Observations on the life history and taxonomy of the sauger (Stizostedion canadense Smith) in Garrison reservoir, North Dakota
by Louis H Carufel

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management Mohtana State College
Montana State University

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A study on the life history and taxonomy of the sauger (Stizostedion canadense) in Garrison Reservoir, its tributaries, and the tailrace was initiated during June, 1959 and continued to July, 1960. A total of 1,558 sauger was used in the study. These ranged in total length from 4.0 to 26.5 inches. Scales were read with aid of micro-projector, and a direct proportion of scale length to body length was used in calculating the length of fish at each year of life. Average calculated total lengths for sauger from Garrison Reservoir at annuli I-VI were 4.9, 8.8, 12.3, 15.5, 18.4, and 23.1 inches respectively while those from the tail-race at annuli I - VIII were 4.8, 9.3, 11.3, 13.8, 16.2, 18.7, 20.8, and 25.6 inches respectively. The number of eggs estimated for 50 sauger ranged from 10,488 to 117,058. Of the 1,466 sauger used in sex determinations 71 percent were females and 29 percent were males. The smallest mature male was 10.6 inches in total length and the female was 12.9 inches. Only 21 percent of the males and 19 percent of the females mature when 3 years old. All males and 63 percent of the females were mature at 4 years. The height of the spawning season was from May 8 to May 28, 1960. A total of 564 sauger, 90 walleye, and 5 hybrids was studied for taxonomic differences.

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Approved:

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Abstract

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Introduction

The sauger (Stizostedion canadense) is indigenous to the Missouri River in North Dakota. The earliest record was that of Girard (1858) who reported this species from a collection taken by Dr. Frederick Hayden near Fort Union. Since then sauger have been collected several times. Personius and Eddy (1955) reported it for the Little Missouri River and the North Dakota Game and Fish Department has taken this species on a number of occasions in their test-netting surveys of Garrison Reservoir.

Sauger was once reported to be of little importance as a game fish in the Missouri River Basin (Evermann and Cox, 1894), but at the present time it is one of the important game fish in North Dakota. Large numbers of sauger are caught by anglers each year, from May to October, in both the Garrison Reservoir and the tailwaters of the dam.

Aside from the limited fisheries surveys conducted on the Missouri River drainage the sauger has not been investigated in North Dakota. A study on the life history of the sauger in Garrison Reservoir, its tributaries, and the tailrace was initiated during June, 1959 and continued to July, 1960. Observations were also made on the taxonomy of this species in comparison with the walleye (Stizostedion vitreum).

Acknowledgments

The writer extends thanks to those individuals and agencies that assisted in this investigation. Dale L. Henegar, Chief of Fisheries, North Dakota Game and Fish Department suggested the problem and gave advice during the study. Dr. C. J. D. Brown directed the study and helped

in the preparation of the manuscript. Dr. E. B. Harvey aided in the histological work. Dr. Reeve M. Bailey, University of Michigan, identified some of the specimens. Robert Needham, Selmar Enger, Dwight Meyers, Ralph Wright, Edmund Hibbard, and James Sprague assisted in the field. My wife, Catherine, aided in the tabulation of data. The U. S. Army, Corps of Engineers, supplied photos, maps, and temperature records. The North Dakota Health Department made the chemical water analysis. The North Dakota Game and Fish Department provided equipment and financial support under Federal Aid Projects F-3-R 7, 8.

Description of Area

The 210 foot high dam impounding Garrison Reservoir was completed in 1954 by the U. S. Army, Corps of Engineers. The spillway (elevation 1825 feet m.s.l.) is at the east end of the dam and the tailrace (elevation 1640 feet m.s.l.) is at the west end. The latter covers approximately 40 surface acres and has a maximum depth of 35 feet (Fig. 1).

Garrison Reservoir is a multiple-purpose impoundment on the mainstem of the Missouri River in McLean and Mercer Counties. It has a length of approximately 200 miles and varies in width from 0.75 mile to 14 miles with an average of 3 miles (Fig. 2). At the maximum operating pool (elevation 1850 feet m.s.l.) the shoreline is approximately 1600 miles long, the surface area about 390,000 acres and the storage capacity 23,000,000 acre feet. In an average year the reservoir level is lowered about 16 feet during the winter to accommodate spring flood waters. The minimum level is attained usually in February and the maximum in late June or

Figure 1. Garrison Dam, spillway, tailrace, and Missouri River below dam showing test netting stations.

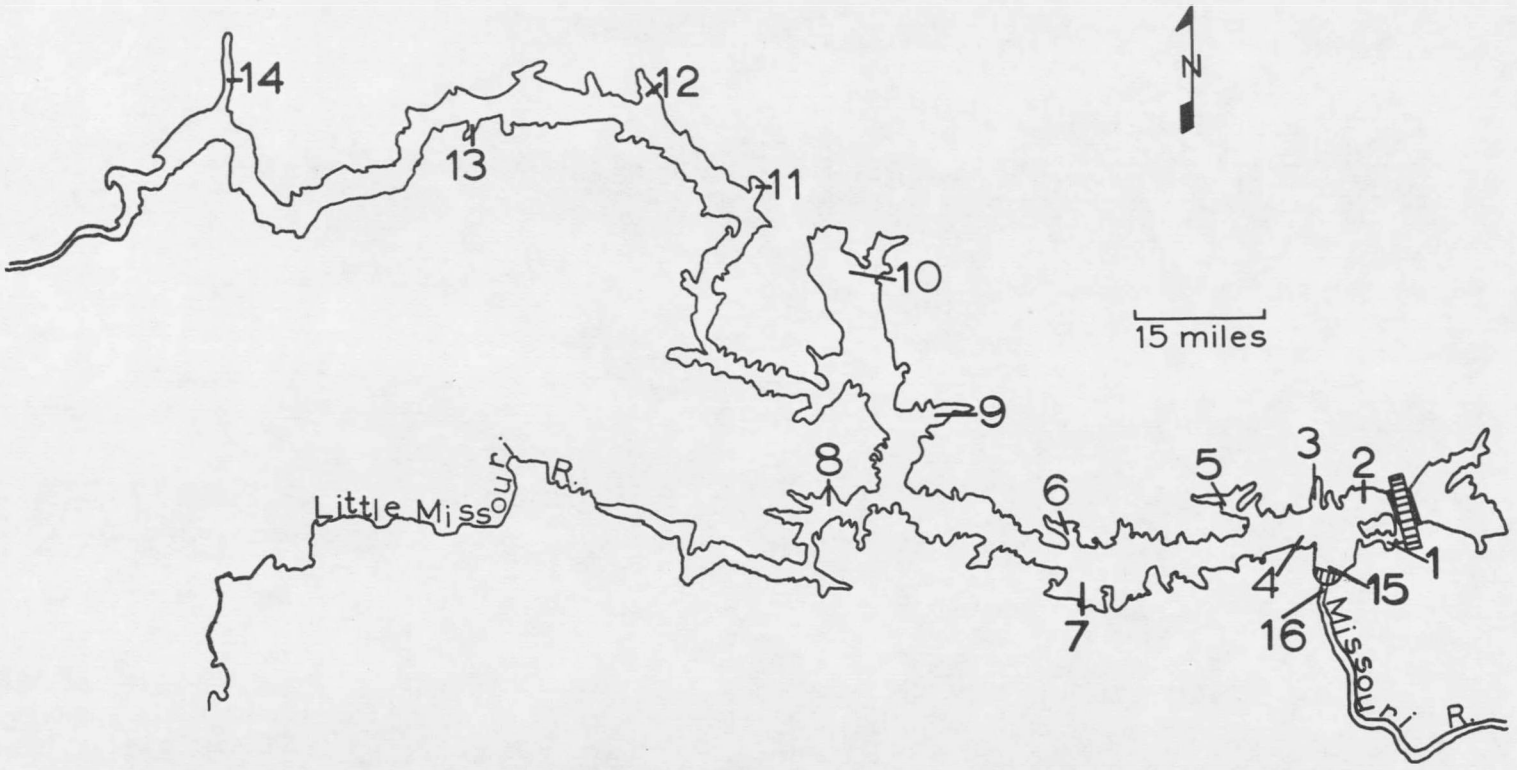

Figure 2. Garrison Reservoir, its tributaries, and tailrace, North Dakota - showing stations.

early July.

The principal source of reservoir water is from the Missouri River, but there are five main tributaries which enter the impoundment, Little Missouri River, Shell Creek, White Earth River, Tobacco Garden Creek, and Little Muddy River.

The maximum recorded water surface temperature for the reservoir during the study period was 77° F. while that of the tailrace was 65° F. Ice usually occurs during late November or early December and disappears in late April or early May and may reach a thickness of 3 to 4 feet. The tailrace did not completely freeze over.

Certain chemical and physical analyses were made at 16 stations in the reservoir during the summer of 1959 and these were repeated for 8 stations in the spring of 1960. Determinations were made of total dissolved solids, total alkalinity, total hardness, conductivity, pH, turbidity, and temperature (Table 1).

A total of 45 species of fish was found in association with sauger in Garrison Reservoir and its tributaries (Table 2). Most of these are native to the drainage; but brown trout, rainbow trout, carp, and largemouth bass are known to have been introduced and several other species may have been. The goldeye was the most abundant species in the reservoir and the white sucker in the tributary streams as judged from net catches.

Methods

Sauger used in this investigation were collected with the following equipment: experimental gill nets (1.25 to 3 inch mesh); fyke nets (rec-

Table 1. Ranges of chemical and physical data for Garrison Reservoir and tailrace, 1959 and 1960 (Dates in parentheses).

Analysis	Reservoir		Tailrace	
	1959	1960	1959	1960
Total dissolved solids p.p.m.	295.0 (9/11) - 422.0 (9/9)	326.5 (6/22) - 492.3 (5/23)	395.0 (8/4)	477.6 (6/25) - 484.8 (5/9)
Total alkalinity p.p.m.	122.0 (8/12) - 166.0 (9/9)	130.0 (6/22) - 185.0 (5/23)	106.0 (8/4)	175.0 (5/9) - 180.0 (5/23)
Total hardness p.p.m.	144.0 (8/12) - 232.0 (9/9)	140.0 (6/22) - 210.0 (5/23)	212.0 (8/4)	205.0 (5/23) - 210.0 (5/9)
Conductivity	1730 (9/9) - 2475 (9/11)	1625 (5/23) - 2450 (6/22)	1845 (8/4)	1650 (5/9) - 1675 (6/25)
pH	7.0 (9/11) - 7.7 (7/23)	7.5 (6/22) - 8.6 (4/30)	5.7 (8/4)	7.3 (5/23) - 8.7 (5/9)
Turbidity p.p.m.	0.5 (7/9) - 3.5 (7/14)	0.2 (6/13) - 18.5 (6/22)	0.7 (8/4)	1.2 (6/25) - 6.0 (5/9)
Temperature $^{o}F.$	33 (1/1) - 77 (7/30)	33 (1/1) - 74 (7/12)	65 (8/4)	33 (1/1) - 41 (6/25)

tangular opening with 100 foot lead fastened to the center of the frame); pocket nets (two typical fyke nets with a single lead fastened to the opening of each net); seines (common sense and 100 foot bag). Some specimens were also secured by the use of toxicants and from sport fishermen.

Measurements were made on 1,558 sauger ranging in total lengths from 4.0 to 26.5 inches. In order to compare measurements made in the present study with those of other workers, standard, fork, and total lengths were taken to the nearest 0.1 inch. The relationships between these lengths were nearly rectilinear and single conversion factors could be used for

Table 2. Fishes associated with sauger in Garrison Reservoir and tributary streams (*abundant species).

Pallid sturgeon	Scaphirhynchus albus
Shovelnose sturgeon	Scaphirhynchus platorynchus
Paddlefish	Polydon spathula
Shortnose gar	Lepisosteus platostomus
Rainbow trout	Salmo gairdneri
Brown trout	Salmo trutta
*Goldeye	Hiodon alosoides
Northern pike	Esox lucius
Northern redbelly dace	Chrosomus eos
*Carp	Cyprinus carpio
Brassy minnow	Hybognathus hankinsoni
Silvery minnow	Hybognathus nuchalis
*Flathead chub	Hybopsis gracilis
Lake chub	Hybopsis plumbea
Golden shiner	Notemigonus crysoleucas
*Emerald shiner	Notropis atherinoides
Sand shiner	Notropis stramineus
*Fathead minnow	Pimephales promelas
*Longnose dace	Rhinichthys cataractae
Creek chub	Semotilus atromaculatus
Pearl dace	Semotilus margarita
*River carpsucker	Carpoides carpio
Longnose sucker	Catostomus catostomus
*White sucker	Catostomus commersoni
Blue sucker	Cycleptus elongatus
Smallmouth buffalo	Ictiobus bubalus
*Bigmouth buffalo	Ictiobus cyprinellus
Black buffalo	Ictiobus niger
*Northern redhorse	Moxostoma macrolepidotum
*Black bullhead	Ictalurus melas
Channel catfish	Ictalurus punctatus
*Stonecat	Noturus flavus
Flathead catfish	Pylodictis olivaris
*Burbot	Lota lota
Brook stickleback	Eucalia inconstans
Pumpkinseed	Lepomis gibbosus
Orangespotted sunfish	Lepomis humilis
Largemouth bass	Micropterus salmoides
*White crappie	Pomoxis annularis
*Black crappie	Pomoxis nigromaculatus
Iowa darter	Etheostoma exile
Johnny darter	Etheostoma nigrum
*Yellow perch	Perca flavescens
Walleye	Stizostedion vitreum
Freshwater drum	Aplodinotus grunniens

all sizes of sauger. Weights were taken on all fish to the nearest 0.02 pound.

Sex was determined by examining the gonads. The right and left gonads in the female are blunt or rounded anteriorly, and those of the male are sharply tapered or pointed (Eschmeyer, 1950). The gonads in both sexes are joined posteriorly immediately anterior to the gential aperture. The union is Y-shaped in the female and V-shaped in the male.

In the spring of 1960, ovaries were collected for determining the number of eggs. In addition, reproductive tracts were also removed and preserved in Bouin's fluid, A F A solution, and 10 percent formalin for histological study of gonad development.

Scale samples were collected for age and growth analysis. These were taken from the left side of each fish below the lateral line posterior and adjacent to the pectoral fin. Plastic impressions were made of scales (Smith, 1954) and annuli were determined with the aid of a micro-projector. Scale measurements were determined from the center of the focus along the median anterior radius. A constant ratio of scale radius to body length was assumed and the length of fish at each year of life was determined by use of a nomograph. Coefficients of condition (C) were calculated for each fish.

Age and Growth

A total of 529 sauger was used for age and growth determinations; 318 of these were from Garrison Reservoir and 211 from the tailrace. Average total lengths of male and female sauger were calculated for each

year of life and a comparison was made between the sexes for each locality.

Male and female sauger from both Garrison Reservoir and the tailrace showed approximately equal growth in age classes I and II, but females were larger than males in age class III and older (Tables 3 and 4). In Minnesota (Carlander, 1942) male and female sauger showed growth rates which were approximately the same for the first three years, but slower than those of Garrison Reservoir and tailrace. In Tennessee (Hassler, 1957) the greatest growth rate of male and female sauger was attained in age class I. This rate was faster than that recorded from Garrison Reservoir and tailrace for the same age classes.

The range of calculated total lengths for male sauger in Garrison Reservoir was 4.8 to 16.9 inches (age classes I - V) and those of the tailrace 4.6 to 18.0 inches (age classes I - VI). The range of calculated total lengths for female sauger in Garrison Reservoir was 5.1 to 23.1 inches (age classes I - VI) and those of the tailrace 4.9 to 25.6 inches (age classes I - VIII).

In order to compare sauger from Garrison Reservoir and tailrace with those of other waters the calculated total lengths of both sexes were combined for each age class (Fig. 3). The sauger from Garrison Reservoir grew at a faster rate than those from the tailrace. The opposite of this was reported for sauger from Fort Randall Reservoir, South Dakota[1/] where

1/ Shields, James T. 1955. Report of fisheries investigations during the second year of impoundment of Fort Randall Reservoir, South Dakota, 1954. Dingell-Johnson Project F-1-R-4, 100 pp. mimeo.

Table 3. Average calculated total length in inches of male and female sauger from Garrison Reservoir, 1959 and 1960.

Age class	Sex	Number of fish	Average calculated total length in inches at each annulus					
			1	2	3	4	5	6
I	Male	96	4.9					
	Female	222	4.8					
II	Male	91	4.7	8.9				
	Female	215	4.8	8.9				
III	Male	65	4.6	8.8	11.8			
	Female	201	4.7	8.8	12.5			
IV	Male	39	4.9	9.1	11.8	14.1		
	Female	156	4.8	9.1	11.7	15.5		
V	Male	3	4.9	8.1	11.7	14.8	16.9	
	Female	64	5.2	8.8	12.9	16.2	18.8	
VI	Male							
	Female	6	6.5	10.9	14.6	18.1	21.0	23.1
Grand average	Male		4.8	8.7	11.8	14.4	16.9	
	Female		5.1	9.3	12.9	16.6	19.9	23.1
Average annual increment	Male		4.8	3.9	3.1	2.6	2.5	
	Female		5.1	4.2	3.6	3.7	3.3	3.2

Table 4. Average calculated total length in inches of male and female sauger from tailrace, 1960.

Age class	Sex	Number of fish	Average calculated total length in inches at each annulus							
			1	2	3	4	5	6	7	8
I	Male	81	4.7							
	Female	130	4.8							
II	Male	81	4.7	8.4						
	Female	130	4.8	8.4						
III	Male	69	4.7	8.3	11.1					
	Female	122	4.8	8.3	13.1					
IV	Male	45	4.5	8.2	11.2	13.4				
	Female	103	4.9	8.4	13.6	14.0				
V	Male	10	4.5	8.1	11.2	13.4	15.1			
	Female	79	5.0	8.5	13.5	14.5	16.6			
VI	Male	2	4.6	8.2	11.2	14.3	16.6	18.0		
	Female	42	4.8	8.3	11.7	14.2	16.6	18.8		
VII	Male									
	Female	20	4.9	8.2	11.5	14.0	16.2	18.6	20.7	
VIII	Male									
	Female	2	5.3	8.5	11.5	14.4	17.5	20.5	23.0	25.6
Grand average	Male		4.6	8.2	11.2	13.7	15.8	18.0		
	Female		4.9	8.4	12.5	14.2	16.7	19.3	21.8	25.6
Average annual increment (inches)	Male		4.6	3.6	3.0	2.5	2.1	2.2		
	Female		4.9	3.5	4.1	1.7	1.5	2.6	2.5	3.8

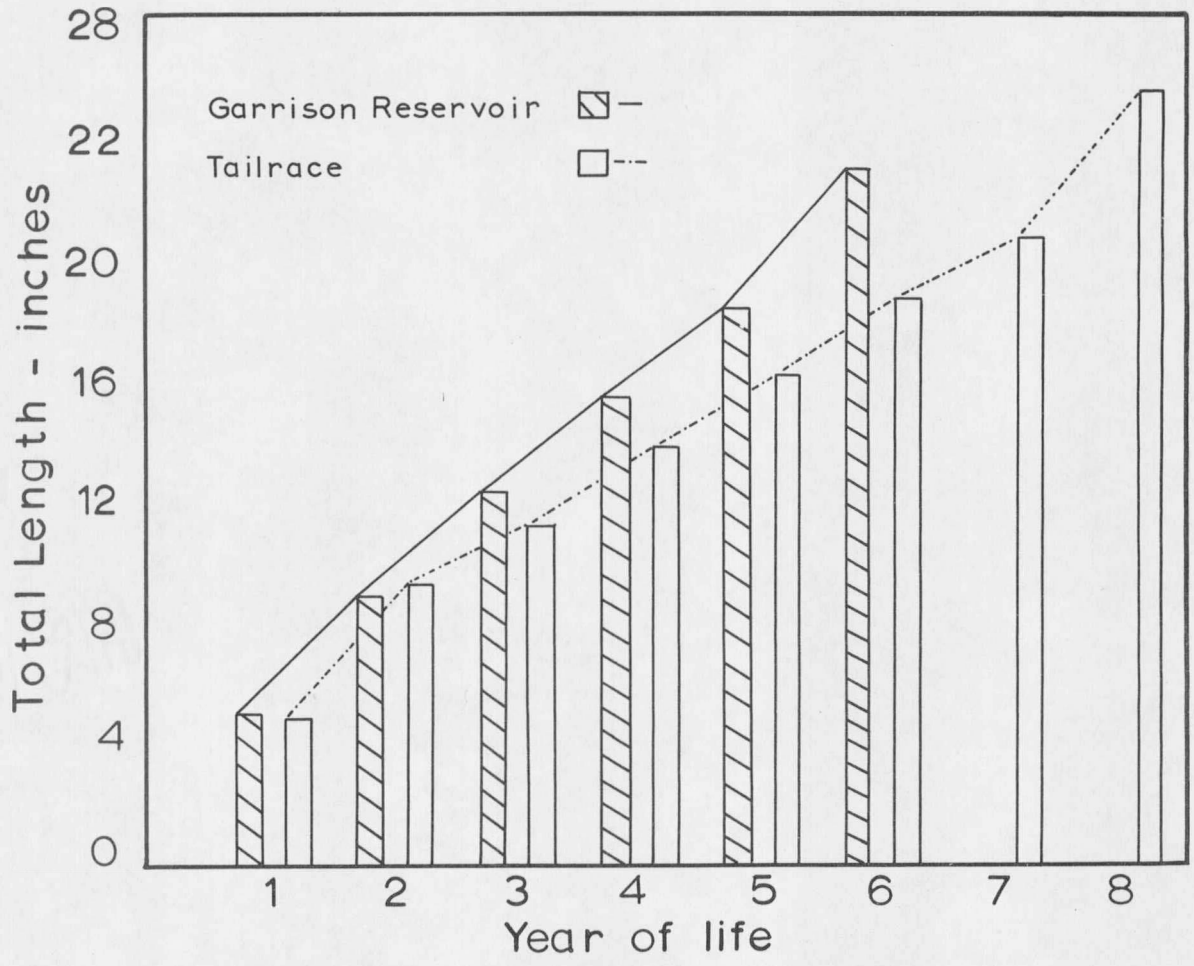

Figure 3. Average calculated total lenth of sauger from Garrison Reservoir and tailrace at each year of life.

growth rates in the reservoir were slower than those from the tailrace. Growth rates and longevity (IX) were also greater for sauger from South Dakota[2/] [3/] than those from North Dakota.

Growth rates of sauger from Garrison Reservoir and the tailrace were approximately the same as those of Fort Peck Reservoir, Montana[4/] for the first four years of life, but North Dakota growth rates were more rapid in age classes V to VIII. Sauger from Fort Peck Reservoir attained a maximum age of 8 years which is the same as that of Garrison Reservoir and tailrace.

Sauger from the T.V.A. Reservoirs (Eschmeyer and Jones, 1941; Stroud, 1949; Hassler, 1957) grew at a faster rate (age classes I - VII) than those from Garrison Reservoir and the tailrace. Annual growth increments for the T.V.A. Reservoirs (age classes I - III) exceeded those of Garrison Reservoir and the tailrace except that those from Norris Reservoir (Hassler, 1957) were less after age class III. The maximum age class attained by sauger from T.V.A. Reservoirs (age VII) was greater than that of Garrison Reservoir but less than that of the tailrace.

2/ Shields, James T. 1956. Report of fisheries investigations during the third year of impoundment of Fort Randall Reservoir, South Dakota, 1955. Dingell-Johnson Project F-1-R-5, 91 pp. mimeo.

3/ Shields, James T. 1957. Report of fisheries investigations during the fourth year of impoundment of Fort Randall Reservoir, South Dakota, 1956. Dingell-Johnson Project F-1-R-6, 60 pp. mimeo.

4/ Alvord, William. 1957. Fort Peck Reservoir investigations. Northeast Montana Fishery Study. Montana State Dept. of Fish and Game. Dingell-Johnson Project F-11-R-4, 4 pp. mimeo.

The growth rates of sauger from both Garrison Reservoir and the tailrace were greater than those reported for waters other than reservoirs: Ontario (Hart, 1928); Manitoba (Bajkov, 1930; Kennedy, 1949), Ohio (Deason, 1933; Roach, 1949), and Minnesota - except for age class I (Carlander, 1950). The maximum age of sauger from Garrison Reservoir and the tailrace was less than that reported by Hart (1928), Bajkov (1930), Kennedy (1949), and Carlander (1950), but greater than those from Ohio (Deason, 1933; Roach, 1949).

The smallest sauger taken from Garrison Reservoir was 4.0 inches in total length (0.02 pounds) and that from the tailrace 8.4 inches (0.16 pounds). The largest individual taken from Garrison Reservoir was 26.5 inches in total length (6.7 pounds) and that from the tailrace 26.4 inches (4.5 pounds).

Male sauger from Garrison Reservoir ranged in weight from 0.08 to 2.20 pounds (average 0.66) and those from the tailrace 0.16 to 1.90 (average 0.64). Female sauger from Garrison Reservoir had a weight range of 0.16 to 6.70 pounds (average 1.43) and those from the tailrace 0.15 to 4.50 (average 1.44).

The youngest sauger appeared in the sport fishery of Garrison Reservoir and the tailrace when 2 years of age while the oldest was 8 years old. The smallest sauger taken in the sport fishery was 7.0 inches in total length (0.12 pounds) while the largest sauger was 26.5 inches (6.7 pounds). The largest sauger ever recorded from this area was 30.0 inches in total length and weighed 8.2 pounds.

The 249 sauger examined in a partial creel census for 1959 and 1960 had an average length of 15.6 inches and weight of 1.12 pounds. Previous creel reports[5/] (4,637 sauger) showed similar average total lengths and weights.

Condition

A total of 552 sauger was used for coefficient of condition (C) determinations; 332 of these were from Garrison Reservoir and 220 from the tailrace. The coefficient of condition (C) was approximately the same for both male and female sauger for both localities (Table 5). The C factor for male sauger from Garrison Reservoir averaged 28.7 (range 17.0 - 30.0) and the female 30.3 (range 21.3 - 48.0). The C factor for male sauger from the tailrace averaged 28.4 (range 15.0 - 43.8) and the female 30.0 (range 11.5 - 46.7).

Fecundity

The number of eggs was estimated for 12 sauger from Garrison Reservoir and 38 from the tailrace by counting the eggs from known portions (5 percent) of each ovary and calculating the total based on the weight of ovaries. This method was checked by making total counts on 6 fish previously studied as described above. The estimated number of eggs based on partial counts ranged from 1.5 to 6.0 percent less than total counts. Good estimates could be made when samples were taken from the central part

5/ Carufel, L. H. (1954-1958) Creel Census Analysis - Tailrace fishing area of Garrison Dam. Northwest Fisheries District. North Dakota Game and Fish Dept. Dingell-Johnson Projects F-3-R-2 to F-3-R-6, 1 to 11 pp. mimeo.

Table 5. Average coefficient of condition (C) for male and female sauger from Garrison Reservoir and the tailrace, 1959 and 1960 (number of fish in parentheses).

Location	Sex	Age Class							
		I	II	III	IV	V	VI	VII	VIII
Garrison Reservoir									
	Male	28.0 (101)	28.0 (98)	28.0 (77)	28.0 (44)	30.0 (4)			
	Female	28.8 (231)	28.9 (230)	28.8 (214)	28.8 (209)	30.8 (74)	33.0 (6)		
Tailrace									
	Male	28.0 (82)	28.0 (82)	28.0 (71)	28.5 (48)	30.1 (13)	30.4 (3)		
	Female	29.7 (138)	29.5 (134)	30.0 (123)	30.4 (108)	30.8 (84)	32.5 (42)	32.0 (18)	27.4 (2)

of the ovary away from the extremities. There was no important difference between the average number of eggs from each locality. Female sauger used for egg counts ranged in total length from 12.9 to 24.6 inches and weighed between 0.60 and 4.62 pounds.

The average number of eggs per pound of fish was calculated, then averaged for all fish in each length group (Table 6). The number of eggs ranged from 10,488 (12.9 inch sauger) to 117,058 (24.6 inch sauger). Carlander (1942) reported a higher average number of eggs for Minnesota sauger (14.0 - 14.2 inches in total length) than was found for fish of similar length in Garrison Reservoir and tailrace.

The average number of eggs for North Dakota sauger was greater than those reported by Hassler (1958) for Tennessee, but was approximately the

Table 6. Estimated number of eggs for sauger from Garrison Reservoir and tailrace, 1960.

Number of females	Total length - inches Range	Average	Number of eggs Minimum	Maximum	Average	Average weight of fish (pounds)	Average number of eggs per pound of fish
2	12.0 - 12.9	12.9	10,448	10,925	10,685	0.60	15,130
3	13.0 - 13.9	13.5	15,888	25,437	20,662	0.71	26,654
13	14.0 - 14.9	14.4	14,092	25,893	20,774	0.88	23,282
4	15.0 - 15.9	15.3	21,194	34,847	28,966	1.13	25,316
7	16.0 - 16.9	16.6	24,510	47,035	34,672	1.34	25,887
4	17.0 - 17.9	17.5	30,117	54,778	41,969	1.64	25,517
3	18.0 - 18.9	18.3	42,861	57,415	49,854	2.09	24,108
9	19.0 - 19.9	19.4	48,634	116,641	78,759	2.32	34,441
1	20.0 - 20.9	20.1	64,400	64,400	64,400	2.66	24,210
1	21.0 - 21.9	21.5	152,110	152,110	152,110	3.92	38,803
2	22.0 - 22.9	22.2	86,395	92,520	89,457	4.16	21,688
0	23.0 - 23.9						
1	24.0 - 24.9	24.6	117,058	117,058	117,058	4.54	25,784

same as those given by Smith (1941) for the same area. Simon (1946) reported 50,000 eggs for a 3 pound sauger from Wyoming which is less than that found in fish of similar weight from Garrison Reservoir and tailrace. The number of eggs produced by North Dakota sauger for the following age classes was: age III - 13,168; IV - 25,932; V - 45,330; VI - 85,465; VII - 101,115. The weight of ovaries increased in proportion to the total length and weight of female sauger from Garrison Reservoir and tailrace. The number of eggs (total diameters) per lineal inch ranged from 15 to 21. Individual egg diameters ranged from 1.0 to 1.8 millimeters (0.04 - 0.07 inches).

Sex Ratios

A total of 1,466 sauger was used for sex determinations; 721 of these were from Garrison Reservoir and 745 from the tailrace. Sex was not determined for an additional 92 immature sauger. There were 1,047 (71 percent) females and 419 (29 percent) males. The sex ratio of male to female (age classes I - III) in Garrison Reservoir was 1:1.2 and the tailrace 1:2.3. The male to female sex ratio of sauger from both localities (age classes IV - VI) ranged from 1:4.0 to 1:22.0. Female sauger were more abundant than males in the older age classes.

In order to determine size distribution of male and female sauger, lengths were arranged in 1 inch intervals (Table 7). Male sauger from Garrison Reservoir had a range in total length of 6.7 to 18.6 inches and those from the tailrace 8.4 to 18.4 inches. Female sauger from Garrison Reservoir had a range in total length of 5.0 to 26.5 inches and those from

Table 7. Size frequency of male and female sauger (1,466) from Garrison Reservoir and tailrace, 1959 and 1960.

Total length in inches	Garrison Reservoir		Tailrace	
	Male	Female	Male	Female
5.0 - 5.9		3		
6.0 - 6.9	2	1		
7.0 - 7.4	1	1		
8.0 - 8.9	6	6	1	1
9.0 - 9.9	3	6	8	2
10.0 - 10.9	10	6	16	25
11.0 - 11.9	24	16	35	47
12.0 - 12.9	45	43	47	62
13.0 - 13.9	71	65	27	83
14.0 - 14.9	37	83	34	113
15.0 - 15.9	20	67	7	100
16.0 - 16.9	7	52	7	52
17.0 - 17.9	4	39		26
18.0 - 18.9	6	29	1	16
19.0 - 19.9		28		15
20.0 - 20.9		25		8
21.0 - 21.9		8		6
22.0 - 22.9		1		2
23.0 - 23.9				2
24.0 - 24.9		5		
25.0 - 25.9				1
26.0 - 26.9		1		1
Total	236	485	183	562

the tailrace 8.9 to 26.4 inches. No male sauger exceeded the 18 inch group and there were only 13 female sauger in the 22 inch group and larger.

The male sauger from Garrison Reservoir were most numerous in the 13.0 inch group while those from the tailrace were most numerous in the 12.0 inch group. The female sauger were most frequent in the 14.0 inch group in both Garrison Reservoir and tailrace.

Maturity

Maturity of sauger was determined by unaided visual examination of the gonads and in a few instances by histological study. The degree of maturity based upon gross examination was designated as follows: immature - gonads small and undeveloped, no eggs or sperm apparent; green - gonads well developed, eggs or sperm apparent, not loose in the gonads; ripe - gonads large, egg or sperm apparent, loose in gonads; spent - gonads flaccid with most eggs or sperm released.

A histological examination of the gonads from 13 sauger (5 males, 8 females) was made to ascertain their development. "Immature" males (2) had testes which were small with the lobules only partly filled with sperm. "Immature" females (4) all had developing ova in the ovaries. A "green" male had swollen testes and most of the lobules contained sperm while a "green" female had ovaries with eggs of nearly maximum diameters (1.0 - 1.3 millimeters). A "ripe" male had testes packed with sperm and the vessels in the dorsal groove were enlarged. A "ripe" female contained ovaries with eggs of maximum size (1.8 millimeters) and dialated trans-

verse blood vessels. Gonads of a "spent" male were recessed and had broken blood vessels as well as clumps of sperm. "Spent" females (2) had recessed ovaries with large amounts of vascular tissue and empty egg follicles.

During the spawning season (1960) the smallest mature male sauger (green and ripe) from Garrison Reservoir was 12.5 inches in total length while that from the tailrace was 10.6 inches. The smallest mature female from Garrison Reservoir was 14.0 inches in total length and that from the tailrace was 12.9 inches. Deason (1933) and Roach (1949) reported on Ohio sauger and found the smallest mature males were 9.0 inches and females 11.5 inches. Hart (1928) gave 14.0 inches as the smallest females for Manitoba sauger.

Ages were determined for sauger from Garrison Reservoir and the tailrace. Only 21 percent of the 3-year-old males and all older individuals were mature. Nineteen percent of the 3-year-old females, 63 percent of the 4-year-olds, and all older than 4 years were mature. Kennedy (1949) reported that the largest number of mature male sauger from Manitoba were 4 years old and the largest number of females were 5 years. Hassler (1958) found that most mature male and female sauger from Tennessee were 3 years old. Carlander (1950) reported that some mature female sauger from Minnesota were 4 years old.

The spawning season for sauger in Garrison Reservoir and the tailrace probably extends from late April to the end of June. In 1960, the first ripe male was observed May 2 and the last June 25. The first ripe female

was found May 15 and the last on June 11. The height of the spawning season was from May 8 to May 28. During the spawning season water temperatures ranged from 39° to 53° F.

Eschmeyer and Smith (1943) reported that sauger did not spawn when water temperatures were below 50° F. They also reported that eggs in ovaries were deformed when cold water temperatures maintained. This condition was not observed for sauger from Garrison Reservoir and the tailrace.

Taxonomic Considerations

During this investigation difficulty was encountered in separating some of the sauger and walleye. An effort was made to establish criteria for separating sauger and walleye and hybrids of these. A total of 564 sauger, 90 walleye, and 5 hybrids was studied for taxonomic differences and the following characteristics were observed: spotting on spinous dorsal fin; black blotch at base of last two dorsal fin spines; number of soft rays in second dorsal fin; spot at base of pectoral fin; white spot on lower part of caudal fin; area of cheek covered by scales; number of lateral line scales; number of pyloric caeca; number of dark saddles on back. The taxonomic characteristics used with some exceptions were those described by Bailey (1956).

The sauger characteristics of hybrids were: spot at base of pectoral fin; number of pyloric caeca; number of dark saddles on back. The walleye characteristics of hybrids were: spotting on spinous dorsal fin; black blotch at base of last dorsal fin spine; white spot on lower part of

caudal fin (Table 8). Other characters were not diagnostic for hybrids. Stroud (1948) reported that hybrids from Tennessee generally appear to have walleye-like heads and sauger-like bodies.

Hybrids from Garrison Reservoir and the tailrace grew at approximately the same rate as the sauger from the same area. Stroud (1948) reported the growth rate of hybrids to be intermediate between that of the parent species in Tennessee.

Summary

1. A study on the life history and taxonomy of sauger in Garrison Reservoir, its tributaries, and the tailrace was initiated during June, 1959 and continued to July, 1960.

2. Garrison Reservoir is a multiple-purpose impoundment on the mainstem of the Missouri River in North Dakota which, at maximum pool, has a length of approximately 200 miles, a shoreline of 1,600 miles, an area of 390,000 surface acres, and a storage capacity of 23,000,000 acre feet.

3. A total of 1,558 sauger was used in the study. These ranged in total length from 4.0 to 26.5 inches.

4. Age and growth determinations were made on 529 sauger.

5. Male and female sauger from Garrison Reservoir and the tailrace showed approximately equal growth at age classes I and II, but females were larger than males in age classes III and older.

6. The average calculated total length for sauger from Garrison Reservoir at annuli I - VI was 4.9, 8.8, 12.3, 15.5, 18.4, and 23.1 inches re-

Table 8. Taxonomic characteristics of 564 sauger, 90 walleye, and 5 sauger and walleye hybrids from Garrison Reservoir and tailrace, 1959 and 1960.

Diagnostic characteristics	Sauger	Walleye	Sauger and walleye hybrids
Spotting on spinous dorsal fin	2 or 3 rows of black spots	Some pigmentation on spines	Same as walleye
Black blotch at base of last two dorsal fin spines	Absent	Present	Black blotch at base of last dorsal fin spine
Number of soft rays in second dorsal fin	15 - 22	19 - 22	19 - 20
Spot at base of pectoral fin	Dark spot present	Light spot present	Dark spot present
White spot on lower part of caudal fin	Absent	Present	Present
Area of cheek covered by scales	Naked to fully scaled	Naked to 75 percent scaled	10 percent scaled
Number of lateral line scales	79 - 91	80 - 89	83 - 92
Number of pyloric caeca	4 - 6 unequal length	3 equal length	4 - 5 unequal length
Number of dark saddles on back	4	8	4

spectively, while those from the tailrace at annuli I - VIII were 4.8, 9.3, 11.3, 13.8, 16.2, 18.7, 20.8, and 25.6 inches respectively.

7. There was little difference in the coefficient of condition (C) between male and female sauger in both Garrison Reservoir and the tailrace.

8. The number of eggs estimated for 50 individuals ranged from 10,488 to 117,058.

9. Sex determinations made on 1,466 sauger showed that 71 percent were females and 29 percent males.

10. Only 21 percent of the males and 19 percent of the females were mature at 3 years while all males and 63 percent of the females were mature at 4 years.

11. The spawning season extended from May 8 to May 28 in 1960.

12. A total of 564 sauger, 90 walleye, and 5 hybrids was studied for taxonomic differences.

Literature Cited

Bailey, Reeve M. 1956. Revised list of the fishes of Iowa, with keys for identification. Iowa Fish and Fishing. Iowa Cons. Com.:327-377.

Bajkov, Alexander. 1930. Fishing industry and fisheries investigations in the prairie provinces. Trans. Am. Fish. Soc., 60: 215-237.

Carlander, Kenneth D. 1942. An investigation of Lake of the Woods, Minnesota, with particular reference to the commercial fisheries. Minn. Bur. Fish. Res. Invest. Rept. 42: 534 pp.

_____. 1950. Growth rate studies of saugers, Stizostedion

canadense canadense (Smith) and yellow perch, Perca flavescens (Mitchell) from Lake of the Woods, Minnesota. Trans. Am. Fish. Soc., 79 (1949): 30-42.

Deason, Hilary J. 1933. Preliminary report on the growth rate, dominance, and maturity of pike-perches (Stizostedion) of Lake Erie. Trans. Am. Fish. Soc., 63: 348-360.

Eschmeyer, Paul H. 1950. The life history of the walleye, Stizostedion vitreum vitreum (Mitchell) in Michigan. Mich. Dept. Cons., Bull. Inst. Fish. Res., 3: 1-99.

Eschmeyer, R. W. and Alden M. Jones. 1941. The growth of game fishes in Norris Reservoir during the first five years of impoundment. Trans. N. Am. Wildlife Conf., 6: 220-240.

Eschmeyer, R. W. and C. G. Smith. 1943. Fish spawning below Norris Dam. Jour. Tenn. Acad. Sci., 18 (1): 405.

Evermann, Barton S. and Ulysses O. Cox. 1896. Report upon the fishes of the Missouri River Basin. Rept. U. S. Fish. Comm. (1894): 325-429.

Girard, Charles. 1858. The fishes of the Pacific Railroad Surveys. Pacific Railroad Report. VI (4): 9-34; X: 1-400.

Hart, John L. 1928. Data on the rate of growth of pike perch (Stizostedion vitreum) and sauger (Stizostedion canadense) in Ontario. Univ. of Toronto Stud., Biol. Ser. 31, Publ. Ont. Fish. Res. Lab., 34: 45-55.

Hassler, William W. 1957. Age and growth of sauger, Stizostedion canadense canadense (Smith) in Norris Reservoir, Tennessee. Jour. Tenn. Acad. Sci., 32 (1): 55-76.

_____. 1958. The fecundity, sex ratio, maturity of sauger, Stizostedion canadense canadense (Smith) in Norris Reservoir, Tennessee. Jour. Tenn. Acad. Sci., 33 (1): 32-38.

Kennedy, W. A. 1949. Relationship of length, weight, and sexual maturity to age in three species of Lake Manitoba Fish. Can. Fish. Res. Bd. Bull. 81: 1-5.

Personius, Robert G. and Samuel Eddy. 1955. Fishes of the Little Missouri River. Copeia, 1955 (1): 41-43.

Roach, Lee. 1949. Sauger: Stizostedion canadense. Ohio Cons. Bull., 13 (2): 13.

Simon, James R. 1946. Wyoming fishes. Wyoming Game and Fish Department. Bull. 4: 129 pp.

Smith, C. G. 1941. Egg production of walleye pike and sauger. Norris Reservoir fish differ from some species in other localities. Prog. Fish-Cult., 54: 32-34.

Smith, S. H. 1954. Method of producing plastic impressions of fish scales without using heat. Prog. Fish-Cult., 16 (2): 75-78.

Stroud, Richard H. 1948. Notes on growth of hybrids between sauger and the walleye (Stizostedion canadense canadense X Stizostedion vitreum vitreum) in Norris Reservoir, Tennessee. Copeia, 1948 (4): 297-298.

_____. 1948. Rate of growth and condition of game and panfish in Cherokee and Douglas Reservoirs, Tennessee and Hiwassee Reservoir, North Carolina. Jour. Tenn. Acad. Sci., 24 (1): 60-74.