JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE
VOLUME 32, NUMBER 1, JANUARY, 1957

AGE AND GROWTH OF THE SAUGER, STIZOSTEDION CANADENSE CANADENSE (SMITH), IN NORRIS RESERVOIR, TENNESSEE

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INTRODUCTION

Since the impoundment of Norris Reservoir, TVA fishery investigators have reported on the age and growth of the principal game and pan fishes in this reservoir. However, few data have been published on the age and growth of the sauger, S[illegible] (Smith). Eschmeyer and Jones (1941) gave limited data for 84 sauger taken over a two-year period in Norris Reservoir (1939-1940). Eschmeyer (1940), also, mentioned the total length in inches and age for two sauger from Norris Reservoir. Elsewhere in the Tennessee Valley a minimum of data is available. Eschmeyer, et al, (1944) published a growth table compiled from 71 two-year-old sauger from Chickamauga Reservoir and 70 two-year-old sauger from Watts Bar Reservoir. Both Watts Bar and Chickamauga are main-stream reservoirs. Stroud (1949) included information on the growth rate of sauger from Cherokee and Douglas Reservoirs which are storage-type impoundments. His growth calculations were based on 64 three-year-old sauger from Cherokee Reservoir and 39 two-year-old sauger from Douglas Reservoir.

Information on other phases of the life history and management of the sauger in Norris Reservoir has been published by a number of investigators. Eschmeyer and Manges (1945) reviewed the effects of a year-round open season in Norris Reservoir. Eschmeyer and Haslbauer (1946) proposed legalized winter netting of sauger as a management plan for this species. Dendy (1946a) published an analysis of the stomach contents of sauger netted during 1943 and 1944. Depth distribution of sauger was determined by Cady (1945), and the depth distribution in relation to other factors by Dendy (1945, 1946b, 1948).

Eschmeyer (1942) discussed the migration and movements of the sauger in Norris Reservoir. This movement of the sauger was treated in detail by Haslbauer and Manges (1947) because the annual tagging program of the Fish and Game Branch of the

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TVA resulted in the accumulation of much data on fish movement. Manges (1950) summarized the results of the tagging program and gave the rates of harvesting for sauger from 1940 to 1949, and, also, the extent of sauger movement in Norris Reservoir.

NORRIS LAKE

Norris Dam is located on the Clinch River at its confluence with Cove Creek. It is approximately 30 miles from Knoxville, Tennessee. The impoundment created by this high dam is a multiple-purpose storage reservoir. It is the oldest storage reservoir constructed by the Tennessee Valley Authority and its date of closure is July 28, 1936.

The Clinch River and the Powell River are the major tributaries of Norris Lake and they converge a few miles upstream from Norris Dam. Numerous minor tributaries also empty into Norris Lake. The reservoir is located in the irregular ridge country between the Cumberland and Clinch mountains. The shore line is very irregular and attains a maximum length of 800 miles. At a maximum elevation of 1020 feet above sea level the lake floods an area of 34,200 acres. The maximum controlled storage is 2,281,000 acre-feet, and the minimum volume is 281,000 acre-feet. The maximum depth at Norris Dam is approximately 210 feet.

The surface elevation of the reservoir is decreased from 60 to 80 feet during the winter for flood control. Generally, the minimum elevation is attained in February, and its maximum elevation is reached in late spring or early summer.

This surface fluctuation retards the growth of aquatic plants along the shore line, and the littoral zone is characterized by the paucity of benthos.

METHODS AND MATERIALS

Many of the specimens used in this study were collected in Norris Reservoir, Tennessee, from 1940 to 1951 by employees of the Fish and Game Branch of the Tennessee Valley Authority. The author also made regular collections of sauger from 1949 to 1952.

The sauger were collected from all regions of the reservoir. The methods of capture were varied. Gill nets (1/2, 1, 1-1/2, 2, and 3 inch bar mesh) accounted for 3,203 sauger. Sixty-eight sauger were taken by angling, while 122 were collected by the use of rotenone.

The length and weight measurements were made in the field on fresh specimens. The total length and standard length were measured to the nearest millimeter on a standard measuring board. The weight of each fish was determined to the nearest gram on either a chemical balance or a nutritional balance.

Scale samples were obtained from the side of each fish just posterior to the distal end of the left pectoral fin. Additional data were recorded on the sex, stomach contents, and parasites of each fish.

Three typical scales were cleaned and mounted with glycerin and sodium silicate (Van Oosten, 1929) on a glass slide. These slides were then examined with a conventional scale microprojector. Approximately one percent of the slides were unreadable because of scale irregularities.

The ages of the fish examined were expressed in Arabic numerals. Since the sauger were captured chiefly during the winter months, an annulus was not laid down until mid-spring. Thus, the periphery of the scale was considered as an annulus. The age of these specimens was recorded as the number of annuli plus one.

Body-Scale Relationship

A dot diagram was plotted on the length of the projected scale radius and the standard length of 735 sauger. The relationship between these two variables appeared to be linear and the regression coefficient for the line of best fit was determined. This regression coefficient was calculated to be:

$$Y = -1.38 + 0.17X$$

where X = standard length in millimeters.
and Y = anterior scale radius in millimeters (projected).

The intercept of —1.38 was considered negligible and was not used in the back calculation of previous scale growth.

Relationship Between Standard and Total Length

A dot frequency diagram was plotted of the total and standard lengths of 388 haphazardly selected sauger. A linear relationship was indicated. The total lengths of these fish ranged from 212 to 553 millimeters. The corresponding range of standard lengths was 176 to 470 millimeters.

Usually, a method of empirical averaging is employed to calculate the conversion factors for each length class and for the classes combined. However, in this study a single coefficient was calculated for the grouped data.

The total lengths were grouped in size classes of 30 millimeters each and the mean values of the corresponding standard lengths were determined. However, in determining the relationship between the two variables, it was necessary to modify the conventional formula for computing the regression equation because there was an unequal number of variates in the length classes. By using the following equation for the sum of the squares of the residuals, a weighted regression equation was obtained by the method of least squares.

$$\text{SS residuals} = \sum_{i=1}^{n_1} (\quad - a - mx)^2$$

The symbols in the equation are those used by Hoel (1947).

The equations which were derived to express the relationship between the total length and the standard length are:

1) $Y = -11.0+0.87X$
2) $X = 1.149Y+12.64$

where Y = the standard length in millimeters
and X = the total length in millimeters

Calculated Growth

During the early years of impoundment of Norris Reservoir, sauger composed only a small fraction of the fisherman's catch. Eschmeyer and Jones (1941) reported that sauger and walleye combined were only three percent of the annual catch in 1938. They further reported that the sauger represented two percent of the total catch of game fish in 1939 and three percent in 1940. These authors concluded that

> Not enough records are available to indicate whether or not the growth rate is declining, nor are the data available for the comparison of growth of this. species in other waters. Little can be said, therefore, about the growth of the sauger, although the growth rate recorded for Norris Reservoir seems to be moderately rapid for this species.

In the decade after this publication, the sauger increased in abundance (approximately 15 percent of the total catch in 1948 and 1950) and many data were collected on this species. These data were available for scale analysis and a total of 3,393 age determinations were made. The average annual growth for each age group over a 13 year period is given in Table 1. The standard error is also listed for each of the averages. Statistics have also been compiled for each age group for every calendar year. Data are also available for each sex. However, these latter data are considered superfluous to include in this publication.

Although fluctuations are evident in the annual growth rate of the sauger, there is no evidence of any progressive decrease in sauger growth coinciding with the increased age of Norris Reservoir. The greatest range in the annual growth rates occurred in the one-year-old age group. The average standard length for this age group ranged from 155 millimeters in 1940 to 209 millimeters in 1949. In respect to the lowest average of 155 millimeters attained in 1940 it is a very rapid rate of growth for the sauger when compared to sauger growth in other localities. Also, in contrast to the typical decline in reservoir fertility, sauger grew most rapidly during the fourteenth year of impoundment.

TABLE 1

Average Calculated Standard Length and Standard Error of Norris Reservoir Sauger Arranged by Year Class. (The collections of different calendar years have been combined. Sexes combined. Number of specimens in parentheses.)

	Calculated Standard Length and Standard Error (At End of Year)						
	1	2	3	4	5	6	7
1937	174- (6)	306- (6)	353- (6)	379— (6)			
1938	206±4.1 (80)	300±1.9 (80)	340±3.8 (44)	390±6.8 (7)	397— (1)	420- (1)	
1939	162±3.2 (48)	278±3.9 (48)	345±3.8 (43)	371±3.5 (7)	399±5.3 (13)	427±8.5 (4)	428- (1)
1940	155±1.2 (618)	269±1.2 (618)	332±0.9 (593)	370±1.5 (193)	399±2.8 (72)	433±8.1 (8)	442±16.3 (2)
1941	200±1.4 (492)	301±1.1 (489)	346±1.4 (225)	380±2.2 (92)	409±5.9 (14)	416±6.7 (8)	
1942	192±2.0 (178)	297±2.4 (160)	355±2.1 (137)	396±3.1 (4)	407±3.1 (34)	419±8.1 (5)	
1943	171±2.7 (114)	287±3.6 (114)	344±3.4 (92)	378±3.6 (71)	401±6.0 (27)	438±9.6 (6)	
1944	162±2.1 (185)	278±2.2 (185)	333±1.9 (176)	362±2.8 (89)	396±5.1 (26)		
1945	173±2.1 (283)	272±2.0 (234)	325±1.6 (196)	354±1.9 (11)	387±6.5 (4)	391±7.5 (3)	
1946	182±2.0 (248)	283±1.5 (242)	332±1.4 (192)	366±11.2 (11)	384±9.5 (4)		
1947	164±2.2 (124)	262±2.2 (112)	322±2.1 (105)	345±6.0 (10)			
1948	157±0.9 (724)	273±1.0 (717)	328±0.7 (520)				
1949	209±1.6 (293)	312±0.9 (229)					
Grand Average Standard Length (mm.)	175±0.6	282±0.5	334±0.5	370±0.6	400±1.6	423±3.9	437±6.4
Grand Average Total Length (inches)	8.4	13.3	15.6	17.2	18.6	19.6	20.3
Average Annual Increment (mm)	175	107	52	36	30	23	14
Average Annual Increment (inches)	8.4	4.9	2.3	1.6	1.4	1.0	0.7
Number of Fish	3393	3234	2327	669	195	35	3

The 1949 year class attained an average total length of 10 inches during the first year of life. At the end of two years the 1949 year class had an average total length of 14.6 inches. The latter figure is based entirely on empirical data from 229 sauger. The maximum average total lengths attained by the various other year classes were 16.6, 18.4, 19.0, 20.3, and 20.4 inches respectively, for age groups 3 to 7.

A considerable size range was evident within the age groups of the sauger. This was in accord with the reports of Carlander (1950) and Kennedy (1949) on the variability in length of sauger of the same age group. An extended spawning season is believed to be the primary cause of this variability.

Scale analysis showed that the oldest sauger were seven years old. Only three of the 3,393 specimens examined attained this age. The distribution of sauger by age groups in Table 1 indicates that few sauger survived more than five years of life.

The grand averages in Table I for the 13 year period show that Norris Reservoir sauger grow most rapidly during the first year and attain an average total length of 8.4 inches. The average total lengths for the next six successive years of life were 13.3, 15.6, 17,2, 18.6, 19.6, and 20.3 inches respectively. The annual increment in length was also greatest during the first year (8.4 inches). The annual increments after the first year were 4.9, 2.3, 1.6, 1.4, 1.0, and 0.7 inches respectively.

The calendar years which were judged to be above average in terms of sauger growth were 1938, 1941, 1942, and 1949. The poorest growing seasons were 1939, 1940, 1944, 1947, and 1948.

Differential Growth Between Male and Female Sauger

Carlander (1950) reported that male and female sauger in the Lake of the Woods, Minnesota, grew at approximately the same rate for the first three years of life. After that age the female grew at a slightly faster rate. Carlander applied "Students t test" to each of the age classes, and found that a statistically significant difference in length between male and female sauger occurred in only two age groups of one year class. Higgins (1936) stated that male and female sauger grew at a similar rate for the first three years of life in Lake Erie, but beyond that age the females were larger than the males. However, the difference between the sexes was not tested statistically.

The histogram in Figure 1 gives the standard length in millimeters and the total length in inches of both sexes of sauger and for the sexes combined for each age group. Since the females apparently grew more rapidly than the males in each age group, the statistical significance of this difference was checked. Haphazard samples of large size were selected, and the mean standard length and standard error were calculated for all age groups of both sexes. These data are included in Table 2. The theory

of Hoel (1947) was applied to determine if a significant difference existed between the means for the sexes.

The one-year-old sauger did not show any significant difference in standard length between the sexes, although the females averaged 2 millimeters more in length than the males. The probability of the occurrence of a difference in length as large or larger than the value obtained (2.00 mm.) may be expected 13 percent of the time in two normally distributed populations with a mean difference of zero.

The two-year-old, three-year-old, four-year-old, and five-year-old sauger exhibit a distinct difference in the standard length of the sexes. The probability of obtaining a length difference

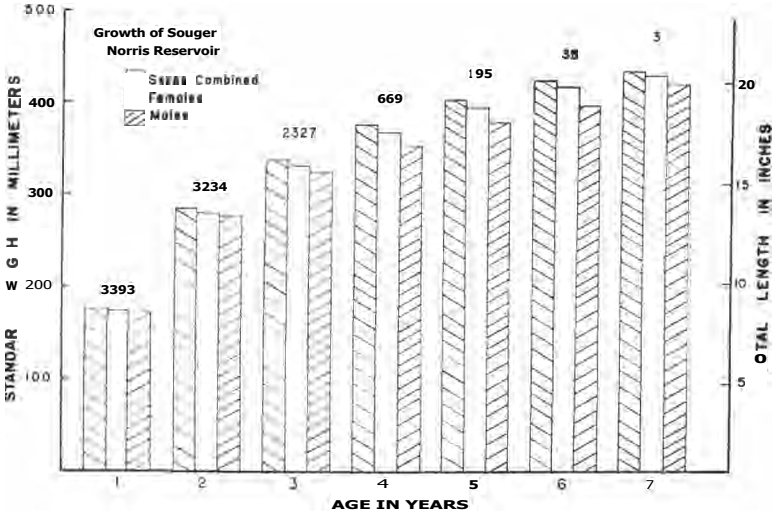

Figure 1. Average total lengths of Norris Reservoir sauger at consecutive ages for each sex and for the sexes combined. All collections combined. Total number of fish indicated above each age group.

between the sexes of sauger as large or larger than the value obtained is rather remote as the probabilities given in Table 2 indicate.

Since the six-year-old age group contained too few specimens to be tested by large sample theory, the "Student's t test" was used to determine if the mean standard lengths of the males and females were different. A highly significant value of "t" was obtained. The sample size is indeed small, but few sauger of this age group are available.

TABLE 2

AVERAGES OF THE CALCULATED STANDARD LENGTHS FOR EACH YEAR OF LIFE OF MALE AND FEMALE SAUGER, AND THE STATISTICAL SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE AVERAGES

Age Group	Number of Males	Mean Standard Length of Males in mm.	Standard Deviation of Males in mm.	Number of Females	Mean Standard Length of Females in mm.	Standard Deviation of Females in mm.	Probability of Larger Difference
1	1428	173.80	35.15	1503	175.80	35.65	P<.13
2	1397	278.65	29.42	1502	285.58	31.29	P<.01
3	1003	326.22	19.50	1212	339.30	22.72	P<.01
4	242	356.87	21.00	387	378.13	24.17	P<.01
5	55	384.14	16.06	121	406.57	20.05	P<.01
6	8	403.25	14.76	26	429.73	20.79	t (.01)=2.73 t=14.83**
7	1	428.00		2	442.00		

The growth differential between the sexes of the sauger thus appears in Norris Reservoir sauger at age two and in the Lake of the Woods sauger at age four. However, the Norris Lake sauger average 282 millimeters in standard length at the end of two years of life, while the Lake of the Woods sauger average 238 millimeters in standard length at the end of four years of life. Thus, the growth differential between male and female sauger appears earlier in life in Norris Reservoir sauger probably because of their rapid growth and earlier sexual maturation.

The Length-Weight Relationship

The length-weight relationship of fish is described by the equation:

$$W = CL^n$$

Where:

W = weight in grams
L = length in millimeters
C = a constant
n = a constant

The empirical data from all collections were grouped into 10-millimeter size classes and the mean weight and length computed for each class. These data are tabulated in Tables 3, 4, and 5. Since a dot diagram of the original data indicated that the relationship was curvilinear, the original formula was transformed by logarithms to:

$$\text{Log } W = \text{Log } C + n \text{ Log } L$$

Next, a regression line was fitted by the method of least squares to the logarithms of the mean length and mean weight for each size group. The logarithmic transformation was not weighted by the sample size of each group since it was found that this method distorts the line of best fit. The unweighted equation gave a closer fit to the empirical data.

The length-weight relationship for the Norris Reservoir sauger may be expressed for each sex and for the sexes combined by the following equations:

1) 1,412 males.
   $\text{Log } W = -5.071 + 3.088 \log L$
   or $W = 1.1752 \times 10^{-5} \times L^{3.088}$
2) 1,680 females.
   $\text{Log } W = -5.4738 + 3.2458 \log L$
   or $W = 2.9775 \times 10^{-6} \times L^{3.2458}$
3) 3,145 males, females, and sex unknown.
   $\text{Log } W = -5.41808 + 3.2259 \log L$
   or $W = 2.6095 \times 10^{-6} \times L^{3.2259}$

TABLE 3
THE LENGTH-WEIGHT RELATIONSHIP AND COEFFICIENT OF CONDITION OF FEMALE SAUGER IN NORRIS LAKE, TENNESSEE

Number of Fish	Calculated Total Length (Inches)	Standard Length Average (Millimeters)	Weight					Calculated
			Empirical Average (Grams)	Std. Dev. of Emp. Average	Calculated (Grams)	Empirical (Ounces)	Calculated (Ounces)	K (Metric)
1	9.0	188	77	— —	82	2.7	2.9	123
2	9.7	204	120	10.0	107	4.2	3.8	1.26
4	10.3	217	148	11.2	131	5.2	4.6	1.28
3	10.7	226	147	1.8	149	5.2	5.3	1.29
3	11.0	232	123	27.7	126	4.3	4.4	1.30
6	11.7	247	183	10.6	199	6.5	7.0	1.32
8	12.0	254	213	10.1	218	7.5	7.7	1.33
8	12.4	264	258	16.4	247	9.1	8.7	1.35
23	12.9	275	296	10.5	282	10.4	10.0	1.35
28	13.4	286	342	15.7	321	12.0	11.3	1.37
61	13.8	295	381	1.4	354	13.4	12.5	1.38
117	14.3	305	421	0.5	395	14.8	14.0	1.39
155	14.8	315	453	2.9	438	16.0	15.5	1.40
211	15.2	325	493	2.2	485	17.4	17.1	1.41
224	15.6	334	526	3.0	531	18.6	18.7	1.42
199	16.1	344	580	3.9	584	20.5	20.6	1.43
142	16.6	355	635	5.8	646	22.4	22.8	1.44
119	17.0	364	694	6.8	701	24.5	24.7	1.45
92	17.4	374	750	7.4	766	26.5	27.0	1.46
69	17.9	385	855	10.0	841	30.2	29.7	1.48
71	18.4	395	896	11.7	915	31.6	32.3	1.48
54	18.8	404	977	12.0	984	34.5	34.7	1.49
27	19.3	415	1048	16.0	1074	40.3	37.9	1.50
28	19.7	424	1121	18.8	1151	39.5	40.6	1.51
13	20.1	434	1191	32.6	1242	42.0	43.8	1.52
4	20.5	443	1100	90.9	1328	38.8	46.8	1.52
4	21.0	454	1547	84.3	1438	54.6	50.7	1.53
3	21.4	463	1680	97.5	1533	59.3	54.1	1.54
1	21.8	470	1584	—	1609	55.9	56.7	1.55
1680	Total						Average	1.43

TABLE 4
THE LENGTH-WEIGHT RELATIONSHIP AND COEFFICIENT OF CONDITION
OF MALE SAUGER IN NORRIS LAKE, TENNESSEE

Number of Fish	Calculated Total Length (Inches)	Standard Length Average (Millimeters)	Weight					Calculated
			Empirical Average (Grams)	Std. Dev. of Emp. Average	Calculated (Grams)	Empirical (Ounces)	Calculated (Ounces)	K (Metric)
2	9.2	192	88	3.0	95	3.1	3.3	1.34
2	9.8	205	116	0.0	117	4.1	4.1	1.36
2	10.2	215	130	17.0	135	4.6	4.8	1.36
6	10.7	225	172	13.3	156	6.3	5.5	1.37
4	11.2	236	167	9.9	181	5.9	6.4	1.37
2	11.6	246	208	5.0	205	7.3	7.2	1.38
10	12.0	255	251	24.4	229	8.8	8.1	1.38
13	12.5	265	245	6.0	258	8.6	9.1	1.39
13	13.0	276	304	8.2	293	10.7	10.3	1.39
28	13.4	285	332	13.8	323	11.7	11.4	1.40
78	13.8	295	373	3.7	360	13.2	12.7	1.40
177	14.3	305	408	2.5	395	14.4	14.0	1.40
250	14.8	315	438	2.6	440	15.5	15.5	1.41
258	15.2	325	479	2.1	474	16.9	16.7	1.41
208	15.6	334	513	2.9	528	18.1	18.6	1.42
138	16.2	344	566	4.9	566	20.0	20.0	1.42
86	16.6	355	620	5.9	637	21.9	22.5	1.42
51	16.9	363	686	9.7	682	24.2	24.1	1.43
27	17.5	375	745	20.3	754	26.3	26.6	1.43
27	17.9	385	825	15.6	819	29.1	28.9	1.43
17	18.3	394	878	16.6	879	31.0	31.0	1.44
6	18.9	406	981	42.6	964	34.6	34.0	1.44
3	19.3	416	1012	71.5	1039	35.7	36.7	1.44
3	19.8	427	1185	91.9	1127	41.8	39.8	1.45
1	21.0	453	1302	——	1352	45.9	47.7	1.45
1412	Total						Average	1.41

TABLE 5
THE LENGTH-WEIGHT RELATIONSHIP AND COEFFICIENT OF CONDITION OF THE SAUGER IN NORRIS LAKE, TENNESSEE. SEXES COMBINED

Number of Fish	Calculated Total Length (Inches)	Standard Length Average (Millimeters)	Weight					Calculated
			Empirical Average (Grams)	Std. Dev. of Emp. Average	Calculated (Grams)	Empirical (Ounces)	Calculated (Ounces)	K (Metric)
3	8.4	174	68	4.6	64	2.4	2.3	1.23
2	9.0	188	76	8.8	83	2.7	3.0	1.25
5	9.3	195	94	2.6	93	3.3	3.3	1.26
10	9.7	203	110	3.3	106	3.9	3.7	1.27
16	10.2	215	129	4.7	128	4.6	4.5	1.28
18	10.7	225	145	7.7	148	5.1	5.2	1.29
14	11.1	235	154	7.7	170	5.4	6.0	1.31
18	11.6	245	176	10.8	195	6.2	6.9	1.31
20	12.0	254	232	13.2	219	8.2	7.7	1.33
22	12.4	264	249	8.4	248	8.8	8.8	1.35
37	12.9	275	298	7.2	283	10.5	10.0	1.35
56	13.4	285	337	5.2	317	11.9	11.2	1.37
139	13.8	295	376	6.6	354	13.3	12.5	1.38
294	14.3	305	413	1.5	395	14.6	14.0	1.39
405	14.8	315	444	0.6	438	15.7	15.5	1.40
469	15.2	325	485	1.1	484	17.1	17.1	1.41
432	15.6	334	520	2.1	529	18.3	18.7	1.42
337	16.2	344	574	3.2	582	20.6	20.5	1.43
228	16.6	355	629	4.3	644	22.2	22.7	1.44
170	17.0	364	691	5.6	698	24.4	24.6	1.45
119	17.4	374	749	7.3	762	26.4	26.9	1.46
96	17.9	385	847	7.4	838	29.9	29.6	1.47
88	18.4	395	893	10.2	908	31.5	32.0	1.47
60	18.8	404	977	11.5	977	34.5	34.5	1.48
30	19.3	415	1044	22.3	1065	39.8	37.6	1.49
31	19.7	424	1127	18.5	1142	39.8	40.3	1.50
13	20.2	434	1191	32.6	1230	42.0	43.4	1.51
4	20.5	443	1100	90.8	1318	38.8	46.5	1.51
5	21.0	454	1498	81.7	1424	52.8	50.2	1.52
3	21.4	463	1680	97.5	1516	59.3	53.5	1.53
1	21.8	470	1584	—	1592	55.9	56.2	1.53
3145*	Total						Average	1.42

nmsexed, immature fish included in this total.

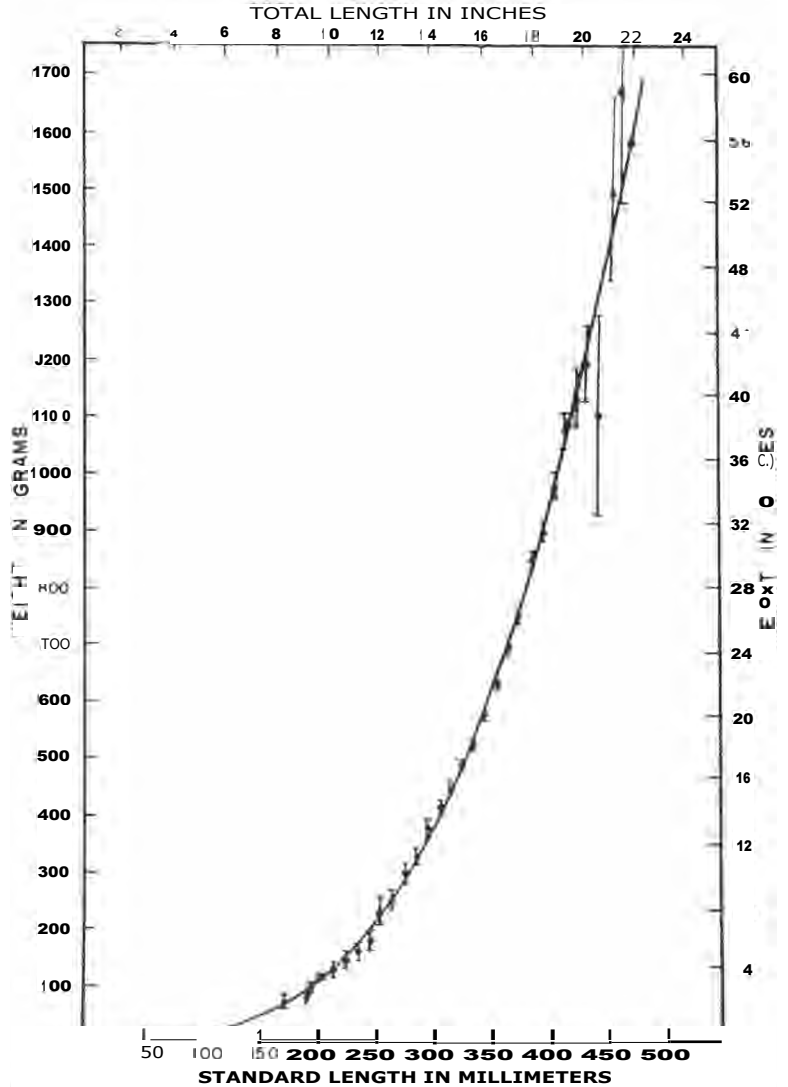

Figure 2. Length-weight relationship of female sauger in Norris Reservoir, Tennessee. The curve is the graph of the length-weight equation: the dots represent the averages of the grouped empirical data. The vertical lines represent two standard deviations of the mean.

The empirical data from which the above equations were derived are given in Tables 3, 4, and 5. Both the empirical and calculated weights are tabulated, and these weights are expressed in grams and in ounces. The standard error is also given for each of the averages of the grouped empirical data.

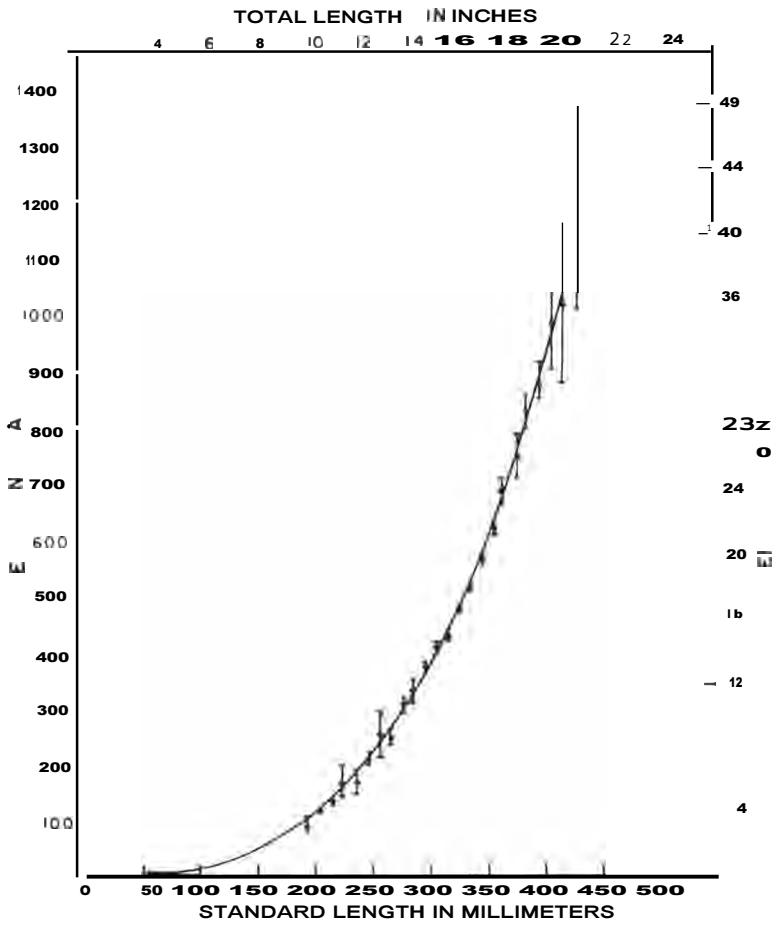

Figure 3. Length-weight relationship of male sauger in Norris Reservoir, Tennessee. The curve is the graph of the length-weight equation; the dots represent the averages of the grouped empirical values. The vertical lines represent two standard deviations of the mean.

The curves of the length-weight relationships were plotted in Figures 2, 3, and 4 from the averages of the standard lengths and the calculated weights. The dots on these graphs represent the averages of the groups of empirical lengths and weights. An estimate of the reliability of these averages is given by the standard error of each average weight. The vertical lines which intersect the dots in Figures 2, 3, and 4 represent a value (on each side of the mean) that is equal to twice the standard error of the mean. The standard error was generally larger in those collections which contained fewer than 30 sauger. The standard error attained its greatest values in those length groups which exceeded a standard length of 400 millimeters.

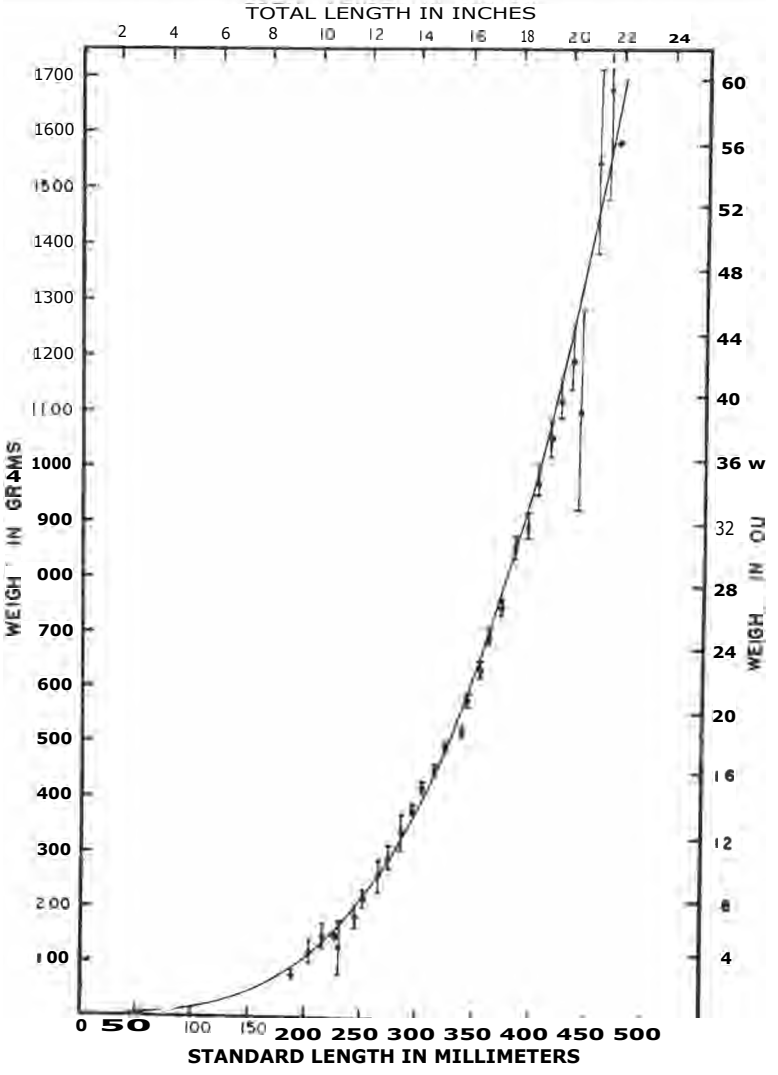

Figure 4. Length-weight relationship of Norris Reservoir sauger. The curve is the graph of the length-weight equation; the dots represent the averages of the grouped empirical values. The vertical lines represent two standard deviations of the mean.

The calculated length-weight equations indicate that the weight increases more rapidly than the cube of the length.

The empirical standard lengths attained by both sexes of sauger have been presented in Table 1 for each year of life. The calculated weights for each year of life are tabulated in Table 6 to supplement this previous information. The calculated weights were derived from the length-weight equations.

In Table 6 the calculated weight of both sexes of sauger for the first two years of life is 2 and 11 ounces repectively. After this age the females outweigh the males. The males weigh approximately one pound at age three, while the females weigh 1-1/4 pounds. The males attain a weight of two pounds at about the sixth year of life and weigh about 2-1/2 pounds at age seven. The females attain a weight of two pounds during the fifth growing season and weigh nearly three pounds at age seven.

TABLE 6

CALCULATED WEIGHT AT SUCCESSIVE AGES FOR MALE AND FEMALE SAUGER IN NORRIS RESERVOIR, TENNESSEE

Year of Life	Females			Males		
	Standard Length (mm.)	Calculated Weight (Grams)	Calculated Weight Pounds & Ounces)	Standard Length (mm.)	Calculated Weight (Grams)	Calculated Weight (Pounds & Ounces)
1	175.8	66	0-2	173.8	70	0-2
2	285.6	319	0-11	278.6	302	0-11
3	339.3	558	1-4	326.2	491	1-1
4	378.1	794	1-12	356.9	647	1 7
5	406.6	1005	2-4	384.1	813	1-13
6	429.7	1199	2-10	403.2	944	2-1
7	442.0	1318	2-14	428.0	1135	2-8

Condition

The relative degree of heaviness in fish is expressed by the formula of Hile (1936)

$$K = \frac{100,000W}{L^3}$$

W = weight in grams

L = standard length in millimeters

The K value in this equation has been called a variety of names such as condition factor, K factor, coefficient of condition, weight-length factor, and ponderal index.

The K factors were calculated from the length-weight relationship using the method of Beckman (1938). These values are given in Tables 3, 4, and 5.

Male sauger had larger calculated K values than female sauger during the first year of life. The K values of the sexes approximated each other during the second growing season. At the end of three growing seasons the female sauger had slightly greater K values than the male sauger. Carlander (1950) reported "There was some indication that the males had slightly higher K values than females of the same length." Since the greater part of the sauger collected by him were distributed over a size range which approximates that of Norris Reservoir sauger, there is considerable agreement on the K values for the sexes. After three years of age the female sauger had greater K values than the male sauger in Norris Reservoir.

TABLE 7

LARGEST FEMALE SAUGER TAKEN BY GILL NETS IN NORRIS RESERVOIR, TENNESSEE, 1942-1951

Year of Capture	Year Class	Age in Years	Weight		Length	
			Grams	Lbs. and Ounces	Millimeters	Inches
1946	1940	6	1873	4-2	545	21.5
1945	1940	5	1627	3-9	520	20.5
1949	1943	6	1607	3-9	541	21.3
1945	1939	6	1585	3-8	535	21.1
1949	1943	6	1584	3-8	553	21.8
1944	1938	6	1560	3-7	536	21.1
1946	1940	6	1506	3-5	515	20.3
1947	1940	7	1471	3-4	529	20.8
1947	1942	5	1385	3-1	488	19.2
1947	1941	6	1339	2-15	517	20.4

TABLE 8

LARGEST MALE SAUGER TAKEN BY GILL NETS IN NORRIS RESERVOIR, TENNESSEE, 1942-1951

Year of Capture	Year Class	Age in Years	Weight		Length	
			Grams	Lbs. and Ounces	Millimeters	Inches
1946	1939	7	1368	3-0	507	20.0
1950	1946	4	1302	2-14	532	20.9
1944	1940	4	1119	2-7	490	19.3
1946	1940	6	1105	2-7	499	19.7
1946	1940	6	1097	2-7	480	18.9
1947	1942	5	1090	2-6	489	19.3
1944	1940	4	1081	2-6	482	19.0
1947	1943	4	1081	2-6	491	19.3
1942	1938	4	1020	2-4	475	18.7
1944	1939	5	1013	2-4	476	18.7

The average K values of 1680 female sauger was 1.43, while the average of 1,412 male sauger was 1.41. The K values for each sex increased with size and age. The average K value for the 3,145 Norris Reservoir sauger of both sexes was 1.42. This coefficient of condition is similar to the K values obtained by other investigators in the Tennessee Valley reservoirs.[2]

[2]Eschmeyer (1944) reported an average K from 1.33 to 1.37 for 46 one-year-old sauger taken at different months from Chickamauga Reservoir, Tennessee. Two-year-old sauger from the same reservoir had an average K value of 1.4. Eschmeyer also reported that 22 yearling sauger from the Clinch River at Norris had an average K of 1.24. Eschmeyer, et al, (1944) calculated an average K of 1.4 for 71 sauger from Chickamauga Reservoir and an average K of 1.6 for 70 sauger from Watts Bar Reservoir. This latter K value is the highest on record for sauger.

Stroud (1949) calculated the average K for 62 sauger from Cherokee Reservoir, Tennessee, to be 1.45. He, also, reported a K value of 1.40 for

45 Douglas Reservoir sauger and a K value of 1.43 for 2348 Norris Reservoir sauger. The average K value for 3145 sauger in this study was 1.42 and the average K value derived by Stroud was 1.42. The first average K value was computed by means of the length-weight constants, while the latter value was the average of the individually calculated K values derived by means of the condition equation.

Carlander (1942) reported an average K value of 1.46 for 1353 sauger from the Lake of the Woods, Minnesota. Carlander (1950) computed the coefficient of condition for 508 Lake of the Woods sauger to be 1.27. These fish ranged in length from 150 mm. to 375 mm. However, the length frequency distribution of his sauger collection indicated that the majority of the sauger collected were less than 300 millimeters in standard length. His smaller K value for the Lake of the Woods sauger as compared to the Norris Reservoir sauger is probably due to the smaller size of the sauger comprising the population which he studied.

Records of Large Sauger

The heaviest sauger from the entire collection of fish in this study have been compiled according to sex in Tables 7 and 8. Altogether, about 5,500 sauger were examined and only one surpassed four pounds. This fish, a six-year-female, weighed four pounds two ounces and was 21.5 inches in total length. The longest sauger measured approximately 21.8 inches in total length, weighed three pounds eight ounces, and was, also, a six-year-old sauger. Only 10 sauger (nine females, one male) out of the 5,500 specimens reached a weight of three pounds or more. The larger size attained by the females is attributed to their longer life span and generally more rapid growth rate.

The heaviest male sauger weighed three pounds. It was seven years old and measured 20 inches in total length. The maximum total length recorded for a male sauger was 20.9 inches.

The western sauger, Stizostedion canadense boreum (Girard) was reported by Simon (1946) to have attained a weight of six pounds eight ounces in the Wind River, Wyoming. Evidently, this subspecies surpasses the maximum growth of the eastern sauger by a large margin.

Growth of Sauger in Norris Reservoir, Tennessee Compared with That in Other Waters

A comparison of the growth in length of Norris Reservoir sauger with its growth in other localities shows that Norris sauger attain the largest size and exhibit a fast rate of growth (Figure 5). Both size and rate of growth for sauger are probably near maximum values in the Tennessee storage reservoirs. Table 9 lists the growth of sauger in various regions of the United States and Canada. The data of Eschmeyer and Jones (1941) indicate that Norris Reservoir sauger grew at a more rapid rate during the early years of impoundment. However, their sample was small, being composed of 84 fish. It should be pointed out that the data from this study in Table 9 are presented as the

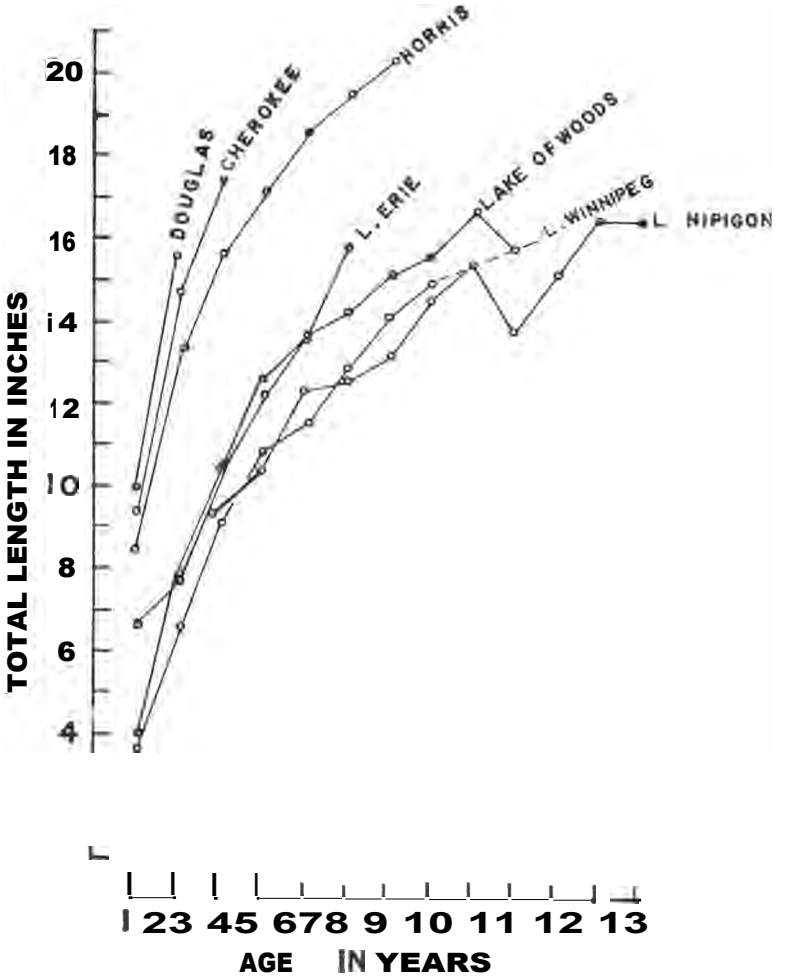

Figure 5. Growth of Norris Reservoir sauger compared with the growth of sauger in other waters.

weighted average for a 13-year period and the annual fluctuations in growth are not discernable. After 14 years of impoundment Norris Reservoir produced a year class of sauger (Table 1) which was growing approximately at the same rate as the fastest growing year class of the early years of impoundment. Stroud (1949) published data on the growth of 64 sauger from Cherokee and 39 from Douglas Reservoirs, Tennessee. The rate of growth was numerically slightly greater than that of Norris Reservoir sauger. However, later samples of sauger from these reservoirs indicate that thee growth rates have not been maintained for Douglas and Cherokee Reservoirs after the initial years.

TABLE 9

GROWTH OF SAUGER IN NORRIS RESERVOIR COMPARED TO GROWTH IN OTHER WATERS. AVERAGE TOTAL LENGTH IN INCHES. TOTAL LENGTH CALCULATED ACCORDING TO FOOTNOTES IF FIGURES IN PARENTHESES WERE FORK OR STANDARD LENGTHS

Location and Author	Average Total Length at End of Year												
		2	3	4	5	6	7	8	9	10	11	12	13
Norris Reservoir, Tennessee	8.4	13.3	15.6	17.2	18.6	19.6	20.3						
Norris Reservoir, Tennessee (Eschmeyer and Jones, 1941)	9.6	13.8	16.5										
Cherokee Reservoir, Tennessee (Stroud, 1949)	9.3	14.7	17.4										
Douglas Reservoir, Tennessee (Stroud, 1949)	9.9	15.6											
Lake Nipigon (Hart, 1928)[1]			9.4 (206)	10.4 (229)	12.3 (270)	12.5 (274)	13.1 (288)	14.5 (318)	15.4 (337)	13.7 (300)	15.1 (330)	16.5 (362)	16.5 (362)
Lake of the Woods (Carlander, 1950)	6.6 (144)	7.7 (169)	10.4 (229)	12.5 (274)	13.7 (300)	14.2 (311)	13.1 (330)	15.5 (340)	16.7 (365)	15.7 (343)			
Lake Erie (Deason, 1933)[1]	3.9 (85)	7.9 (173)	10.4 (229)	12.2 (268)	13.6 (299)	15.8 (346)							
Lake Winnipeg (Bajkov, 1933)[2]	3.7 (90)	6.6 (160)	9.1 (220)	10.8 (260)	11.6 (280)	12.8 (310)	14.1 (340)	14.9 (360)	15.3 (370)	15.7 (389)			

[1]Total length in inches estimated from standard length in millimeters (in parentheses) x 0.04563. (T.L./S.L. ratio of 1.159 derived by Carlander, 1950.)

[2]Total length in inches calculated from fork length in millimeters by the coefficient of Carlander (*op. cio.* (Fork length 1.102 standard length, total length=1.159 standard length. Total length in inches=fork length in millimeters x 0.04141.)

Growth rates of sauger compiled by various investigators in the northern United States and southern Canada are lower than the growth rates in the Tennessee Valley storage reservoirs. The slow rate of growth of the sauger in northern regions appears to be associated with increased longevity. Hart (1928) reports that sauger attained an age of 13 years and a length of 16.5 inches in Lake Nipigon. The maximum age recorded for Norris Reservoir sauger was 7 years, and the maximum average length at this age was 20.3 inches.

The growth of Norris Reservoir sauger exceeds the growth of eastern sauger elsewhere in its distribution. An earlier spawning season, longer growing season, and abundant food supply are all factors in the rapid growth of this species in Norris Reservoir.

SUMMARY

1. A 13-year age and growth study of the eastern sauger, Stizostedion canadense canadense (Smith) in Norris Reservoir Tennessee was based on scale analysis of 3,393 sauger. The 13-year average growth for age groups 1 to 7 (sexes combined) were 8.4, 13.3, 15.6, 17.2, 18.6, 19.6, and 20.3 inches respectively.
2. The weighted regression coefficients were calculated for both total and standard length.
3. Comparison of year classes of sauger from 1937 to 1949 did not indicate any progressive decrease in sauger growth. The 1949 year class grew at the most rapid rate.
4. The age of the oldest sauger in this study was determined by scale analysis to be seven years. Few sauger lived more than five years.
5. Male and female sauger grew at approximately the same rate for the first year of life. A significant difference in standard length occurred between the sexes for age groups two to six.
6. The length-weight equations were derived for each sex and for the sexes combined.
7. "K" values were calculated for each sex and for the sexes combined. The average K value was 1.42.
8. The largest sauger weighed four pounds two ounces. The greatest length attained was 21.8 inches.
9. The average growth rate of the eastern sauger in Norris Reservoir surpassed the growth of this subspecies in other localities.

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