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LAKE STURGEON MANAGEMENT ON THE MENOMINEE RIVER

Technical Bulletin Number 67
DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin
1973

ABSTRACT

The Menominee River, a border stream between Wisconsin and Michigan, contains one of the last fishable lake sturgeon populations in Wisconsin and Michigan. A section between the White Rapids and Grand Rapids dams, 26 river miles, was intensively studied in 1969 and 1970 to determine the population present and the rate of exploitation. A randomly designed creel census schedule was employed. The population estimate based on the mark and recapture method employing four A.C. boom shockers as a means of capture was 234 and 185 legal-sized fish (42 inches and larger) in 1969 and 1970, respectively. The calculated fishing pressure was 14,300 hours in 1969 and 11,400 hours in 1970. Weekend angler counts were significantly larger than weekday counts and September counts were larger than October counts in 1969 and 1970. The estimated exploitation rate based on the anglers' harvest data was 13 percent in 1969 and 17 percent in 1970, which is considered too high. To maintain a harvestable population, an exploitation rate of 5 percent would be desirable. Wisconsin residents accounted for 78 percent of the fishing effort in both years.

The fish ranged in age from 1 to 45 years and the age data indicated that there is natural reproduction occurring every year although varying in degree of success. Legal-sized fish (42 inches) began to enter the fishery at age 12.

Surveys in other sections of the Menominee River in 1971 and 1972 indicated that if there is a lake sturgeon population above the White Rapids dam it is only nominal as no fish were captured. Lake sturgeon were taken from the White Rapids dam downstream to the mouth of the Menominee River, a distance of 50 river miles.

**LAKE STURGEON MANAGEMENT
ON THE MENOMINEE RIVER**

By
Gordon R. Priegel

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INTRODUCTION

The lake sturgeon, *Acipenser fulvescens* Rafinesque is a threatened species that has been classified as rare by the Committee on Rare and Endangered Wildlife Species, Bureau of Sport Fisheries and Wildlife (1966). It is a slow-growing, late-maturing fish which does not survive a high level of exploitation. Stream modification (dams, pollution and disturbance of spawning sites) resulting from human settlement and industrial development have produced conditions unfavorable for its survival throughout most of its range.

The Menominee River, a border stream between Wisconsin and Michigan, contains one of the last fishable lake sturgeon populations in Wisconsin and Michigan. Both states are concerned about protecting this unique fish population. The most direct pro-

ductive measure is to regulate the angler harvest; however, the intensity of the fishing effort and the effect it has on the lake sturgeon population was not known.

To answer these questions in order to devise realistic regulations, a study was initiated in 1969 and continued in 1970 to determine the size of the lake sturgeon population and the rate of exploitation for a section of the Menominee River between the White Rapids and Grand Rapids dams, a distance of 26 river miles. In addition, other sections of the river between the various power dams were surveyed in 1971 and 1972 to determine the relative abundance of the lake sturgeon populations in these sections compared to that of the intensively studied section and to determine the upstream distribution.

STUDY AREA

The 93.8-mile-long Menominee River originates at the junction of the Brule and Michigamme rivers in north-eastern Florence County, Wisconsin, and flows into Green Bay, Lake Michigan. The drainage area including both Wisconsin and Michigan is 4,055 square miles. There are currently 10 dams (7 hydroelectric and 3 paper mills) on the Menominee River (Fig. 1). Bottom types in the sections studied are rubble (30%), gravel (25%), sand (25%), boulder (10%), bedrock (6%) and muck (4%). The majority of the muck is situated in the impoundments above the dams.

The water is classified as medium hard with a total alkalinity of 93 mg/l, CaCO_3 , a pH value of 7.1 and specific conductance of 300 micromhos/cm² at 25 C. Water color is light brown.

The intensive study section was located between the White Rapids and Grand Rapids dams, a distance of 26 river miles (Fig. 2). Both dams are operated for hydroelectric power. The average width in this section is 475 feet and the gradient approximately 2

feet per mile. During the mark and recapture period the power companies cooperated by drawing down the impoundment water levels as much as possible; however, a few holes with maximum depths of 12 to 15 feet still remained.

The other sections surveyed consisted of the section from the Grand Rapids dam downstream to the Upper Scott dam in Marinette, a distance of 21 river miles. The sections sampled above the White Rapids dam consisted of 3 river miles between the White Rapids and Chalk Hills dams and a section upstream from the Chalk Hills dam to Pemene Falls, which is a natural barrier, a distance of 9 river miles.

Present 1973 hook-and-line regulations for the lake sturgeon on the Menominee River in both Wisconsin and Michigan provide for an annual season from the first Saturday in September through November 1 with a size limit of 42 inches and a bag limit of 2 fish per season.

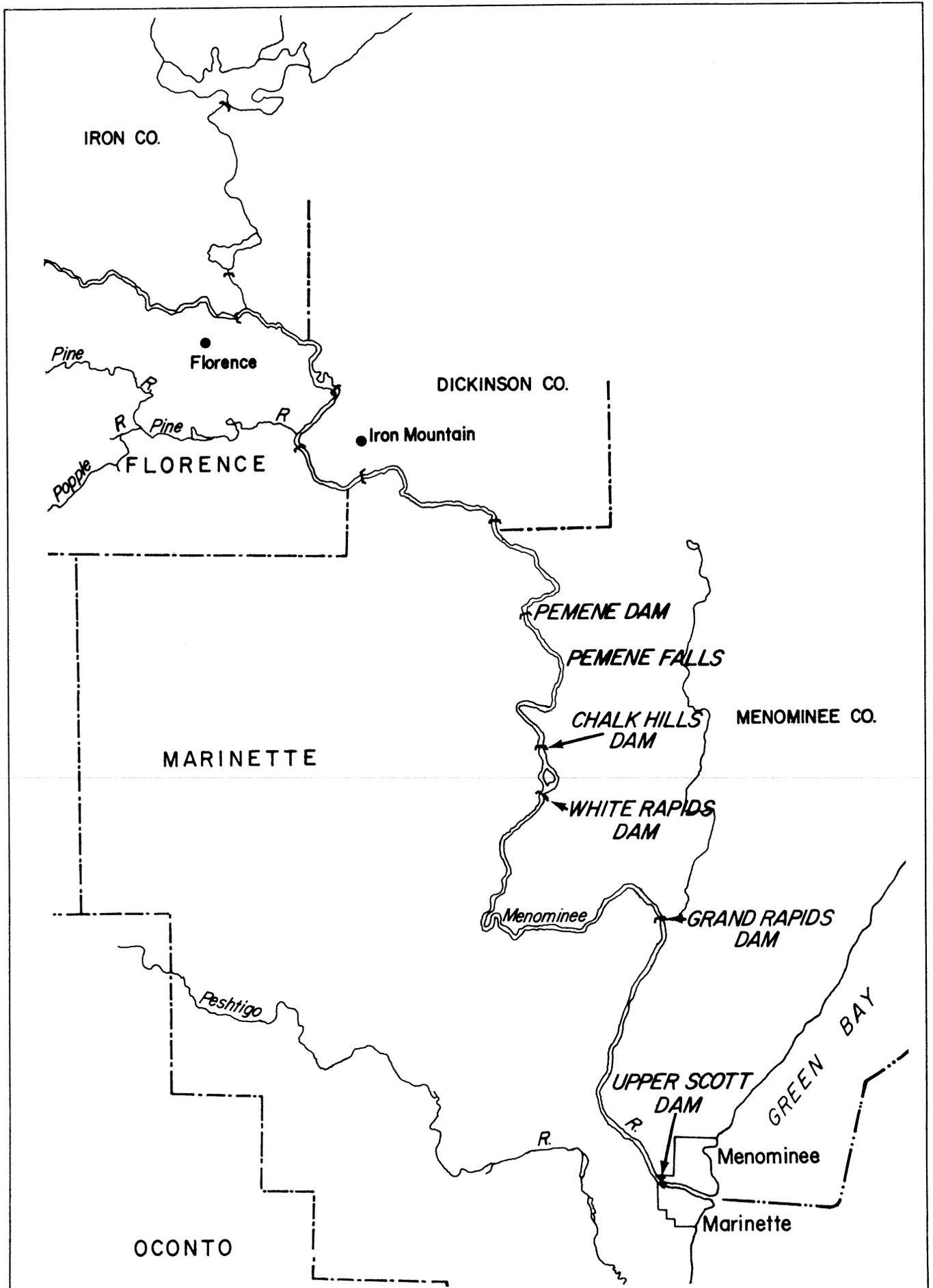


FIGURE 1. Water areas involved in the study and sections sampled.

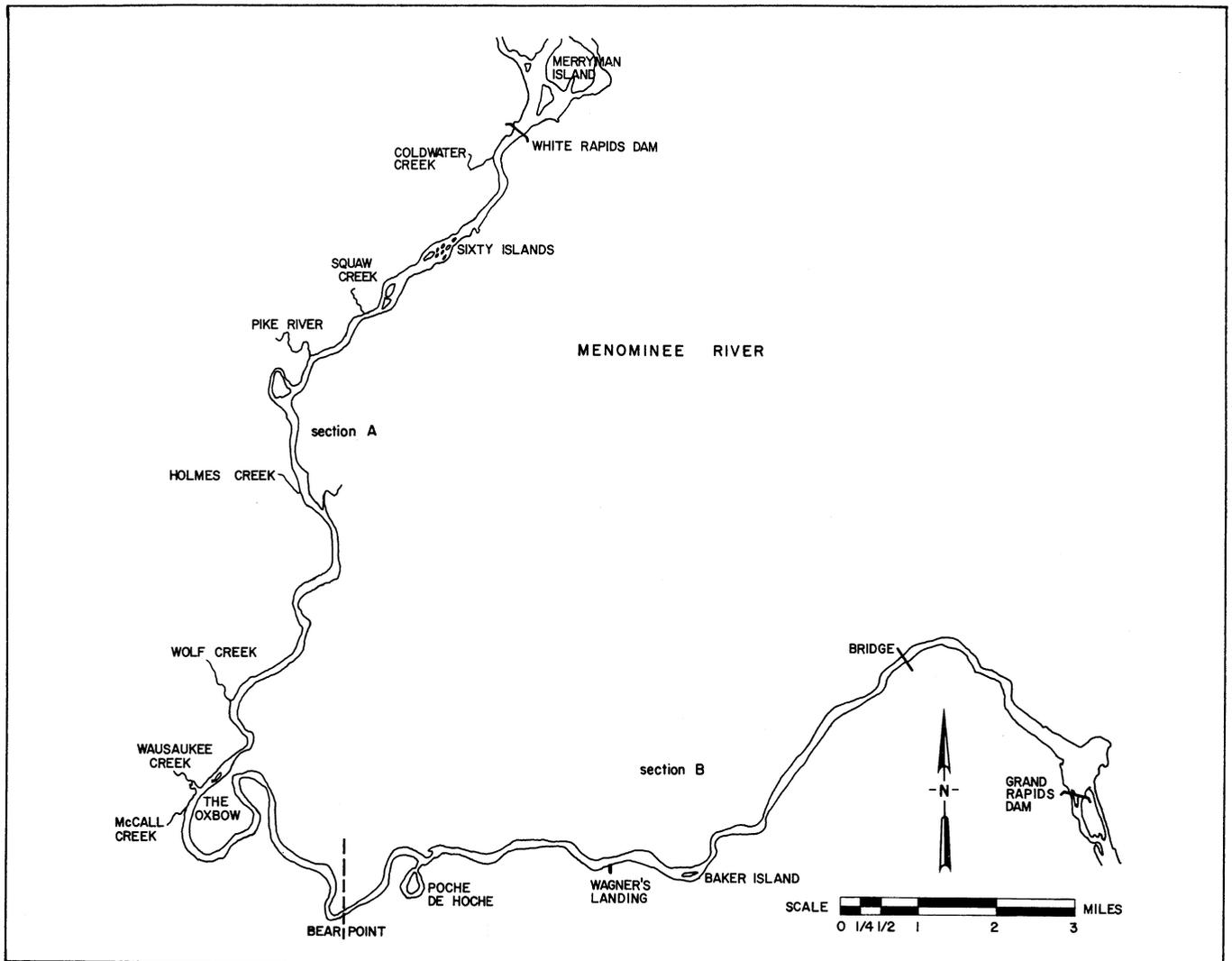


FIGURE 2. *The intensive study section on the Menominee River between the White Rapids and Grand Rapids dams.*

METHODS

Population Estimates

During the periods of August 4–14, 1969 and July 18–29, 1970, Wisconsin and Michigan personnel, working together, completed mark and recapture studies on the study area with the use of 4 A.C. boom shocker units. Captured lake sturgeon over 16 inches were marked with a FD-67 anchor tag (No.20 vinyl tubing) in the caudal fin or alongside of the dorsal fin and/or with a No. 681 monel self-piercing tag in the dorsal fin. A pectoral fin was removed from all fish to permit subsequent identification of untagged fish

under 16 inches, identification of those fish which had lost their tags and age determination. Captured specimens were all measured (total length in inches) and a representative sample was weighed (pounds).

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

To insure an unbiased estimate, the requirement for the modified Peterson formula ($MC > 4N$) was calculated (Robson and Reiger, 1964). The product of the two sample sizes M

(number marked and released) and C (number subsequently examined for marks) must exceed 4 times the population size (N).

Robson and Reiger's (1964) method of determining sample size (given the constraints that $1 - \alpha = 0.95$ [level of precision], $p = 0.25$ [level of accuracy] and a rough population estimate of 200 lake sturgeon of exploitable size) was used. About 150 lake sturgeon of legal size and 550 sub-legal fish had to be marked and subsequently examined for marks. The number of fish to be marked and

examined can be any combination that totals 150 for legal fish and 550 for sub-legal fish.

Creel Census

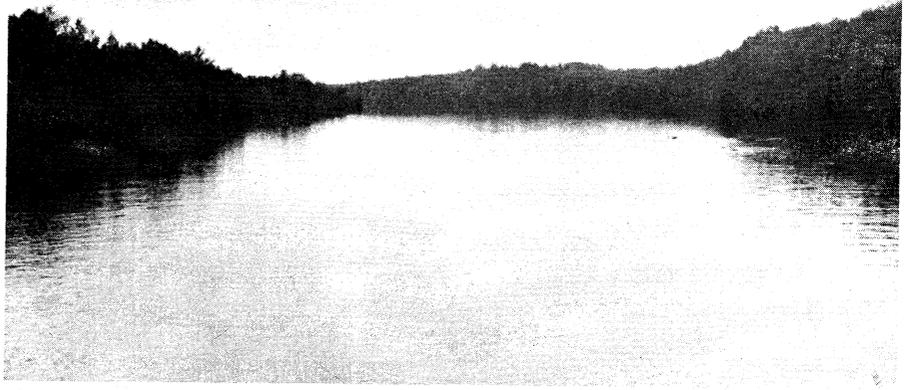
That segment of the Menominee River to be creel censused was divided into two equal sections of 13 miles each: Section A was between the White Rapids dam and Bear Point and Section B was from Bear Point to the Grand Rapids dam (Fig. 2). The creel census covered the period from September 6 through November 1, 1969 and September 5 through November 1, 1970.

The creel census consisted of a series of angler counts by a clerk traversing the entire length of his assigned section (A or B) and interviews with all anglers in a preassigned section of the stream in a specified period. Dates, times and locations were predetermined by a randomly designed schedule (Appendix A). Procedure was the same in both years and results should be entirely comparable.

The creel census was composed of two parts, an angler count to determine effort and an angler interview to determine success. Three schedules, one for Section A during September, one for Section B during September and one for both Sections A and B for October, were predetermined by a randomly designed plan. The schedules listed the launching point, the launching time and the count time. The launching point was either the upper (u), mid-point (m) or lower (l) end of the assigned section (A or B). The launching time was the time by which the census clerk should have arrived at the river, have his boat launched and car parked. The count time was the time the clerk was to be at the upper end of his section (A or B) prepared to make his downstream counting run.

The count always started at the upper end of the assigned section (A or B) at the designated time, which was randomly set at either 7:00, 9:00 or 11:00 in the morning and at 1:00, 3:00 or 5:00 in the afternoon. Motoring downstream as rapidly as feasible, the clerk recorded the number of boats, boat anglers and bank anglers that he passed. No angler interviews took place at this time.

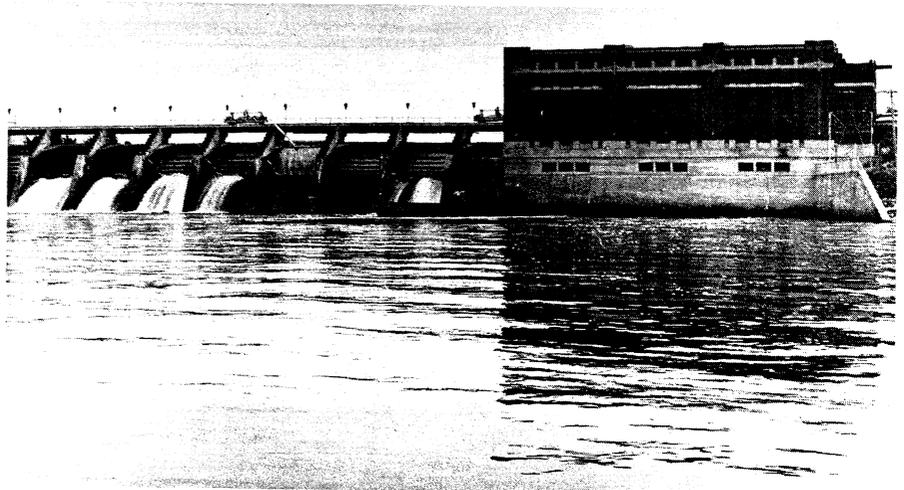
Census clerks interviewed anglers on their upstream trip before and/or after their downstream count trip. For example, the schedule indicated the launching point and time as m-7 a.m. and count time as 9 a.m. The clerk would launch his boat at the mid-point



A representative section of the Menominee River that was sampled.



Pemene Falls, located above the Chalk Hills Dam is a natural barrier for upstream movement of lake sturgeon.



Hydroelectric power dam that now prevents upstream movement of lake sturgeon in the Menominee River.



A.C. boom shocker used to stun and capture lake sturgeon. Note the large nets.

of his assigned section (A or B) by 7 a.m. and start motoring upstream interviewing anglers that he encountered. If necessary, he would discontinue interviews to insure his arrival at the upper end of his section by 9 a.m. Beginning at 9 a.m. he would motor downstream as rapidly as feasible, making the required counts. Upon reaching the lower end of his section, he would again motor upstream, interviewing all anglers that he encountered until he returned to his launching point, presumably by 1 p.m. after a 6-hour tour of duty on the river.

In order to obtain as many completed trip interviews as possible, self-addressed postcards were handed out to each angler who had not completed his fishing trip (Appendix B). He was encouraged to complete the information asked for and mail the card. If the angler had completed his fishing trip at the time of contact, the clerk would complete the entire census card and retain it.

At the time of the interview, pectoral fin bones were collected from all creel lake sturgeon. They were placed in envelopes and the following information noted: Serial number of census card, total length of lake sturgeon, fin clips and/or tag numbers, if present.

Total fishing pressure for the season was calculated on the basis of a 12-hour fishing day. Separate calcula-

tions were made for weekend and weekdays for September and October. In addition, pressure for the opening weekend was calculated separately and Labor Day was treated as a weekend day. Counts made on the two sections on the same day were combined into a single count for the entire study area. Counts made during the last two weeks of census on only one section per day were doubled and treated as a total area count for the day. The calculation was projected through November 1 on the assumption of uniform fishing pressure during this period. Total hours of fishing were calculated for each category of days as: number of days x 12 x appropriate average angler count.

Age Determination

Age was determined from a cross section of a pectoral fin bone for 491 fish in 1969 and 772 fish in 1970. The fish were assigned an annulus on the outer edge of the fin even though they were captured in late July or early August. Some additional growth most likely occurred; however, since it is impractical to back calculate from sturgeon fin bones, the data were recorded in this manner. Thus a fish with one annulus was assigned to age group 2.

Survey Data

In 1971, four A.C. boom shocker units were used while in 1972 only

two units were operated. The fish were all handled as described previously in respect to lengths, weights, tags and pectoral fin bones for aging.

RESULTS AND DISCUSSION

Population Estimates

In 1969, population estimates were calculated for each age group of lake sturgeon present in the sample. Of the 39 age groups (ages ranged from 1 to 45 years) only two groups (ages 10 and 11) satisfied the requirements for the modified Peterson formula ($MC > 4N$) to insure an unbiased estimate (Robson and Reiger, 1964). A numerical size of each year class was obtained by multiplying the total population estimate by the proportion that each year class comprised of the sample (Table 1).

In order to obtain some idea of the size of the exploitable population, and to satisfy the requirement that $MC > 4N$, the 1969 mark and recapture data were grouped into two length categories—under 42 inches (sub-legal size) and 42 inches (legal size) and larger. Population estimates based on these two length classes were 1,641 (95% confidence interval of $\pm 35\%$) sub-legals and 243 (95% confidence interval of $\pm 71\%$) legal-sized lake sturgeon (Table 2). The confidence interval of $\pm 71\%$ on the population estimate for legal-sized lake sturgeon is unacceptably large, because the number of fish caught was not large enough to meet the requirements of the sampling procedure.

The 1970 population estimates based on the two length classes were 2,680 (95% confidence interval of $\pm 19\%$) sub-legals and 185 (95% confidence interval of $\pm 30\%$) legal-sized lake sturgeon (Table 2). For the exploitable size fish 55 were marked and 53 were examined for marks, which did not fall within the restraints (combination of 150 marked and examined) for a sufficient sample size.

Fishing Pressure

The number of anglers counted per day on weekends was significantly

larger than the number counted on weekdays, and in September the number of anglers counted was larger than in October in 1969 and 1970 (Table 3). The opening weekend angler count was larger in 1970 (126 anglers) than in 1969 (87 anglers); however, the average number of anglers counted per day for the rest of the season was lower in 1970 (Table 3). There was no significant difference between anglers counted on the two sections (A and B) in 1969 for weekends, 24.0 and 25.5, respectively, or for weekdays, 7.0 and 6.9, respectively. In 1970 weekend counts (11.8 and 11.4) were similar but weekday counts were larger in Section A (6.3) as compared to Section B (3.0).

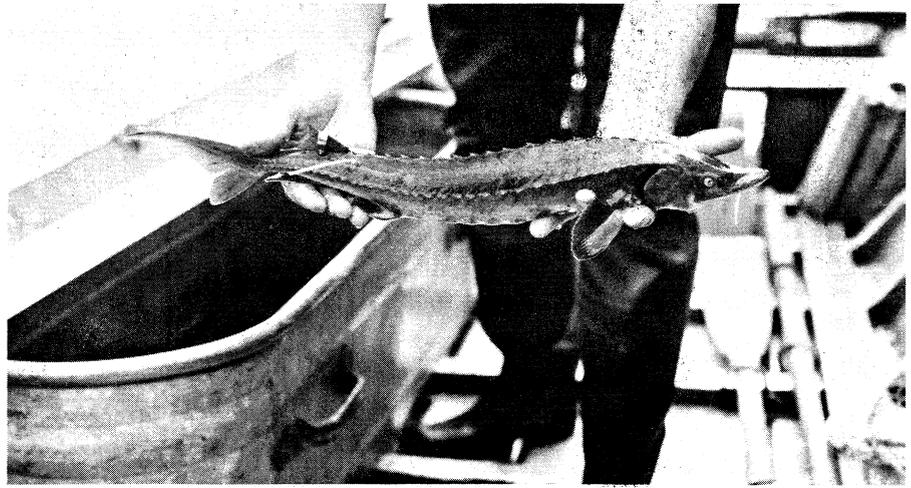
While fishing pressure was much higher on the opening weekend in 1970 (4,600 hours as compared to 3,100 hours in 1969), it was lower during the rest of the season, resulting in the significantly lower total of 11,400 hours as compared to 14,300 hours in 1969.

Anglers returned 69 percent of the creel census cards in 1969 and 56 percent in 1970 (Table 4).

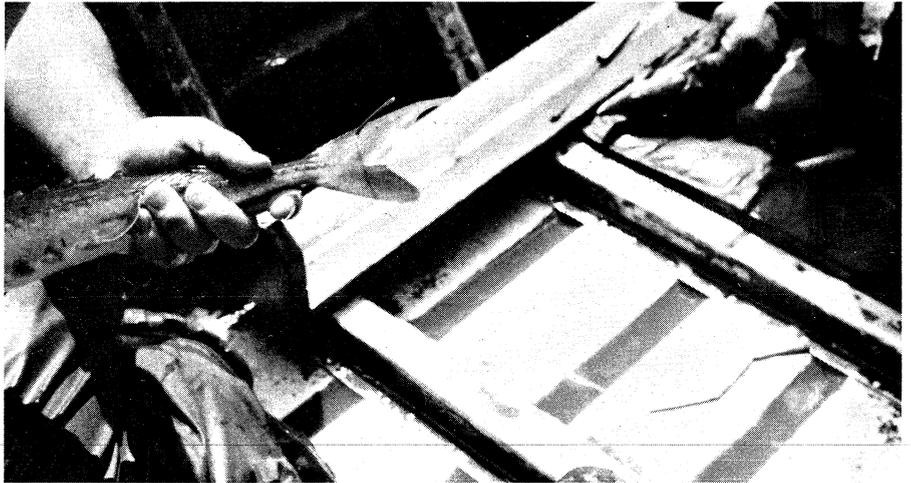
At 7.0 hours per completed trip, the estimated 14,300 hours of fishing would represent about 2,050 individual angler trips in 1969 as compared to 1,750 in 1970. Many anglers were contacted more than once by the creel census clerks (Table 5). The 552 contacts in 1969 included only 330 individual anglers (some fished as many as 9 times). In 1970, the 411 contacts represented only 257 individuals (one was encountered on 11 different days). The average number of trips per individual contacted was 1.7 in 1969 and 1.6 in 1970. There was no relationship between number of times contacted and percent returns of census cards. The number of individuals participating in the Menominee River sturgeon fishery is estimated at 1,200 in 1969 and 1,100 in 1970 (Table 4), based on the average number of trips per individual contacted and the total estimated individual angler trips.

Harvest and Exploitation

In 1969, anglers returning reports accounted for 2,655 hours of fishing out of the total of 14,300 estimated hours. Since they reported 11 legal fish, the season harvest is estimated to be 59 lake sturgeon (Tables 3 and 4). The estimated exploitation rate based on the angler's harvest data was 13 percent in 1969. Anglers reported the



Lake sturgeon were marked with a monel tag in the dorsal fin, with a plastic dart tag in the flesh just anterior to the dorsal fin, and by removal of the outer ray of the right pectoral fin.



Plastic dart tag applied to the caudal fin. These tags had greater detention when applied in the caudal fin.



Removing the outer ray of the right pectoral fin which will be sectioned later for determination of age.



Weekend fishing pressure at a favorite hole on the Menominee River.

catching and returning of 200 sub-legals and based on the harvest data, an estimated 1,075 sub-legals were caught and returned.

In 1970, anglers accounted for 1,414 hours of fishing out of the total of 11,400 estimated hours. Nine legal fish were reported and the season harvest is estimated to be 48 legal lake sturgeon, with an estimated exploitation rate of 17 percent based on the angler's harvest (Tables 3 and 4). Anglers reported the catching and returning of 271 sub-legals and based on the harvest data, an estimated 1,420 sub-legals were caught and returned in 1970.

The 20 percent decrease in estimated total fishing pressure in 1970 is confirmed by a 20 percent decrease in number of contacts by the same creel census procedure and a 20 percent

TABLE 1. Estimated Year Class Strength on Menominee River Lake Sturgeon, August, 1969

Age Group	Year Class	Estimated Number
1	1969	148
2	1968	95
3	1967	209
4	1966	156
5	1965	251
6	1964	160
7	1963	80
8	1962	76
9	1961	42
10	1960	84
11	1959	156
12	1958	106
13	1957	42
14	1956	19
15	1955	11
16	1954	0
17	1953	11
18	1952	15
19	1951	38
20	1950	30
21	1949	8
22	1948	4
23	1947	11
24	1946	11
25	1945	4
26	1944	4
27	1943	30
28	1942	19
29	1941	4
30	1940	4
31	1939	8
32	1938	4
33	1937	0
34	1936	8
35	1935	4
36	1934	0
37	1933	4
38	1932	8
39	1931	8
40	1930	0
41	1929	4
42	1928	0
43	1927	0
44	1926	4
45	1925	4
TOTAL		1,884

TABLE 2. Population Estimates of Menominee River Lake Sturgeon, 1969 and 1970

Size Class (Inches)	Year	Population Estimate	95% Confidence Interval
< 42	1969	1,641	+ 35%
	1970	2,680	+ 19%
≥ 42	1969	243	+ 71%
	1970	185	+ 30%

TABLE 3. Average Daily Counts of Anglers and Calculated Fishing Pressure (Hours) on the Menominee River During the Lake Sturgeon Season, 1969 and 1970

Periods	Average Daily Counts		Calculated Pressure	
	1969	1970	1969	1970
First weekend*	87	126	3,100	4,600
Other September weekends	50	29	3,600	2,100
September weekdays	18	11	3,400	2,200
October weekends	22	8	2,300	1,000
October weekdays	7	6	1,900	1,500
Total season			14,300	11,400

*Includes Labor Day.

decrease in harvest. The principal difference between the two years was the lower rate of returns of creel census cards and the larger number of under-sized sturgeon reported in 1970, 271 as compared to 200 in 1969.

Angler Characteristics

Wisconsin residents accounted for 78 percent of the fishing effort in 1969 and 1970, while 14 percent was done by Michigan residents in 1969 and 9 percent in 1970 (Table 6). Nonresidents from Illinois and Indiana accounted for 8 percent of the fishing effort in 1969 and 13 percent in 1970. About 60 percent was done by Wisconsin and Michigan residents living in the counties adjacent to the river in 1969 and 1970.

Age Determination

Age determination from a cross section of a pectoral fin bone was made for 491 fish in 1969 and 772 fish in 1970 (Table 7). The fish ranged in age from 1 to 45 years during both years; however, 85.5 and 84.3 percent of the fish were under 14 years of age in 1969 and 1970, respectively.

The age data indicate that natural reproduction is occurring every year although the degree of success varies. In 1969, 39 young-of-the-year fish were captured while only 2 were captured in 1970. Greater numbers of young-of-the-year could have been captured in 1969 but only a sample of these 5.0- to 6.5-inch fish were actually collected.

Some fish attained the minimum legal size of 42 inches at age 12; however, some were still under 42 inches at age 15 (Table 8). At age 15 the average length was 42 inches; however, there was a range in length from 38 to 46 inches in this age group. At age 17, all fish were 42 inches or more in length. There is a drastic decline in the numbers of fish available in the population after age 14. Our sampling gear (electrofishing) may be selective for fish under 30 inches; however, it should be noted that at age group 15, lake sturgeon reach the minimum legal size limit which may indicate high exploitation as soon as they reach the minimum size of 42 inches. If the shocker was selective, the number of fish in the age group immediately below age group 15 should have also shown a drastic decrease, but this did not occur.

Length Frequency

The length frequency distribution (5-inch groups) was essentially the



A 5-inch lake sturgeon.

TABLE 4. Lake Sturgeon Fishery and Harvest Statistics on the Menominee River, 1969 and 1970

Statistics	1969	1970
Number of personal contacts	552	411
Number of postcard returns	379	230
Percent returns	69	56
Total hours of fishing reported on returns	2,655	1,414
Average hours per completed trip	7.0	6.5
Total hours precontact fishing recorded	—	689
Total hours censused	2,655	2,103
Estimated number of fishing trips	2,050	1,750
Percent contacted	25	23
Estimated number of anglers	1,200	1,100
Legal lake sturgeon taken	11	9
Estimated total harvest	59	48
Legal lake sturgeon per hour	.004	.004
Sub-legal lake sturgeon reported	200	271
Estimated total sub-legals	1,075	1,420
Sub-legals per hour	.075	.129
Exploitation rate (percent)	13	17

TABLE 5. Frequency of Contacts of Individuals in the Creel Census, 1969

Number of Times Contacted	Number of Individuals	Number of Contacts	Number of Returns	Percent Returns
1	213	213	133	62
2	62	124	90	72
3	32	96	69	72
4	8	32	21	66
5	12	60	50	83
9	3	27	16	59
TOTAL	330	552	379	69

TABLE 6. Residence of Menominee River Lake Sturgeon Fishermen, 1969 and 1970

Residence	Percent of Fishing Trips	
	1969	1970
Michigan		
City of Menominee	10	7
Other Upper Peninsula	3	2
Lower Michigan	1	0
TOTAL	14	9
Wisconsin		
City of Marinette	24	26
Marinette County	24	24
Other Wisconsin	30	28
TOTAL	78	78
Other States	8	13
Total Contacts	552	411

TABLE 7. Age-Length Relationship of Menominee River Lake Sturgeon, 1969-70

Age Group	Average Length (Inches)		Age Group	Average Length (Inches)	
	1969	1970		1969	1970
1	6 (39)*	6 (2)	23	53 (3)	51 (4)
2	11 (25)	11 (26)	24	53 (3)	50 (3)
3	13 (55)	12 (131)	25	56 (1)	52 (5)
4	16 (36)	16 (67)	26	53 (1)	49 (1)
5	20 (66)	18 (53)	27	54 (7)	51 (2)
6	23 (42)	21 (81)	28	56 (4)	52 (6)
7	25 (22)	24 (105)	29	62 (1)	55 (4)
8	28 (20)	27 (41)	30	58 (1)	53 (1)
9	30 (11)	29 (19)	31	59 (2)	59 (1)
10	32 (22)	31 (15)	32	61 (1)	59 (2)
11	35 (42)	33 (23)	33	-	62 (1)
12	36 (29)	35 (54)	34	60 (2)	57 (1)
13	40 (11)	37 (34)	35	60 (1)	56 (4)
14	42 (5)	38 (28)	36	-	59 (3)
15	45 (3)	41 (11)	37	66 (1)	59 (5)
16	-	41 (2)	38	58 (2)	62 (2)
17	47 (3)	46 (4)	39	64 (2)	58 (1)
18	46 (4)	47 (3)	40	-	65 (1)
19	49 (10)	48 (4)	41	62 (1)	64 (1)
20	50 (8)	47 (4)	42	-	-
21	49 (1)	49 (7)	43	-	55 (1)
22	49 (2)	49 (8)	44	62 (1)	-
			45	63 (1)	58 (1)

* () = sample size.

same in 1969 and 1970 (Fig. 3). The two principal peaks of the length distribution occurred in the 10-14 and 20-24 inch groups during both years; however, these two peaks were higher in 1970. Another significant peak occurred in the 30-34 inch group in 1969 and this peak shifted to the 35-39 inch group in 1970.

The total lengths of 499 lake sturgeon captured in 1969 extended from 5 to 69 inches, while the 778 fish taken in 1970 varied from 5 to 65 inches.

Age — Length Relationship

The age — length relationship, based on 1,263 fish from age groups 1 through 45, was computed to fit the linear, logarithmic and parabolic equations; however, the data did not fit any of these correlations. The extreme variation in lengths for a given age group make the age — length relationship impractical. Fish in age group 5 varied from 15 to 23.5 inches, while at age 10 the variation was from 24 to 38 inches (Table 8). This wide variation existed in all age groups, especially the

older ones.

Growth of Menominee River lake sturgeon is considerably slower than that of lake sturgeon in Lake Winnebago, a shallow, 137,708-acre lake in east central Wisconsin. In the Menominee River, a lake sturgeon on the average reaches the minimum legal size of 42 inches at age 15, while in Lake Winnebago lake sturgeon at age 8 are 42 inches long (Table 8).

Age — Weight Relationship

The age — weight relationship,

TABLE 8. Comparison of Age-Length* Relationship Between Lake Sturgeon in the Menominee River and Lake Winnebago

Age Group	Menominee River			Lake Winnebago		
	Number	Average	Range	Number	Average	Range
1	41	6	5.0- 6.5	2	11	10.5-12.0
2	51	11	9.5-12.0	56	16	13.0-20.0
3	186	12	9.0-16.0	89	23	18.0-28.5
4	103	16	14.0-19.0	198	26	22.0-33.0
5	119	19	15.0-23.5	204	31	25.0-35.5
6	123	21	18.0-24.5	128	33	28.5-38.0
7	127	24	18.0-27.5	67	36	28.0-39.0
8	61	27	23.0-32.5	73	42	32.0-46.0
9	30	29	25.0-34.0	64	44	31.0-52.0
10	37	32	24.0-38.0	74	45	35.0-50.0
11	65	34	27.0-40.5	59	46	35.0-52.0
12	83	35	31.0-42.0	74	47	34.5-54.0
13	45	38	31.0-44.0	59	46	35.0-52.0
14	33	39	32.0-45.0	54	49	44.0-65.0
15	14	42	38.0-46.0	94	51	44.0-63.0
16	2	41	40.0-42.0	122	51	45.0-58.0
17	7	46	43.5-50.5	88	52	41.0-59.0
18	7	46	42.0-50.0	49	52	42.0-59.0
19	14	47	42.5-51.0	45	54	49.0-60.0
20	12	49	45.0-56.5	29	54	46.0-61.0
21	8	49	45.0-53.5	40	54	46.0-64.0
22	10	49	45.0-52.5	27	56	52.0-62.0
23	7	52	49.0-57.0	30	55	48.0-62.0
24	6	51	47.0-55.0	48	58	46.0-65.0
25	6	53	48.0-56.0	60	59	50.0-67.0
26	2	51	48.5-53.0	27	61	51.0-66.0
27	9	53	48.0-58.0	28	60	49.0-69.0
28	10	54	50.0-58.0	24	61	56.0-68.0
29	5	56	53.0-62.0	34	62	55.0-69.0
30	2	56	53.0-57.5	22	62	55.0-68.0
31	3	59	53.0-64.0	17	63	51.0-69.0
32	3	60	57.0-61.0	12	64	55.0-67.0
33	1	62	62.0	10	62	53.0-65.0
34	3	59	56.5-61.5	8	62	53.0-67.0
35	5	57	51.5-60.0	18	65	56.0-74.0
36	3	59	59.0-60.0	14	66	53.0-71.0
37	6	60	53.0-65.5	25	65	59.0-70.0
38	4	60	57.5-63.0	15	66	61.0-70.0
39	3	62	58.0-69.0	16	69	65.0-73.0
40	1	65	65.0	11	68	63.0-78.0
41	2	63	62.0-63.5	9	68	61.0-76.0
42	-	-	-	8	68	62.0-71.0
43	1	55	55.0	8	65	57.0-70.0
44	1	62	62.0	6	66	61.0-70.0
45	2	61	58.0-63.0	5	72	70.0-75.0

*Length = total length in inches.

based on 767 fish from age groups 1 through 45 was computed to be:

$$\text{Log } W = -0.0906 + 0.0613 X$$

where W = weight in pounds
and X = age groups in years

The standard error of the regression was 0.3653 which is considered large and the discrepancies between the calculated and observed data are quite pronounced, especially after age group 10. The lack of fish in age groups older than 10 and the extreme variation in the weight ranges for a given age group accounts for the extreme variations.

At age 10, the fish varied in weight from 2.5 to 11.0 pounds while at age 20 the weight variation was 21 to 35 pounds (Table 9).

As with length, the lake sturgeon in Lake Winnebago weighed considerably more than fish from the Menominee River at a given age. At age 15, lake sturgeon in the Menominee River weighed 14.5 pounds on the average, while in Lake Winnebago the average weight was 32 pounds (Table 9).

Length - Weight Relationship

The length - weight relationship of lake sturgeon was computed to be:

$$\text{Log } W = -3.8207 + 3.0540 \text{ Log } L$$

where W = weight in pounds
and L = total length in inches

The standard error of the regression was 0.1182 which is considered large and the discrepancies between the calculated and observed data are quite pronounced, especially after length group 39. Few fish in the larger length groups and extreme variations in the weight ranges within a given length

group account for the discrepancies, which make the use of the length — weight regression questionable (Table 10). The observed weight of the fish does increase in approximately the same proportion as the length through length group 39; however, this relationship does not hold up in the larger length groups.

Survey Data

Above Intensive Study Section. No lake sturgeon were captured in the sections between White Rapids and Chalk Hills dams or between Chalk Hills dam and Pemene Falls. Two lake sturgeon were reported as observed but not captured in the section between the White Rapids and Chalk Hills dams. Both of these sections are immediately upstream from the intensive section studied.

Below Intensive Study Section. In the section immediately downstream from the intensive study section, Grand Rapids to Upper Scott dam, 403 lake sturgeon were captured. In 1971, when the entire section (21 river miles) was sampled, 328 lake sturgeon were captured. In 1972, only a 2-mile stretch immediately below the Grand Rapids dam was sampled and 75 fish were captured.

The 403 fish ranged in total length from 11 to 61 inches with 11.9 percent of the fish being in the 15-inch group (Table 11). Only 7.8 percent of the sample was comprised of fish 42 inches (minimum legal size) or larger. The fish ranged in age from 3 to 33 years; however, 88.6 percent were under 14 years (Table 12).

The length frequency distribution between fish in the intensive study area and immediately below this area, shows a virtual lack of fish under 15 inches in the area below the intensive study area (Table 11). The length frequency of fish over 30 inches is essentially the same in both areas. The age — length relationship between these two areas is essentially the same (Table 12).

In 1971, six fish were captured that had originally been handled above the Grand Rapids dam. Five had the right fin bone removed with no indication of tag loss. The total lengths of these five fish were 15.0, 20.0, 20.5, 48.5 and 54.0 inches. The sixth fish had retained a plastic dart tag which was placed in the caudal fin on August 14, 1969. The fish had grown from 19.2 to 25 inches (age 5 to 7).

below the Grand Rapids dam, 12 fish were recaptured of which 11 had been tagged in the same approximate area in 1971. The other, a 19.0-inch fish, had no evidence of tag loss but both the

right and left pectoral fins had been removed previously which indicated that it had been handled previously above the Grand Rapids dam in either 1969 or 1970.

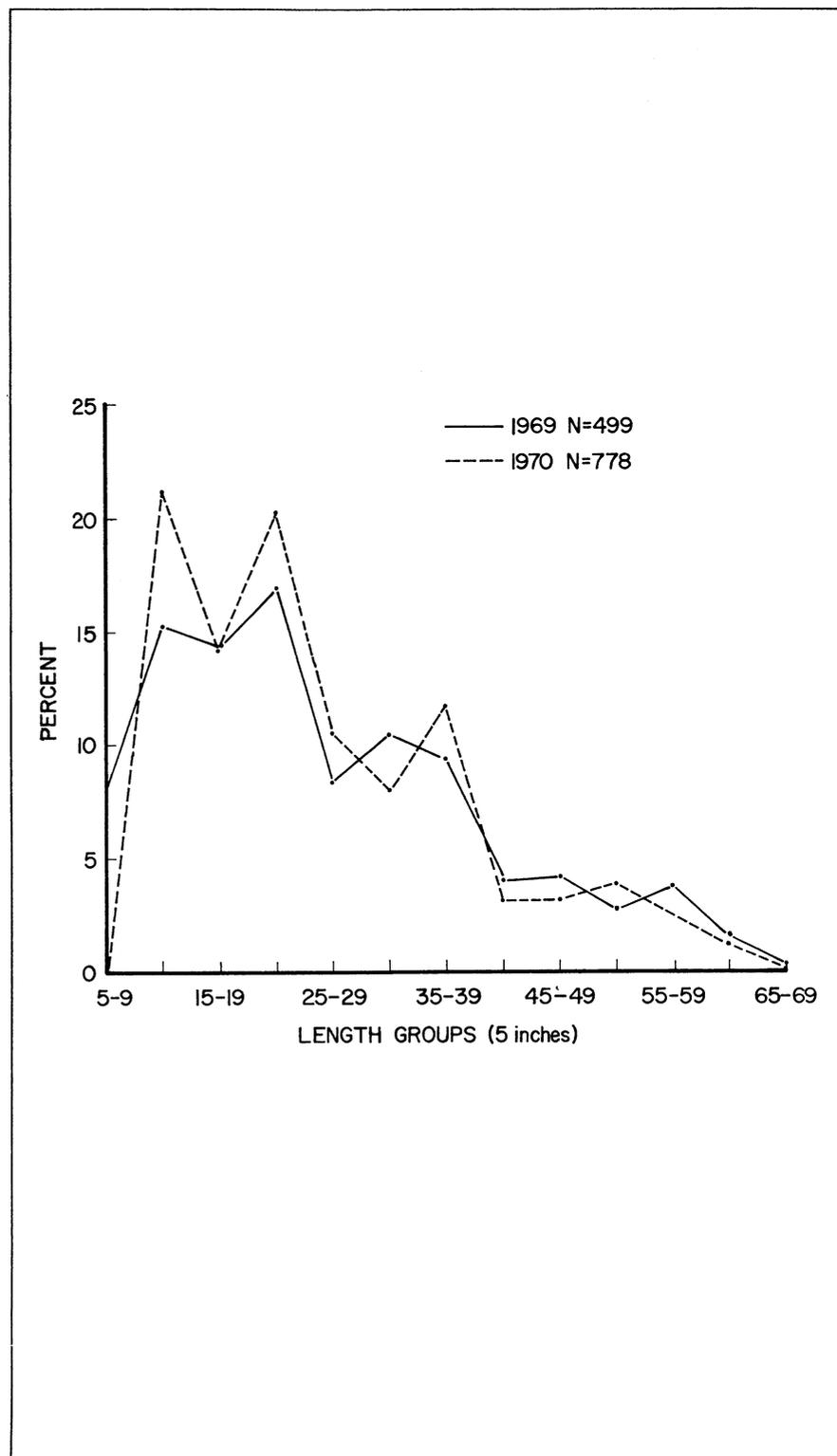


FIGURE 3. Length frequency by percent of lake sturgeon taken in the Menominee River, 1969-70.

TABLE 9. Comparison of Age-Weight* Relationship Between Lake Sturgeon in the Menominee River and Lake Winnebago

Age Groups	Menominee River			Lake Winnebago		
	Number	Average	Range	Number	Average	Range
1	2	0.1	0.1	—	—	—
2	23	0.3	0.2–0.5	—	—	—
3	129	0.3	0.2–1.0	—	—	—
4	70	0.6	0.3–1.3	—	—	—
5	51	0.9	0.4–2.0	—	—	—
6	81	1.5	0.8–3.0	—	—	—
7	104	2.3	1.5–4.0	7	15	11–18
8	41	3.3	2.0–5.0	73	17	13–22
9	19	4.7	3.3–6.0	64	19	12–34
10	15	5.8	2.5–11.0	74	21	15–30
11	23	6.9	3.5–14.0	59	22	14–33
12	53	9.6	5.5–15.0	74	25	14–40
13	34	11.5	5.0–21.0	71	28	18–46
14	28	11.7	6.0–20.0	54	29	18–47
15	11	14.5	10.0–20.0	94	32	18–64
16	2	14.0	13.0–15.0	122	34	21–55
17	4	24.5	18.0–30.0	88	34	14–50
18	3	25.7	22.0–28.0	49	35	18–52
19	4	29.3	22.0–36.0	45	39	20–56
20	4	25.3	21.0–35.0	29	42	26–60
21	7	31.2	24.0–39.0	40	40	15–61
22	8	30.3	26.0–38.0	27	44	30–68
23	4	34.4	32.0–39.0	30	44	25–64
24	3	31.0	24.0–44.0	48	51	30–70
25	5	39.0	32.0–50.0	60	53	21–88
26	1	26.0	26.0	27	61	32–91
27	2	31.5	26.0–48.0	28	56	22–92
28	6	37.3	30.0–45.5	24	63	35–98
29	4	48.1	38.5–63.0	34	63	46–87
30	1	34.0	34.0	22	66	45–97
31	2	64.5	48.0–81.0	17	70	48–101
32	2	50.5	38.0–63.0	12	68	30–114
33	1	73.5	73.6	10	62	43–82
34	1	50.0	50.0	8	63	40–90
35	4	43.1	34.0–54.0	18	72	43–112
36	3	55.7	48.0–66.0	14	77	50–104
37	5	52.8	42.0–66.5	25	74	50–106
38	2	55.0	52.0–58.0	15	75	54–110
39	2	64.0	48.0–82.0	16	88	65–110
40	1	73.5	73.5	11	88	60–120
41	1	75.0	75.0	9	93	62–120
42	—	—	—	8	82	55–110
43	1	48.0	48.0	8	76	65–107
44	—	—	—	6	83	68–92
45	1	47.0	47.0	5	91	75–110

*Weight in pounds.

TABLE 10. Length and Weight Relationship for Menominee River Lake Sturgeon

Length (Inches)	Weight (Lbs)			Length (Inches)	Weight (Lbs)		
	Number	Average	Range		Number	Average	Range
5	2	0.1	0.1	36	23	10.0	6.0-13.0
6	2	0.1	0.1	37	17	10.6	7.0-14.0
7	-	-	-	38	19	12.1	8.0-15.0
8	-	-	-	39	12	14.1	11.0-19.5
9	5	0.2	0.1-0.3	40	5	13.0	12.0-15.0
10	6	0.3	0.2-0.3	41	5	15.1	10.5-19.0
11	32	0.3	0.2-0.3	42	6	15.8	15.0-19.0
12	79	0.3	0.3-0.5	43	3	21.0	20.0-22.0
13	37	0.3	0.3-0.5	44	2	22.0	20.0-24.0
14	6	0.4	0.3-0.5	45	7	22.4	18.0-26.0
15	29	0.5	0.3-0.8	46	3	27.3	25.0-30.0
16	33	0.6	0.5-1.0	47	4	25.3	24.0-27.0
17	23	0.7	0.5-1.0	48	7	29.4	26.0-35.0
18	15	1.0	0.5-1.3	49	6	30.7	28.0-34.0
19	23	1.1	0.8-1.5	50	11	33.4	28.0-40.0
20	21	1.3	1.0-2.0	51	3	35.8	32.0-39.5
21	33	1.6	1.5-3.0	52	6	36.7	32.0-39.0
22	39	1.9	1.5-4.0	53	6	40.5	34.0-47.0
23	31	2.0	1.5-2.5	54	3	43.8	42.0-45.5
24	29	2.4	2.0-3.3	55	4	41.4	38.5-48.0
25	24	2.7	2.5-3.3	56	4	43.1	34.0-50.0
26	18	3.2	2.5-4.0	57	1	38.0	38.0
27	17	3.5	3.0-4.0	58	7	51.0	45.0-63.0
28	11	3.9	2.5-6.0	59	2	50.5	48.0-53.0
29	7	4.4	4.0-5.0	60	4	57.6	49.5-66.0
30	12	5.2	4.0-6.0	61	-	-	-
31	13	5.7	5.0-7.0	62	2	67.8	62.0-73.5
32	7	7.1	6.0-9.0	63	2	66.5	58.0-75.0
33	15	7.6	6.0-9.0	64	1	66.5	66.5
34	16	7.8	6.0-10.0	65	1	73.5	73.5
35	16	9.5	6.0-12.0				

TABLE 11. Length Frequency by One-Inch Groups of Lake Sturgeon in Two Sections of the Menominee River

Length (Inches)	Sample Size (Percent)		Length (Inches)	Sample Size (Percent)	
	Section 1*	Section 2**		Section 1	Section 2
5	-	-	36	19(2.4)	7(1.7)
6	2(0.3)	-	37	20(2.6)	8(2.0)
7	-	-	38	21(2.7)	8(2.0)
8	-	-	39	13(1.7)	7(1.7)
9	-	-	40	7(0.9)	5(1.2)
10	4(0.5)	-	41	5(0.6)	4(1.0)
11	15(1.9)	2(0.5)	42	6(0.8)	2(0.5)
12	71(9.1)	2(0.5)	43	2(0.3)	3(0.8)
13	64(8.2)	2(0.5)	44	4(0.5)	2(0.5)
14	10(1.3)	8(2.0)	45	5(0.6)	3(0.8)
15	19(2.4)	48(11.9)	46	4(0.5)	2(0.5)
16	30(3.9)	19(4.7)	47	5(0.6)	-
17	30(3.9)	29(7.2)	48	3(0.4)	2(0.5)
18	15(1.9)	16(4.0)	49	8(1.0)	3(0.8)
19	16(2.1)	21(5.2)	50	11(1.4)	2(0.5)
20	26(3.3)	17(4.2)	51	5(0.6)	2(0.5)
21	27(3.5)	23(5.7)	52	4(0.5)	2(0.5)
22	31(4.0)	30(7.4)	53	7(0.9)	-
23	40(5.1)	19(4.7)	54	4(0.5)	1(0.2)
24	34(4.4)	15(3.7)	55	4(0.5)	-
25	25(3.2)	14(3.5)	56	4(0.5)	1(0.2)
26	23(3.0)	12(3.0)	57	2(0.3)	3(0.8)
27	15(1.9)	8(2.0)	58	3(0.4)	-
28	13(1.7)	9(2.2)	59	6(0.8)	1(0.2)
29	6(0.8)	6(1.5)	60	3(0.4)	1(0.2)
30	12(1.5)	2(0.5)	61	1(0.1)	1(0.2)
31	14(1.8)	10(2.5)	62	2(0.3)	-
32	7(0.9)	2(0.5)	63	1(0.1)	-
33	13(1.7)	5(1.2)	64	2(0.3)	-
34	16(2.1)	9(2.2)	65	1(0.1)	-
35	18(2.3)	5(1.2)	Total	778	403

*Section 1: White Rapids to Grand Rapids dams, 1970.
 **Section 2: Grand Rapids to Upper Scott dams, 1971-72.

TABLE 12. Age-Length Relationship of Lake Sturgeon in Two Sections of the Menominee River

Age Group	Average Length (Inches)		Age Group	Average Length (Inches)	
	Section 1*	Section 2**		Section 1	Section 2
1	6(41) ¹	—	23	52(7)	49(1)
2	11(51)	—	24	51(6)	—
3	12(186)	13(9)	25	53(6)	55(2)
4	16(103)	15(59)	26	51(2)	49(1)
5	19(119)	17(45)	27	53(9)	54(3)
6	21(123)	19(34)	28	54(10)	57(1)
7	24(127)	22(44)	29	56(5)	52(1)
8	27(61)	24(56)	30	56(2)	60(1)
9	29(30)	25(29)	31	59(3)	51(1)
10	32(37)	29(18)	32	60(3)	—
11	34(65)	34(15)	33	62(1)	61(1)
12	35(83)	35(19)	34	59(3)	—
13	38(45)	37(15)	35	57(5)	—
14	39(33)	40(11)	36	59(3)	—
15	42(14)	40(8)	37	60(6)	—
16	41(2)	41(3)	38	60(4)	—
17	46(7)	45(3)	39	62(3)	—
18	46(7)	—	40	65(1)	—
19	47(14)	47(2)	41	63(2)	—
20	49(12)	50(1)	42	—	—
21	49(8)	53(3)	43	55(1)	—
22	49(10)	51(1)	44	62(1)	—
			45	61(2)	—

*Section 1: White Rapids to Grand Rapids dams, 1969–70.

**Section 2: Grand Rapids to Upper Scott dams, 1971–72.

¹() = sample size.

SUMMARY

The Menominee River from its mouth at Green Bay to the White Rapids dam does have a harvestable population of lake sturgeon with evidence of annual natural reproduction, although varying in degree of success. There is evidence of downstream migration over the hydroelectric power dams.

The calculated fishing pressure in the intensive area studied was 14,300 hours in 1969 and 11,400 hours in 1970. For the entire river from White Rapids dam to the lower most dam in Marinette fishing pressure would have

approximately doubled these figures, based on spot checks during the season. Opening weekends accounted for 20 to 40 percent of the annual fishing pressure. Only 20 to 30 percent of the annual fishing pressure occurred during October.

Although the estimated harvest in the intensive study area was only 59 lake sturgeon in 1969 and 48 in 1970, this harvest was too great, resulting in an exploitation rate of 13 and 17 percent, respectively. To maintain a harvestable population, an exploitation rate no higher than 5 percent

would be desirable.

Some fish attained the minimum legal size of 42 inches at age 12; at age 17, all fish were 42 inches or more in length.

Growth of lake sturgeon in the Menominee River was considerably slower than that in Lake Winnebago. Likewise, lake sturgeon in Lake Winnebago weighed considerably more than fish from the Menominee River at a given age.

There was a virtual lack of lake sturgeon under 15 inches in the area below the intensive study area.

MANAGEMENT RECOMMENDATIONS

Although the lake sturgeon is found in several Wisconsin waters, it is classified as threatened over much of its original range in the United States by the U.S. Fish and Wildlife Service. It is a slow-growing, late-maturing fish which does not survive a high level of exploitation. The exploitation rate of 13 percent in 1969 and 17 percent in 1970 on the Menominee River is considered too high. An annual exploitation rate no higher than 5 percent would be more desirable. If overexploitation is occurring, the fishery will suffer for many years and could conceivably be eliminated if the fishing pressure continues at the present level.

Unlike other game and panfish species, the lake sturgeon will give only a relatively small sustained yield. We do not have adequate information to enable us to decide whether, under different management techniques, a higher continuous yield than that now being realized could be attained. There are a number of regulation changes that should be considered to permit a sustained yield and to prevent over-exploitation.

Size Limit

Based on biological evidence the size limit would be the best regulation to manipulate to achieve immediate effects. The present minimum legal size of 42 inches should be increased to 50 inches. Two assumptions are made in connection with the concept of permitting fish to grow to a larger size before being caught: (1) by permitting the fish to remain in the water to grow, a greater weight can be anticipated at capture, and (2) if fish are caught before they have grown to the size at which they begin to spawn, recruitment is depressed.

Based on the first assumption, the minimum legal size should be increased to 50 inches, as a 42-inch fish in the Menominee River averages 16

pounds while a 50-inch fish averages 33 pounds, approximately a 100 percent increase in weight. Over 50 inches, the average weight increases some but begins to level off.

As far as the second assumption is concerned, a 50-inch size limit could protect some males as the available literature shows that male lake sturgeon become sexually mature at age 14 to 20 (Harkness and Dymond, 1961). On the Menominee River, fish in age group 20 averaged 49 inches with a range from 45.0 to 56.5 inches. Unfortunately the fish taken on the Menominee River could not be sexed to determine if growth differed between the sexes, nor was age at first maturity determined. Throughout the geographic range of the lake sturgeon most females attain sexual maturity at age 25 (Harkness and Dymond, 1961), thus the 50-inch size limit would offer little protection for females on the Menominee River.

Another reason in favor of a 50-inch size limit should be the desire to consider the lake sturgeon as a trophy fish. A 42-inch, 16-pound lake sturgeon is not a trophy fish.

Other regulation changes follow that should be considered either on their own merit or in conjunction with a 50-inch size limit.

Licensing

The results of this study have given us some information on the population size, fishing pressure and exploitation over a two-year period; however, it is essential that we know what the annual fishing pressure and harvest is so that appropriate management regulations can be formulated annually to prevent overexploitation. Some form of a special fishing license or permit for lake sturgeon and registration would be desirable and should be seriously considered.

Bag Limit

The current season bag limit of two fish should be reduced to one fish per season. Although we do not have precise figures on the number of anglers who did take two fish per season, a reduction to one per season would spread the harvest more equitably, especially if a 50-inch minimum size limit and licensing system regulations were in effect.

Season Length

Closing the season during the month of October would have reduced the pressure by approximately one-fourth; this would have reduced the estimated harvest by 15 fish in 1969 and 12 fish in 1970. An open season during October under the present regulations is difficult to enforce, as many of the major hunting seasons are beginning during October and the manpower shortage makes it difficult for the law enforcement agencies to adequately check the fishery.

Closed Seasons

Since no fish were taken in the waters above the White Rapids dam, it is safe to assume that if a population does exist in these waters it is only nominal. Therefore, lake sturgeon fishing should only be permitted from the White Rapids dam downstream to preserve the population in the waters above this dam.

Closing the season completely every other year would reduce the harvest by one-half if the present bag and size limits were maintained.

An annual season could be maintained if various sections between the dams were closed annually. This would, however, put greater pressure on the sections that were open.

APPENDIX A Creel Census Schedule

First Month—Man #1 Working in Section A

Date	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
September 6 Boat & Angler Counts	1 a.m. 7:00 a.m.		m p.m. 5:00 p.m.		u p.m. 3:00 p.m.	1 a.m. 7:00 a.m.	1 p.m. 3:00 p.m. 1 p.m. 1:00 p.m.
September 13 Boat & Angler Counts	u p.m. 5:00 p.m.	m a.m. 9:00 a.m.		m p.m. 1:00 p.m.		1 a.m. 11:00 a.m.	m p.m. 3:00 p.m.
September 20 Boat & Angler Counts	u a.m. 9:00 a.m.	m p.m. 1:00 p.m.	m p.m. 5:00 p.m.		u a.m. 9:00 a.m.		1 a.m. 11:00 a.m.
September 27 Boat & Angler Counts	m a.m. 11:00 a.m.			m a.m. 7:00 a.m.	u p.m. 3:00 p.m.	m a.m. 9:00 a.m.	u p.m. 3:00 p.m.

First Month—Man #2 Working in Section B

Date	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
September 6 Boat & Angler Counts	1 p.m. 1:00 p.m.		1 a.m. 11:00 a.m.		u a.m. 9:00 a.m.	u p.m. 1:00 p.m.	1 a.m. 9:00 a.m. m a.m. 7:00 a.m.
September 13 Boat & Angler Counts	m a.m. 11:00 a.m.	1 p.m. 3:00 p.m.		m a.m. 7:00 a.m.		u p.m. 5:00 p.m.	m a.m. 9:00 a.m.
September 20 Boat & Angler Counts	m p.m. 3:00 p.m.	m a.m. 7:00 a.m.	1 a.m. 1:00 a.m.		u p.m. 3:00 p.m.		1 p.m. 5:00 p.m.
September 27 Boat & Angler Counts	u p.m. 5:00 p.m.			m p.m. 1:00 p.m.	m a.m. 9:00 a.m.	u p.m. 3:00 p.m.	1 a.m. 9:00 a.m.

Second Month—One Man Working Both Sections A & B

Date	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
October 4 Boat & Angler Counts	B1 p.m. 2:00 p.m.			Am p.m. 12:00 Noon	Bu p.m. 2:00 p.m.	Am a.m. 11:00 a.m.	Au p.m. 4:00 p.m.
October 11 Boat & Angler Counts	Au a.m. 9:00 a.m.	Al a.m. 7:00 a.m.	Bu p.m. 2:00 p.m.		Al p.m. 12:00 Noon		B1 a.m. 7:00 a.m.
October 18 Boat & Angler Counts	Al p.m. 2:00 p.m.		B1 p.m. 4:00 p.m.	Am a.m. 11:00 a.m.		Au p.m. 4:00 p.m.	Am a.m. 9:00 a.m.
October 25 Boat & Angler Counts	Bm p.m. 12:00 Noon	Al p.m. 2:00 p.m.		Bm a.m. 11:00 a.m.	Au a.m. 9:00 a.m.		Bm p.m. 4:00 p.m.
November 1 Boat & Angler Counts	Bm p.m. 4:00 p.m.						

APPENDIX B Creel Census Post Cards

MICHIGAN - WISCONSIN MENOMINEE RIVER SURVEY

Please complete this card when you are through fishing today by recording (1) the number of hours which you fished, (2) the kinds and numbers of fish which you caught and kept, and (3) the size of sturgeon. You can help us, yourself and other fishermen by filling out the card and mailing it soon.

(1) NUMBER OF HOURS FISHED				
(2) YOUR CATCH		(3) SIZE OF STURGEON		
KIND	NUMBER	LENGTH	POUNDS	TAG NO.

I did not catch any fish.

MO. DAY YEAR BOAT SHORE SECTION: A B

MICHIGAN - WISCONSIN MENOMINEE RIVER SURVEY

Mr. MO. DAY YEAR

Mrs.

Miss

_____ (Fisherman's Name)

_____ (Number and Street)

_____ (City) _____ (State) _____ (Zip)

BOAT SHORE SECTION: A B

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