The Lake Winnebago sauger: age, growth, reproduction, food habits and early life history. Number 43 1969

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DEPARTMENT OF NATURAL RESOURCES
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THE LAKE WINNEBAGO SAUGER

Age, Growth, Reproduction, Food Habits and Early Life History

C. D. BESADNY

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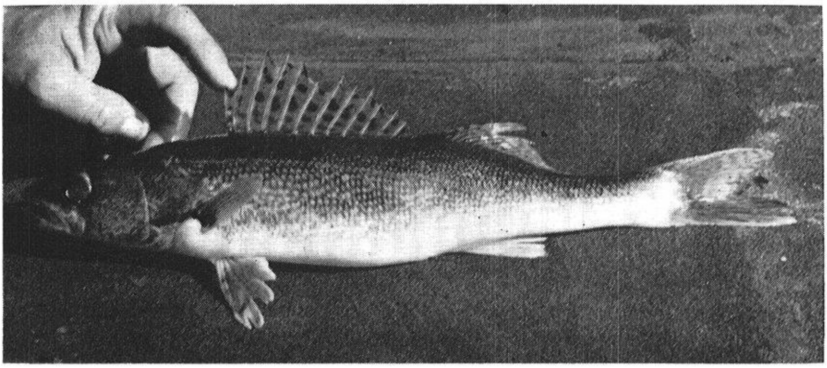

by

Gordon R. Priegel

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The author is a Fishery Biologist with the Department of Natural Resources, Madison, Wisconsin.

Edited by Ruth L. Hine

ABSTRACT

The abundant but little known sauger in Lake Winnebago was studied from 1957–1967 to obtain life history information.

Age and growth information is based on 1,824 saugers. A large range of length in each age group and resulting overlap of age groups makes length a poor index of age. Calculated lengths for male and female saugers are not significantly different beyond the second year. Both sexes of Lake Winnebago saugers made their greatest annual growth in length (4.9 inches for males and 5.3 inches for females) during the first year of life. The largest weight increments (0.23 pound for males and 0.22 pound for females) came in the third year. There was no significant difference in weight between the sexes. Only one fish surpassed 2 pounds and only 95 exceeded 1 pound.

Male saugers were mature at the end of the second year of life, and females at the end of the fourth year. Few saugers lived beyond 5 years in Lake Winnebago. The average number of eggs per ovary for saugers 10.1 to 14.6 inches in total length was 15,871 eggs.

Spawning was initiated at a water temperature of 43 F, which occurs in late April to early May, and occurred over a sand and gravel substrate along the north shore. The external characteristic used to distinguish between 1- to 3-inch walleyes and saugers of the same size was the abundance or lack of melanophores on the dorsal surface of the head.

Saugers less than 50 mm were considered plankton feeders; yearling and older saugers relied heavily on forage fish for food items. Troutperch were the preferred forage fish, although young and yearling freshwater drum were also a major food item.

Trawling with small mesh trawls provided reliable data for determining year class strength for young saugers. Year-class strength is usually set by late September or October.

Saugers in Lake Winnebago could support a greater harvest. The population is short-lived, very stable and can attain high levels.

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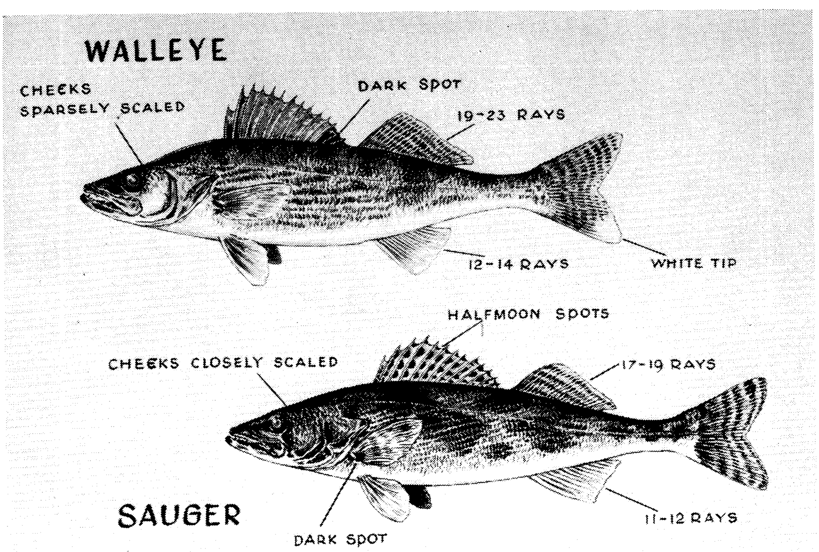
INTRODUCTION

The sauger, *Stizostedion canadense* (Smith), is most often found in somewhat silty rivers and large lakes (Hubbs and Lagler, 1949). In Lake Erie the sauger was more tolerant of a silted bottom and turbid waters than was the walleye, *Stizostedion vitreum vitreum* (Mitchill) according to Doan (1941). The largest Ohio River drainage populations occurred in the larger, deeper waters of rather low gradients, and the species was notably more tolerant of turbid waters and silted bottoms than the walleye (Trautman, 1957). According to Greene (1935), it was not very common in Wisconsin and he reported it only from the Mississippi River below Lake Pepin, and mentioned that the sauger had been reported in Lake Winnebago where it may be present as a result of introduction. Greene believed its scarcity in Wisconsin was partly due to the competition of its very common, near relative the walleye. Wagner (1908) reported that the sauger is a common fish in Lake Pepin and it is one of the few that is readily hooked, but is a rare occurrence in the nets.

In all probability, saugers are native to Lake Winnebago as there are no records which would indicate that they were ever stocked. Greene's work (1935) was based mainly on summer collections from 1925 through 1928 and although no saugers were taken while sampling Lake Winnebago, this species has provided a fabulous fishery during the winter since the early 1920's as noted from discussions with relia-



ble, long-term residents who know the difference between the sauger and walleye.

The sauger now is an abundant and important game fish species in Lake Winnebago (Priegel, 1967a). The majority of saugers are caught through the ice and this species usually comprises over half of the ice fisherman's catch. On Saturday, January 28, 1961, a partial creel census on Lake Winnebago showed that the 2,813 anglers checked had taken 3,998 sauger, which was 74.8 percent of all fish taken.

Although the sauger is abundant in Lake Winnebago, very limited information is available on it. The general objective of this study was to provide information on the sauger's life history which is needed for a better understanding of the ecological role of this species in Lake Winnebago. This study is concerned with its age, rate of growth, reproduction, early life history and food habits. Data reported here were accumulated from 1957 to 1967.

Although the sauger has a wide distribution and is an important game fish, life history research has been limited. Nelson (1968a) reported on reproduction and early life history in Lewis and Clark Lake, South Dakota. The influence of certain environmental factors on growth of Norris Reservoir, Tennessee, sauger was reported by Hassler (1956). Fish (1932) described larval saugers but this work was based on three specimens. Age and growth of saugers were reported by Vanicek (1964) for Lewis and Clark Lake; Carlander (1950) for Lake of the Woods, Minnesota; Deason (1933) for Lake Erie; Hassler (1957) for Norris Reservoir; Carufel (1963) for Garrison Reservoir, North Dakota; Stroud (1949) for Cherokee and Douglas Reservoir, Tennessee; Roach (1949) for saugers from Ohio; Hart (1928) for Lake Nipigon, Ontario; and Christenson and Smith (1965) for the Upper Mississippi River.

DESCRIPTION OF STUDY AREA

Lake Winnebago is a very large (137,798 acres), shallow, eutrophic lake in east central Wisconsin (Fig. 1). This roughly rectangular-shaped lake, 28 miles long and 10.5 miles wide at its widest point, has a maximum depth of 21 feet and an average depth of 15.5 feet (Wirth, 1959). Two big river systems enter Lake Winnebago: the 107-mile-long Fox River and the 216-mile-long Wolf River which joins the Fox River 10 miles above Lake Winnebago and enters the lake at Oshkosh as the Fox River. The Fox River also flows out of Lake Winnebago at Neenah and Menasha and flows 39 river miles north to Green Bay, Lake Michigan. The runoff water from 6,000 square miles enters Lake Winnebago.

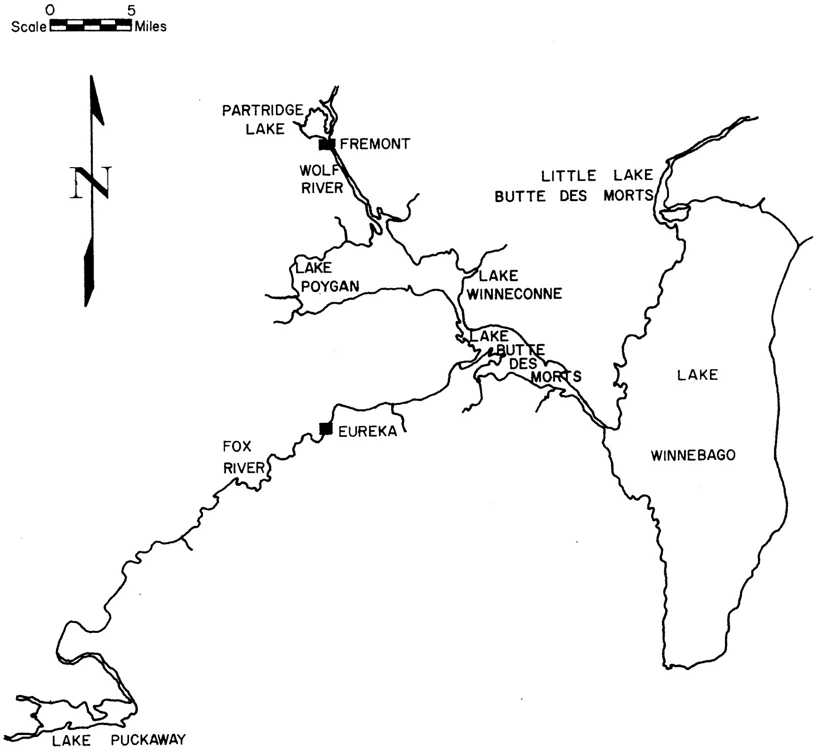


Figure 1. Lake Winnebago and connecting water areas involved in the study.

The bottom of Lake Winnebago is an extensive plain broken only by reefs on the west shore. Except for these reefs and the rock, gravel and sand shorelines and shoals of the lake, the bottom is finely divided, soft mud mixed with peat in the vicinity of the river mouth. Rooted aquatic plants are not abundant in the lake and occur only in rather localized areas.

Water samples were collected from the lake proper on August 9, 1966 and through the ice on March 21, 1967. Analysis showed Lake Winnebago to be a fertile lake (Table 1). The water is hard with a methyl-orange alkalinity of 119–124 ppm and has an alkaline pH varying from 7.7 to 8.5. Dissolved phosphates (PO_4-D) are such that heavy algal growth might be stimulated. Heavy algae blooms are common during the summer months.

Lake Winnebago has a rich fauna of fishes. Seventy-six species belonging to 22 families are now present or have been reported in the past (Priegel, 1967a).

TABLE 1

Water Analysis Data for Lake Winnebago, 1966–67

Measurement*	August 9, 1966	March 21, 1967
PH	8.5	7.7
Total alkalinity	124	119
Cl^-	6.8	6.9
NH_4—N	—	0.19
NO_3—N	—	0.39
PO_4(D)	0.13	0.03
PO_4(T)	0.41	0.09
Ca^{++}	38.42	26.80
Mg^{++}	16.71	15.20
Na^+	4.55	5.10
K^+	2.05	1.97

*Units are ppm with the exception of pH.

METHODS AND MATERIALS

Age and Growth

Age and growth information is based on data from 1,824 sauger collected in Lake Winnebago. During January and February, 1960, a sample of 572 saugers was obtained from anglers. Trap nets fished during September and October, 1961 and April, 1963 accounted for 591 saugers in the collection. These nets, set throughout the open-water period for the commercial removal of the freshwater drum, *Aplodinotus grunniens* (Rafinesque), have stretch mesh sizes of 2½ inches in the crib and 6 inches in the lead. Trawls fished by state commercial fishing crews in September and October, 1961 provided 469 saugers. The trawls had a headrope length of 30 feet and stretch mesh sizes of 4 to 5 inches in the wings and body and 2½ inches in the cod end. Small experimental otter trawls with a headrope length of 12 feet and stretch mesh sizes of 1½ inches in the wings and body with a nylon bobbinet liner in the cod end were used to collect 110 adult sauger during September and October, 1961 and 82 young-of-the-year sauger during the open-water season, 1959–1962.

The length measurements of adult saugers were made on fresh specimens. The total and standard lengths were measured to the nearest millimeter on a standard measuring board. Since there was a marked difference in the ratio of standard length to total length, conversion factors were determined (Table 2). The length measurements of young-of-the-year saugers were made on preserved specimens (10% formalin). The weight of most adult fish was determined to the nearest 0.01 pound, while no young-of-the-year fish were weighed.

TABLE 2

Factors for Conversion Between Total (T.L.) and Standard (S.L.) Lengths of Lake Winnebago Sauger, With and Without Change of Units

Length Intervals (inches)	No. of Fish	T.L. to S.L. (No Change in Units)	S.L. to T.L. (No Change in Units)	T.L. (inches) to S.L. (mm)	S.L. (mm) to T.L. (inches)
2.0– 7.9	83	0.81	1.24	20.49	0.05
8.0– 8.9	18	0.81	1.24	20.58	0.05
9.0– 9.9	149	0.82	1.22	20.74	0.05
10.0–10.9	193	0.82	1.22	20.76	0.05
11.0–11.9	229	0.82	1.22	20.87	0.05
12.0–12.9	287	0.83	1.21	21.04	0.05
13.0–13.9	491	0.83	1.20	21.04	0.05
14.0–14.9	186	0.83	1.20	21.11	0.05
15.0–15.9	117	0.83	1.20	21.10	0.05
16.0–16.9	43	0.84	1.19	21.22	0.05
17.0–17.9	13	0.84	1.19	21.39	0.05
18.0–18.9	2	0.85	1.18	21.44	0.05

For purposes of compilation and analysis, conversions were made to inches and grams as desired. All fish, for which lengths and weights were recorded (1,501 fish), were used in the study of the length-weight relation.

Scales were taken from above the lateral line on the left side and came from the intersection of the third row above the lateral line and the first scale row anterior to the first dorsal spine. The scales were impressed on cellulose acetate slides, 0.03 inch thick, by a roller press similar to that described by Smith (1954). Butler and Smith (1953) demonstrated that this method of preparation does not affect the measurements of scales. The examination and measurements of scales were made by means of a microprojector at the magnification X43. The length of each scale and the distance from the focus to each annulus were measured along the anterior radius most nearly collinear with the focus as described by Hile (1954) and were recorded to the nearest millimeter on the back of scale envelopes.

Age Analysis

Use of the scale method to determine the age of the Lake Winnebago sauger is justified by the following observations:

1. Fish known to be young-of-the-year had no annuli on the scales.
2. The number of annuli increased with the size of the fish.
3. Lengths at the end of various years of life calculated from scale measurements agree well with the corresponding lengths of younger age groups whose ages were determined by scale examination.

Deason's (1933) study of the Lake Erie pike-perches showed that the scale method was applicable to all three species of *Stizostedion.*

Sex Determination

Sex and state of maturity were determined for all fish except the 82 young-of-the-year. Determination of sex in adult, mature saugers is easy as the testes have a whitish-gray appearance, and the ovaries are yellowish with readily visible eggs. Size and shape of gonads, blood vessels on gonads, and color of gonads were the characteristics used to sex immature saugers. These characteristics are similar to the ones used by Eschmeyer (1950) to sex immature walleyes. In fish of comparable size, the gonads are distinctly wider in the female. The testis tapers toward the apical and over a considerable portion of its total length, while the region of tapering is much shorter in the ovary. Ordinarily, at least one of the ovaries tends to be translucent. The dorsal blood vessel of the testis lies in a groove; that of the ovary on the surface. Veins are usually visible passing across the ovary, while this cross-venation is not present on the testis.

Fecundity

Estimates of the number of eggs in 192 sauger ovaries collected in April, 1963 were made by the gravimetric or dry-weight method. The ovaries from these saugers were preserved in 10 percent formalin. The preserved weight of each ovary being air dried was determined just prior to sampling. Two transverse sections were made at random through an ovary. The two sections were weighed and the number of eggs within each section was determined by actual count. The total number of eggs per fish was estimated on a proportional basis for each section and the average of the two total counts was expressed.

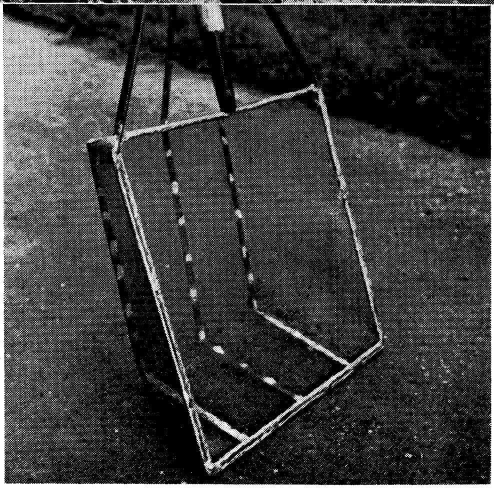
Food Studies

A monthly sample from June through October of 100 to 200 yearling and older saugers was intended, but sample size varied from 52 to 213 saugers and did not permit a monthly breakdown. The saugers were obtained from trawls commercially fished by the state and usually represented the entire day's catch. The total sample consisted of 2,093 sauger (848 in 1965, 651 in 1966 and 594 in 1967). Of these, 986 (47.1%) had empty stomachs.

A 12-foot bait trawl made entirely of 1½-inch stretch mesh with a ¼-inch bobbin web liner in the cod end was used in 1965 to collect 139 yearling saugers representing a strong 1964 year class. Thirty-four (24.5%) of these yearlings had empty stomachs.

The 12-foot bait trawl was also used to collect young-of-the-year saugers from June through October, 1964–67. A total sample of 591

Dipping for sauger eggs.



young-of-the-year was obtained (216 in 1964, 132 in 1965, 212 in 1966 and 31 in 1967), of which 108 (18.3%) had empty stomachs.

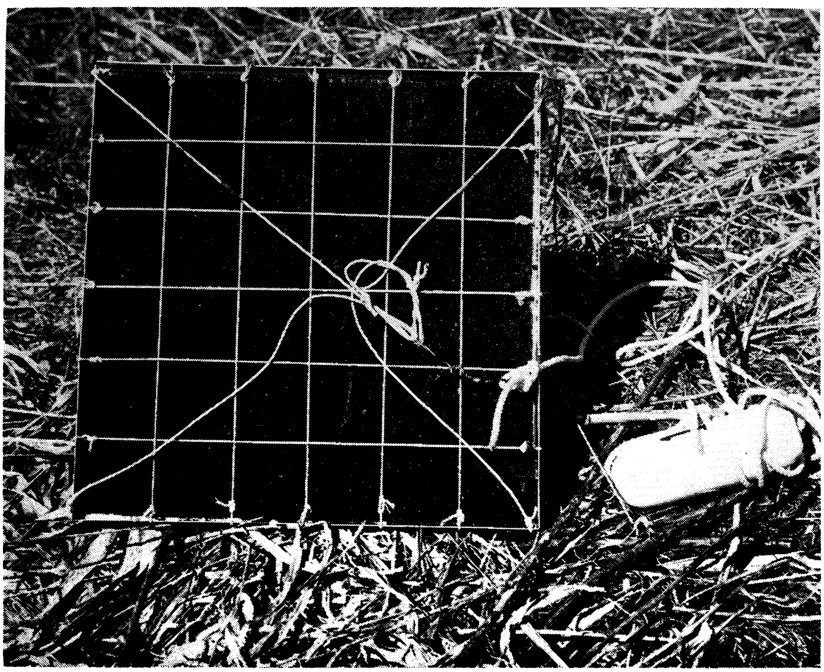
Quantitative determinations consisted of counting each individual food item (whole organisms and fragments) for each fish. Volumetric measurements of whole organisms and fragments of each kind of food in yearling and older sauger were made by water displacement in a 0.1 ml graduated cylinder. Miscellaneous plant remains and items that were assumed taken incidental to feeding (sand, pebbles and wood material) were not recorded. Percentages are based on the number of stomachs containing food.

The food items in the sauger stomachs are expressed as percentage of total volume (where volumes were determined) and as percentage frequency of occurrence. The mean number of organisms found in young-of-the-year stomachs is expressed. The young-of-the-year were analyzed by length groups (12–50 mm, 51–75 mm, and 76–150 mm).

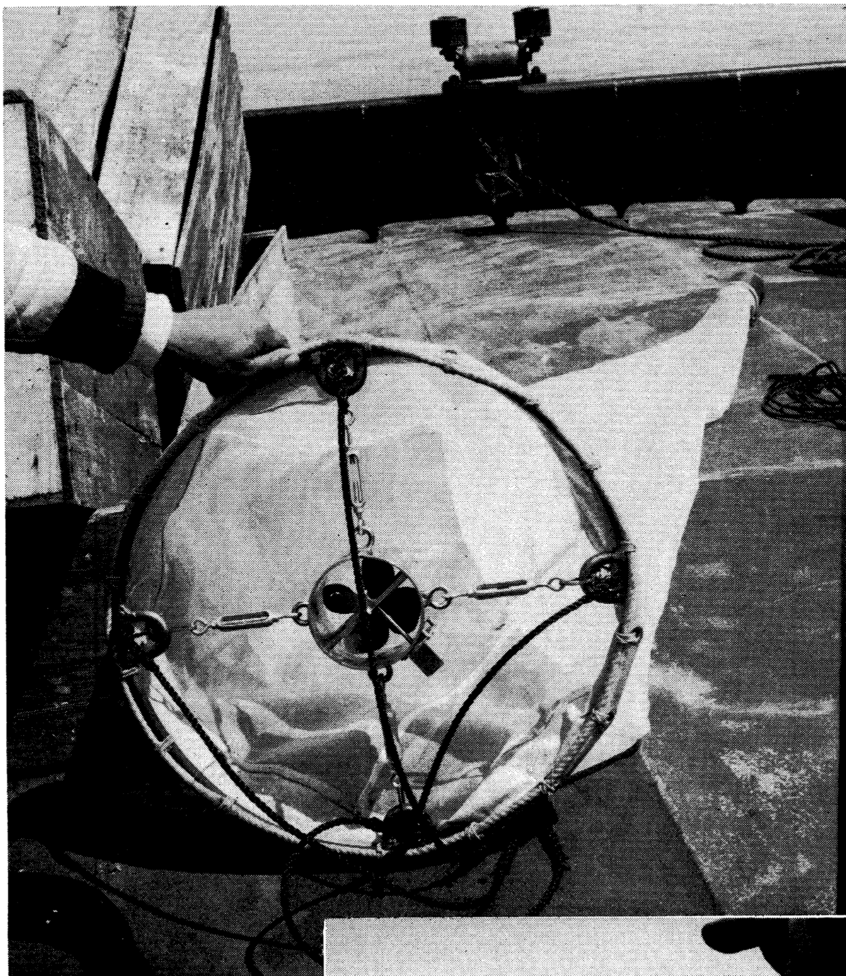
Reproduction

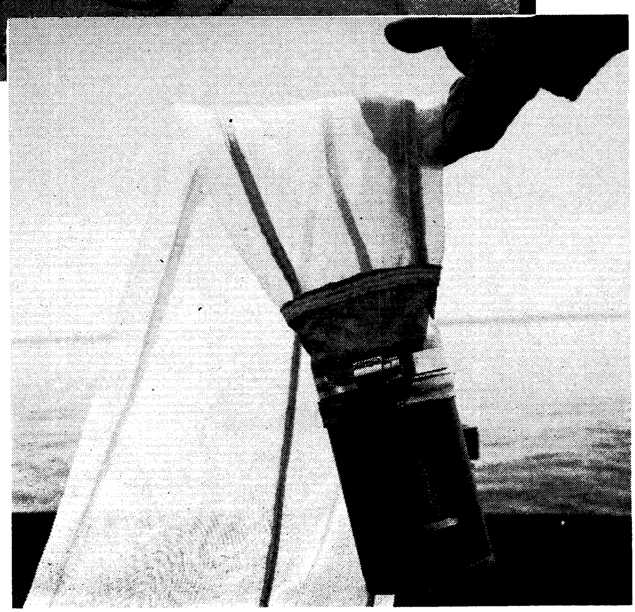
Spawning sauger were sampled with trap nets and 12-foot bait trawls. Water temperature before and during the spawning period was recorded on a 30-day Ryan thermograph. A screened basket, with 21 meshes per lineal inch, was used to collect eggs at various stages of development.

In 1965 and 1966, fertilized sauger eggs were placed on 1-foot-square rubberized horse-hair or nylon fiber mats supported in aluminum or galvanized steel racks. These mats were placed in various locations in the lake to facilitate observations of development. In 1966, one mat with fertilized eggs was suspended in a stainless steel screen basket (36 inches in diameter and 40 inches in depth) to follow egg development.



Egg mat used to follow sauger egg development.





One-meter fry net with flow meter (above), and zooplankton bucket (below).

Eggs from ripe females taken in trap nets, 1965–67, were fertilized and transported to the Wild Rose Fish Hatchery for hatching. After hatching, the fry were placed in a 75-gallon aquarium or a muslin basket (36 inches in diameter and 40 inches in depth) to follow development of the fry for taxonomic studies.

Fry Sampling

A meter net constructed of No. 20 grit gauze (19 meshes per lineal inch) was pulled behind a 16-foot boat to capture sauger frv during May and June, 1965–67.

Plankton Sampling

Zooplankton samples were collected periodically during the sauger sampling periods in 1965–67. Horizontal tows at depths ranging from the surface to 18 feet were made with a Clarke–Bumpus plankton sampler. Plankton hauls were of 5-minute duration at a constant boat speed of approximately 3 miles per hour. In all sampling, a #2 plankton net was used on the sampler. Number 2 netting does not efficiently sample phytoplankton and some of the smaller zooplankters, especially copepod nauplii; however, in this study young saugers were not observed to have fed upon either phytoplankton or nauplii.

DISTRIBUTION IN WISCONSIN

The present distribution of saugers in Wisconsin was determined incidental to fisheries surveys conducted by Fish Management Bureau personnel. This information was assembled through written communication with district fish managers and biologists in 1968.

In Wisconsin the sauger occurs in both the Lake Michigan and Mississippi River drainage basins but not in the Lake Superior drainage (Fig. 2).

In the Lake Michigan drainage the sauger is very abundant in Lake Winnebago. It is occasionally taken in the three upriver lakes of Poygan, Winnecone and Big Lake Butte des Morts, which are widenings of the Fox and Wolf Rivers. In the Upper Fox River, saugers have been taken as far upstream as the Eureka Dam. The species is also present in Little Lake Butte des Morts, the Lower Fox River and Green Bay.

In the Mississippi River drainage the sauger is common in the Mississippi River itself and is found in the following tributaries: St. Croix River upstream to the dam at St. Croix Falls, Kinnickinnic River from River Falls dam downstream to the St. Croix River, Chippewa River upstream to the dam at Eau Claire, Eau Claire River to the

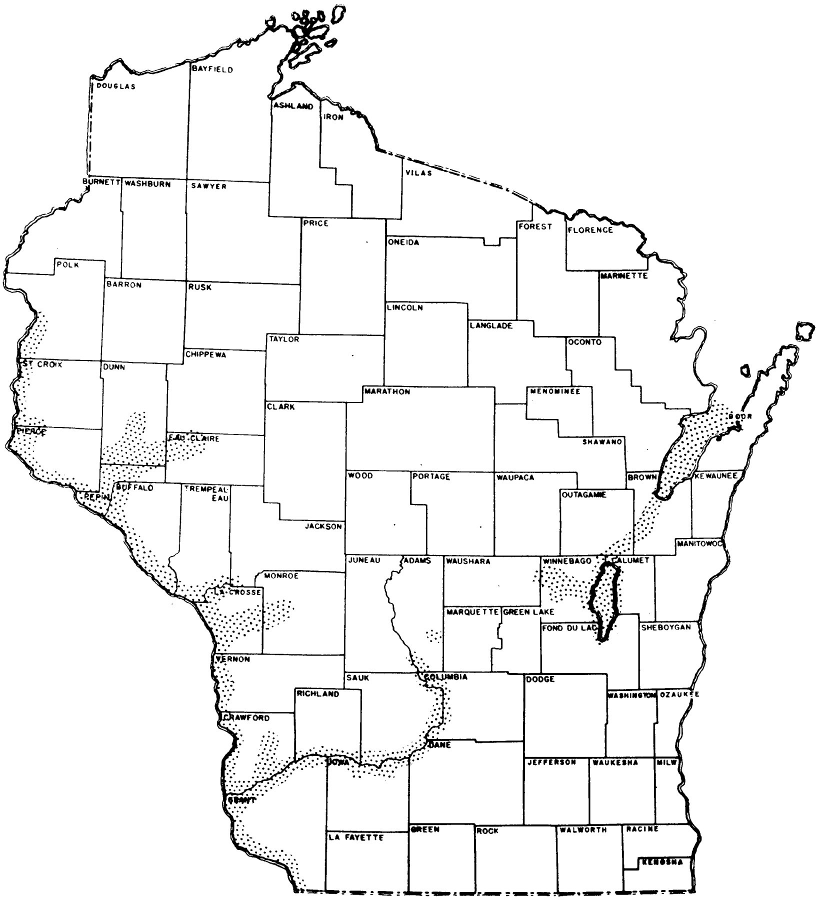


Figure 2. The present distribution of the sauger in Wisconsin.

dam at Lake Altoona, Eau Galle River to the Eau Galle dam, Red Cedar River to the dam at Menomonie, Black River upstream to the Jackson County line, LaCrosse River to the dam at Lake Neshonoc and the lower reaches of the Bad Axe River. Saugers are also found in the Wisconsin River into lower Adams County and in lower reaches of two tributaries, Otter Creek and the Kickapoo River. Two saugers were reported from Jordan Lake, Adams County in 1958 (C. L. Cline, pers. comm.).

AGE AND GROWTH

The precise time of annulus formation of Lake Winnebago saugers was not established. No fish obtained during April had formed a new annulus. Annulus formation probably occurs in mid-May. Hassler (1957) stated that an annulus is not laid down until midspring on saugers from Norris Reservoir, Tennessee.

Body–Scale Relationship

The body-scale relationship was determined from the measurement of 1,824 saugers which were grouped into 0.5-inch groups from 2.3 to 17.8 inches. The mean body length for each group was plotted against the corresponding mean length of the anterior scale radii (Fig. 3) and the relationship may be expressed as:

$$L = 1.078 + 3.204\ (R)$$

where L = total length of fish (inches); and R = anterior scale radius × 43. The body-scale relationship was linear.

The calculations of length at each annulus were made from measurements of the anterior radius applied in the equation:

$$L_1 = C + \frac{S_1}{S}\ (L - C)$$

where L_1 is the length of the fish at the time of each annulus formation; L is the total length of the fish at time of capture; C is the length of the fish at the time of scale formation; S_1 is the length of the anterior radius of the scale at each annulus; and S is the length of the anterior radius at capture.

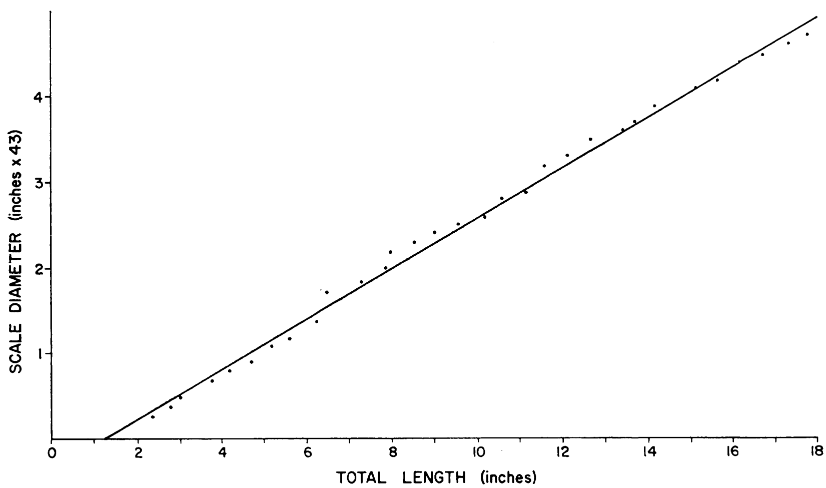


Figure 3. Relation between total length of fish and magnified (x43) scale diameter for sauger from Lake Winnebago. The dots represent the empirical data; the line is a graph of the equation given in the text.

TABLE 3

Length–Weight Relationship of Lake Winnebago Sauger

Total Length Interval (inches)	No. of Fish	Avg. Total Length (inches)	Avg. Standard Length (mm)	Empirical Weight (g)	Calculated Weight (g)	Empirical Weight (lb.)	Calculated Weight (lb.)
8.0– 8.4	7	8.3	169	63	60	0.14	0.13
8.5– 8.9	11	8.8	181	68	68	0.15	0.15
9.0– 9.4	71	9.3	191	77	83	0.17	0.18
9.5– 9.9	78	9.7	202	96	100	0.21	0.22
10.0–10.4	92	10.2	214	109	117	0.24	0.26
10.5–10.9	72	10.7	224	132	136	0.29	0.30
11.0–11.4	57	11.2	234	168	159	0.37	0.35
11.5–11.9	69	11.7	245	190	182	0.42	0.40
12.0–12.4	93	12.3	257	213	209	0.47	0.46
12.5–12.9	138	12.8	268	245	236	0.54	0.52
13.0–13.4	260	13.2	283	272	282	0.60	0.62
13.5–13.9	205	13.7	289	295	300	0.65	0.66
14.0–14.4	108	14.2	299	327	336	0.72	0.74
14.5–14.9	67	14.7	311	376	381	0.83	0.84
15.0–15.4	62	15.3	322	422	414	0.93	0.91
15.5–15.9	55	15.8	333	477	470	1.05	1.03
16.0–16.4	25	16.2	343	504	514	1.11	1.13
16.5–16.9	16	16.7	354	586	569	1.29	1.25
17.0–17.4	9	17.2	366	622	632	1.37	1.39
17.5–17.9	4	17.6	377	708	720	1.56	1.59
18.0–18.4	2	18.1	388	744	760	1.64	1.67

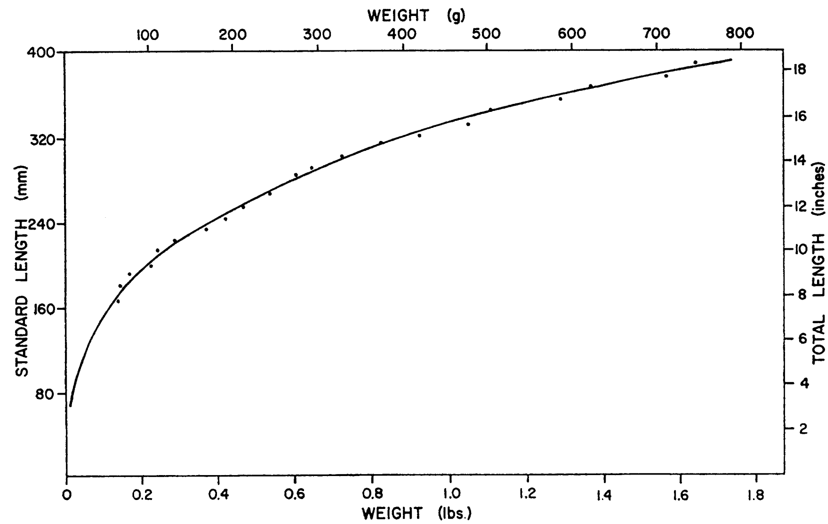


Figure 4. Length–weight relation of sauger from Lake Winnebago. The curve represents the calculated weights and the dots the empirical weights.

Length–Weight Relationship

The general length-weight relationship was calculated from a combined sample of 572 saugers collected in January–February, 1960 and 929 saugers collected in September–October, 1961. They ranged in total length from 8.2 to 18.1 inches. Average lengths for 0.5-inch intervals are shown in Table 3. The length-weight equation for the 1,501 saugers was: $\text{Log } W = -2.5091 + 3.1309 \text{ Log } L$, where (L) represents total length in inches and (W) weight in pounds (Fig. 4). Differences between empirical and calculated weights were generally small with greatest disagreement among the upper length intervals (16.5 — 18.4 inches) which were represented by few specimens.

Length Distribution of the Age Groups

The length distribution of the age groups of sauger from Lake Winnebago (Table 4) is based on length at capture during the late fall or winter (presumably after completion of the season's growth) and in the spring (prior to the onset of new growth). No fish from age group I were taken in our samples.

The length distribution of age group II for male and female sauger was completely overlapped by age group III. Age group III was comprised of a fast-growing 1958 year class and a strong, slow-growing 1959 year class, which is most likely the reason for this overlap. Distributions of males for age groups IV, V, VI, VII, and VIII overlapped from 2.0 to 6.0 inches while the female sauger in these age groups overlapped from 1.5 to 5.5 inches. Length is definitely a poor index of age for sauger in Lake Winnebago.

Calculated Growth in Length

The estimates of general growth in length at the bottom of Table 5 were derived by two methods. One estimate is based on the grand average calculated lengths and the other on the summation of the grand average increments of calculated length. The two methods did not give similar results for males and females. The summations of the average increments were chosen for the preparation of Figure 5, because they avoid the irregularities caused by successive dropping out of age groups and this curve should represent the average growth that saugers might have if the population was not subjected to the selective elimination of individuals with the more rapid growth.

The calculated lengths of the sexes, based on the summation of the grand average increments of calculated length, showed a 0.4-inch advantage for the females at the end of the first year of life (4.9 to 5.3 inches). Female saugers were 0.4 inches longer than males at the end of the second year of life (9.5 and 9.9 inches); this advantage decreased to 0.1 inch at the end of the third year of life and remained

TABLE 4

Length Distribution of the Age Groups of Sauger from Lake Winnebago

Length (T.L.) Intervals (inches)	Age Group and Sex													
	II		III		IV		V		VI		VII		VIII	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
8.0– 8.4			3	4										
8.5– 8.9			5	6										
9.0– 9.4			40	26	1									
9.5– 9.9			37	40	2	2								
10.0–10.4	2	2	40	48		7								
10.5–10.9	9	2	21	45		23								
11.0–11.4	20	11	9	11	2	52		7						
11.5–11.9	10	10	8	2	19	62	2	4						
12.0–12.4	3	2	27	5	40	39	5	10						
12.5–12.9			48	26	27	34	7	15						
13.0–13.4			82	51	43	40	28	27	2					
13.5–13.9			29	59	27	40	33	22	1	2				
14.0–14.4			6	18	7	35	28	22		1				
14.5–14.9			1	6	3	15	11	17	8	3	2	2		
15.0–15.4					2	9	8	7	10	8	15	1	1	
15.5–15.9						10	3	1	10	7	9	8	7	
16.0–16.4						1		2	2	5	8	3	3	1
16.5–16.9							1	2	1	5	3	2	2	1
17.0–17.4										4		4		1
17.5–17.9								1		1		2		
18.0–18.4								1						1
Number of fish	44	27	356	347	173	369	126	138	34	36	37	22	13	4
Average length (T.L.)	11.3	11.4	11.7	10.4	12.8	12.6	13.8	13.7	15.2	15.8	15.7	16.2	16.1	16.9

TABLE 5

Calculated Total Length at End of Each Year of Life and Average Growth of Sauger for the Combined Age Groups

Age Group	Sex	No. Fish	Total Length at End of Year (in Inches) 1	2	3	4	5	6	7	8
II	Male	44	5.2	11.4						
	Female	27	4.9	11.6						
III	Male	356	5.1	9.2	11.8					
	Female	347	5.4	9.2	11.7					
IV	Male	173	4.5	9.5	12.0	12.9				
	Female	378	5.3	9.6	11.6	12.7				
V	Male	126	4.5	9.2	11.7	13.2	14.0			
	Female	138	4.9	9.4	11.8	13.0	13.8			
VI	Male	34	5.2	10.2	12.8	13.5	14.4	15.4		
	Female	42	5.6	10.3	12.4	13.6	14.4	15.2		
VII	Male	37	4.8	10.2	12.8	13.7	14.5	15.3	15.8	
	Female	22	4.7	10.4	12.9	14.1	15.1	15.9	16.4	
VVVI	Male	14	5.0	10.4	12.6	13.4	14.4	15.1	15.7	16.2
	Female	3	5.3	10.4	13.1	14.4	15.2	16.0	16.7	17.1
Grand average calculated length	Male		4.9	9.5	11.9	13.1	14.2	15.3	15.8	16.2
	Female		5.3	9.5	11.7	12.8	14.1	15.5	16.4	17.1
Grand average increment of length	Male		4.9	4.6	2.6	1.1	0.8	0.8	0.5	0.5
	Female		5.3	4.6	2.3	1.1	0.8	0.8	0.5	0.4
Sum of average increment	Male		4.9	9.5	12.1	13.2	14.0	14.8	15.3	15.8
	Female		5.3	9.9	12.2	13.3	14.1	14.9	15.4	15.8
Equivalent standard length (mm)	Male		101	198	252	276	292	310	322	333
	Female		108	205	256	279	297	314	324	333

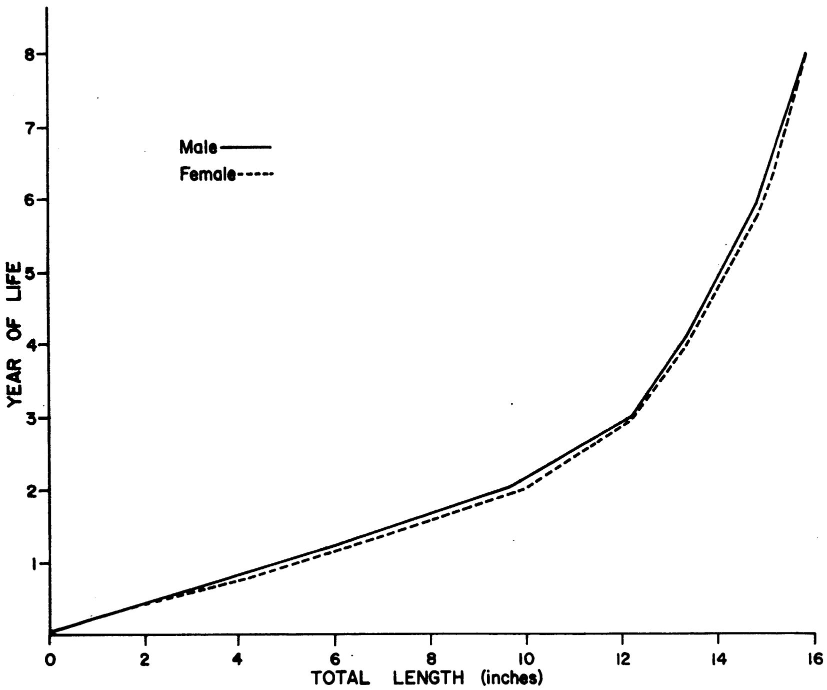


Figure 5. General growth in length of male and female sauger from Lake Winnebago.

at 0.1 inch through the seventh year of life. The calculated lengths of the sexes were the same at the end of the eighth year of life (15.8 inches).

In other waters there is a noticeable increase in growth of females over males. In Garrison Reservoir, North Dakota, male and female saugers showed approximately equal rates of growth during the first two years, but females were larger than males in later years (Carufel, 1963). In Lake of the Woods, Minnesota (Carlander, 1950) and Lake Erie (Deason, 1933), female saugers did not grow more rapidly than males until after three years of life. In Norris Reservoir (Hassler, 1957), female saugers grew faster than males after the first year.

Both sexes of Lake Winnebago saugers made their greatest annual growth in length (4.9 inches for males and 5.3 inches for females) during the first year of life. Beyond the first year the increments decreased from 4.6 inches (male and female) in the second year to 0.5 inch for males in the seventh and eighth years and 0.4 inch for females in the eighth year.

Calculated Growth in Weight

The calculated growth in weight of Lake Winnebago saugers was

TABLE 6

Calculated Growth in Weight of Sauger from Lake Winnebago

Year of Life	Male		Female	
	Calculated Weight (lb.)	Increment	Calculated Weight (lb.)	Increment
1	0.02	0.02	0.03	0.03
2	0.20	0.18	0.23	0.20
3	0.43	0.23	0.45	0.22
4	0.57	0.14	0.59	0.14
5	0.69	0.12	0.72	0.13
6	0.82	0.13	0.86	0.14
7	0.93	0.11	0.95	0.11
8	1.03	0.10	1.03	0.08

determined by applying the length-weight equation given previously to the calculated lengths at the end of each year of life (Table 6 and Fig. 6).

At the end of the first year, the weight of females (0.03 pound) exceeded that of males (0.02 pound) by only 0.01 pound. The greatest difference in weight was noticed in the sixth year with females weighing 0.86 pound and males 0.82 pound. At the end of the eighth year, males and females weighed the same (1.03 pounds).

Both sexes had their best growth in weight during the third year (0.23 pound for males and 0.22 pound for females) despite the fact

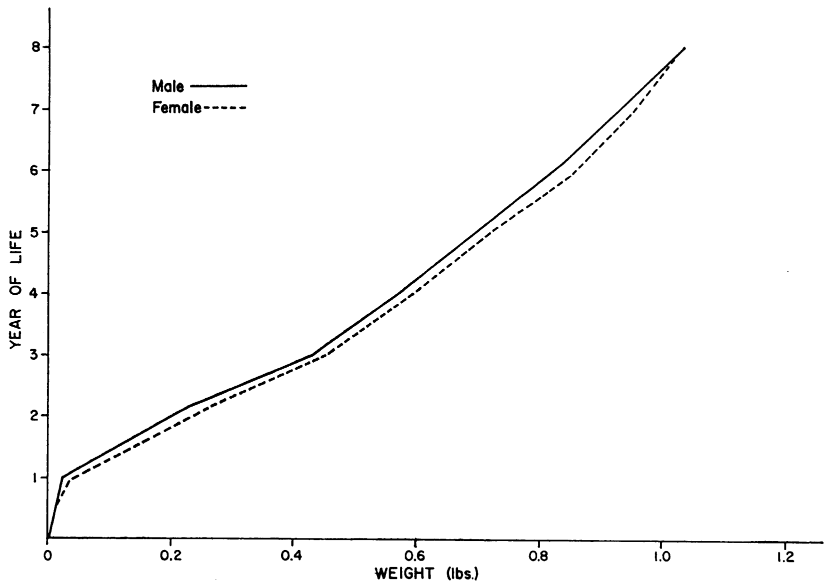


Figure 6. General growth in weight of male and female sauger from Lake Winnebago.

that the greatest annual increments of length were attained during the first and second years. Annual weight increments for male sauger declined to 0.14 pound in the fourth year and 0.10 pound in the eighth year; increments for females fell within the limits of 0.11 and 0.14 pound in the fourth through seventh years of life and decreased to 0.08 pound in the eighth year.

Growth in Other Waters

A comparison of the growth in length of Lake Winnebago saugers with their growth in other localities in the United States and Canada are listed in Table 7. Data on growth rates of the sauger throughout its range are lacking, and there are no growth rate data for Wisconsin except for backwater areas of the Upper Mississippi River (Christenson and Smith, 1965), where growth is similar to the Lake Winnebago sauger.

The Lake Winnebago sauger is a faster-growing fish than the sauger found in Lake of the Woods, Minnesota, Lake Nipigon, Canada, and Lake Erie during the first five years. Growth in the Lake Winnebago sauger is greater during the first three years than the sauger in Garrison Reservoir, North Dakota; but, older fish in Garrison Reservoir showed greater growth rates. The sauger in Norris Reservoir, Tennessee, exhibited a faster rate of growth. The greatest rate of growth was attained in Louis and Clark Lake, South Dakota, by sauger which reached 21.2 inches at the end of six growing seasons. An earlier spawning season, longer growing season, and abundant food supply are factors most likely responsible for rapid growth in the Tennessee storage reservoirs.

Hassler (1957) reasoned that slow rate of growth of the sauger in northern regions appears to be associated with increased longevity. Hart (1928) reported that saugers attained an age of 13 years in Lake Nipigon, while the maximum age recorded for Norris Reservoir sauger was 7 years. Lack of forage fishes during some years, shorter growing season, and competition from other fish species (burbot, walleye and yellow perch) in Lake Winnebago are probably the limiting factors accounting for the slower growth rates in the Lake Winnebago sauger.

Records of Large Saugers

Altogether 1,824 sauger were examined; only one surpassed 2 pounds. This fish, a 5-year-old female, weighed 2.1 pounds and was 18.1 inches in total length. This was also the longest fish in our sample. Of the 958 known female saugers, only 19 (1.9%) exceeded 1.5 pounds and 57 (5.9%) exceeded 1.0 pound.

The heaviest male sauger weighed 1.4 pounds. It was 7 years old and measured 16.5 inches in total length. Of the 784 known males in the sample, only 38 (4.8%) exceeded 1.0 pound.

TABLE 7

Calculated Growth of Saugers Reported from Various Waters

Locality	Number of Fish	Average Calculated Total Length at End of Year (in Inches)												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Lake Winnebago (present study)	784 (males)	4.9	9.5	12.1	13.2	14.0	14.8	15.3	15.8					
	957 (females)	5.3	9.9	12.2	13.3	14.1	14.9	15.4	15.8					
Garrison Reservoir, North Dakota (Carufel, 1963)	96 (males)	4.8	8.5	11.5	14.1	17.6								
	222 (females)	5.0	8.8	12.5	15.7	18.4	23.1							
Norris Reservoir, Tennessee (Hassler, 1957)	3,393	8.4	13.3	15.6	17.2	18.6	19.6	20.3						
Cherokee Reservoir, Tennessee (Stroud, 1949)	64	9.3	14.7	17.4										
Ohio (Roach, 1949)	-----	3.5	7.5	10.5	12.8	14.1								
Douglas Reservoir, Tennessee (Stroud, 1949)	39	9.9	15.6											
Lake Erie (Deason, 1933)*	905	3.9	7.9	10.4	12.2	13.6	15.8							
Lake of the Woods, Minnesota (Carlander, 1950)*	883	6.6	7.7	10.4	12.5	13.7	14.2	15.1	15.5	16.7	15.7			
Lake Nipigon (Hart, 1928)*	-----			9.4	10.4	12.3	12.5	13.1	14.5	15.4	13.7	15.1	16.5	16.5
Upper Mississippi River backwater areas (Christenson & Smith, 1965)	42	4.9	9.0	11.9	13.6									
Lewis and Clark Lake, South Dakota (Vanicek, 1964)	479	6.3	12.3	16.3	19.0	20.5	21.2							

*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).

In Norris Reservoir, Tennessee, Hassler (1957) reported that a 6-year-old female weighed 4 pounds 2 ounces and was 21.5 inches in total length. Only 10 sauger (9 females, 1 male) of the 5,500 specimens in Norris Reservoir examined reached a weight of 3 pounds or more. Carufel (1963) reported that the largest sauger ever recorded from the Garrison Reservoir, North Dakota, was 30.0 inches in total length and weighed 8.2 pounds, while in his sample the largest sauger was 26.5 inches (6.7 pounds). The world record sauger (8 pounds, 5 ounces) was taken on October 22, 1961, in the Missouri River near Niobrara, Nebraska (Schaffer, 1962). Gentry (pers. comm.) mentioned a sauger taken in Tennessee that weighed about 7 pounds. It, however, was identified as a hybrid and he wondered if the 7- and 8-pound saugers reported from South Dakota were also walleye-sauger hybrids. Trautman (1957) stated that Lake Erie fishermen reported maximum weights of 3 to 4 pounds; possibly some of the larger supposed saugers are hybrids between sauger and walleye.

Sex Ratios

Of 1,742 saugers from Lake Winnebago, 54.9 percent were females. The sex ratio of male to female for all fish was 1:1.2 (Table 8). The male to female sex ratio ranged from 1:2.1 for age group IV to 1:0.2 for age group VIII. Most of the males were found in age group III (45.4%) while the largest numbers of females were found in age groups III and IV (36.3 and 39.5%, respectively). No saugers over age group VIII were taken.

Carufel (1963) reported the sex ratio of male to female sauger (age group I–III) in Garrison Reservoir was 1:2.5 and in the tailwaters below the dam, 1:1.6. The male to female sex ratio of saugers from

TABLE 8

Sex Ratio of Lake Winnebago Sauger

Age Group	Number of Males	Number of Females	Sex Ratio: Males to Females
II	44 (5.6)*	27 (2.8)	1:0.6
III	356 (45.4)	348 (36.3)	1:0.9
IV	173 (22.1)	378 (39.5)	1:2.1
V	126 (16.1)	138 (14.4)	1:1.1
VI	34 (4.3)	42 (4.4)	1:1.2
VII	37 (4.7)	22 (2.3)	1:0.6
VIII	14 (1.8)	3 (0.3)	1:0.2
Total	784 (45.1)	958 (54.9)	1:1.2

* ( ) = percent in each age group.

both localities (age groups IV–VI) ranged from 1:4 to 1:22. Of 721 saugers from Garrison Reservoir and 745 from the tailrace, 71 percent were females. Carlander (1950) found 66 percent of 1,561 Lake of the Woods saugers to be females. Of the sexed fish in Lewis and Clark Lake 62 percent were females (Vanicek, 1964). Hassler (1958) stated that the sexes are equally abundant for the first two years of life. However, the females are significantly more abundant than the males for age groups III through VI in Norris Reservoir. Hassler (1958) reasoned that differential mortality accounts for differences in sex ratio. He suggested that the males are less viable than the females after the second year of life, and this accounts for the difference in sex ratio. The oldest saugers captured in Norris Reservoir were predominantly females. This was not the case in Lake Winnebago as the males were more numerous in age group VI through VIII, comprising 10.8 percent of the total males sampled as compared to 7.0 percent of the females in these age groups.

Size and Age at Maturity

Only the females showing eggs forming in the ovary were considered mature, and the males were considered mature if the testis showed the characteristic whitish color. Since all fish used in this study were collected during the fall, winter or early spring, no difficulties were encountered between distinguishing immature and mature fish.

All male saugers under 9.0 inches were immature (Table 9). The average total length at which more than 50 percent of the males are mature is 9.8 inches (9.5–9.9 inch group). Female saugers under 9.0 inches were immature, and only one (2.4%) in the 9.0–9.5 inch group was mature. The average total length at which more than 50 percent of the females are mature is 11.2 inches (11.0–11.4 inch group).

The data on the age and degree of maturity of sauger included in this sample are presented in Table 10. The average age of maturity was considered as the age at which 50 percent of the fish reached maturity. The male sauger would generally be considered mature at the end of the second year of life. Only males in age group VIII were all mature. The female sauger would be considered mature at the end of the fourth year of life. Female saugers in age groups IV, V, and VI represented the potential spawning population, as 69.1, 72.1 and 67.6 percent, respectively, were mature in each age group. Only 18.1 percent of the females in age group VII were mature.

It is evident that very few saugers live beyond 5 years in Lake Winnebago as only 10.8 percent of the males were over 5 years of age (age groups VI, VII, and VIII) compared to only 7.0 percent of the females.

TABLE 9

Relation Between Length and Sexual Maturity of Sauger from Lake Winnebago

Length (T.L.) Intervals (inches)	Males			Females		
	Number Immature	Number Mature	Percentage Mature	Number Immature	Number Mature	Percentage Mature
8.0– 8.4	3		—	4		—
8.5– 8.9	5		—	6		—
9.0– 9.4	23	17	42.5	26		—
9.5– 9.9	8	31	79.4	41	1	2.4
10.0–10.4	9	33	78.6	48	9	15.8
10.5–10.9	6	24	80.0	44	26	37.1
11.0–11.4	3	28	93.2	25	56	69.1
11.5–11.9	3	36	92.3	20	69	77.3
12.0–12.4	11	64	85.3	15	44	74.6
12.5–12.9	5	79	94.0	28	47	62.7
13.0–13.4	7	148	95.5	50	68	57.6
13.5–13.9	12	78	86.6	63	60	48.8
14.0–14.4	3	38	92.7	38	38	50.0
14.5–14.9		25	100.0	21	21	50.0
15.0–15.4	1	35	97.2	12	13	52.0
15.5–15.9	1	28	96.5	14	12	46.2
16.0–16.4	1	12	92.3	5	9	64.3
16.5–16.9		7	100.0	2	8	80.0
17.0–17.4				2	7	77.8
17.5–17.9					4	100.0
18.0–18.4				1	1	50.0
Total	101	683	87.1	465	493	51.4

The size at which saugers attain maturity in Lake Erie has been reported by Deason (1933) as 9.5 inches for the males and 11.5 inches for the females. Hassler (1958) considered the average age of maturity in Norris Reservoir saugers as that age at which 50 percent of the

TABLE 10

Percentage Mature Sauger in Various Age Groups

Age Group	Number of Males	Number of Females	Percent Males
II	44 (90.9)*	27	61.9
III	356 (83.5)	348 (24.4)	50.6
IV	173 (81.1)	378 (69.1)	31.4
V	126 (90.5)	138 (72.1)	47.7
VI	34 (94.1)	42 (67.6)	44.7
VII	37 (89.2)	22 (18.1)	62.7
VIII	14 (100.0)	3 (33.3)	82.4
Total	784 (87.1)	958 (51.4)	45.1

*( ) = percent mature.

fish reached maturity. Consequently, male and female saugers would generally be considered mature at the end of the second year of life, and the minimum total length would be 13.0 inches for males and 13.5 inches for females. Hart (1928) stated that the smallest, mature female sauger from Lake Nipigon in his collection measured 14.0 inches. For Garrison Reservoir, North Dakota, Carufel (1963) reported that 21 percent of the 3-year-old males and all older males were mature and 19 percent of the 3-year-old females, 63 percent of the 4-year-olds, and all females older than 5 years were mature. Kennedy (1949) reported the largest number of mature male and mature female saugers from Manitoba were 4 and 5 years old, respectively.

In Lake Winnebago, male saugers attain maturity at age II while females attain maturity at age IV. Only in Norris Reservoir did male and female sauger attain maturity at an earlier age, which was age II for both sexes. In other waters, male saugers attained maturity at age III or IV while female saugers first attained maturity at age IV, V or VI.

The respective lengths at which more than 50 percent of male and female saugers in Lake Winnebago attained maturity were 9.8 and 11.2 inches, respectively. In Norris Reservoir, male and female saugers were 13.0 and 13.5 inches, respectively at maturity, thus exhibiting more rapid growth than the Lake Winnebago saugers. The lengths at which male and female saugers attained maturity in Lake Erie was essentially the same as in Lake Winnebago. In other waters, male and female saugers attained larger lengths at maturity but first attained maturity at an older age.

Fecundity

The estimates of the egg production for saugers by half-inch size groups are given in Table 11. The average number of eggs per ovary for saugers 10.1 to 14.6 inches in total length from Lake Winnebago was 15.871 eggs. There was a range of 4,208 eggs for a 10.6-inch, 0.3-pound sauger to 43,396 for a 14.5-inch, 1.0-pound sauger.

Only a few estimates have been published on the egg production of the sauger. All of these estimates have been made on a small number of fish; however, all estimates have shown higher egg production than that found in the sauger in Lake Winnebago. Hassler (1957) estimated that 14 Norris Reservoir saugers over a size range extending from 11.3 to 19.0 inches in total length (0.4 to 2.8 pounds) produced an average of 41,139 eggs. There was a range from 9,360 eggs for a 11.7-inch, 0.4-pound sauger to 96,277 eggs for a 19.0-inch, 2.8-pound sauger. Carufel (1963) calculated that 50 Garrison Reservoir, North Dakota, saugers from 12.9 to 24.6 inches in total length (0.6 to 4.5 pounds) produced an average of 45,197 eggs. The number of eggs ranged from

TABLE 11

Estimated Egg Production of Lake Winnebago Saugers, 1963

Total Length Groups (inches)	Number Sampled	Average Weight of Fish (lb.)	Average Weight of Entire Ovaries (g)	Average Sample Weight of Ovaries (g)	Average Percentage of Ovaries Actually Counted	Average Calculated Number of Eggs
10.0–10.4	7	0.3	13.7	1.4	10.5	9,932
10.5–10.9	21	0.3	14.5	1.6	10.7	11,461
11.0–11.4	41	0.4	15.5	1.6	10.2	13,503
11.5–11.9	41	0.4	19.5	2.0	10.0	14,441
12.0–12.4	34	0.5	23.7	2.3	9.8	17,265
12.5–12.9	15	0.5	25.6	2.6	10.2	16,906
13.0–13.4	15	0.6	30.0	2.9	9.8	21,039
13.5–13.9	9	0.7	33.0	3.1	9.4	24,626
14.0–14.4	7	0.7	27.4	2.7	9.9	19,548
14.5–14.9	2	0.9	58.8	5.0	8.5	38,307
Total	192				Average	15,871

10,488 (12.9-inch sauger) to 152,110 (21.5-inch sauger). Carlander (1942) calculated that three Lake of the Woods saugers of 14.0–14.2 inches in total length produced an average of 45,000 eggs. Smith (1941) reported an estimate of 36,000 eggs from an 18-ounce (1.6-pounds sauger, and an average of 78,000 eggs for two 36-ounce (2.2-pound) sauger. Simon (1946) reported 50,000 eggs for a 3-pound sauger from Wyoming.

REPRODUCTION

Spawning Sites

Saugers are known to spawn either in streams or lakes, apparently depending upon local conditions in the waters concerned. There is little mention in the literature of specific spawning sites or bottom type utilized. The following are among the spawning sites reported by various workers: In Garrison Reservoir, spawning occurs in the reservoir and tailwaters of the dam (Carufel, 1963); in Norris Reservoir, it appears that the sauger spawns in the running water at the heads of the several major arms (Haslbauer and Manges, 1947); tailwaters of Missouri River reservoirs are used by spawning saugers (Nelson, Hines and Beckman, 1965) and over a rubble substrate in the Missouri River below Fort Randall Dam (Nelson, 1968a).

The principal spawning sites of saugers in Lake Winnebago extend almost without interruption for a distance of approximately 8 miles along the north shore of the lake (Fig. 7). Some spawning was noted

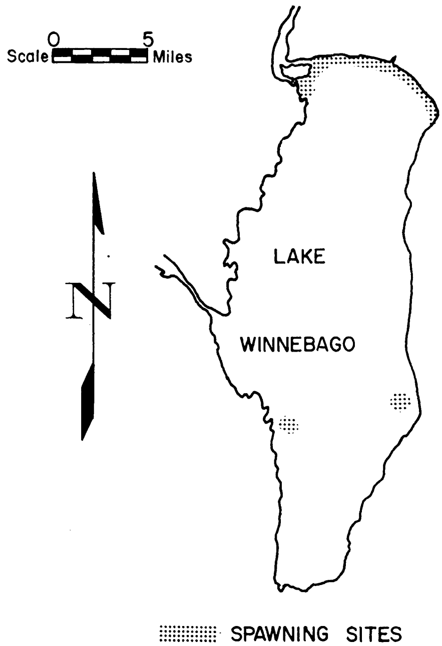


Figure 7. Distribution of sauger spawning sites in Lake Winnebago.

on the Calumetville reef along the east shore and on the Long Point Island reef along the west shore. There was no indication of spawning migrations in either the Wolf or Fox rivers.

The bottom along the entire north shore is composed mainly of sand and fine gravel with a few small scattered areas of rubble and small boulders. On the Calumetville and Long Point Island reefs, the bottom is composed of gravel, rubble and boulders.

Spawning is not restricted to certain portions of the north shoreline, as eggs were found on all types of bottom along the entire shoreline. Gravel and rubble areas were, however, the most heavily utilized areas.

Spawning

In 1965, sauger spawning occurred from May 2 to 9 with peak activity on May 3–6. Water temperatures during this period ranged from 43–49 F (Fig. 8). Spawning intensity and extensity in Lake Winnebago was difficult to assess in 1966 as only a few mature fish were taken in trap nets and trawls from April 25 to 29, and no spawning activity was observed. In 1966, water temperatures ranged between 45–50 F during this period. Spawning in 1967 extended from April 24 through May 6 with a peak on May 1–2. Water temperatures during the spawning period in 1967 ranged from 46–52 F. The above observations indicate sauger spawning had occurred between April 24 and May 9, with water temperatures ranging between 43–52 F. Spawning was essentially completed in less than 2 weeks.

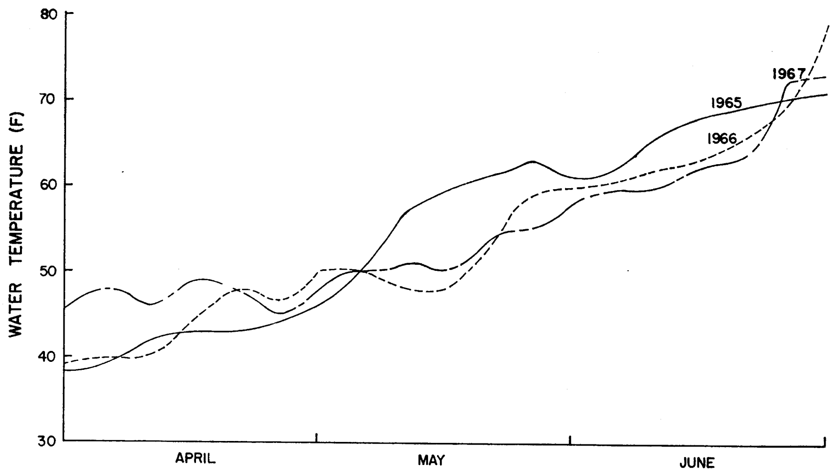


Figure 8. Water temperature in Lake Winnebago during the sauger spawning period, April–June, 1965–67.

Carufel (1963) indicated that for saugers in Garrison Reservoir and the tailrace, the spawning season is probably from late April to the end of June with water temperatures ranging from 39–53 F. Nelson (1968a) reporting on the sauger in Lewis and Clark Lake showed that spawning is initiated at a water temperature of 43 F and is complete in approximately 2 weeks, with spawning beginning on April 27 in 1964 and April 29 in 1965. Eschmeyer and Smith (1943) reported that saugers below Norris Dam, Tennessee did not spawn when water temperatures were below 50 F.

In 1965 and 1966, no sauger eggs could be found on known spawning sites in Lake Winnebago by sampling with an egg basket or finemesh dredge net that was pulled behind a boat. Using only the basket in 1967, eggs were readily taken by disturbing the bottom along the entire north shore in water depths up to 4 feet. Eggs were found on sand and gravel substrates and among rocks with greater numbers being taken on gravel.

Fertilized eggs were semibuoyant and were not strongly adhesive. In no situation were the eggs found clinging to rocks or any other substrate after water hardening. Nelson (1968a) stated that fertilized eggs placed in shallow water at the study site adhered to rocks or were carried by currents downstream into cracks and crevices. He also found that eggs were strongly adhesive even after water hardening.

In Lake Winnebago, fertilized eggs lost their adhesiveness after water hardening. Water-hardened sauger eggs placed on nylon fiber or rubberized horsehair mats demonstrated no adhesive qualities. Only the eggs that settled among the fibers were held on the mats.

Mats with viable eggs were placed along the north shore in water depths varying from 2 to 18 feet in 1965 and 1966 to follow sauger egg development. Negative results occurred both years due to wave action. Extreme wave action resulted in the deposit of sand and silt over the egg mats causing egg suffocation.

Extreme and prolonged wave action could be a major factor in egg mortality as was noted in 1965 and 1967. Winds up to 30 mph and extensive wave action over a prolonged period deposited numerous sauger eggs onto the beach along the north and northeast shores of Lake Winnebago. Egg mortality was especially extensive in 1967.

On April 29, 1966, fertilized eggs were placed on a one-foot square rubberized horsehair mat and suspended in a stainless steel screen basket (36 inches in diameter and 40 inches in depth). The basket was placed in Lake Winnebago where a free exchange of water was possible. Egg development was progressing satisfactorily until May 8 when winds up to 30 miles per hour caused heavy siltation on the eggs so that by May 9, all of the eggs were dead.

During the study, the incubation period was never determined. In Lewis and Clark Lake, the incubation period was approximately 21 days at an average water temperature of 47 F (Nelson, 1968b). In a fish hatchery, sauger eggs hatched in 13 to 15 days at a water temperature of 51 F.

Sauger and perch eggs washed up on Lake Winnebago shore due to easterly winds.

Sauger embryos averaged 1.3 mm in diameter (range, 1.0–1.5 mm). Nelson (1968b) reported that sauger embryos in Lewis and Clark Lake averaged 1.66 mm in diameter (range, 1.44 to 1.86 mm).

Fry Sampling

During May and June, 1965–67, a meter net was pulled behind a 16-foot boat in an attempt to capture sauger fry; however, no fry were ever taken. Most of the sampling was done at or near the surface. The first young saugers were taken with 12-foot bait trawls during June. On June 3, 1964, 56 fry were taken ranging in size from 12–20 mm with an average length of 17 mm. Usually the first fry are captured after June 20 and exceed 20 mm. In Lewis and Clark Lake (Nelson, 1968a) the smallest fry captured were 7.79 mm, but they usually exceeded 8.5 mm. Sauger fry were captured in Lewis and Clark Lake with plankton nets until they reached approximately 15 mm. Highest catches occurred at a depth of 10 ft and some were caught below 20 ft.

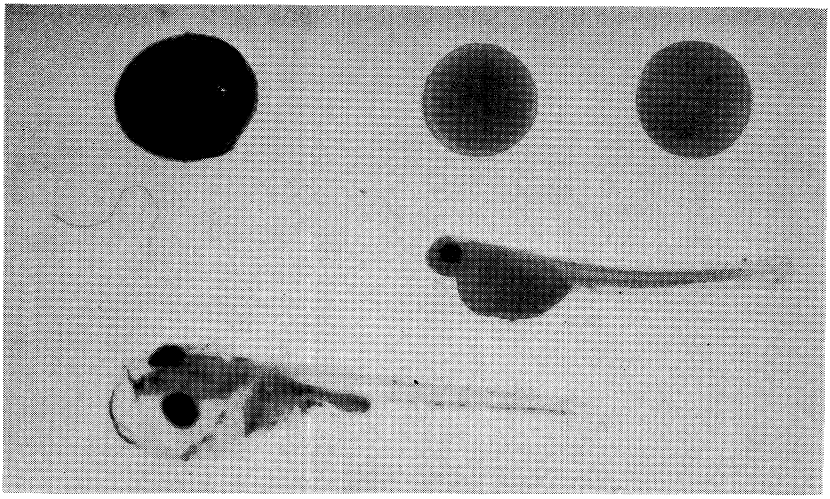
Identifying Eggs, Fry and Fingerling

Because both saugers and walleyes occur in Lake Winnebago, and spawning periods might overlap, the possibility existed that eggs and young of the two species might be difficult to separate. Since 1964, there has been considerable walleye spawning in Lake Winnebago with most activity noted near the mouth of the Fox River. Walleye spawning activity decreases as the distance from the mouth of the Fox River increases with no spawning noted along the north, east and south shores. Most of the sauger spawning occurred along the north shore; however, sporadic sauger spawning did occur along the west shore. In 1965, the period of sauger and walleye spawning overlapped by 2–4 days while in 1966, there was a 5–7 day overlap.

Diameters of mature eggs from ripe saugers ranged from 1.0–1.5 mm, while the diameter of mature eggs from ripe walleyes were 1.8–2.1 mm. The diameters of the eggs of the two species did not overlap and there was no problem in distinguishing between the eggs of the two species.

At the time of hatching in the Wild Rose Hatchery, saugers ranged from 4.7–5.1 mm in total length while walleyes taken on the spawning sites immediately after hatching ranged from 6.6–7.6 mm in total length. The yolk sac of saugers was considerably more oval than that of walleyes. The smaller size and shape of the yolk sac can be used to distinguish between yolk sac fry of these species.

Saugers completed the prolarval stage (absorption of oil globule complete) at 7.7 mm, while in the walleye this stage was completed at 10.0 mm. Prolarval sauger had deeper bodies than walleyes. Pigmentation was more pronounced on walleyes with distinct chroma-



Sauger fry development. From left to right: head of a pin, fertilized egg, eyed egg, yolk sac stage and fry first beginning to feed.

tophores on the yolk sac and ventral line from the anus to caudal fin. Pigmentation in the sauger was limited to a few faint chromatophores on the yolk sac.

Since only a few saugers were reared to 13 mm and none were taken by sampling, no comparison can be made between saugers and walleyes until a length of 20–25 mm is obtained. Nelson (1968b), working with hatchery-reared sauger, made the following observations for larval saugers and walleyes. Generally, pigmentation is more profuse in walleyes ranging in length from 10–14 mm than it is in saugers. In larger specimens, individual variation in pigmentation is greater than the difference betwen species. Myomere counts also exhibit large individual variation although walleyes are more likely to have a greater number of preanal than postanal myomeres. Saugers consistently have a longer head than walleyes and ossification of the pectoral, pelvic and spiny dorsal rays occurs at a smaller size in saugers. At a length of 13–18 mm, the number of ossified spiny dorsal rays is the most useful single characteristic separating the two species. The number of pyloric caeca differentiates fish longer than 19 mm.

Fish (1932) used location and concentration of pigment and myomere counts to identify walleye and sauger fry. Norden (1961) depended upon postanal myomere count, length of the yolk sac, length of the intestine, snout-to-anus and anus-to-caudal measurements, and location of the lower jaw articulation to distinguish between larval walleyes and yellow perch *(Perca flavescens)*. Though these characteristics are useful in distinguishing betwen very young walleyes and saugers, they involve time-consuming techniques and the work must be done in the laboratory with special equipment. Priegel (1967b) described a technique to distinguish between young walleyes and saugers 1 to 3 inches in length by external examination.

The external characteristic used by Priegel (1967b) to distinguish between young walleyes and saugers in this study was the abundance or lack of melanophores on the dorsal surface of the head, especially in the area of the parietal bone. The difference in melanophore abundance is most noticeable where the outline of the right and left corpora bigemina of the optic tectum (mesencephalon) and corpus cerebelli (metencephalon) area of the brain can be observed through the parietal bone. In the walleye, this area is heavily pigmented and appears dark to black; in the sauger, this area is pale, with little pigmentation (Fig. 9). This difference is noticeable on both fresh and preserved specimens.

The fish were identified by using the "color spot" technique, and the identifications were checked by counting the pyloric caeca, a procedure considered accurate but requiring internal examination of the fish. The walleye has 3 or 4 pyloric caeca, while the sauger has 5 or 6 (Eddy, 1957). Table 12 shows the number of fish in the sample and the number of walleyes and saugers misidentified when the "color spot" technique was used.

Error in the "color spot" technique occurred in both directions but at different rates: 6.9 percent of all saugers were misidentified, as opposed to 0.8 percent of all walleyes. The average error was relatively small over all samples, but individual errors were as high as 32.8 percent in 1959. Errors occurred in only one direction in any one sample and at greatly varying degrees.

No correction factors are used, since the number of saugers identi-

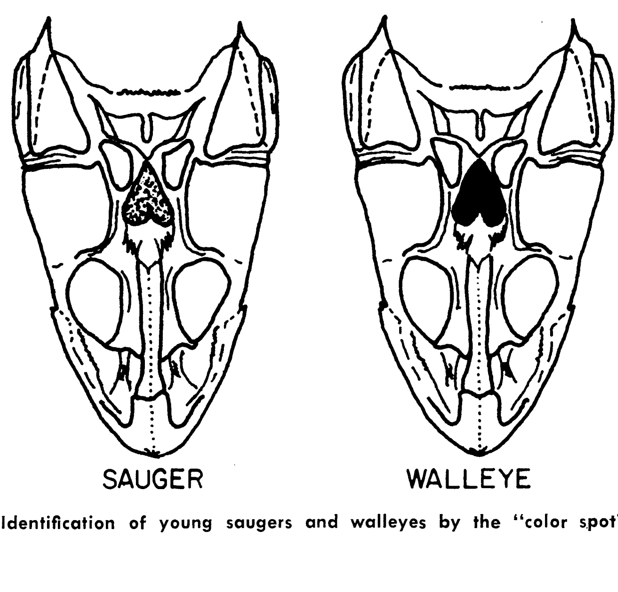


Figure 9. Identification of young saugers and walleyes by the "color spot" technique.

TABLE 12

Identification of Young Walleyes and Saugers Using "Color Spot" Technique and Caeca Count

Year	No. Fish Sampled		Identified by Spot as Sauger and by Caeca as Walleye	Identified by Spot as Walleye and by Caeca as Sauger
	Sauger	Walleye		
1955*	24	23	--------	1 (4.1)[1]
1957*	333	183	--------	12 (3.6)
1958*	78	18	No disagreements	
1959*	58	411	--------	19 (32.8)
1960**	19	514	No disagreements	
1961**	48	740	17 (2.3)[1]	--------
1962**	198	150	--------	21 (10.6)
1963**	16	1	--------	1 (6.3)

*Preserved specimens.
**Fresh and preserved specimens.
[1]( ) = percentage.

fied by the "color spot" technique is, on the average, 6.9 percent below the true number. If 6.9 percent is added to the number of saugers in each of the eight individual samples, the accuracy is not increased as determined by the pyloric caeca count. The uncorrected "color spot" count will be as accurate as any corrected enumeration.

Norden (1961) stated that pigmentation and chromatophore development, although of some value, may be quite variable, showing rather conspicuous differences among larvae collected from different bodies of water. When applied to young walleyes and saugers from Lake Winnebago, however, the method described here gives adequate results in determining the success of hatch and abundance while sampling large numbers of fish collected with bait trawls. Workers in other waters may have to check with other methods (pyloric caeca counts, myomere counts, etc.) before they can feel confident enough to use the method described here. Other methods will have to be developed to distinguish between the walleyes and saugers measuring less than 1 inch, since there is not much noticeable difference in the pigmentation at this stage.

FOOD

Food of Young Saugers

12–50 mm Size Class

Trawling in deeper open-water areas of the lake readily took saugers in the 12–50 mm size class. Saugers usually attained a length of 50 mm by mid-July.

Of the invertebrates utilized by saugers in the 12–50 mm size class, *Daphnia* sp. was the most important item consumed. *Daphnia* was found in 66.1, 59.1, 59.4 and 17.7 percent of the stomachs in 1964–67, respectively (Table 13). Copepods were utilized but only in 1965 were they of any importance when 63.6 percent of the stomachs examined contained *Cyclops* sp. Chironomid larvae and pupae were utilized to a limited extent.

Fry of troutperch, *Percopsis omiscomaycus* (Walbaum), white bass, *Roccus chrysops* (Rafinesque) and freshwater drum, *Aplodinotus grunniens* (Rafinesque) were consumed by this size sauger in 1966 and 1967 (Table 14). Fry were found in 46.9 and 64.7 percent of the stomachs in 1966–67, respectively. Troutperch fry were utilized by young saugers only in 1967. In this year the average catch per trawl haul was 25 troutperch during June (Table 16). White bass fry were consumed only in 1966, and only in July, when the average catch per trawl haul was 466 white bass. Freshwater drum fry were utilized in both years.

TABLE 13

Food of Young Saugers (12–50 mm Class) in Lake Winnebago, 1964–67

Item	Percentage Occurrence			
	1964	1965	1966	1967
Number of stomachs	59	25	34	18
Number empty (%)	3 (5.1)	3 (12.0)	2 (5.9)	1 (5.5)
Fish			46.9	64.7
Unidentified fish			12.5 (1)	47.1 (1)
Percopsis omiscomaycus				11.8 (1)
Roccus chrysops			6.2 (1)	
Aplodinotus grunniens			28.1 (1)	5.9 (1)
Copepods	10.7	63.6	15.6	11.8
Cyclops sp.	8.9 (2)*	63.6 (7)	3.1 (5)	11.8 (10)
Diaptomus sp.	1.8 (4)		12.5 (4)	11.8 (30)
Cladocera	92.8	59.1	59.4	35.3
Daphnia sp.	66.1 (2)	59.1 (6)	59.4 (12)	17.7 (7)
Leptodora sp.	37.5 (2)		15.6 (3)	17.7 (10)
Chironomids—larvae	3.6 (1)	9.1 (1)		5.9 (1)
Chironomids—pupae		4.5 (1)	3.1 (1)	

*( ) = Average number of organisms per stomach.

TABLE 14

Food of Young Saugers (51–75 mm Class) in Lake Winnebago, 1964–67

Item	Percentage Occurrence			
	1964	1965	1966	1967
Number of stomachs	72	94	62	2
Number empty (%)	2 (2.8)	24 (25.5)	5 (8.1)	0
Fish	10.0	12.9	91.2	50.0
Unidentified fish	1.4 (1)*	2.9 (1)	1.7 (1)	50.0 (1)
Percopsis omiscomaycus	4.3 (1)	2.9 (1)		
Roccus chrysops	1.4 (1)		8.8 (1)	
Aplodinotus grunniens	2.9 (1)	7.1 (1)	82.5 (1)	
Copepods	64.3	17.1		50.0
Cyclops sp.	64.3 (35)	17.1 (35)		50.0 (1)
Diaptomus sp.	25.7 (9)			
Cladocera	48.6	2.9	7.0	
Daphnia sp.	47.1 (33)	1.4 (1)	5.3 (11)	
Leptodora sp.	4.3 (2)	1.4 (2)	7.0 (11)	
Hyalella sp.	8.6 (8)			
Chironomids—larvae	32.8 (4)	14.3 (2)	1.7 (1)	
Chironomids—pupae	4.3 (1)	72.9 (3)		

*( ) = Average number of organisms per stomach.

51–75 mm Size Class

Saugers in the 51–75 mm size class were collected by trawling in the openwater areas of the lake from mid-July through mid-August.

Availability also governed the food preferences of the sauger in this size class. From mid-July through mid-August, 1964 and 1965, when young freshwater drum, troutperch and white bass were not available in sufficient quantities, the sauger utilized invertebrates. In 1964, *Cyclops* and *Daphnia* occurred in 64.3 and 47.1 percent of the stomachs, respectively, with chironomid larvae occurring in 32.8 percent. Chironomid pupae occurred in 72.9 percent of the stomachs in 1965 (Table 14).

In 1966, fish occurred in 91.2 percent of the stomachs, with young freshwater drum occurring in 82.5 percent. Young freshwater drum were numerous in the July and August, 1966 trawl samples as compared to the other sample years (Table 16).

76–150 mm Size Class

Chironomid larvae were the most important food item consumed by saugers in this size range in 1964 and 1965, occurring in 39.1 and 76.9 percent of the stomachs, respectively (Table 15). *Leptodora* was an important item in 1965, occurring in 69.2 percent of the stomachs.

In 1964, fish remains were found in 43.8 percent of the sauger

TABLE 15

Food of Young Saugers (76–150 mm Class) in Lake Winnebago, 1964–67

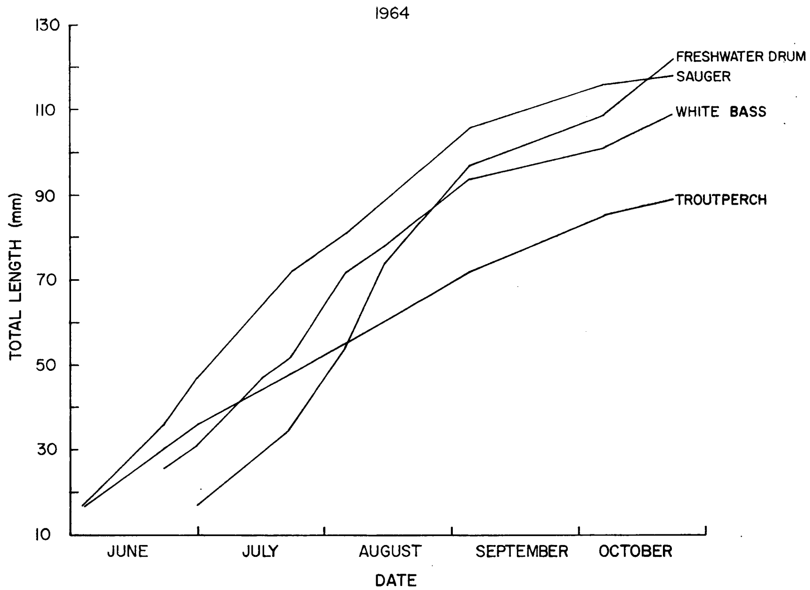
Item	Percentage Occurrence			
	1964	1965	1966	1967
Number of stomachs	85	13	116	11
Number empty (%)	21 (24.7)	0	38 (32.8)	9 (81.8)
Fish	43.8		58.9	
Unidentified fish	1.6 (1)*		1.3 (1)	
Percopsis omiscomaycus	34.4 (1)		46.1 (1)	
Roccus chrysops			1.3 (1)	
Aplodinotus grunniens	7.8 (1)		10.2 (1)	
Copepods	1.6	7.7	6.4	50.0
Cyclops sp.	1.6 (104)	7.7 (17)	6.4 (2)	50.0 (1)
Diaptomus sp.	1.6 (7)			
Cladocera	12.5	76.9	37.2	50.0
Daphnia sp.	3.1 (18)	7.7 (3)	29.6 (103)	
Leptodora sp.	9.4 (34)	69.2 (39)	23.1 (21)	50.0 (11)
Hyalella sp.	6.2 (6)			
Chironomids—larvae	39.1 (14)	76.9 (6)	7.7 (1)	
Chironomids—pupae	26.6 (5)	38.5 (3)		

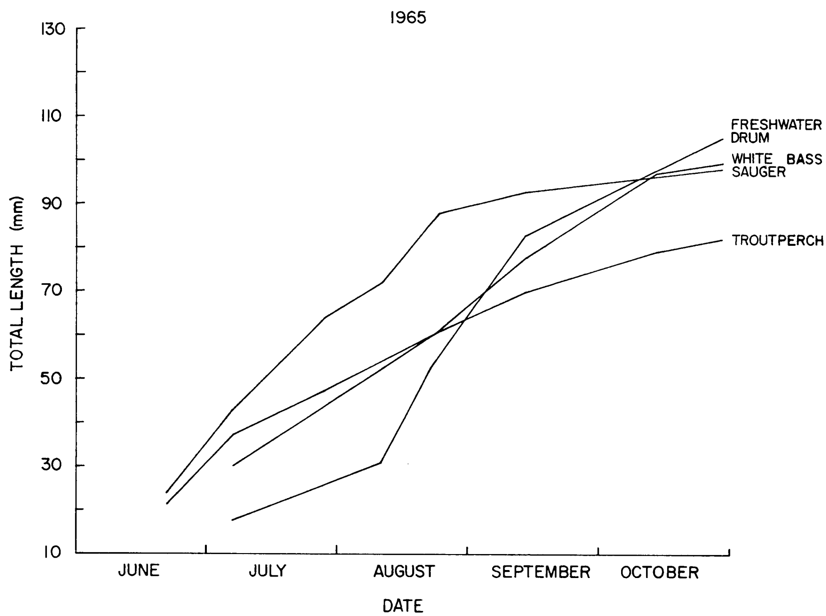
*( ) = Average number of organisms per stomach.

stomachs with identifiable young troutperch occurring in 34.4 percent. Fish remains occurred in 58.9 percent of the sauger stomachs in 1966 with young troutperch being found in 46.1 percent.

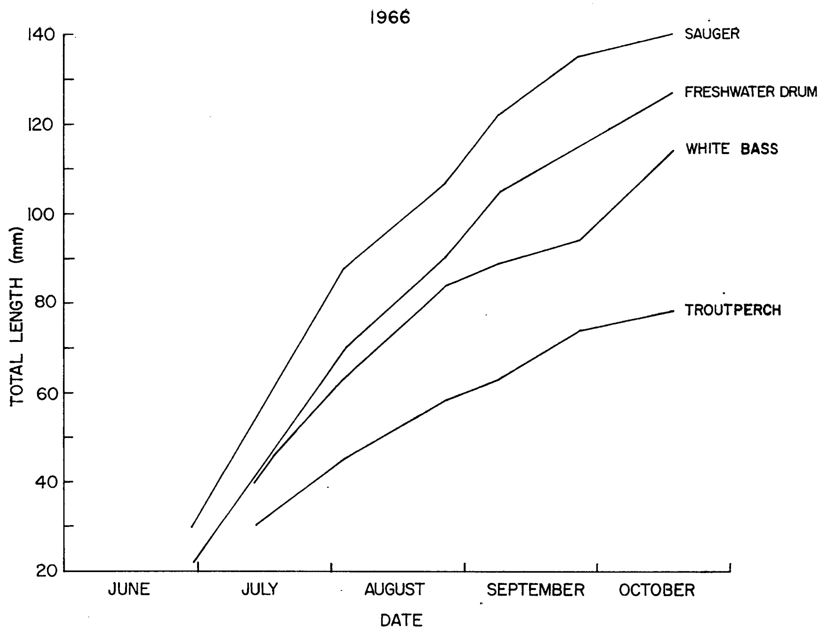
Saugers less than 50 mm were considered plankton feeders but would cease being plankton feeders at this length (50 mm) if forage fishes were extremely abundant. This was not usually the situation, however, in Lake Winnebago. The 1966 sauger year class was the largest observed during the study period; but the growth was also the most rapid as the average total length by mid-October was 140 mm, suggesting that the food supply was adequate despite the sauger abundance. The 1964 year class was the second most abundant year class and it attained an average total length of 118 mm by mid-October. Saugers from the 1964 year class when they reached a length of 50 mm began to utilize forage fish which were available by August, and utilization of forage fishes increased as saugers increased in length and forage fishes became more available.

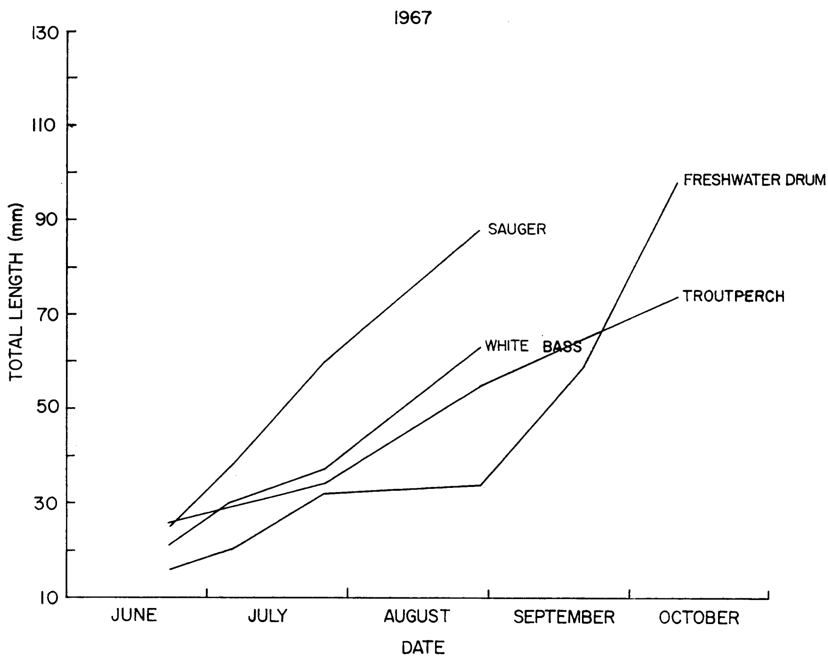
Even though young troutperch were numerous in 1965 and 1967, they were not utilized by saugers to any extent since there was little growth difference in body length between young saugers and troutperch in 1965 and 1967 (Figs. 10–13). By mid-August few young freshwater drum and white bass were consumed by saugers even if these forage fishes were abundant, as body lengths were quite similar.





Figures 10 and 11. Growth (total length in mm) of young sauger, white bass, troutperch and freshwater drum in Lake Winnebago, 1964 and 1965.





Figures 12 and 13. Growth (total length in mm) of young sauger, white bass, troutperch and freshwater drum in Lake Winnebago, 1966 and 1967.

In Lewis and Clark Lake (Nelson, 1968a) the sauger absorbed their yolk sac in 7–9 days and the larvae fed primarily upon *Cyclops*. Larger-size saugers fed on *Daphnia* and *Diaptomus*. Fish were a major food after saugers reached 70–110 mm lengths. Insects were of minor importance in the diet of young saugers.

TABLE 16

Average Catch of Some Young Fish Species Taken Per 7-Minute Tow of a 12-Foot Trawl in Lake Winnebago, 1964–67

Date	Sauger	Walleye	Yellow Perch	Trout Perch	Freshwater Drum	White Bass
1964						
June	7.2	3.5	219.6	1.0	0.2	31.6
July	8.4	4.9	31.2	55.1	0.6	59.4
Aug.	0.5	1.1	1.7	95.7	6.1	12.9
Sept.	0.6	0	2.8	104.4	11.0	59.3
Oct.	0.5	1.0	0.4	38.9	4.2	22.9
1965						
June	0.6	36.3	4.3	7.6	0	0.2
July	4.8	17.4	53.7	229.3	1.3	4.7
Aug.	1.0	2.2	1.2	207.7	4.6	0.7
Sept.	0.6	8.9	0.8	362.8	2.4	0.6
Oct.	0.1	1.0	0	47.9	0.7	0.1
1966						
June	1.5	0.2	7.3	6.5	0	8.7
July	7.3	0.6	116.2	647.5	29.1	466.3
Aug.	2.2	0.4	2.2	426.7	59.8	2.8
Sept.	2.3	0.9	1.5	347.9	53.5	3.5
Oct.	1.7	0.7	1.8	232.8	30.3	4.0
1967						
June	0.4	1.5	7.7	24.7	0.2	0.1
July	0.8	12.7	0	41.0	0.7	2.0
Aug.	1.2	0.1	1.7	329.9	2.3	1.4
Sept.	*	*	*	*	*	*
Oct.	0	0.7	0.7	50.0	2.3	0.3

*No Trawl Sample.

Food Selection by Young Saugers

Data on the abundance of food organisms in plankton samples and occurrence of these food items in stomachs of saugers collected on identical sampling dates were analyzed to determine if certain items were selected. Measurements of food selectivity of fry must be calculated from estimates of the ratio of occurrence of the food items in the environment and the ratio of occurrence of the same item in fry stomachs.

An idex of selection, termed "electivity" by Ivlev (1961), provides a convenient method for determining if feeding is selective. This "electivity index" is represented in the following equation:

$$E = \frac{r_i - P_i}{r_i + P_i}$$

where r_i is the relative quantity of any food item in the stomach as a percentage of the food consumed, and P_i is the relative quantity of the same food item in the environment expressed as a percentage. Values of E may range from -1 to $+1$, the former value indicating negative selection while the latter indicates positive selection. An E value of zero is expected for a food item when no selective processes operate.

Daphnia, Leptodora, Cyclops, and *Diaptomus* were the only zooplankton food items used in significant quantities (Tables 13–15). Electivity was calculated for each day on which stomach and plankton samples were available on the same day. Percentages of items in stomachs (r_i) and percentages in the plankton (P_i) were calculated from the number of items found in stomach analyses and zooplankton samples (Tables 17–20).

Electivity for *Cyclops* was positive from June through early August in 1965, and only in June, 1966 and July, 1967. It became strongly negative for the later dates (Fig. 14). *Diaptomus* was positively selected on only June 29, 1966 during the three years and was strongly negative for all other dates (Fig. 15).

Electivity for *Daphnia* was generally negative during the three years with some positive selection occurring each year; however there was no definite pattern except for positive selection during early July each year (Fig. 16).

Electivity values suggest that *Leptodora* was positively selected on most sampling dates during the three years (Fig. 17). There was negative selection during the earlier sampling dates in 1965 and 1967. *Leptodora* occurred more frequently in stomachs of larger fry.

Daphnia was the most abundant zooplankton in Lake Winnebago, and was consumed by young saugers in greater quantity than any other zooplankton. However, *Daphnia* were consumed only in proportion to their abundance, with little evidence that young saugers positively sought them out.

On the other hand, *Leptodora,* which was the least abundant zooplankton in Lake Winnebago, was positively sought and selected by young saugers. The preference shown by young saugers for *Leptodora* may be due to the relatively large size of this zooplankton, making it more attractive prey.

TABLE 17

Electivity Values (E) Calculated from Percentage Frequency of *Cyclops* sp. from Sauger Stomachs (r_i) and Percentage Frequency of *Cyclops* sp. in Plankton Samples (P_i), 1965–67

	Sauger Stomachs			Plankton				
Date	No. Examined	No. of Plankter in Stomachs	Percent *Cyclops* (r_i)	No. of Samples	Mean No. in Sample Concentrate	Percent *Cyclops* (P_i)	E	Avg. Fish Length (mm)
1965								
June 21	12	4	66	4	3	5	+0.85	24
July 6	13	9	53	4	7	20	+0.45	43
July 27	83	34	97	4	27	52	+0.30	64
August 10	11	42	95	4	15	45	+0.35	72
August 23	7	0	0	4	7	20	—1.00	88
September 13	6	17	22	4	14	24	—0.04	93
1966								
June 29	18	5	29	4	9	14	+0.34	30
July 13	79	0	0	4	41	48	—1.00	54
August 3	12	0	0	4	25	50	—1.00	88
August 26	25	0	0	4	80	60	—1.00	107
September 8	20	0	0	4	31	48	—1.00	122
September 26	26	2	2	4	52	39	—0.90	135
October 17	16	0	0	4	56	40	—1.00	140
1967								
June 22	4	0	0	4	4	8	—1.00	25
July 5	14	30	52	4	10	25	+0.35	37
August 28	12	1	8	4	86	21	—0.44	88

TABLE 18

Electivity Values (E) Calculated from Percentage Frequency of *Diaptomus* sp. from Sauger Stomachs (r_i) and Percentage Frequency of *Diaptomus* sp. in Plankton Samples (P_i), 1965–67

Date	Sauger Stomachs			Plankton			E	Avg. Fish Length (mm)
	No. Examined	No. of Plankter in Stomachs	Percent *Diaptomus* (r_i)	No. of Samples	Mean No. in Sample Concentrate	Percent *Diaptomus* (P_i)		
1965								
June 21	12	0	0	4	19	30	—1.00	24
July 6	13	0	0	4	26	74	—1.00	43
July 27	83	0	0	4	8	16	—1.00	64
August 10	11	0	0	4	17	53	—1.00	72
August 23	7	0	0	4	14	39	—1.00	88
September 13	6	0	0	4	1	2	—1.00	93
1966								
June 29	18	4	24	4	9	14	+0.26	30
July 13	79	0	0	4	21	25	—1.00	54
August 3	12	0	0	4	14	28	—1.00	88
August 26	25	0	0	4	24	18	—1.00	107
September 8	20	0	0	4	12	19	—1.00	122
September 26	26	0	0	4	13	10	—1.00	135
October 17	16	0	0	4	20	14	—1.00	140
1967								
June 22	4	0	0	4	6	12	—1.00	25
July 5	14	10	17	4	27	68	—0.60	37
August 28	12	0	0	4	291	70	—1.00	88

TABLE 19

Electivity Values (E) Calculated from Percentage Frequency of *Daphnia* sp. from Sauger Stomachs (r_i) and Percentage Frequency of *Daphnia* sp. in Plankton Samples (P_i), 1965–67

Date	Sauger Stomachs			Plankton			E	Avg. Fish Length (mm)
	No. Examined	No. of Plankter in Stomachs	Percent *Daphnia* (r_i)	No. of Samples	Mean No. in Sample Concentrate	Percent *Daphnia* (P_i)		
1965								
June 21	12	2	33	4	38	60	—0.29	24
July 6	13	8	47	4	1	4	+0.84	43
July 27	83	1	3	4	14	27	—0.80	64
August 10	11	0	0	4	0	0	—1.00	72
August 23	7	0	0	4	13	36	—1.00	88
September 13	6	3	4	4	42	71	—0.89	93
1966								
June 29	18	7	41	4	43	67	—0.24	30
July 13	79	20	74	4	22	26	+0.48	54
August 3	12	0	0	4	10	20	—1.00	88
August 26	25	0	0	4	29	21	—1.00	107
September 8	20	2	6	4	19	30	—0.66	122
September 26	26	96	81	4	63	47	+0.26	135
October 17	16	123	94	4	63	45	+0.35	140
1967								
June 22	4	4	100	4	37	74	+0.14	25
July 5	14	8	14	4	1	2	+0.75	37
August 28	12	0	0	4	24	6	—1.00	88

TABLE 20

Electivity Values (E) Calculated from Percentage Frequency of *Leptodora* sp. from Sauger Stomachs (r_i) and Percentage Frequency of *Leptodora* sp. in Plankton Samples (P_i), 1965–67

Date	Sauger Stomachs			Plankton			E	Avg. Fish Length (mm)
	No. Examined	No. of Plankter in Stomachs	Percent *Leptodora* (r_i)	No. of Samples	Mean No. in Sample Concentrate	Percent *Leptodora* (P_i)		
1965								
June 21	12	0	0	4	2	3	—1.00	24
July 6	13	0	0	4	0	0	0	43
July 27	83	0	0	4	1	2	—1.00	64
August 10	11	2	5	4	0	0	+1.00	72
August 23	7	17	100	4	1	3	+0.94	88
September 13	6	56	74	4	1	2	+0.94	93
1966								
June 29	18	1	6	4	2	3	+0.33	30
July 13	79	7	26	4	1	1	+0.92	54
August 3	12	0	0	4	0	0	0	88
August 26	25	2	100	4	0	0	+1.00	107
September 8	20	33	94	4	1	2	+0.95	122
September 26	26	20	17	4	5	4	+0.61	135
October 17	16	8	6	4	1	1	+0.71	140
1967								
June 22	4	0	0	4	2	4	—1.00	25
July 5	14	10	17	4	1	2	+0.78	37
August 28	12	11	92	4	12	3	+0.93	88

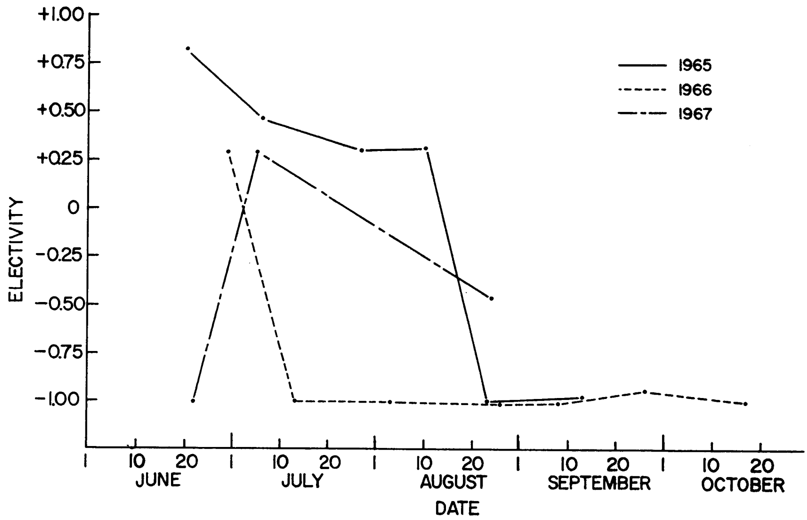


Figure 14. Electivity index of *Cyclops* sp. for sampling dates, 1965–67.

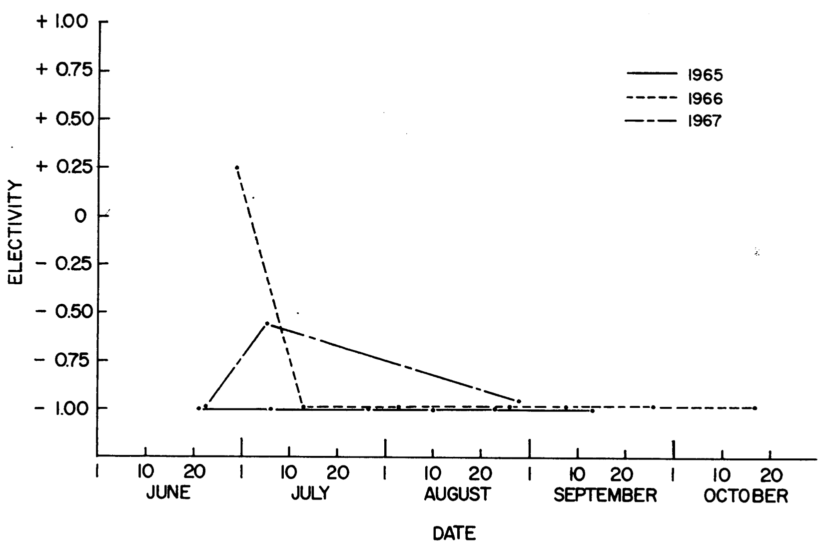


Figure 15. Electivity index of *Diaptomus* sp. for sampling dates, 1965–67.

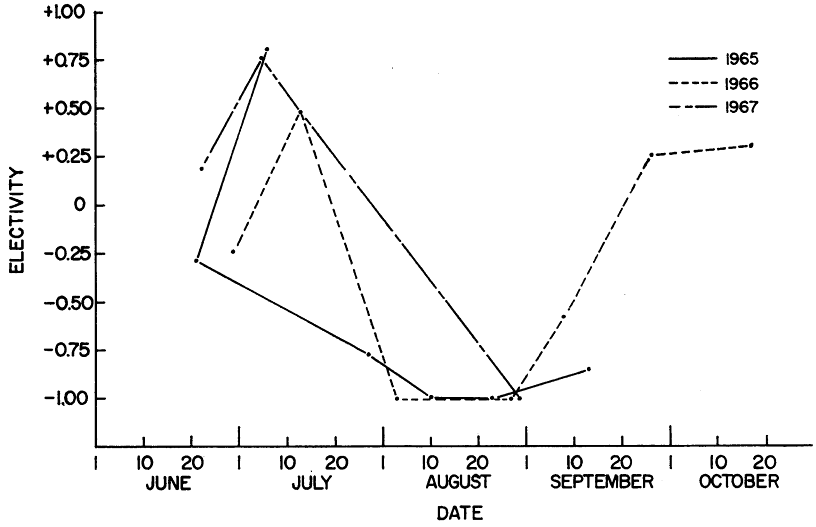


Figure 16. Electivity index of *Daphnia* sp. for sampling dates, 1965–67.

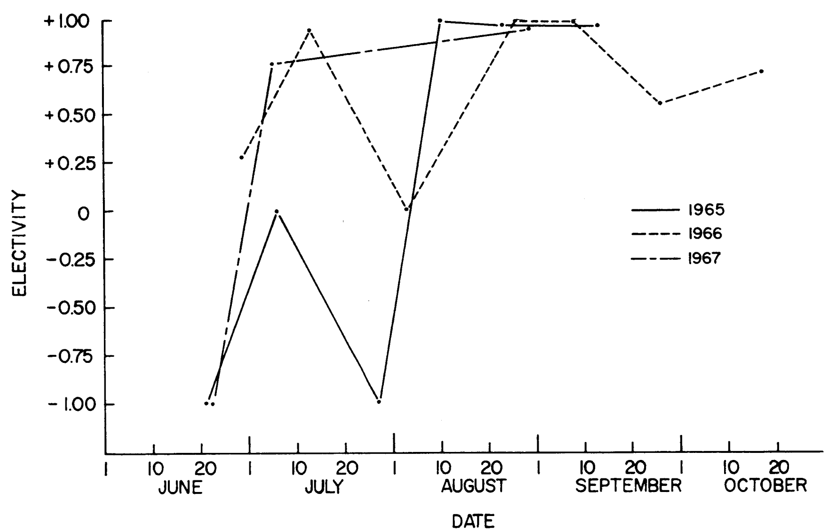


Figure 17. Electivity index of *Leptodora* sp. for sampling dates, 1965–67.

Food of Yearling Saugers

The 1964 sauger year class was large enough to follow as yearlings throughout the 1965 open-water trawling season, thus providing sufficient samples to determine their food consumption. Yearling saugers were sampled over eight periods from June 7 to October 28, 1965.

Except for the August 23 sample when fish occurred in only 33.3 percent of the stomachs, fish were the most important item consumed occurring in 60–100 percent of the stomachs during each sampling period (Table 21). Troutperch were the preferred fish item consumed and their importance increased from August through October especially as young troutperch became available. Young yellow perch were of major importance from June 21 through July 27. Young walleye, sauger and white bass were consumed but were of minor importance.

Of the invertebrates utilized, Chironomid larvae *(Tendipes* sp.) were found in stomachs during 5 sampling periods and occurred in 6.2–66.6 percent of the stomachs. *Leptodora* and *Daphnia* occurred in 20 percent of the stomachs examined on June 7. *Leptodora* were never utilized again and *Daphnia* only occurred again in the June 21 sample.

Food of Adult Saugers

During a three-year period, 1965–67, stomachs from 2,093 saugers were examined of which 986 (47.9%) were empty. The percentage of empty stomachs from the 14 samples varied from 20.0 to 64.8. The saugers examined ranged in total length from 8 to 18 inches.

Fish were the most important items consumed on all sampling dates during the three years, occurring in 63.4–100.0 percent of the stomachs and accounting for 90.4–100.0 percent of the total food volume consumed (Table 22).

Troutperch were the most frequently utilized forage fish, occurring in all samples in 8.6–82.1 percent of the stomachs. Although young and yearling freshwater drum were not present in stomachs on all sampling dates, they were a major food item especially in 1966 and 1967. In 1966, freshwater drum occurred in 21.9–83.3 percent of the sauger stomachs while in 1967, they occurred in 12.0–42.5 percent of the stomachs.

Young walleyes were present in the sauger stomachs during the five sampling dates in 1965, occurring in 1.0–19.3 percent of the stomachs. Young walleyes did not occur in any of the stomachs in 1966 and were of minor importance in 1967. Young saugers and burbots *(Lota lota)* were present in 1965 and black crappies *(Pomoxis nigromaculatus)* were present in 1966.

Young yellow perch were found in 26.9 and 21.1 percent of the

TABLE 21

Food of Yearling Sauger in Lake Winnebago in Percentage Frequency of Occurrence and Percentage of Total Volume for Each Food Item, 1965

Date	Date							
	June 7	June 21	July 6	July 27	Aug. 10	Aug. 23	Sept. 13	Oct. 28
Number of stomachs	9	14	21	18	26	6	19	26
Number empty (%)	4 (44.4)	0	0	5 (27.8)	11 (42.3)	0	8 (42.1)	6 (23.1)
Fish length (inches)	4.6—7.7	4.6—6.7	5.5—7.7	6.7—8.4	7.8—9.4	8.3—9.7	8.9—10.3	9.3—10.9
Fish	60.0 (92.3)*	100.0 (99.9)	100.0 (100.0)	76.9 (98.7)	100.0 (100.0)	33.3 (50.0)	100.0 (100.0)	93.8 (99.9)
Unidentified fish	40.0 (69.2)	21.4 (3.3)	19.1 (4.9)				9.1 (2.4)	
Stizostedion vitreum		42.8 (53.3)	4.8 (3.5)	7.7 (18.1)				
Stizostedion canadense					6.6 (9.0)			
Perca flavescens		35.7 (40.0)	76.2 (91.6)	30.7 (61.8)		16.6 (27.7)		
Roccus chrysops					6.6 (4.5)			
Percopsis omiscomaycus	20.0 (23.1)	7.1 (3.3)		38.4 (18.8)	86.6 (86.5)	16.6 (22.3)	90.9 (97.6)	93.8 (99.9)
Invertebrates	80.0 (7.7)	42.8 (tr.)		38.4 (1.3)		66.6 (50.0)		6.2 (0.1)
Leptodora sp.	20.0 (tr.)**							
Daphnia sp.	20.0 (tr.)	7.1 (tr.)						
Tendipes sp.	40.0 (7.7)	35.7 (tr.)		38.4 (1.3)		66.6 (50.0)		6.2 (0.1)

*( ) = Percentage of total volume for each food item.
**Percent less than 0.1 indicated as trace (tr.).

TABLE 22

Food of the Sauger in Lake Winnebago in Percentage Frequency of Occurrence and Percentage of Total Volume for Each Food Item, 1965–67

Item	1965				
	June 17	July 29	Sept. 13	Oct. 13	Nov. 2
Number of stomachs	194	114	195	187	158
Number empty (%)	101 (52.1)	57 (50.0)	39 (20.0)	87 (46.5)	74 (46.8)
Fish length (inches)	10—17	11—17	9—17	12—18	9—17
Fish	100.0 (100.0)*	92.9 (99.4)	100.0 (100.0)	100.0 (99.6)	100.0 (100.0)
Unidentified fish	47.3 (9.3)	21.1 (3.2)	16.0 (1.5)	29.0 (9.9)	19.1 (3.6)
Stizostedion vitreum	2.1 (0.3	19.3 (34.9)	3.8 (5.4)	1.0 (2.6)	1.2 (3.6)
Stizostedion canadense	2.1 (9.9)				
Perca flavescens	26.9 (51.4)	21.1 (20.0)	2.6 (2.4)		
Roccus chrysops	7.5 (12.7)	14.0 (8.0)	1.3 (0.5)		
Aplodinotus grunniens	8.6 (13.5)		1.3 (0.6)	5.0 (11.5)	4.8 (7.7)
Percopsis omiscomaycus	8.6 (2.2)	17.5 (33.3)	82.1 (89.6)	68.0 (75.6)	75.0 (85.1)
Lota lota	1.1 (0.7)				
Invertebrates		19.3 (0.6)		4.0 (0.4)	
Tendipes sp.		19.3 (0.6)		4.0 (0.4)	

Item	1966				
	June 27	July 19	Aug. 29	Sept. 20	Oct. 19
Number of stomachs	202	52	84	100	213
Number empty (%)	131 (64.8)	18 (34.6)	27 (32.1)	32 (32.)	81 (38.0)
Fish length (inches)	9—17	9—17	8—17	11—17	10—18
Fish	63.4 (90.4)*	100.0 (99.6)	100.0 (99.9)	100.0 (100.0)	100.0 (100.0)
Unidentified fish	28.1 (9.6)	50.0 (24.5)	5.5 (0.7)	19.1 (3.5)	37.1 (10.4)
Perca flavescens	4.2 (3.6)	11.8 (16.3)			0.7 (0.6)
Roccus chrysops		2.9 (5.4)	1.9 (2.3)		0.7 (1.5)
Aplodinotus grunniens		35.3 (20.3)	83.3 (85.4)	54.4 (80.2)	21.9 (37.7)
Percopsis omiscomaycus	30.9 (77.2)	26.5 (43.1)	25.9 (10.1)	30.9 (16.3)	53.8 (49.8)
Pomoxis nigromaculatus			1.9 (1.4)		
Invertebrates	47.9 (9.6)	8.8 (0.4)	1.9 (0.1)		
Helobdella sp.	4.2 (0.1)				
Tendipes sp.	40.8 (9.4)	8.8 (0.4)	1.9 (0.1)		
Physa sp.	2.8 (0.1)				

TABLE 22 (Cont.)

Item	1967			
	June 13	July 26	Aug. 17	Sept. 12
Number of stomachs	195	97	203	99
Number empty (%)	120 (61.5)	45 (46.4)	122 (60.1)	52 (52.5)
Fish length (inches)	10—17	11—17	11—18	10—18
Fish	84.0 (99.7)*	100.0 (99.8)	92.6 (99.9)	100.0 (100.0)
Unidentified fish	22.7 (1.1)	21.1 (1.8)	13.6 (0.9)	12.8 (0.5)
Stizostedion vitreum	1.3 (0.2)			4.2 (11.1)
Perca flavescens			1.2 (1.1)	
Aplodinotus grunniens	12.0 (41.1)	17.2 (2.6)	37.0 (39.1)	42.5 (32.2)
Percopsis omiscomaycus	48.0 (57.3)	63.5 (95.4)	40.7 (58.8)	40.5 (56.2)
Invertebrates	18.7 (0.3)	7.7 (0.2)	9.9 (0.1)	
Tendipes sp.	16.0 (0.1)	5.7 (0.1)	9.9 (0.1)	
Physa sp.	2.7 (0.2)	1.9 (0.1)		

*( ) = Percentage of total volume for each food item.

stomachs in the June 17 and July 29, 1965 samples, respectively, and were of minor importance in other samples. Young and yearling white bass were a minor forage fish species in 1965 and 1966.

In Lake Winnebago, during the winter of 1960, saugers consumed equal amounts of troutperch and lake emerald shiners, *Notropis atherinoides* (Priegel, 1963). When troutperch and lake emerald shiners were scarce (January–February, 1961) the sauger demonstrated an increased utilization of chironomid larvae. Chironomid larvae were found in 61.0 percent of the sauger stomachs.

Young gizzard shad, *Dorosoma cepedianum* were the most abundant fish in Lewis and Clark Lake and were the most important food for the sauger (Vanicek, 1964). Gizzard shad were also the predominant food of Norris Reservoir saugers (Dendy, 1945). Although the lake emerald shiner was abundant in Lewis and Clark Lake it was found in only 5 percent of the stomachs; young of other fish species occurred in only 5 percent of the stomachs and only one sauger had eaten a young sauger (Vanicek, 1964).

YEAR-CLASS STRENGTH AND GROWTH OF YOUNG SAUGERS

Small otter trawls have been used successfully in Lake Winnebago since 1957 to sample young fish. Trawling has provided information which is useful in determining relative population abundance, growth, survival and other information essential to any life history study. Trawling data from 1957 to 1967 has provided reliable data essential in estimating relative year-class strength of saugers.

Trawling data indicate that year-class strength is usually set by late September or October. Strong year classes were observed in 1957, 1959 and 1966 (Table 23). Year classes are considered strong when an average catch of over 1.5 young fish per trawl haul are taken in late September or October. An average catch of 0.5 to 1.5 fish per haul would indicate a good year class, which was observed in 1964. A weak year class was assigned the 1958, 1963 and 1965 year classes as the average catch was only 0.1 to 0.2 fish per haul. No year classes were observed in 1960, 1961, 1962 and 1967.

A check on estimates of year-class strength can be made by observing the catch of yearling saugers the following year as taken in trawl samples (Table 23). In 1957, 1959 and 1966, when strong year classes occurred, the catch of yearling saugers remained high the following year. The average catch of 5.2 young saugers per haul in October, 1957 was followed in 1958 by an average catch of 3.0, 3.4, 2.1, 3.2 and 3.2 yearling saugers per trawl haul from June through October, re-

TABLE 23

The Average Catch of Young and Yearling Saugers Per Trawl Haul in Lake Winnebago, 1957–67

	June			July			August			September			October		
Year	No. Yg.	No. Yrl.	No. Hauls	No. Yg.	No. Yrl.	No. Hauls	No. Yg.	No. Yrl.	No. Hauls	No. Yg.	No. Yrl.	No. Hauls	No. Yg.	No. Yrl.	No. Hauls
1957	*	*	*	*	*	*	6.2	0	25	*	*	*	5.2	0	61
1958	0	3.0	19	0	3.4	19	0.9	2.1	27	3.3	3.2	12	0.2	3.2	13
1959	3.5	0	2	1.8	0.2	40	3.4	0.1	35	2.6	0.1	36	2.0	0.1	12
1960	0	1.9	9	0	2.8	9	0	3.7	72	0	5.0	30	0	3.4	14
1961	0.6	0	40	0.6	0	40	0.1	0	59	0	0	59	0	0	35
1962	0	0	40	0	0	40	0	0	50	0	0	30	0	0	30
1963	0	0	20	0.7	0	20	0.1	0	20	0	0	20	0.1	0	30
1964	7.2	0	25	8.4	0	20	0.5	0	20	0.6	0	10	0.5	0	20
1965	0.6	1.2	20	4.8	4.8	20	1.0	1.6	20	0.6	2.0	10	0.1	1.2	20
1966	1.5	0	12	7.3	0.2	10	2.2	0.2	17	2.3	0.3	20	1.7	0.2	20
1967	0.4	0	10	0.8	1.0	20	1.2	1.7	10	*	*	*	0	1.6	3

*No hauls made.

spectively. Similar conditions were noted for the 1959 and 1966 year classes.

The average lengths of saugers captured during each trawl sampling series in 1957 through 1967 and the growth curves are illustrated in Figures 18 and 19.

The fastest growth was exhibited by the strong 1959 year class, which attained an average length of 154 mm (range, 104–190 mm) on October 27, 1959. The strong 1966 year class reached an average length of 140 mm (range, 98–168 mm) on October 22, 1966. The 1957 year class, although strong, only averaged 144 mm (range, 89–152 mm) on October 28, 1957.

In Lake Winnebago, the greatest growth increase occurred during July. By the end of July a young sauger in Lake Winnebago is generally longer than 60 mm in total length; however, in 1959, 1961, 1963 and 1966, young saugers were over 80 mm at this time. As noted in the section regarding food of young saugers, the greatest growth was realized in the years when forage fishes were available by mid-July and utilized by young saugers.

By the end of October, growth of young saugers in Lake Winnebago varied from a low of 98 mm in 1965 to 154 mm in 1959. In Lewis and Clark Lake saugers by October 1 averaged 171 mm long in 1963 and 134 mm in 1965 (Nelson, 1968a).

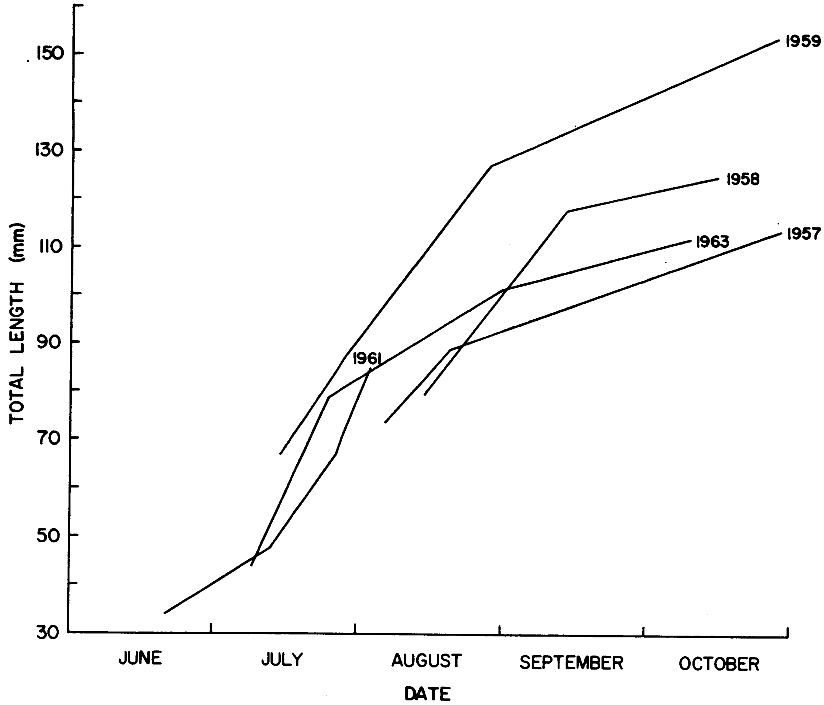


Figure 18. Rate of growth of young saugers in Lake Winnebago, 1957–63.

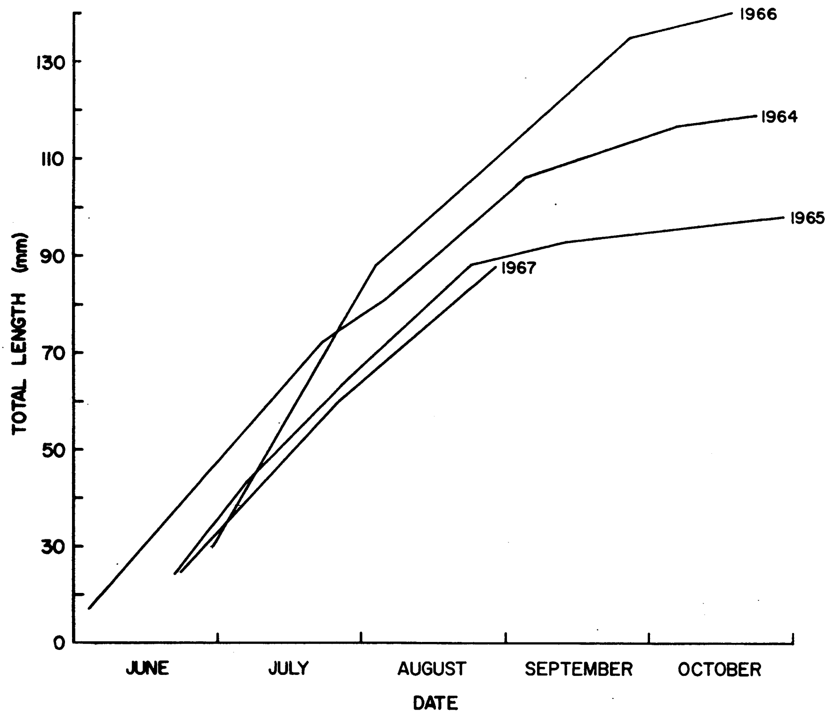


Figure 19. Rate of growth of young saugers in Lake Winnebago, 1964–67.

DISEASES AND PARASITES

Little is known of the disease problems of natural sauger populations. Nine Lake Winnebago sauger were sent to the Bureau of Sport Fisheries and Wildlife laboratory at La Crosse, Wisconsin in 1961. All specimens were examined internally and externally for parasites and bacterial disease. The following conditions were found: (1) no external parasites; (2) gills normal on all specimens; (3) all internal organs appeared normal; (4) no bacterial infection observed, and (5) large numbers of digenetic trematode cysts were found in the pericardial cavity of all specimens, with some cysts actually imbedded in the heart. These trematodes were identified as *Cotylurus communis*. Numerous cysts were found in 36 saugers examined on October 29, 1962; 12 examined on January 22, 1963, and 58 examined on February 18, 1963.

In Lewis and Clark Lake (Vanicek, 1964), a parasitic nematode, *Camallanus* sp., was found in 3 stomachs of young-of-the-year saugers in late August. Another *Camallanus* was found protruding from the anus of an adult sauger taken in late July. Another parasitic nematode, *Contracaecum* sp. was found in the visceral mesentaries of two saugers taken in July.

Hugghins (1959) examined two saugers from the Missouri River at Fort Randall Dam, South Dakota and found the parasitic tapeworm, *Bothriocephalus cuspidatus* in the pyloric caeca and upper intestine. The parasitic roundworm, *Camallanus oxycephalus* was also found in the intestine particularly near the posterior end.

SUMMARY AND CONCLUSIONS

In Wisconsin the sauger occurs in both the Lake Michigan and Mississippi River drainage basins, reaching its greatest abundance in Lake Winnebago and Mississippi River.

Length is definitely a poor index of age for saugers in Lake Winnebago. A simple length frequency is of little value when used to determine the existence of good or poor year classes.

Also it is difficult to distinguish sex by length alone, for male and female saugers grew at approximately the same rate.

Sauger growth in Lake Winnebago is slower than the growth observed in sauger from the Tennessee storage reservoirs; however, it is greater than the growth observed in saugers from northern Minnesota lakes, Canadian lakes and Lake Erie.

Altogether 1,824 saugers were examined; only one surpassed 2 pounds and only 95 exceeded 1 pound.

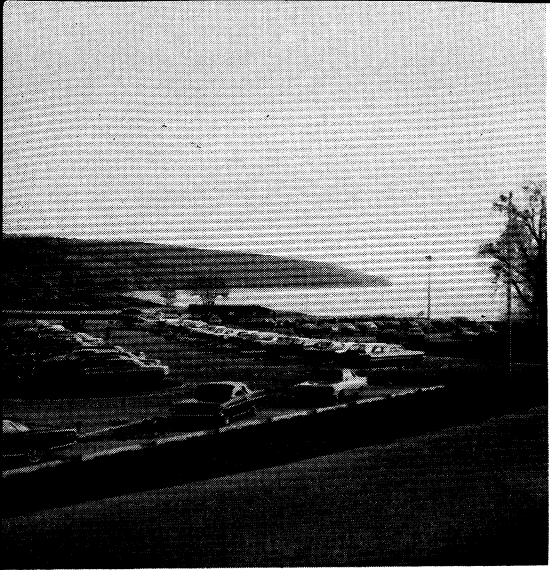
It is evident that very few saugers live beyond 5 years in Lake Winnebago, as only 10.8 percent of the males were over 5 years of age compared to only 7.0 percent of the females.

Male saugers attain maturity at age II while females attain maturity at age IV. The respective lengths at which more than 50 percent of male and female saugers attained maturity were 9.8 and 11.2 inches.

The average number of eggs per ovary for sauger 10.1 to 14.6 inches in total length from Lake Winnebago was 15,871 eggs.

Spawning sites have been well documented in Lake Winnebago and at present, habitat destruction does not seem to be a limiting factor. Spawning occurs in late April through early May with water temperatures ranging between 43 and 53 F. Eggs were found on sand and gravel substrates and among rocks with greater numbers being taken on gravel in water depths up to 4 feet.

Fertilized eggs were not strongly adhesive. The eggs were considered semibuoyant and in no situation were the eggs found clinging to rocks or any other substrate after water hardening. Extreme and prolonged wave action could be a major factor in egg mortality as was

The sauger run is on (High Cliff State Park, May, 1969).

noted in 1965 and 1967. Winds up to 30 mph and extensive wave action over a prolonged period deposited numerous sauger eggs onto the beach along the north and northeast shores of Lake Winnebago.

Saugers less than 50 mm were considered plankton feeders but would cease being plankton feeders at this length (50 mm) if forage fishes were extremely abundant. This was not usually the situation, however, in Lake Winnebago.

The major forage fishes consumed by young saugers were young troutperch, freshwater drum and white bass; however, when sauger and forage fish growth was similar there was little utilization of these forage species by young saugers.

Young saugers selected *Cyclops* from June through early August in 1965 and only in June, 1966 and July, 1967. *Leptodora* was positively selected on most sampling dates during the three years, 1965–67.

Fish were the most important item consumed by yearling saugers from June through October. Troutperch were the preferred fish item consumed and this importance increased from August through October especially as young troutperch became available.

Fish were the most important items consumed by adult saugers on all sampling dates during the three years, 1965–67, occurring in 63.4–100 percent of the stomachs. Troutperch were the most frequently utilized forage fish. Although young and yearling freshwater drum were not present in stomachs on all sampling dates, they were a major food item, especially in 1966 and 1967.

Trawling with small-mesh otter trawls in late September and October provided reliable data essential in estimating relative year-class strength of young sauger in Lake Winnebago.

MANAGEMENT IMPLICATIONS

If the 13-inch size limit were still in effect, the sauger fishery in Lake Winnebago would be very limited, since both the males and females did not reach this size on the average until the end of their fourth year. In our sample, only 25.9 percent of the males and 21.4 percent of the females would have been legal-sized fish.

The sauger in Lake Winnebago could stand a greater harvest. The present daily bag limit of 5 walleyes and saugers in aggregate is not sufficient to harvest a sauger population that is short-lived, very stable and can attain high population levels. A daily bag limit of 5 saugers and 5 walleyes should be tried on Lake Winnebago to increase the sauger harvest. The argument that anglers cannot distinguish saugers from walleyes is not very realistic in view of similar problems existing with the northern pike and muskellunge and largemouth bass and smallmouth bass, which, nevertheless, have separate bag limits.

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