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LAKE STURGEON HARVEST, GROWTH, AND RECRUITMENT IN LAKE WINNEBAGO, WISCONSIN



Technical Bulletin No. 83
WISCONSIN DEPARTMENT OF NATURAL RESOURCES
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ABSTRACT

The harvest, age structure, and estimated recruitment of the lake sturgeon population in Lake Winnebago was determined through a registration system from 1955 through 1969. The average annual harvest during this period was 599 fish. Extreme fluctuations in the annual harvest are governed by weather conditions and water clarity and not by scarcity of legal-sized fish. Neither a continuous sport fishery in effect since 1932 nor an unknown harvest by illegal methods has resulted in a rapid decline in the fishery as far as can be determined to date.

The sturgeon population in Lake Winnebago to date has demonstrated little decline in the average age and size of fish harvested and in the catch per unit of effort.

The standing crop of lake sturgeon over 40 inches in Lake Winnebago is probably no more than 11,500. Because of unknown harvest by illegal methods, 4.7 percent (recruitment) or 540 fish is the maximum segment of the legal population that can safely be taken annually if the population present in 1969 is to be maintained.

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By

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INTRODUCTION

The lake sturgeon, *Acipenser fulvescens* Rafinesque, is a threatened species and is classified as rare over much of its original range (Bureau of Sport Fisheries and Wildlife 1966). It is a long lived, late maturing fish which does not survive a high level of exploitation. Stream modifications (dams, pollution and disturbance of spawning sites) resulting from human settlement and industrial development have produced conditions unfavorable for its survival.

The current management problem is centered on limiting the harvest to maintain a sustained yield. When a lake sturgeon fishery exists, it is vital to know the harvest and population

size of the fish stock so that over-exploitation can be prevented. If over-exploitation were to occur, the fishery would suffer for many years, and it is conceivable that it might even be eliminated if the fishing pressure were intensive enough. There is reason to believe that sustained yields larger than those now being attained in Lake Winnebago are not possible.

Before 1955, estimates of the Lake Winnebago harvest were based on creel census cards (Schneberger and Woodbury 1946; Probst and Cooper 1955). Because of the poor return of these cards and their questionable accuracy, a registration system was initiated in 1955 and has been in continuous

effect since that date. This system of registration has provided an accurate measurement of the harvest, and the use of fin bones of all sturgeon registered has provided a means by which age structure can be determined, and recruitment, estimated.

The objectives of this study were, therefore, to determine the harvest and the level of recruitment into the fishery of legal-sized sturgeon from 1955 to 1969. Another objective was to evaluate several types of tags and tagging procedures. Results from this part of the study will be summarized in a separate report.

STUDY AREA

DESCRIPTION OF STUDY AREA

Lake Winnebago is a large (137,798 acres), shallow, eutrophic lake in east central Wisconsin (Fig. 1). This roughly rectangular lake, 28 miles long and 10.5 miles wide at its widest point, has a maximum depth of 21 ft and an average depth of 15.5 ft (Wirth 1959). Two large river systems enter Lake Winnebago: the 107-mile-long Fox River and 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.

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 mainly in bays that are protected from the wind and in water shallow enough to prevent shading out by algae.

Lake Winnebago is considered a very fertile lake. The water is hard, with a methyl-orange alkalinity of 119-124 ppm, and alkaline, with a pH varying from 7.7 to 8.5. Plant nutrients stimulate heavy algae blooms 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 1967).

HISTORY OF THE FISHERY

Lake sturgeon populations, markedly reduced throughout most of

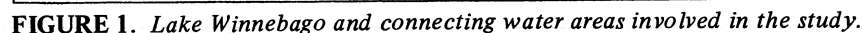
their geographical range, now support commercial or sport fisheries in few regions. No sport fishery for lake sturgeon in any area of the United States or Canada is known to surpass that now in existence on Lake Winnebago and its associated upriver lakes (Poygan, Winneconne, and Big Lake Butte des Morts).

The history of the fishery in this area has included fishing by several methods. Spearing as a means of harvesting sturgeon from these lakes is traditional and was originally practiced by Indians living in the region.

In the 3 upriver lakes, "set line" fishing was permitted during a fall season of several weeks in the 1930's and 1940's. This method of harvest involved using long lines with 100 drop lines with baited hooks on them. During these years, illegal harvests were sometimes made by fishermen using set lines of several thousand hooks. In 1952, the method of harvest

In Lake Winnebago, there was no fishery for sturgeon from 1915 until January 1932 when a spearing season was established. Since then, there has been an annual spearing season through the ice. A spear fishery, besides being traditional here, is the only practical method of harvesting lake sturgeon in Lake Winnebago. Although lake sturgeon are known to take a baited hook, especially in rivers, angling as a means of harvest is virtually impossible in Lake Winnebago where fish are spread out over a large (137,798-acre) area. The lake sturgeon spearing fishery in the Lake Winnebago area is unique to Wisconsin, except for a limited sport fishery for lake sturgeon in 3 Michigan lakes—Black, Mullet, and Burt, in the Cheboygan River drainage.*

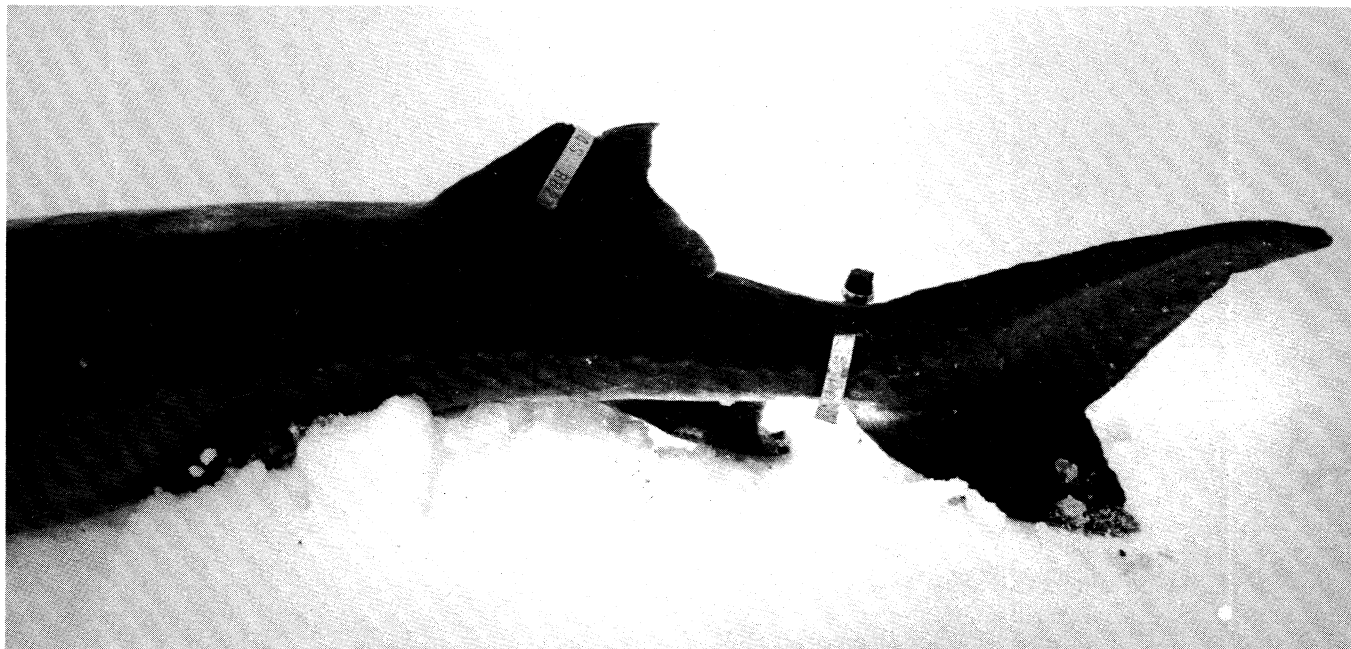
*Elsewhere in Wisconsin, in the state's larger river systems, sturgeon are taken by hook and line.



REGULATIONS

size was further increased to 45 inches. The length of the season on Lake Winnebago has varied from 17 to 29 days depending on the opening day, which is from the Saturday nearest 5 February through 1 March.

Beginning in 1960, spearing licenses (@ \$2.50) were required to participate in this sport. With each license, a metal seal (called a "tag") bearing the license number was provided. Spearing was not permitted by persons under 14 years of age. Persons age 16 and older were also required to possess a current hook and line fishing license (spearmen age 14 and 15 were exempt). Regulations required the "tag" to be locked through the tail of each speared sturgeon. On the day that the fish was speared, it had to be taken to a registration station where it was registered and where a second numbered seal ("registration tag") was locked through the tail.



On the caudal peduncle is the seal which the spearer attached to this sturgeon immediately after it was speared. Attached to the dorsal fin is a Monel self-piercing tag which was applied previously to obtain information about the size of the sturgeon population in Lake Winnebago.

METHODS

REGISTRATION

A standard checking procedure was followed for each fish brought to the registration station. The fish was carefully examined for tags or marks indicating tag loss. The location (1 of 6 areas) on Lake Winnebago where the fish was speared was recorded. Total length to the nearest inch and total weight to the nearest pound were recorded. The clerk removed the leading fin ray from the two pectoral fins by cutting through the joint and stripping the leading ray from the fin. The fin bones were placed in a special envelope on which the above data was recorded.

After the clerk tagged the fish with the numbered registration seal, he recorded the above data on a registration sheet along with the following information: date, time speared, age, name and address of spearer, spearer's seal number, and registration seal number. From 1961 through 1967, age, sex, and residence information obtained from the spearing licenses were used to determine characteristics of the spear fishermen.

From 1956 through 1961, a \$10.00

reward was offered to anyone registering a tagged sturgeon. In addition to the data obtained through the regular registration procedure, the complete entrails were obtained from the tagged fish to determine gonad condition and feeding habits. The tag was kept intact so that its condition could be determined.

ESTIMATES OF POPULATION SIZE

During the open water periods (April-October) in 1955 through 1959, state and private commercial fishermen using Lake Erie-type trap nets in Lake Winnebago for freshwater drum removal (Priegel 1971) tagged any lake sturgeon that they captured which were 40 inches and over in total length. They recorded the total length in inches to the nearest inch, type of tag applied, tag number, area of the lake where fish was tagged and released, and the date.

In 1955 through 1957, large Monel self-piercing tags (of the cattle ear type) were applied at the base of the dorsal fin. In 1958 and 1959, plastic dart tags similar to the ones described

by Yamashita and Waldron (1958) were applied just below and anterior to the dorsal fin.

Tagged fish were recovered through the registration system during the spearing season.

Population estimates were calculated from the Petersen mark-recapture formula as modified by Bailey (1951).

CONDITION AND AGE DETERMINATION

The coefficient of condition, "C", was used to determine the well-being or relative plumpness of the lake sturgeon by the following formula:

$$C = \frac{W 10^5}{L^3}$$

where C is the condition, W is the weight in pounds, and L is the total length in inches.

Age of the sturgeon was determined as follows: once the fin ray had dried sufficiently, a thin cross section (0.3-0.5 mm thick) was made with a jeweler's saw. Under a binocular



Obtaining fish length at registration station. (Note numbered registration seal in right hand of registration clerk.)



Removing a fin bone from a speared sturgeon for use in determining the age of the fish.

microscope, wide opaque zones alternating with narrow clear zones are seen. These correspond to summer and winter growths, respectively. By

counting the number of narrow clear zones, the number of winters through which the fish has lived and hence its age can be determined (Cuerrier 1951;

Roussow 1957). The outer edge of the fin section was assigned an annulus.

RESULTS

SPEARER CHARACTERISTICS

From 1961 through 1967, information obtained from the lake sturgeon spearing licenses was accumulated to provide some insight into the general characteristics of the spearer (Table 1). The 1962 and 1965 data are not included in this Table since the smaller upriver lakes had a spearing season in those years and it is impossible to determine on which body of water the individual speared, based on license stubs. The data here include only the individuals spearing on Lake Winnebago.

Licenses sold prior to the opening of the spearing season varied from 28.0 percent of the total in 1963 to 50.4 percent in 1961 (Table 1). Weather conditions and spearing suc-

cess during the opening weekend or during the first week influenced license sales after opening weekend.

Residents of the 4 counties surrounding Lake Winnebago (Winnebago, Calumet, Fond du Lac, and Outagamie) accounted for 66.4-71.6 percent of the license sales annually. Residents from 42 other Wisconsin counties usually participated in the sport. Nonresidents, mainly from Illinois and Minnesota, accounted for only 1.2-1.7 percent of the license sales annually.

Spearing success per license holder varied from 6.9 percent in 1966 to 23.7 percent in 1967, with an average success of 15.9 percent. Male spearers purchased 88.5-93.9 percent of the licenses and 5.2-20.3 percent speared a fish. Female spearers purchased

6.1-11.5 percent of the licenses but they were more successful—22.4-46.9 percent registered a fish.* Only 0.2-1.0 percent of the nonresident spearers were successful. Residents of the 4 counties surrounding Lake Winnebago accounted for 78.2-83.8 percent of the fish speared.

People who participated in sturgeon spearing ranged in age from 14 (no one under 14 is allowed to spear) to over 80 (Fig. 2). Fifty percent of the total number of spearers each year were between age 31 and 50.

*Success by female spearers is probably not real. Females may have tagged fish caught by male members of a family to enable the male to continue fishing.



While female spearers purchase only 6.1-11.5 percent of all licenses sold, they are more successful than male spearers.

TABLE 1. Sturgeon License Data for Lake Winnebago, 1961, 1963-64, and 1966-67

Parameter	Year				
	1961	1963	1964	1966	1967
<i>Total number of licenses sold</i>	3,352	4,522	5,400	4,301	6,000
<i>Licenses sold prior to season opening</i>					
Number	1,688	1,266	2,149	1,973	1,751
Percent	50.4	28.0	39.8	45.9	29.2
<i>Licenses sold to male spearers</i>					
Number	3,149	4,108	4,970	3,967	5,308
Percent	93.9	91.1	92.0	92.2	88.5
<i>Licenses sold to female spearers</i>					
Number	203	414	430	334	692
Percent	6.1	8.9	8.0	7.8	11.5
<i>Residence of license holders</i>					
Residents of 4 counties bordering lake					
Number	2,401	3,082	3,585	3,037	4,277
Percent	71.6	68.2	66.4	70.6	71.3
Other Wisconsin residents					
Number	909	1,386	1,749	1,195	1,644
Percent	27.1	30.6	32.4	27.7	27.4
Nonresidents					
Number	42	54	66	69	79
Percent	1.3	1.2	1.2	1.7	1.3
<i>Total sturgeon speared</i>	340	1,001	685	300	1,424
Percent licensees spearing fish	10.3	22.1	12.7	6.9	23.7
Percent male licensees spearing fish	9.1	19.6	10.8	5.2	20.3
Percent female licensees spearing fish	27.6	46.9	32.9	22.4	49.9
<i>Residence of spearers spearing fish</i>					
Residents of 4 counties bordering lake	83.8	78.2	83.2	80.7	82.2
Other Wisconsin residents	15.9	21.6	16.5	18.3	17.0
Nonresidents	0.3	0.2	0.3	1.0	0.8

HARVEST

Total Harvest

From 1955 through 1969, the total harvest of lake sturgeon from Lake Winnebago based on registration figures was 8,981 fish. The annual harvest varied from a low of 8 fish in 1969 during a 22-day season to a high of 1,505 fish in 1955 during a 29-day season; however, in 1955 the season bag limit was 3 fish while in 1969, the bag limit was 1 fish per season (Table 2). In 1967, during a 26-day season and with a season bag limit of 1, spearers registered 1,424 fish. The average annual harvest was 599 fish.

If the season bag limit had been 1 in 1955, at least 30 percent fewer fish would likely have been registered since 22.4 percent (337 fish) of the fish registered were the second fish caught by the same spearer, and 7.6 percent (114 fish) were the third fish. In 1956,

78 spearers (11.8 percent) registered 2 fish when the season bag limit was 2 fish per season. A season bag limit of 2 fish in 1957 resulted in 94 spearers (11.0 percent) registering a second fish.

The total weight harvested over the 15 years was 395,565 lb (2.8 lb/acre) and the average was 26,371 lb annually (1 lb/5.2 acres). The annual weight harvested varied from 312 lb in 1969 to 64,715 lb in 1955.

The season length varied from 17 days in 1965 to 29 days in 1955, with an average season length of 22 days. The season bag limit was reduced from 3 in 1955, to 2 in 1956, and then to 1 in 1958 where it has remained. The size limit between 1955 and 1973 was 40 inches.

Shanty counts by aerial observations were used to estimate the fishing pressure until 1960, the first year that a sturgeon spearing license was required (Table 2). From 1955 through 1959, the shanty count varied from

1,238 in 1956, to 2,152 in 1958, and averaged 1,540. Even though license sales were available after 1960 to provide actual numbers of people participating in the sport, shanty counts were taken from 1960 through 1965 to provide information on distribution of the spearing pressure. Since 1960, the shanty count varied from a low of 1,180 in 1962 to a high of 1,967 in 1964. The average count during the 1960-65 period was 1,720; shanty counts since 1963 have remained quite consistent, varying between 1,816 and 1,967.

License sales varied from 2,167 in 1969, to 6,624 in 1965, and averaged 4,405. In 1962, 1965, and 1968, license sales include spearers who fished on the smaller upriver lakes (Poygan, Winneconne, and Big Lake Butte des Morts) which have a spearing season every third year (Table 2). When considering only Lake Winnebago, the greatest number of individuals (6,000) participating

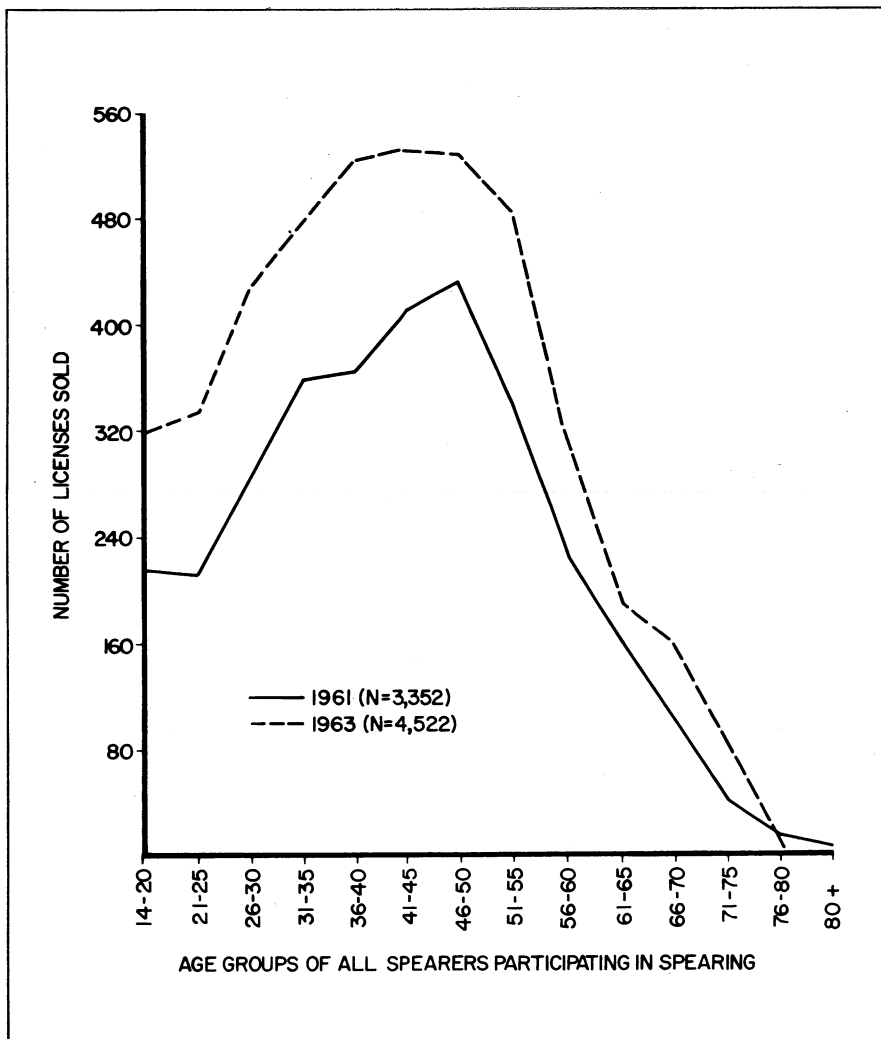


FIGURE 2. Age groups of spearers participating in lake sturgeon spearing on Lake Winnebago, 1961 and 1963.

occurred in 1967. Weather conditions and water clarity were the two factors most responsible for the fluctuations in license sales. In 1969 when only 2,167 licenses were sold, weather conditions were good but water clarity was extremely poor (Table 3). In contrast, excellent weather conditions and water clarity in 1967 resulted in the sale of 6,000 licenses.

Lake Winnebago was divided into 6 areas (Fig. 3) to determine the areas of highest fishing pressure and to relate pressure with spearing success over a 6-year period, 1960-65. Area 4 (east central) accounted for 28.8-52.6 percent of the fishing pressure from 1960 through 1963 (Table 4). In 1964, the greatest pressure (26.4 percent) was in Area 5 (southwest), while in 1965, it was in Area 6 (29.9 percent) located in the southeast portion of the lake. Over the 6 years, the combined pressure on Areas 4 and 6 accounted for 41.3-60.1 percent of the pressure. Areas 4 and 6 combined also accounted for 49.2-65.2 percent of the harvest over this period; however, the harvest was highest in Area 6 for 4 of the 6 years.

The number of lake sturgeon harvested each day on Lake Winnebago (1955, 1956, 1958, and 1959) was fairly constant (Table 5). Harvest on opening weekends was not greater than the remaining days even though spearing pressure was obviously greater. The same holds true for the

TABLE 2. Lake Winnebago Sturgeon Spearing Season Data, 1955-69

Year	Season Regulations		Indexes to Fishermen Present and Records of Sturgeon Caught				
	Season Length (days)	Bag Limit	No. Shanties	Licenses Sold	Sturgeon Registered		
					No.	Avg. Length (inches)	Avg. Weight (lb)
1955	29	3	1,291		1,505	54	43
1956	20	2	1,238		661	56	46
1957	19	2	1,538		851	56	49
1958	22	1	2,152		464	56	50
1959	19	1	1,481		221	55	46
1960	20	1	1,417	2,688*	520	55	44
1961	19	1	1,917	3,352	340	54	42
1962	20	1	1,180	3,242**	262	53	42
1963	21	1	1,830	4,522	1,001	53	39
1964	23	1	1,967	5,400	685	55	47
1965	17	1	1,816	6,624**	718	54	46
1966	25	1	—	4,292	300	54	45
1967	26	1	1,916	6,000	1,424	53	41
1968	28	1	—	5,768**	21	51	36
1969	22	1	—	2,167	8	52	39

* Marks the first year of \$2.50 licenses.

** Includes licenses sold on upriver lakes.

TABLE 3. Weather and Water Clarity During the Sturgeon Spearing Season on Lake Winnebago, 1955-69

Year	No. Fish Harvested	Weather Conditions*	Water Clarity**
1955	1,505	Excellent	Excellent
1956	661	Excellent	Excellent
1957	851	Excellent	Excellent
1958	464	Poor (first 12 days below or near 0 F, drifting snow which hampered travel on ice)	Good
1959	221	Poor (cold weather, drifting snow, winter long to be remembered)	Excellent
1960	520	Poor (drifting snow)	Poor
1961	340	Excellent	Poor
1962	262	Poor (drifting snow)	Good
1963	1,001	Excellent	Excellent
1964	685	Good	Good
1965	718	Good	Good
1966	300	Poor (rain first week, all shanties pulled off ice for 8 days)	Poor
1967	1,424	Excellent	Excellent
1968	21	Poor (rain)	Extremely poor
1969	8	Good	Extremely poor

*** Weather Conditions**

Excellent – car travel possible over entire lake
 Good – car travel possible in most areas of lake during most of the season
 Poor – car travel severely restricted during all or most of the season

**** Water Clarity**

Excellent – bottom visible (8-foot depth considered bottom)
 Good – visibility down to a depth of 12 feet
 Poor – visibility down to a depth of 8 feet
 Extremely poor – visibility less than 4 feet

TABLE 4. Distribution of the Harvest and Fishing Pressure, by Six Areas on Lake Winnebago, 1960-65

Area*	1960		1961		1962		1963		1964		1965	
	F**	S***	F	S	F	S	F	S	F	S	F	S
1	5.7	12.4	8.5	18.2	9.1	16.3	12.8	18.5	5.4	17.1	12.1	21.9
2	43.9	10.0	25.5	15.4	25.6	13.0	24.1	12.3	17.2	11.5	12.3	8.1
3	0.6	5.4	—	4.3	—	7.3	0.4	4.3	—	3.5	—	4.1
4	49.0	52.6	29.7	33.4	40.4	30.8	26.5	28.8	20.4	23.2	17.1	17.3
5	—	1.9	0.6	3.4	1.5	5.2	6.2	8.0	28.1	26.4	19.5	17.1
6	0.6	17.5	35.5	25.2	23.3	27.4	30.1	28.0	28.8	18.1	39.0	29.9
Total												
No. fish registered	520		340		262		1,001		685		718	
No. shanties		1,417		1,917		1,180		1,830		1,967		1,816

*See figure 3 for location of 6 areas.

**Fish registered (percent).

***Shanty count (percent).

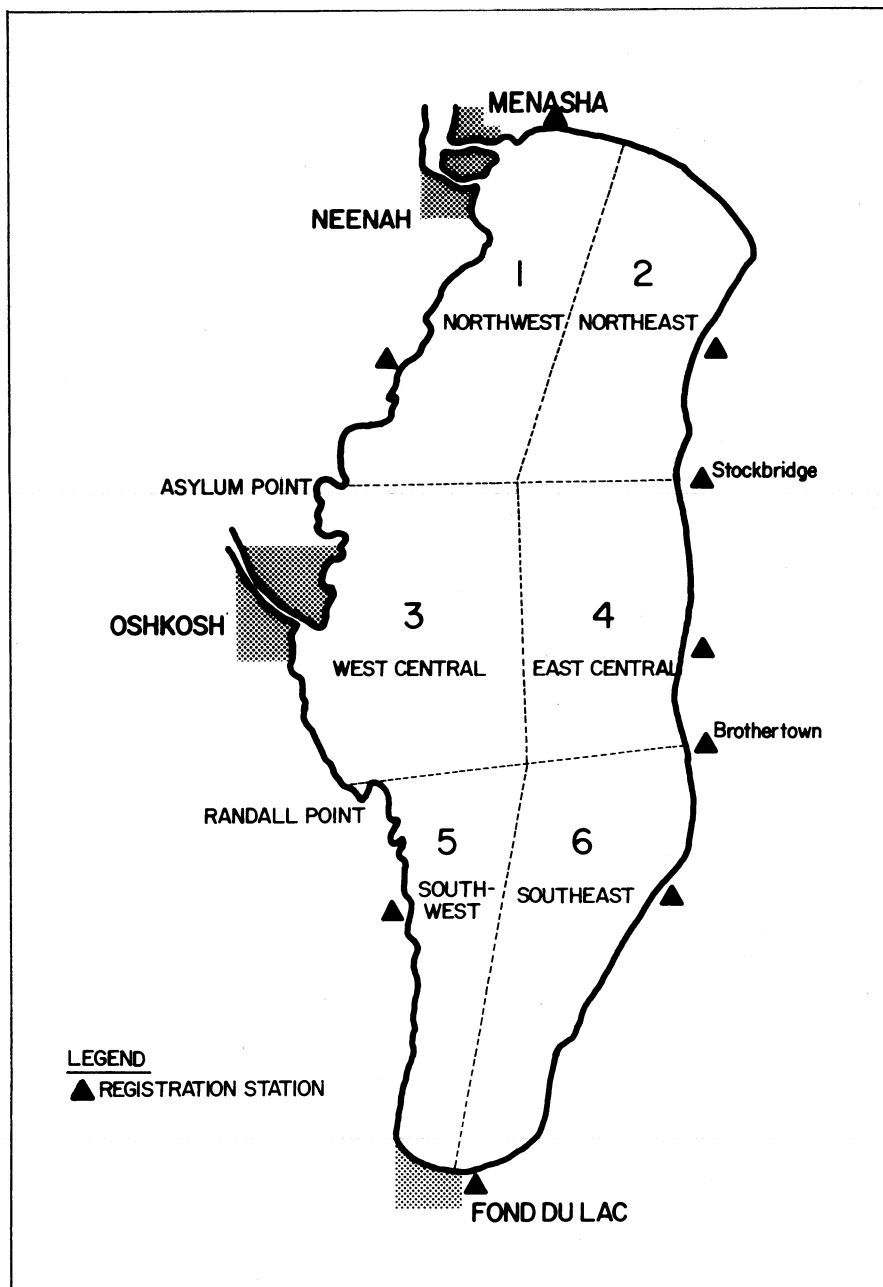


FIGURE 3. Distribution of six sampling areas in Lake Winnebago and recent registration stations.

other weekend days. When the season is grouped into weekly periods (Table 6), weekly harvest varied over the years checked. In 1955, harvest was the highest (32.6 percent) during the first week, while in 1956, harvest during the 3 weeks was quite consistent, with the highest occurring during the second week (36.0 percent). In 1958 and 1959, harvest was the highest during the third (last) week of the season—43.9 and 38.0 percent, respectively.

The time of the day in which most lake sturgeon were speared remained quite constant over the years. Figure 4 graphically demonstrates for 1956 and 1961 the hourly periods in which lake sturgeon were speared. In 1956, 42.5

percent of the total number of fish harvested were taken between 11:00 a.m. and 1:00 p.m., while in 1961, this time period accounted for 43.5 percent of the total harvest. Most of the fish for the years, 1955 through 1967, were speared at this same time of the day. Another harvest peak occurred between 2:00 p.m. and 3:00 p.m. for all years and amounted to 25.0 and 27.1 percent for 1956 and 1961, respectively.

Harvest of Individual Year Classes

The year classes in the harvest from 1955 through 1967 were represented

by the 1907-1960 year classes, in addition to one fish from each of the 1887, 1893, and 1901 year classes (Table 9A and 9B, Appendix). No individual year class demonstrated a peak, followed by a gradual or abrupt decline over the 13-year period. For example, the 1940 year class accounted for 3.8 percent of the harvest in 1955, declined in 1956 to 2.7 percent, increased to 7.6 percent in 1957, declined in 1958 and 1959, reached a high of 8.7 percent in 1960, and then declined over the following years but in no systematic order.

The 1907-1947 year classes were present or were available to the fishery over the 13-year period. The 1939 year class was the most utilized year



On opening date of the spearing season, Lake Winnebago is dotted with shanties.

TABLE 5. Daily Sturgeon Harvest on Lake Winnebago, 1955-56 and 1958-59

Date	1955 No. (%)	1956 No. (%)	1958 No. (%)	1959 No. (%)
Feb. 1	61 (4.0)*			
2	67 (4.4)**			
3	89 (5.9)			
4	75 (5.0)			
5	81 (5.4)			
6	62 (4.1)			
7	58 (3.8)			
8	70 (4.6)		24 (5.2)*	
9	78 (5.2)		17 (3.7)	
10	48 (3.2)		3 (0.6)	
11	16 (1.1)	27 (4.1)*	16 (3.4)	1 (0.5)*
12	52 (3.5)	30 (4.5)	13 (2.8)	0 (—)
13	58 (3.8)	25 (3.8)	21 (4.5)	7 (3.2)
14	43 (2.9)	26 (3.9)	32 (6.9)	10 (4.5)
15	57 (3.8)	28 (4.2)	28 (6.0)	14 (6.3)
16	48 (3.2)	41 (6.2)	18 (3.9)	8 (3.6)
17	47 (3.1)	23 (3.5)	6 (1.3)	16 (7.2)
18	57 (3.8)	48 (7.3)	19 (4.1)	10 (4.5)
19	63 (4.2)	43 (6.5)	20 (4.3)	22 (9.9)
20	5 (0.3)	27 (4.1)	18 (3.9)	6 (2.7)
21	18 (1.2)	25 (3.8)	26 (5.6)	14 (6.3)
22	37 (2.5)	38 (5.7)	46 (9.9)	19 (8.6)
23	37 (2.5)	24 (3.6)	42 (9.1)	1 (0.5)
24	13 (0.9)	33 (5.0)	17 (3.7)	9 (4.1)
25	42 (2.8)	32 (4.8)	24 (5.2)	12 (5.4)
26	75 (5.0)	53 (8.0)	22 (4.7)	14 (6.3)
27	65 (4.3)	33 (5.0)	11 (2.4)	11 (5.0)
28	37 (2.5)	38 (5.7)	17 (3.7)	24 (10.9)
29		41 (6.2)		
Mar. 1	46 (3.1)	26 (3.9)	24 (5.2)	23 (10.4)

*Opening day

**Weekend days in italics

TABLE 6. Sturgeon Harvest (Percent) by Weekly Periods During the Spearing Season on Lake Winnebago, 1955-56 and 1958-59

Period (Week)	1955	1956	1958	1959
First	32.6	30.2	27.1	25.3
Second	24.3	36.0	29.1	36.6
Third	19.6	33.6	43.9	38.0
Fourth	23.6	*	*	*

*Three-week season only.

class, accounting for 6.0 percent of the total harvest. The 1941, 1942, and 1943 year classes were harvested at a rate of 4.9, 4.2 and 4.3 percent, respectively. The harvest of the majority of year classes was below 3.6 percent of the total.

The 1948-60 year classes were not old enough to be available to the fishery over the entire 13-year period. However, after 9 years (1959-67), the 1951 year class accounted for 6.4 percent of the total harvest, while after 8 years (1960-67), the 1952 year class accounted for 4.0 percent of the total harvest.

AGE, LENGTH, AND WEIGHT

Length Frequency

The length frequency was based on lake sturgeon registered from 1955 through 1967, since only 21 fish were taken in 1968 and 8 in 1969. Also the length of only 845 fish from a total harvest of 1,505 was obtained in 1955.

The percentage of fish in the 40- to 44-inch and 45- to 49-inch size groups varied from 5.6 to 18.3 and 12.3 to 26.5 percent, respectively (Table 10, Appendix). These two groups combined accounted for 20.6-41.7 percent of the annual harvest; however, there was no systematic shift indicating an increase or decrease in the harvest of these two length groups over the 13 years.

Fish in the 50- to 54-inch group accounted for between 17.2 and 26.6 percent of the harvest while in the 55- to 59-inch group, variation ranged from 15.3 to 27.7 percent. The harvest of these two groups also varied irregularly over the years. The same variation in annual harvest of the larger fish also occurred.

The average annual length of all lake sturgeon harvested showed little variation (53-56 inches) from a mean of 54.5 inches, with 95 percent confidence limits of ± 2.5 inches (Fig. 5).

Length-Weight Relationship

The length-weight relationship was calculated from a combined sample of 7,013 lake sturgeon collected in February 1955 through 1967. They ranged in total length from 40 to 70 inches and were grouped in 1-inch intervals. The length-weight equation was:

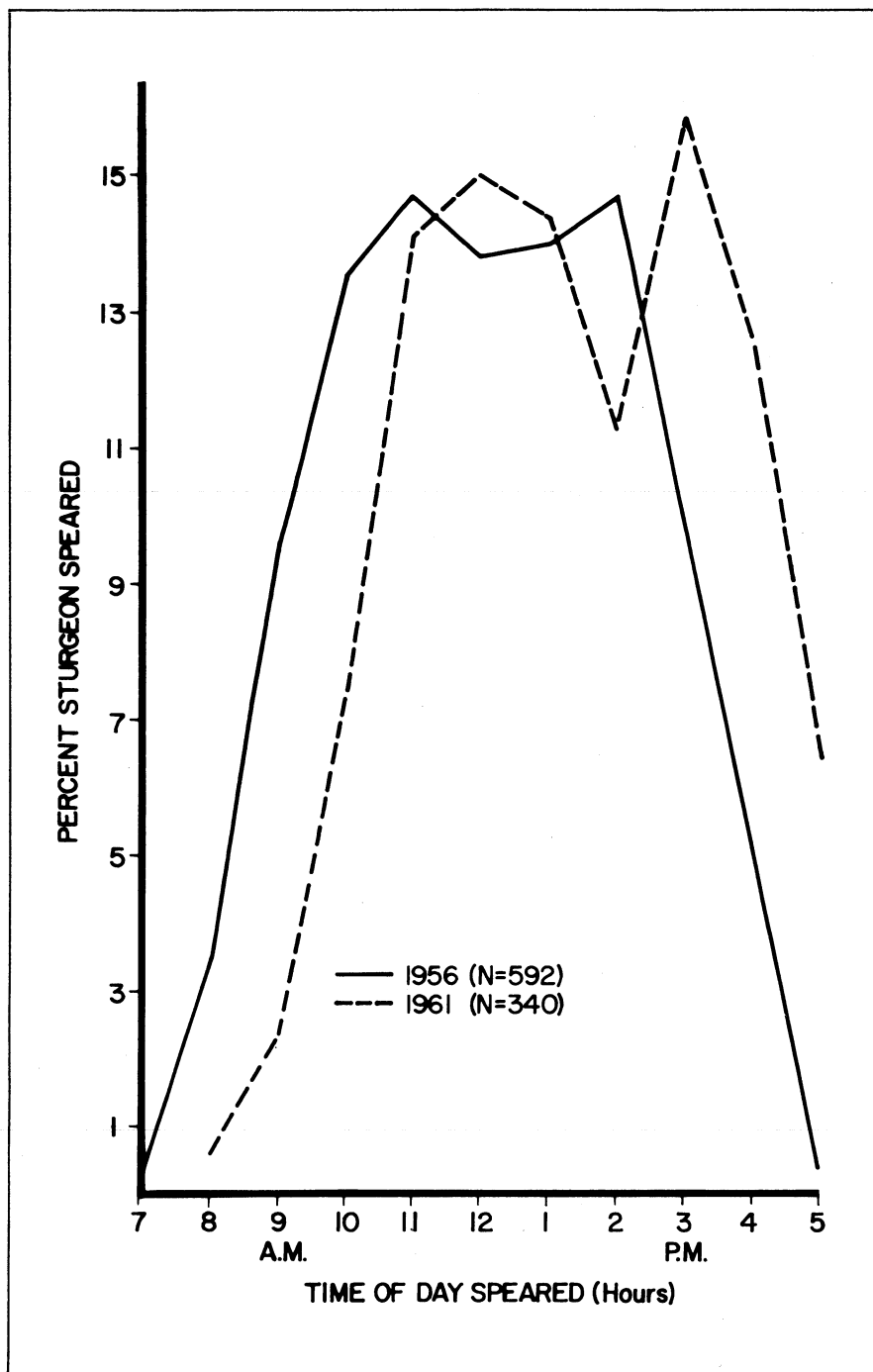


FIGURE 4. Time of the day (in hours) lake sturgeon were speared on Lake Winnebago, 1956 and 1961.

$$\log W = -4.0371 + 3.2530 \log L$$

where $\log L$ is the total length in inches and $\log W$ is the weight in pounds (Fig. 6). Differences between empirical and calculated weights from 40 to 70 inches were very slight. The curve under 40 inches is based on calculated date only because 40 inches was the minimum size limit.

Age Frequency

The registered lake sturgeon ranged in age from 7 to 68 years. However, age frequency is presented in age groups from 7 to 39; age groups 40 and over were combined (Table 11, Appendix). Out of 7,013 aged fish, age group 16 accounted for the highest harvest (374 fish, 5.3 percent). There

was a gradual increase in the harvest from age group 7 to age group 16 followed by a gradual decrease through age group 39; however, the increases and decreases were not systematic (Fig. 7). Age groups 12-17 accounted for 29.4 percent of the total harvest. No individual age group was consistently the age group most frequently speared in all years.

Age-Length

There was no statistical difference in the average-length for registered lake sturgeon speared in the years from 1955 through 1967 for any age group. For age group 20, the yearly average length over this period only varied from 50 to 57 inches with a mean of 54 inches (Table 12, Appendix). At age 30, the average yearly length ranged from 58 to 67 inches with a mean of 61 inches.

The average length of the fish gradually increased with an increase in age from 41 inches for an age 7 fish to 67 inches for an age 40 fish (Fig. 8).

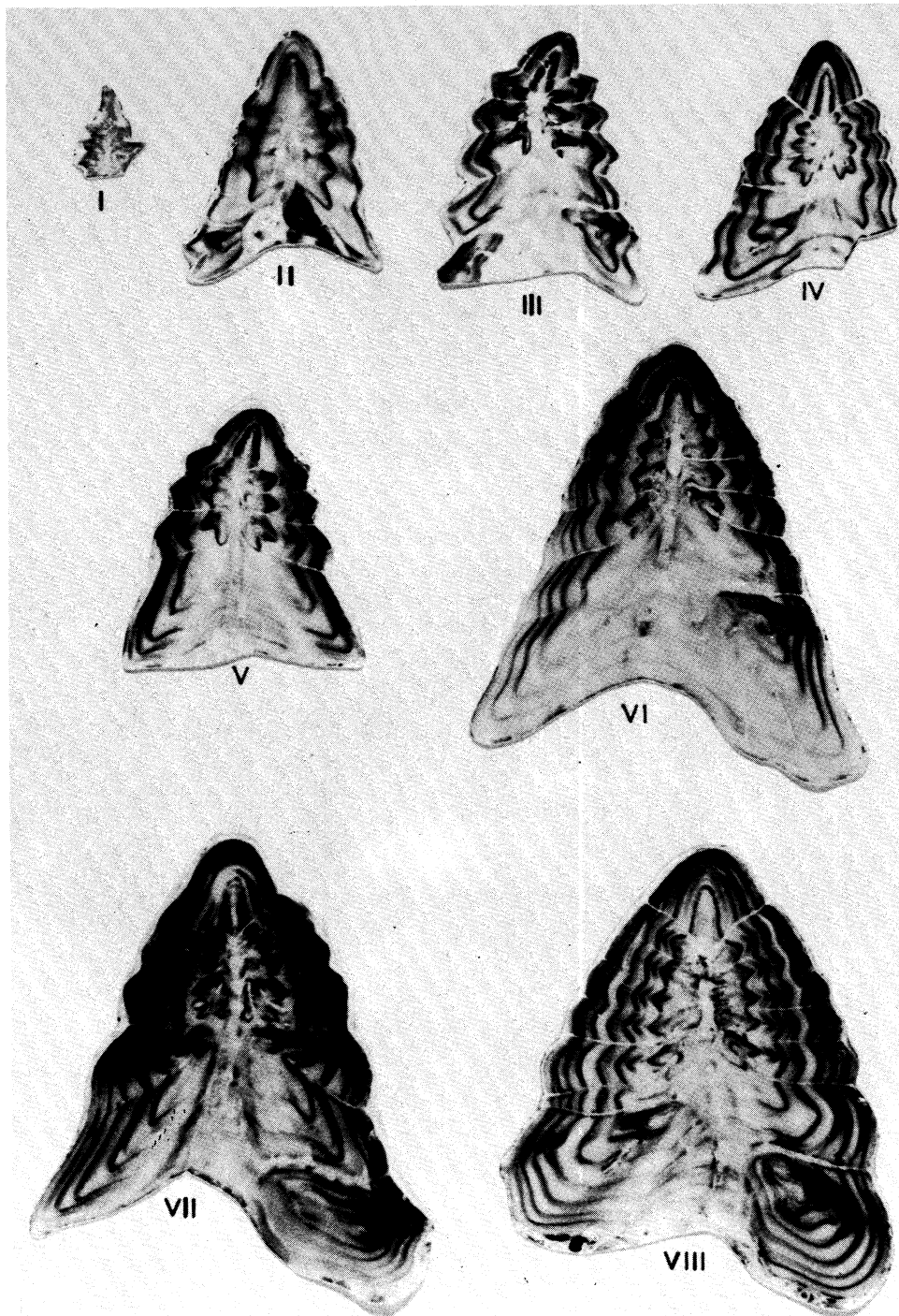
Age-Weight

For age groups 7-24, there was no statistical difference in the average annual weight over a 13-year period (1955-67). The average weight for age group 20 varied from 33 to 46 lb with a mean of 39 lb (Table 13, Appendix). Female lake sturgeon attain sexual maturity at age 25 and there was a statistical difference for the average weight of age groups 25-40. For age group 30, the yearly average weight varied from 52 to 73 lb, with a mean of 61 lb.

The average weight increased gradually with an increase in age, from 15 lb for an age 7 fish to 83 lb for an age 40 fish (Fig. 8).

Condition

Average condition factors for lake sturgeon speared on Lake Winnebago from 1955 through 1967 showed considerable yearly variation for length groups from 40 to 60 inches. There was a noticeable decrease in condition for most length groups in 1960 and 1963 (Fig. 9). Otherwise, there was no indication that the average condition of the various length groups changed over the years.



Cross sections of pectoral fins showing 8 age classes of lake sturgeon.

POPULATION SIZE

The return of tagged lake sturgeon was the best method of estimating the legal-sized population each season. From 1955 through 1959, between 1.8 and 9.1 percent of the maximum number of tagged fish available each year were returned each spearing season. Estimates each year were based only on the fish that were tagged during the year immediately preceding the February spearing season. Although the number of fish tagged was small (except for 1958 and 1959)

and the returns were limited, the estimates were quite consistent, varying from 8,700 to 13,800 fish. Estimates for 3 of these years (1956, 1957, and 1959) varied from 11,100 to 11,500 fish which strongly indicates fair significance (Table 7). The standing crop of lake sturgeon over 40 inches long in Lake Winnebago was probably not more than 11,500.

RECRUITMENT

Because of variable reproductive

success over the years, the strength of a single year class cannot be used to estimate the average number of sturgeon recruited annually into the harvestable population (i.e., those sturgeon over 40 inches in total length). To estimate minimum recruitment, it was assumed that year classes of fish old enough so that most were over 40 inches in total length represented recruitment into the harvestable population. The portion of the total catch that these year classes comprised was assumed to be the segment that was recruited.

Seventeen year classes—1936 through 1952—were available to examine. The 15- through 19-year-old fish were chosen as the sample on which to estimate recruitment (Table 8). Based on the number of 15- to 19-year-old sturgeon harvested from 1955 to 1967, the simple arithmetic average portion of the catch for all age groups was 4.7 percent. This figure is below the actual average recruitment because: (1) faster growing individuals of these age groups were harvested prior to their representation in the sample, and (2) spearers are likely to pass up smaller fish to chance spearing a larger one, thus under-representing these younger age groups.

To estimate actual recruitment, a catch curve of Lake Winnebago sturgeon was constructed from the harvest during the same 13-year period (Fig. 10). The regression of the log of the number of sturgeon harvested when compared to age represents the survival rate. This survival rate can be approximated by two straight lines, each representing a uniform rate within the age range shown. For sturgeon between ages 16 and 36, the survival rate is 0.946 (mortality rate is 0.054) and for older fish, it is 0.866 (mortality rate is 0.134). Based on these mortality estimates and on the conclusion that the population size and age structure has not changed over the years of study, the actual recruitment of sturgeon into the harvestable population is estimated at 5.4 percent by this method.

The catch curve is noted to have a depression that occurs between ages 17 and 24. Although no explanation for this depression was found, it may have been related to spawning behavior since male sturgeon reach maturity at an age close to 17 years and females first mature at about 25 years (Priegle and Wirth 1971).

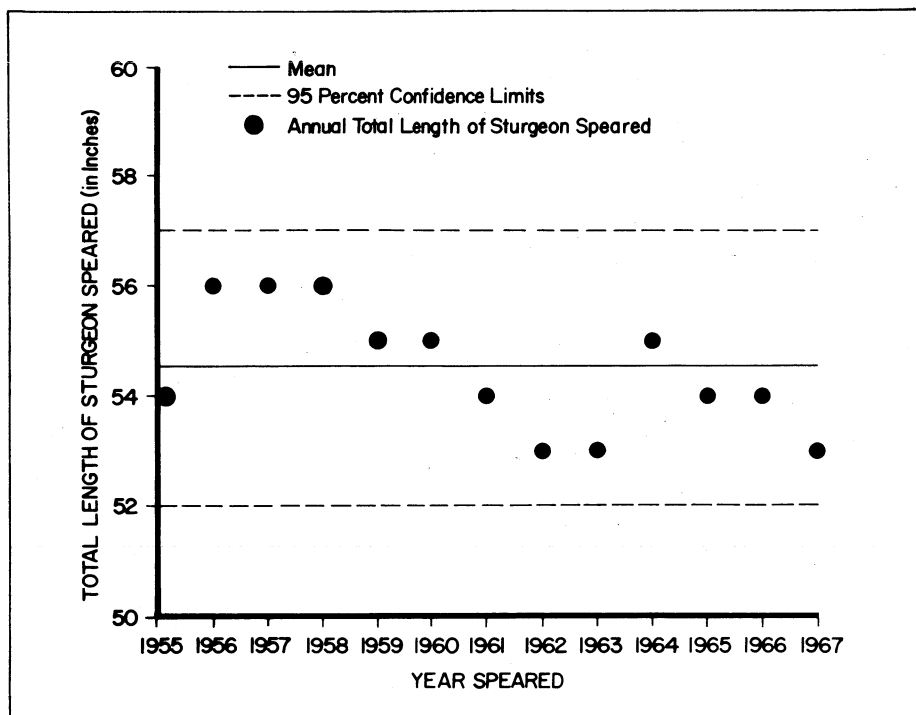


FIGURE 5. Variation in average total length (in inches) for lake sturgeon from Lake Winnebago, 1955-67.

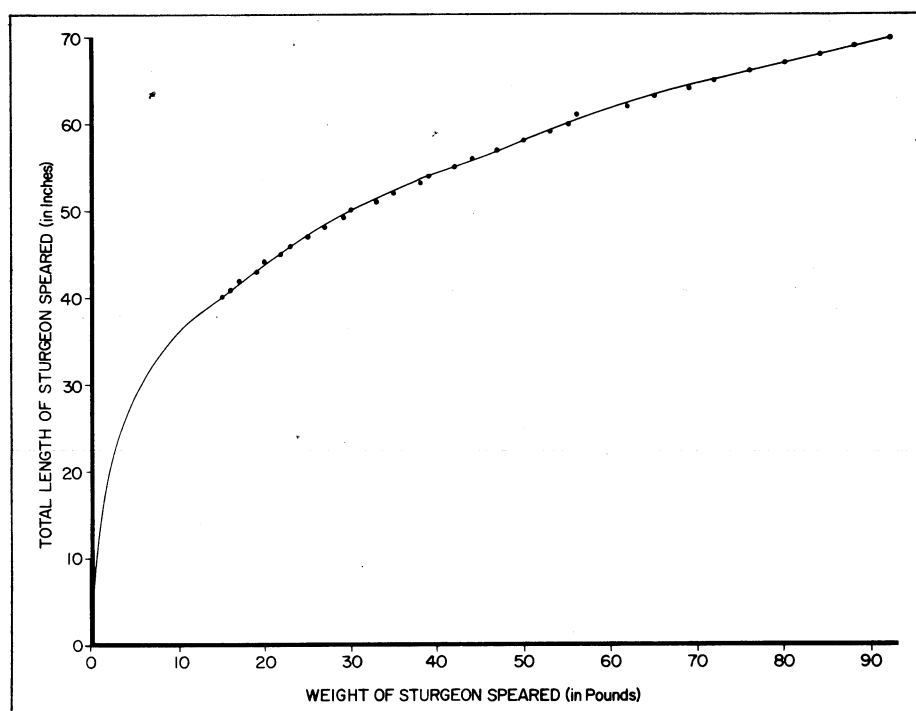


FIGURE 6. Length-weight relationship of lake sturgeon from Lake Winnebago. (The curve represents the calculated weights and the dots, the empirical weights.)

TABLE 7. Population Estimates of Lake Sturgeon over 40 Inches in Length from Lake Winnebago, 1955-59

Year	Total Harvest	Number of Fish Tagged	Number of Tags Returned	Population Estimate	95% Confidence Limits
1955	1,505	55	5	13,800	3,200-24,400
1956	661	173	9	11,500	4,500-18,400
1957	851	176	12	11,500	5,400-17,600
1958	464	450	23	8,700	5,300-12,100
1959	221	499	9	11,100	4,300-17,800

FIGURE 7.
Age frequency for lake sturgeon
speared in Lake Winnebago, 1955-67.

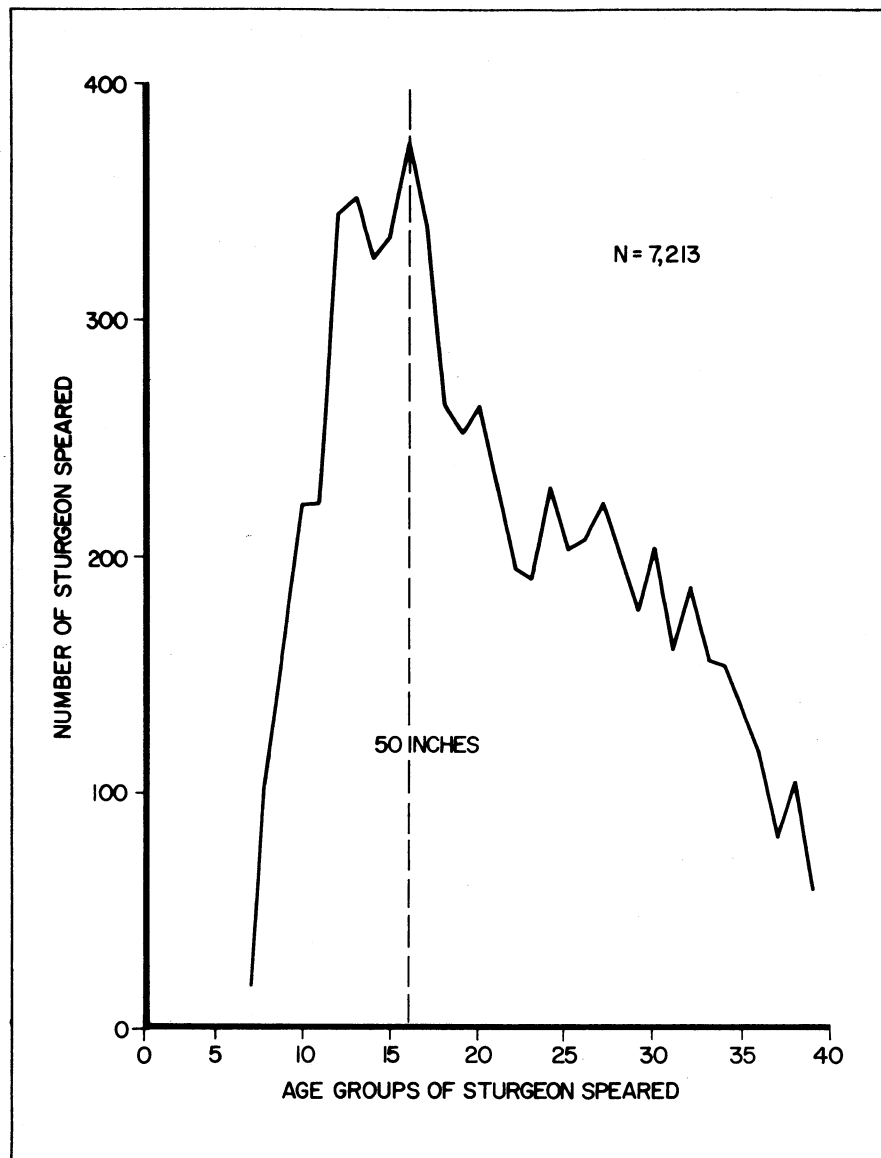
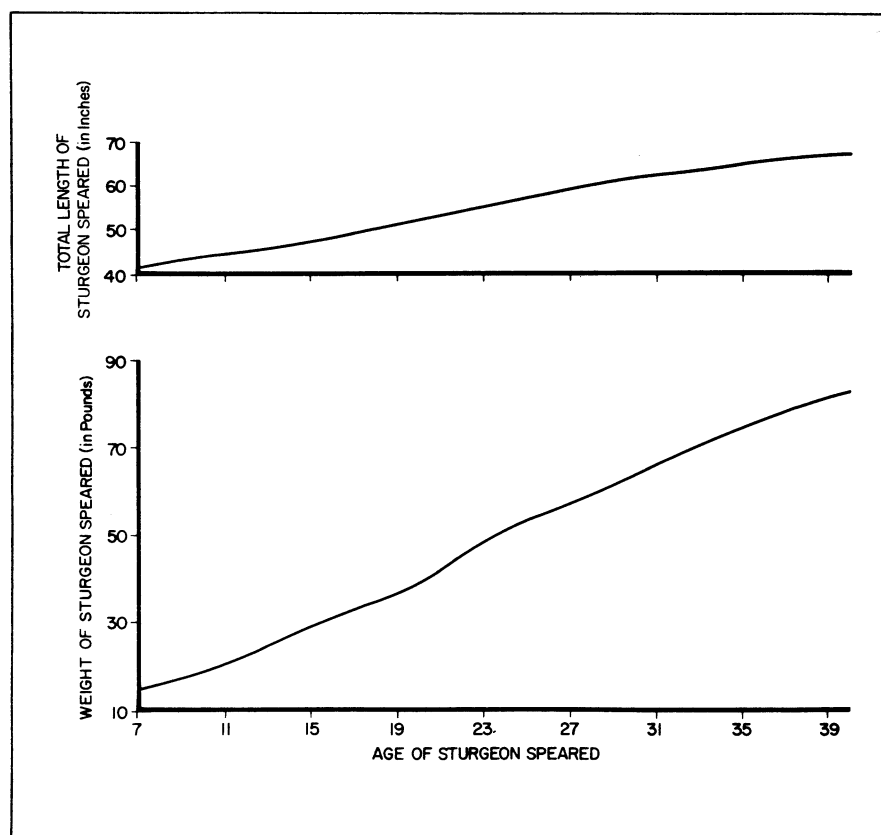


FIGURE 8.
Age-length (total in inches) and
age-weight (pounds) relationship of lake
sturgeon from Lake Winnebago, 1955-67.



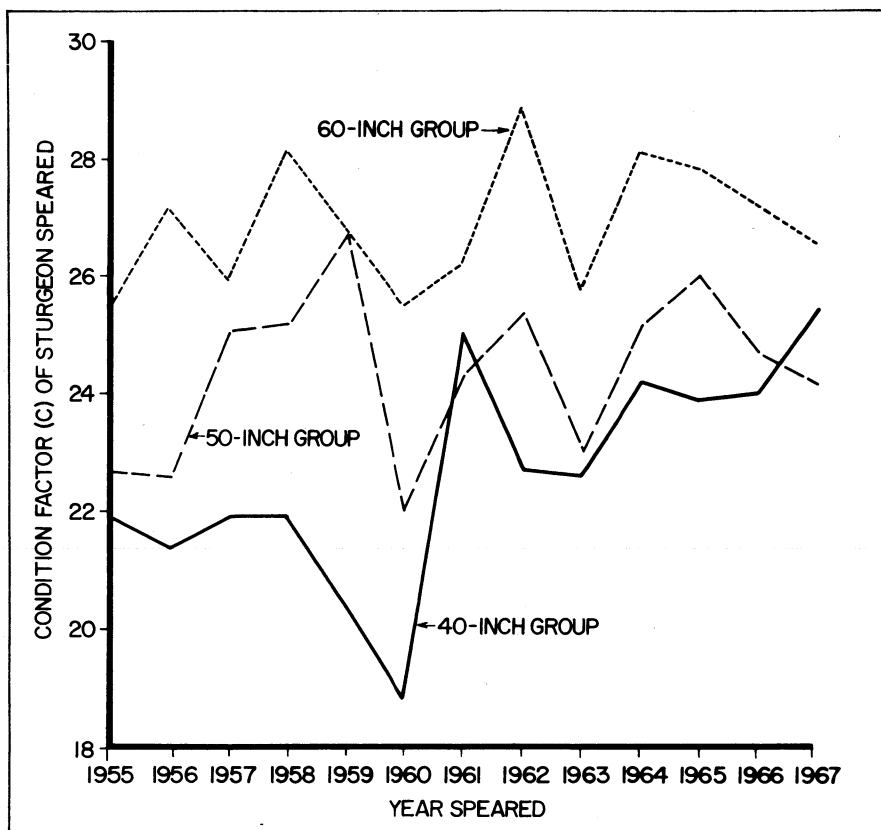


FIGURE 9.
Annual average condition factors (C)
for 40-, 50- and 60-inch lake
sturgeon from Lake Winnebago, 1955-67.

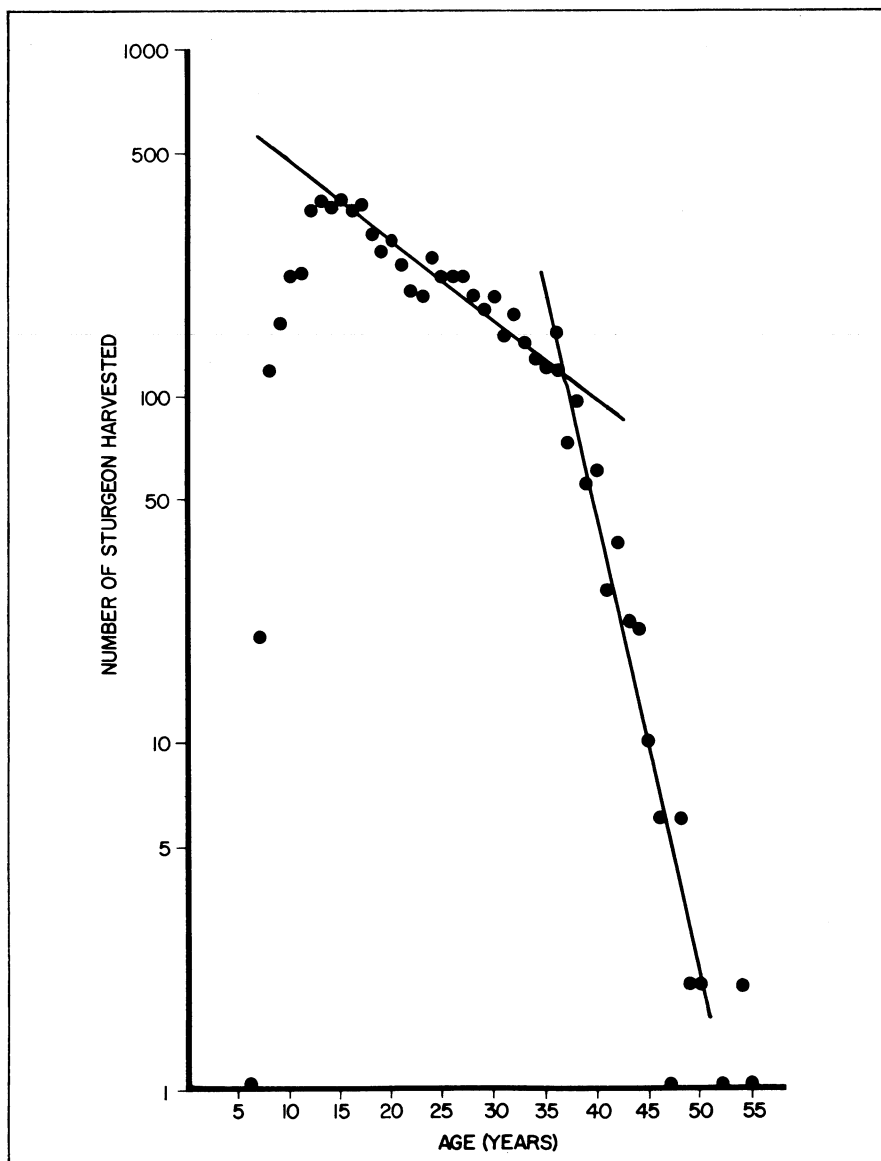


FIGURE 10.
Catch curve of Lake Winnebago lake
sturgeon harvested from 1955 to 1967.

TABLE 8. *Percent of the Total Harvest of 15- to 19-year-old Lake Sturgeon Speared in Lake Winnebago, 1955-67**

Year Class	Year of Harvest													Avg.
	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	
1952													6.6	6.6
1951												10.5	8.6	9.6
1950											6.3	8.8	6.1	7.1
1949										4.2	2.8	3.4	3.5	3.5
1948									4.3	4.8	3.5	3.4	3.2	3.8
1947								4.2	4.3	1.9	3.3	3.4		3.4
1946							2.4	4.2	1.7	1.9	2.4			2.5
1945						1.2	1.2	2.4	1.7	1.3				1.6
1944					1.8	2.4	3.0	1.2	2.2					2.1
1943				5.2	3.6	7.1	6.3	1.8						4.8
1942			10.2	5.6	5.9	5.3	3.9							6.2
1941		4.7	11.7	7.2	6.4	5.5								7.1
1940	3.8	2.7	7.6	4.5	4.1									4.5
1939	8.7	11.5	7.9	8.3										9.1
1938	3.8	5.2	6.0											5.0
1937	5.7	4.8												5.3
1936	3.8													3.8
Average	5.1	5.6	8.7	6.2	4.3	4.3	3.4	2.8	2.8	2.8	3.6	5.9	5.6	

*No growth is assumed to take place during the year in which the fish are harvested because the harvest takes place in February.

DISCUSSION



Bridges across pressure cracks allow vehicle travel over most of the lake.

Extreme fluctuations in the annual harvest are governed by weather conditions and water clarity and not by scarcity of legal-sized fish (Table 2). Until the coming of snowmobiles, travel on the lake was confined to automobile or truck travel. Any accumulation of snow or drifting snow restricted travel to well-plowed roads leading to sturgeon shanty concentrations, thus preventing the spearer from moving his shanty to more productive areas.*

Water clarity is the most limiting factor in determining the annual harvest. Even if the spearer can freely

*In recent years, snowmobiles and all-terrain vehicles permit travel to all parts of the lake regardless of snow drift or accumulation. Shanties, however, must still be pulled onto the lake by means of heavier vehicles (i.e., tractors, trucks, and automobiles). Use of snowmobiles and "all-terrain vehicles" has thus made the spearer, but not his shanty, more mobile.

travel around the lake, under water visibility must be good, otherwise he cannot detect his target. Although sturgeon are occasionally speared just below the ice, they are more often taken at lower depths and for this reason, spearing is most productive when water clarity is excellent. In 1969, weather conditions were good, permitting car travel on all areas of the lake during most of the season; however, water clarity was extremely poor (i.e., visibility was less than 4 ft) and thus, the season harvest was only 8 fish.

According to harvest data reported in the literature for lakes which have supported a commercial fishery for lake sturgeon, a rapid decline in yield occurs when such populations are fished.* The results have always been the same—a relatively high, initial yield, followed by a sudden and permanent decline to very low levels. Within 10 years (1885-95), the Lake Erie catch fell from over 5,000,000 lb to less than 1,000,000 lb—a decline of over 80 percent from which the fishery never recovered, producing only 20,000 lb in 1951 (Anderson and Peterson 1954). In Lake of the Woods, Minnesota, the fishery declined 90 percent in 7 years (1893-1900), from just under 2,000,000 lb to under 200,000 lb. By 1930, the Lake of the Woods fishery had declined to less than 10,000 lb (Harkness and Dymond 1961) and since 1941, the lake sturgeon has been on the protected list (Heyerdahl and Smith 1972). Previously unfished sturgeon waters in Ontario, Canada do not exist and production in previously productive waters has settled down to a relatively low, continuous yield (Harkness and Dymond 1961).

In Lake Winnebago neither a continuous sport fishery in effect since 1932, nor an unknown harvest by illegal methods has resulted in a rapid decline in the fishery as far as can be determined from records available from 1941 to 1943, and 1947 to 1951 (Probst and Cooper 1955), and 1955 to 1967. The harvest during these periods has evidently never been sufficient to show the rapid decline that would have occurred if the population were over-exploited. Instead, there have been great fluctuations in the harvest (Fig. 11). The total harvest was

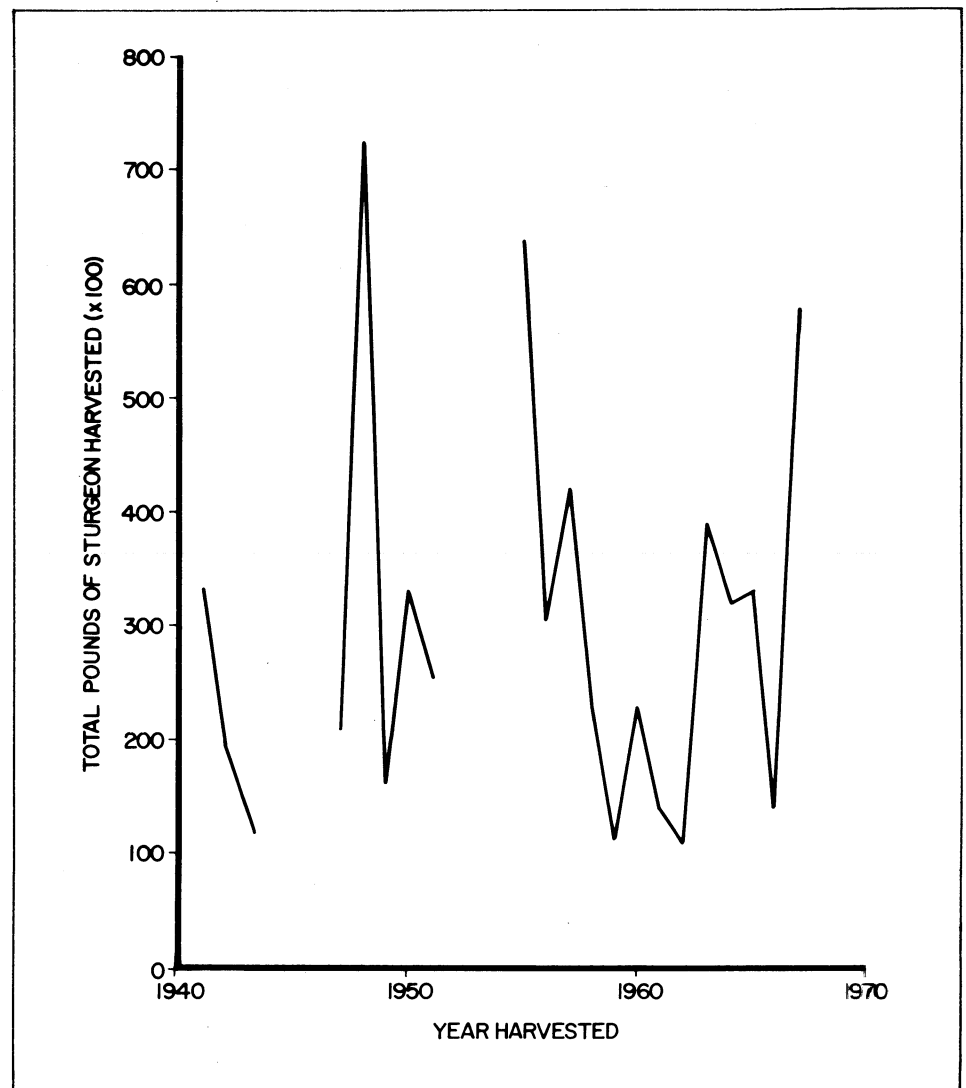


FIGURE 11. Harvest (total pounds) of lake sturgeon from Lake Winnebago, 1941-43, 1947-51, and 1955-67.

never dropped below 10,000 lb per year except in 1968 and 1969 when poor water clarity resulted in only 756 and 312 lb, respectively, being taken.

Although the lake sturgeon population in Lake Winnebago has demonstrated no rapid decline, its numbers are small when compared to numbers of other fish species in Lake Winnebago. The total lake sturgeon harvest in Lake Winnebago from 1955 through 1969 only amounted to 122 lb/square mile (215 square miles). During essentially the same period (1955-66), state and private commercial fishermen removed 12,945 lb/square mile of freshwater drum annually (Priegel 1971).

The average annual harvest from 1955 through 1969 was 599 fish; however, if the 1968 and 1969 harvests in which only 29 fish were taken are deducted, the annual average harvest would be 688 fish. Probst and Cooper (1955) reported an estimated annual harvest of 695 fish for 1941-43

and 1947-51. The estimate was based on a partial return of creel census cards, projected to the total number of spearing participants. In 1955, when creel census cards were distributed and when mandatory registration also took effect, it was found that the estimate of harvest based on census card returns was 2 times as great as the estimate of harvest based on the number of fish registered. During the 8-year period, Probst and Cooper (1955) reported that only 22 percent of the census cards were returned and that the number of sturgeon reported speared averaged 50 percent of the number of spears reporting. Obviously successful spears were more prone to report than unsuccessful spears. Therefore, it seems reasonable to cut the harvest estimates in half for 1941-43 and 1947-51.

Even with this adjustment, spearing success was better when computed on a "sturgeon-per-spearer" basis for the 8 early years compared to the 1960-69

*There has never been a commercial fishery for lake sturgeon in Lake Winnebago.

period. During the early years, one sturgeon was harvested per 4 spearers, while during the latter period, 1 sturgeon per 7.7 spearers was harvested. Spearing restrictions were tighter during the latter period—season length was cut 30 percent, bag limit was cut from three sturgeon during the earlier period to one sturgeon per season, and the minimum size limit was increased from 30 to 40 inches. In addition, the number of people participating in the sport tripled during the latter period (about 1,355 vs. 4,060 per year), so that a lower catch per person could be expected due at least in part to greater numbers of inexperienced spearers.

In a fishery in which a sustained yield is desired, the average age and size of the fish in the harvest should not decrease. When more fish are harvested than are recruited by growth, younger and smaller fish are harvested during each successive season. The catch per unit of effort may also decline. The sturgeon population in Lake Winnebago to date has demonstrated none of these declines. The average length of the total harvest has shown little variation from a mean of 54.5 inches. There has been no decrease in the ages of the fish harvested. There is no statistical difference in the average length for registered lake sturgeon for any age group. These data on average age and length frequency of fish harvested indicate that the sturgeon population being exploited in Lake Winnebago has remained fairly stable.

To maintain a sustained yield in any population, it is imperative that no more of the population than is recruited by growth or immigration be harvested either through natural or angler (spearing in this case) mortality. It is assumed that natural mortality is not significant in the legal-sized lake sturgeon population in Lake Winnebago and that annual recruitment and growth will continue at the same pace that they have in the past. The only factors that may upset these assumptions are an illegal harvest, especially during the spawning migration into the Wolf and Fox rivers, and mortality due to collisions with boat propellers. The latter factor has been observed and may increase with increased use of pleasure boats.

On the basis of tag returns, population estimates were made on the Lake Winnebago sturgeon population. These estimates assumed that: (1) a sufficient number of fish are sampled during the season; (2) all tagged fish retain their tags; (3) all tagged fish that are speared are reported; (4) tagged fish are taken in the same proportion as the unmarked segment of the population; (5) tagged fish do not migrate out of the study area; (6) natural mortality, if any, of tagged and unmarked fish is equal; and (7) sizes and ages of tagged fish are similar enough to unmarked fish so that a harvest bias is not present.

All of the above assumptions except the first 3 appear to be valid. Sufficient numbers of tagged fish were not

taken during the season. Some tag loss occurs but the extent is unknown. Until a \$10.00 reward was offered for the return of tags, few tags were returned. The reward first offered in 1956 increased the rate of tag returns significantly; therefore, the substantial reward plus required registration helped to maximize tag returns.

The standing crop of lake sturgeon in Lake Winnebago is probably not more than 11,500. To protect this population, it appears safest to limit the harvest to the recruitment estimate of 4.7 percent rather than the higher estimate of 5.4 percent. Over a period of years, this would dictate an average annual harvest of 540 fish. The actual average annual harvest from 1955 through 1969 has been 599 fish. The increase in the minimum legal length from 40 to 45 inches is calculated to decrease the average annual harvest from 1955 to 1969 by 11 percent, which would have lowered this average harvest to 533. A 45-inch size limit will bring the harvest more in line with the lower estimate of annual recruitment.

If over-exploitation should occur in future years, the minimum size limit could be increased to 50 inches and this, on the average, could save another 18 percent. Based on the 1955-1969 harvest figures, a 50-inch size limit would have reduced the average annual harvest to 425 fish, with all other conditions remaining the same.

MANAGEMENT RECOMMENDATIONS

The size limit at present, appears to be the best method of regulating the harvest on Lake Winnebago. In 1974, the minimal legal size for sturgeon was increased from 40 to 45 inches. This change in the regulations is expected to decrease the average annual harvest by 11 percent and bring the harvest in line with average annual recruitment. An increase in the minimum size limit to 50 inches could decrease the average annual harvest by another 18 percent and should be considered if over-exploitation occurs in the future. In either case, increased fishing effort and/or success will nullify the desired

reduction in exploitation.

Reducing the length of the open season will also reduce the catch, unless fishing effort increases, with a proportional increase in harvest.

Closure of the sturgeon fishery for a period of years was formerly considered a good management practice to permit the population to return to something like its original abundance. This has not occurred on the smaller upriver lakes which have a short 2-day season every third year. A 10-year closed period in Manitoba, beginning in 1927, was insufficient to permit the fishery to recover (Hinks 1943). A

21-year closure of Lake Michigan (1929-50) had no apparent effect on the population (Van Oosten 1956). Failure of some sturgeon fisheries to recover during a closed period up to 20 years is probably due to a combination of factors. First of all, in some waters, it takes a sturgeon that long to reach a size at which it may be legally caught. Thus, fish hatched at the beginning of such a closed season only begin to enter the fishery by the time the season is opened again. Secondly, spawning grounds may be destroyed by such encroachments as dams on river spawning routes.

It is essential on Lake Winnebago to continue the system of registration including the measurement of all fish speared. Such measurements will be used to determine if the length frequency of the harvest is changing to a harvest of smaller and younger fish. The registration system should also include the collection, every fifth year, of fin bones from all fish harvested to determine if there is an increase in the harvest of younger fish. Since harvest success varies considerably because of weather conditions and water clarity,

it may be necessary to collect fin bones over a period of 3 years. For example, a program should now be established to collect fin bones in 1975, 1976, and 1977, followed by another collection period in 1981, 1982, and 1983. If sufficient fin bones are collected in the first year, collections can be dropped the following two years. A collection of 300 or more fin bones would be sufficient if the collection was a true random sample of the total harvest, and therefore representative of the age structure of

the population.

It is vital that the lake sturgeon population and harvest in Lake Winnebago should be sampled on a regular basis to watch for any signs of over-exploitation and to initiate studies to determine causes of over-harvest should evidence warrant it. Once the population is over-exploited, it is almost a safe assumption that the population will never recover to former abundance, as has already been shown throughout the natural geographical range of the lake sturgeon.

SUMMARY

From 1955 through 1969, the total harvest of lake sturgeon based on registration figures was 8,981 fish. The average annual harvest was 599 fish. Since 1960, license sales varied from 2,167 in 1969 to 6,624 in 1965 and averaged 4,405. Weather conditions and water clarity are the two factors most responsible for the fluctuations in the annual harvest and license sales.

The year classes in the harvest (1955-69) were represented by the 1907-60 year classes, including one fish from each of the 1887, 1893, and 1901 year classes. No individual year class demonstrated a peak, followed by a gradual or abrupt decline over the 13-year period.

Spearing success per license holder has varied from 6.9 percent in 1966 to 23.7 percent in 1967, with an average

success of 15.9 percent. Only 0.2-1.0 percent of the nonresident spearers are successful.

Lake sturgeon in the 40- to 44-inch and 45- to 49-inch groups combined accounted for 20.6-41.7 percent of the annual harvest; however, there has been no systematic shift indicating an increase or decrease in the harvest of these two length groups over the 13 years. The average annual length of all lake sturgeon harvested has shown little variation (53-56 inches) from a mean of 54.5 inches.

The registered lake sturgeon ranged in age from 7 to 68 years. No individual age group was consistently the age group most frequently speared in all years.

There was no statistical difference in the average length for registered

lake sturgeon speared for any age group. The average length of the fish gradually increased with an increase of age from 41 inches for an age 7 fish to 67 inches for an age 40 fish.

The average weight increased gradually with an increase in age, from 15 lb for an age 7 fish to 83 lb for an age 40 fish.

The return of tagged lake sturgeon was the best available method of estimating the legal-sized population each season. The standing crop of lake sturgeon over 40 inches long is probably not more than 11,500.

Because of unknown loss in addition to spearing mortality, 4.7 percent is the maximum segment of the legal population that is recommended to be taken annually if the population present in 1969 is to be maintained.

TABLE 9A. Number and Percent (in Parentheses) of Lake Sturgeon Speared on Lake Winnebago by Year Class, 1955-61

Year Class	1955	1956	1957	1958	1959	1960	1961
1960							
59							
58							
57							
56							
55							
54							
53						1(0.2)	2(0.6)
52						1(0.2)	10(3.0)
51					2(0.9)	17(3.4)	26(7.8)
1950				1(0.2)	3(1.4)	11(2.2)	13(3.9)
49					2(0.9)	7(1.4)	7(2.1)
48				7(1.6)	4(1.8)	9(1.8)	13(3.9)
47	1(0.1)	4(0.7)		6(1.3)	9(4.1)	21(4.2)	24(7.2)
46	5(0.6)	3(0.5)		17(3.8)	14(6.4)	15(2.9)	8(2.4)
45		2(0.4)	1(0.3)	4(0.9)	1(0.5)	6(1.2)	4(1.2)
44	11(1.3)	7(1.3)	11(3.5)	10(2.2)	4(1.8)	12(2.4)	10(3.0)
43	38(4.5)	20(3.6)	18(5.7)	23(5.2)	8(3.6)	36(7.1)	21(6.3)
42	24(2.9)	12(2.1)	32(10.2)	25(5.6)	13(5.9)	27(5.3)	13(3.9)
41	49(5.8)	26(4.7)	37(11.7)	32(7.2)	14(6.4)	28(5.5)	24(7.2)
1940	32(3.8)	15(2.7)	24(7.6)	20(4.5)	9(4.1)	44(8.7)	15(4.5)
39	73(8.7)	64(11.5)	25(7.9)	37(8.3)	25(11.4)	35(6.9)	21(6.3)
38	32(3.8)	29(5.2)	19(6.0)	23(5.2)	13(5.9)	22(4.4)	8(2.4)
37	48(5.7)	27(4.8)	20(6.3)	20(4.5)	13(5.9)	19(3.8)	14(4.2)
36	32(3.8)	22(3.9)	13(4.1)	16(3.6)	5(2.3)	15(2.9)	5(1.5)
35	17(2.0)	20(3.6)	6(1.9)	18(4.0)	3(1.4)	8(1.6)	7(2.1)
34	10(1.2)	2(0.4)	4(1.3)	12(2.7)	2(0.9)	5(0.9)	9(2.7)
33	4(0.5)	9(1.6)	12(3.8)	8(1.8)	5(2.3)	16(3.2)	7(2.1)
32	9(1.0)	9(1.6)	18(5.7)	18(4.0)	8(3.6)	20(3.9)	5(1.5)
31	11(1.3)	11(1.9)	16(5.1)	23(5.2)	9(4.1)	10(1.9)	7(2.1)
1930	32(3.8)	17(3.1)	9(2.8)	16(3.6)	6(2.7)	20(3.9)	12(3.6)
29	43(5.1)	41(7.4)	15(4.8)	20(4.5)	12(5.5)	19(3.8)	7(2.1)
28	37(4.4)	28(5.0)	9(2.8)	18(4.0)	6(2.7)	9(1.8)	6(1.8)
27	35(4.2)	25(4.5)	7(2.2)	19(4.3)	9(4.1)	13(2.6)	11(3.3)
26	44(5.3)	31(5.6)	8(2.5)	26(5.8)	3(1.4)	19(3.8)	10(3.0)
25	43(5.1)	18(3.2)	3(0.9)	7(1.6)	4(1.8)	14(2.8)	1(0.3)
24	34(4.1)	18(3.2)	2(0.6)	3(0.7)	3(1.4)	12(2.4)	1(0.3)
23	43(5.1)	30(5.4)	1(0.3)	4(0.9)	4(1.8)	1(0.2)	2(0.6)
22	27(3.2)	19(3.4)	3(0.9)	7(1.6)	2(0.9)	4(0.8)	6(1.8)
21	11(1.3)	11(1.9)			1(0.5)	1(0.2)	1(0.3)
1920	25(3.0)	7(1.3)		3(0.7)	1(0.5)	2(0.4)	1(0.3)
19	17(2.0)	6(1.1)	2(0.6)		1(0.5)		1(0.3)
18	13(1.5)	7(1.3)		1(0.2)		2(0.4)	1(0.3)
17	9(1.0)	2(0.4)				2(0.4)	
16	4(0.5)	6(1.1)				1(0.2)	
15	6(0.7)	2(0.4)					
14	2(0.2)	1(0.2)		1(0.2)	1(0.5)		
13	7(0.8)	1(0.2)					
12	1(0.1)	1(0.2)					
11	3(0.4)						
1910	1(0.1)	1(0.2)				1(0.2)	
09		1(0.2)					
08							1(0.3)
07	1(0.1)						
1901	1(0.1)						
1893		1(0.2)					
1887	1(0.1)						
Total	836	556	315	445	219	505	333

TABLE 9B. Number and Percent (in Parentheses) of Lake Sturgeon Speared in Lake Winnebago by Year Class, 1962-67

Year Class	1962	1963	1964	1965	1966	1967	Total (1955-1967)
1960						6(0.4)	6(0.1)
59				1(0.1)	2(0.7)	70(4.9)	73(1.0)
58				7(0.9)	11(3.7)	63(4.5)	81(1.1)
57			3(0.4)	12(1.7)	5(1.7)	71(5.1)	91(1.3)
56		1(0.1)	6(0.9)	23(3.3)	8(2.7)	57(4.1)	95(1.3)
55		9(1.4)	8(1.2)	36(5.1)	7(2.4)	73(5.2)	133(1.9)
54	2(1.2)	20(3.1)	22(3.3)	29(4.1)	14(4.8)	68(4.8)	155(2.2)
53	1(0.6)	23(3.5)	13(1.9)	23(3.3)	7(2.4)	54(3.8)	134(1.9)
52	12(7.3)	52(8.0)	47(7.1)	53(7.5)	16(5.4)	93(6.6)	284(4.0)
51	22(13.3)	92(14.2)	73(10.9)	74(10.5)	31(10.5)	120(8.6)	457(6.4)
1950	8(4.8)	47(7.2)	48(7.2)	44(6.3)	26(8.8)	86(6.1)	287(4.0)
49	7(4.2)	24(3.7)	28(4.2)	20(2.8)	10(3.4)	49(3.5)	154(2.2)
48	7(4.2)	28(4.3)	32(4.8)	25(3.5)	10(3.4)	45(3.2)	180(2.5)
47	7(4.2)	28(4.3)	13(1.9)	23(3.3)	10(3.4)	29(2.1)	175(2.4)
46	7(4.2)	11(1.7)	13(1.9)	17(2.4)	10(3.4)	39(2.8)	159(2.2)
45	4(2.4)	11(1.7)	9(1.3)	10(1.4)	5(1.7)	27(1.9)	84(1.2)
44	2(1.2)	14(2.2)	20(3.0)	13(1.8)	8(2.7)	30(2.1)	152(2.1)
43	3(1.8)	27(4.2)	26(3.9)	23(3.3)	14(4.8)	48(3.4)	305(4.3)
42	9(5.5)	22(3.4)	24(3.6)	25(3.5)	11(3.7)	60(4.3)	297(4.2)
41	8(4.8)	27(4.2)	24(3.6)	36(5.1)	14(4.8)	27(1.9)	346(4.9)
1940	5(3.0)	13(2.0)	22(3.3)	18(2.6)	8(2.7)	28(2.0)	253(3.6)
39	14(8.5)	39(6.0)	29(4.4)	30(4.3)	10(3.4)	24(1.7)	426(6.0)
38	5(3.0)	12(1.8)	18(2.7)	13(1.8)	4(1.4)	33(2.3)	231(3.3)
37	1(0.6)	25(3.8)	18(2.7)	19(2.7)	5(1.7)	23(1.6)	252(3.6)
36	1(0.6)	4(0.6)	8(1.2)	9(1.3)	2(0.7)	16(1.1)	148(2.1)
35	4(2.4)	7(1.1)	3(0.4)	12(1.7)	5(1.7)	11(0.8)	121(1.7)
34		4(0.6)	9(1.3)	4(0.6)	2(0.7)	10(0.7)	73(1.0)
33	4(2.4)	9(1.4)	4(0.6)	11(1.6)	2(0.7)	8(0.6)	99(1.4)
32	1(0.6)	1(0.1)	21(3.2)	5(0.7)	7(2.4)	18(1.3)	140(2.0)
31	2(1.2)	10(1.5)	18(2.7)	15(2.1)	4(1.4)	12(0.9)	148(2.1)
1930	1(0.6)	9(1.4)	18(2.7)	5(0.7)		25(1.8)	170(2.3)
29	4(2.4)	10(1.5)	6(0.9)	11(1.6)	1(0.3)	15(1.1)	204(2.9)
28	2(1.2)	14(2.2)	15(2.3)	6(0.8)	8(2.7)	16(1.1)	174(2.4)
27	4(2.4)	18(2.8)	9(1.3)	16(2.3)	7(2.4)	11(0.8)	184(2.6)
26	4(2.4)	7(1.1)	12(1.8)	6(0.8)	6(2.0)	9(0.6)	185(2.6)
25	1(0.6)	13(2.0)	10(1.5)	11(1.6)		7(0.5)	132(1.9)
24	4(2.4)	2(0.3)	9(1.3)	2(0.3)		8(0.6)	98(1.4)
23	1(0.6)	5(0.8)	3(0.4)	2(0.3)		6(0.4)	102(1.4)
22	1(0.6)	4(0.6)	13(1.9)	3(0.4)	2(0.7)	5(0.4)	96(1.3)
21	4(2.4)	4(0.6)	5(0.8)	2(0.3)			40(0.6)
1920	1(0.6)		3(0.4)	2(0.3)	1(0.3)		46(0.6)
19	1(0.6)	2(0.3)		2(0.3)		1(0.1)	33(0.5)
18		1(0.1)	2(0.3)				27(0.4)
17				4(0.6)	1(0.3)		18(0.3)
16							11(0.2)
15			1(0.1)	1(0.1)		1(0.1)	11(0.2)
14							5(0.1)
13							8(0.1)
12							2(>0.1)
11							3(>0.1)
1910							3(>0.1)
09					1(0.3)		2(>0.1)
08							1(>0.1)
07							1(>0.1)
1901							1(>0.1)
1893							1(>0.1)
1887							1(>0.1)
Total	165	649	665	704	294	1,402	7,098

TABLE 10. Length Frequency in Percent of Registered Lake Sturgeon Speared in Lake Winnebago, 1955-67

Year	No. Fish	Average Length (inches)	No. Fish by Size Groups (Total length in inches)						
			40-44	45-49	50-54	55-59	60-64	65-69	70+
1955	845*	54	12.2	18.3	19.6	18.9	20.4	8.5	2.1
1956	661	56	5.6	14.5	24.5	19.7	22.8	11.0	1.8
1957	851	56	6.4	16.8	19.6	20.8	22.4	11.4	2.6
1958	456	56	8.3	12.3	21.9	20.8	21.7	12.5	2.4
1959	220	55	10.5	12.7	20.0	27.7	22.7	4.6	1.8
1960	520	55	10.4	13.3	21.7	22.9	19.8	10.4	1.5
1961	340	54	15.9	18.2	18.8	21.8	14.7	8.5	2.1
1962	262	53	18.3	22.9	17.2	15.3	16.4	8.4	1.5
1963	1,001	53	15.2	26.5	18.9	17.7	12.8	7.0	1.8
1964	685	55	9.1	23.7	17.9	15.6	19.1	11.2	3.4
1965	718	54	12.1	23.3	19.9	16.7	15.2	9.5	3.3
1966	300	54	11.0	18.0	26.6	19.0	12.0	11.7	1.7
1967	1,424	53	13.0	22.9	25.0	16.1	12.5	8.0	2.5

*Only a sample from a total harvest of 1,505 fish.

TABLE 11. Age Frequency of Lake Sturgeon Speared in Lake Winnebago, 1955-67

Age Groups	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	Total*	Percent
7	-	-	-	-	-	1	-	-	1	3	7	2	6	20	0.3
8	1	-	-	1	2	1	1	2	9	6	12	11	71	117	1.7
9	5	4	-	-	3	17	11	1	20	8	23	5	62	159	2.3
10	-	3	-	7	2	13	26	12	23	22	36	8	71	223	3.2
11	11	2	-	6	4	7	13	21	52	13	29	8	57	223	3.2
12	38	8	1	17	9	9	7	8	92	47	23	13	73	345	4.9
13	24	20	-	4	14	22	13	7	47	72	53	8	68	352	5.0
14	49	12	4	10	1	15	24	7	24	46	74	16	54	326	4.6
15	32	27	3	22	4	6	8	7	28	29	44	32	92	334	4.8
16	73	15	1	26	8	13	4	7	28	32	20	27	120	374	5.3
17	32	64	3	32	13	36	10	4	11	13	25	11	86	340	4.8
18	47	30	4	20	14	22	21	2	11	13	23	10	48	265	3.8
19	31	28	5	37	9	30	13	3	14	9	17	10	45	251	3.6
20	17	21	5	23	25	44	24	9	27	20	11	9	29	264	3.8
21	10	22	3	20	13	24	15	8	22	26	13	5	39	220	2.1
22	3	2	3	16	13	22	21	5	27	24	23	8	27	194	2.8
23	9	10	1	18	5	18	8	14	13	24	25	14	30	190	2.7
24	10	9	1	12	3	19	14	5	39	22	36	11	48	229	3.3
25	32	11	1	8	2	10	5	1	12	29	18	14	60	203	2.9
26	43	17	3	18	5	5	7	1	25	18	30	8	27	207	3.0
27	37	42	10	23	8	17	9	4	4	18	13	10	28	223	3.2
28	35	28	17	16	9	20	7	-	7	8	19	4	24	194	2.8
29	43	25	11	20	6	10	5	4	4	3	9	5	32	177	2.5
30	44	33	14	18	12	21	7	1	9	9	12	2	22	204	2.9
31	34	19	16	19	6	20	12	2	1	4	4	5	17	160	2.3
32	42	18	19	26	9	9	7	1	10	21	11	3	11	187	2.7
33	28	31	21	7	3	13	6	4	9	18	5	2	10	157	2.2
34	11	23	22	3	4	20	11	2	10	18	15	7	8	154	2.1
35	25	12	20	4	3	14	10	4	14	6	5	5	18	140	1.9
36	17	7	10	7	4	12	1	3	18	15	11	-	12	117	1.7
37	12	6	11	-	2	1	1	1	7	9	6	1	25	82	1.2
38	9	7	11	3	1	4	2	4	13	12	16	8	15	105	1.5
39	3	2	4	-	1	1	6	1	2	10	6	7	16	59	0.8
40+	21	14	17	2	2	8	4	8	17	36	30	11	48	218	3.1

*Total number of fish = 7,013

**TABLE 12. Age-Length Frequency (Total Length in Inches) of Lake Sturgeon
Speared in Lake Winnebago, 1955-67**

Age Groups	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	Average
7	—	—	—	—	—	40	—	—	40	41	41	42	42	41
8	41	—	—	41	42	42	46	43	42	41	42	42	42	42
9	42	41	—	—	41	42	42	41	42	42	42	43	44	43
10	—	42	—	43	41	42	43	43	43	45	44	44	45	44
11	44	42	—	43	43	43	44	45	45	45	45	45	46	45
12	44	44	42	44	45	45	44	46	46	47	47	47	47	46
13	44	44	—	46	45	45	47	45	46	48	48	47	49	47
14	46	48	44	46	42	46	47	47	47	49	49	50	49	48
15	47	48	45	48	47	48	47	49	50	48	50	51	51	49
16	48	48	48	49	52	49	50	48	49	52	49	51	51	50
17	49	50	46	51	52	49	51	51	50	52	51	50	52	51
18	50	51	51	51	51	51	51	47	50	52	51	52	52	51
19	51	51	56	52	55	54	54	52	53	51	54	52	54	53
20	53	52	50	55	54	54	53	54	53	53	57	54	54	54
21	53	52	56	56	55	56	54	54	55	55	56	55	54	55
22	57	54	55	57	57	56	56	54	56	56	57	57	56	56
23	53	55	62	58	57	57	55	57	55	57	58	57	55	56
24	56	57	56	59	57	58	58	56	58	59	59	58	58	58
25	56	57	64	56	58	58	58	55	57	60	59	58	59	58
26	57	58	61	62	60	60	60	60	57	60	61	56	61	59
27	58	58	62	61	62	58	61	60	59	60	60	61	60	59
28	58	59	60	61	61	62	58	—	61	61	60	61	61	60
29	58	60	62	63	58	60	64	61	59	59	63	64	62	61
30	59	61	61	63	62	63	62	64	63	63	58	67	62	61
31	60	61	61	64	62	64	64	67	56	65	67	61	63	62
32	62	62	63	65	65	63	63	64	63	64	62	67	63	63
33	63	62	64	66	60	63	64	62	63	63	66	68	62	63
34	62	62	62	66	62	64	63	64	64	64	63	64	62	63
35	63	64	66	65	66	65	66	63	64	64	68	64	65	65
36	63	63	65	65	67	65	60	66	62	66	64	—	66	65
37	63	67	65	—	66	60	65	61	65	64	65	73	65	65
38	68	67	65	67	64	63	62	63	64	67	67	66	66	66
39	69	62	65	—	65	64	65	67	71	65	66	67	69	67
40+	69	68	64	67	75	64	68	64	66	65	67	68	68	67

**TABLE 13. Age-Weight Frequency (in Pounds) of Lake Sturgeon
Speared in Lake Winnebago, 1955-67**

Age Groups	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	Average
7	—	—	—	—	—	12	—	—	13	17	16	18	15	15
8	14	—	—	15	15	17	15	16	14	17	18	17	17	17
9	14	13	—	—	15	15	16	17	15	16	19	18	19	17
10	—	14	—	18	15	16	18	17	17	22	21	21	21	19
11	18	14	—	19	18	17	20	21	19	23	24	23	22	21
12	18	17	—	20	20	20	20	23	21	25	26	25	25	22
13	17	19	—	25	21	20	23	21	22	28	28	26	28	25
14	22	24	19	23	15	21	25	24	23	29	31	32	29	27
15	23	24	22	27	27	24	27	27	28	29	33	32	32	29
16	26	25	28	31	34	26	26	27	28	34	32	33	34	31
17	27	30	24	33	34	27	32	30	28	36	33	30	34	31
18	30	30	34	33	34	28	32	29	36	37	38	35	33	33
19	32	31	46	38	41	35	38	31	35	33	43	38	39	37
20	35	34	33	42	41	39	37	41	35	41	46	41	42	39
21	34	35	53	44	42	41	41	38	39	43	48	40	40	41
22	47	41	48	49	47	42	50	39	44	48	52	48	44	47
23	34	41	72	53	48	47	45	51	40	51	53	49	44	47
24	40	46	44	54	44	50	52	47	50	54	55	53	51	51
25	43	47	80	46	53	49	52	36	46	60	56	54	53	51
26	48	51	71	63	57	55	64	59	48	58	63	50	61	56
27	50	49	64	59	63	49	53	61	53	60	62	61	56	55
28	48	54	63	65	60	61	54	—	58	64	64	68	63	58
29	49	58	68	70	54	57	66	67	51	54	67	67	63	60
30	52	57	61	69	71	66	65	59	62	73	57	70	66	61
31	57	61	61	75	68	71	69	78	44	78	85	64	70	66
32	62	64	71	77	79	66	68	72	62	73	67	87	68	69
33	66	63	76	85	59	64	66	64	65	72	80	84	62	68
34	65	64	69	78	61	66	68	76	63	71	75	69	63	68
35	66	69	77	80	90	74	74	77	72	75	95	78	72	74
36	70	64	76	82	92	73	56	86	66	74	80	—	77	74
37	64	79	79	—	70	60	81	49	71	74	74	95	74	74
38	78	80	81	82	80	71	59	71	68	81	81	78	75	77
39	73	53	77	—	77	67	77	98	105	71	87	89	88	82
40+	85	81	68	80	107	67	74	73	80	82	87	85	88	83

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