pomoxis annularis* Rafinesque) in Lake Texoma, Oklahoma, has been conducted using 868 fish collected in 1949.
2. Previous to mounting in a glycerin-gelatin medium, cleaning of white crappie scales was expedited by use of a weak solution of sodium hydroxide.
3. Although net selectivity is important in evaluation of white crappie collections, it does not prevent adequate sampling.
4. The ratio of male to female white crappie taken was 9 : 11.
5. False annuli, although present, did not prevent age determination.
6. In establishing the body-scale relationship for purposes of calculating growth, the regression line y on x was used, where y represents fish fish length and x represents scale length.
7. No significant difference was found in average calculated lengths for each year of life between males and females.
8. Calculated growth to the end of each year of life indicates that Lake

Texoma white crappie grow to an average length of 3.8 inches the first year of life, 5.6 inches the second year, 7.3 inches the third year, 8.9 inches the fourth year, and 10.0 inches the fifth year.

9. No significant difference in calculated weights was found between sexes.
10. The data indicate that "stunting" of both sexes occurred at Station 1.

LITERATURE CONSULTED

1. CREASER, CHARLES W. 1926. The structure and growth of the scales of fishes in relation to the interpretation of their life-history, with special reference to the sunfish *Eupomotis gibbosus*. Misc. Publ. Univ. Mich. Mus. Zool. 17: 1-82.
2. GEISER, S. W. 1923. Evidences of a differential death rate of the sexes among animals. Am. Midland Naturalist. *8(7)*: 153-163.
3. ————. 1924. Sex ratios and spermatogenesis in the top-minnow, *Gambusia holbrooki* Grd. Biol. Bull. *47(3)*: 175-212.
4. ————. 1924. The differential death rate of the sexes among animals, with suggested explanation. Wash. Univ. Studies *12(1)*: 73-96.
5. HANSEN, DONALD F. 1936. The date of annual ring formation in the scales of the white crappie. Trans. Amer. Fisheries Soc. *66*: 227-236.
6. HILE, RALPH. 1936. Age and growth of the cisco, *Leucichthys artedi* (Le Sueur) in the lakes of the Northwestern Highlands, Wisconsin. Bull. U. S. Bur. Fish. *48*: 211-317.
7. ————. 1941. Age and growth of the rock bass *Ambloplites rupestris* (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wis. Acad. Sci., *33*: 189-337.
8. HUTTON, J. ARTHUR. 1921. The literature of fish scales. Salmon and Trout Magazine, *26* : 203-213. (London).
9. JOHNSON, WENDELL L. 1945. Age and growth of the black and white crappie of Greenwood Lake, Indiana. Invest. Ind. Lakes and Streams, *2(15)*: 297-324.
10. LAGLER, KARL F. 1949. Studies in fresh water biology. Ann Arbor, Michigan: Edwards Bros., Inc.
11. MOHR, ERNA W. 1930. Bibliographie der Alters - und Wachstums - Bestimming bei Fischen, II. Nachtrage und Fortsetzung. J. Conseil, *9(3)*: 377-391. (Copenhagen)
12. ROACH, LEE S., and IRENE M. EVANS. 1948. Growth of game and pan fish in Ohio 2. Crappies. Ohio Div. Cons., Sec. Fish Management, 225:1-21.
13. RICKER, WILLIAM E., and KARL F. LAGLER. 1942. The growth of spiney-rayed fishes in Foots Pond, Indiana. Invest. Ind. Lakes and Streams *2(5)*: 85-97.
14. SCHOFFMAN, ROBERT J. 1940. Age and growth of the black and white crappies, the warmouth bass, and the yellow bass in Reelfoot Lake. Rept. Reelfoot Lake Biol. Sta. *4*: 22-43.
15. SNEED, K., and W. H. THOMPSON. 1950. Unpublished data.
16. STROUD, RICHARD H. 1949. Rate of growth and condition of game and pan fish in Cherokee, and Douglas Reservoirs, Tennessee, and Hiwasse Reservoir, North Carolina. J. Tenn. Acad. Sci. *24(1)*: 60-74.
17. TAYLOR, HARDEN F. 1916. The structure and growth of the scales of the squeteague and the pigfish as indicative of life history. Bull. U. S. Bur. Fish. *24*: 285-330.
18. VAN OOSTEN, JOHN. 1929. Life history of the lake herring *(Leucichthys artedi* Le-Sueur) of Lake Huron as revealed by its scales, with a critique of the scale method. Bull. U. S. Bur. Fish. *44*: 265-428.
19. DEASON, J. H. and F. W. JOBES. 1934. A microprojection machine designed for the study of fish scales. J. Conseil *9(2)*: 241-248.
20. WILLER, ALFRED. 1924. Die kleine Marane *(Coregonus albula* L.) in Ostpreussen. Intern. Rev. ges. Hydrobiol. Hydrog. *12*, Heft ¾, 248-365. Leipzig.
21. WINSOR, CHARLES P. 1946. Which regression? Biometrics *2(6)*: 101-109.