The shovelnose sturgeon, Scaphirynchus platorynchus (Rafinesque) in the Red Cedar-Chippewa River System, Wisconsin: an interim report. Report 82 [1975]

Christenson, Lyle M.
Madison, Wisconsin: Dept. of Natural Resources, [1975]

DEPARTMENT OF NATURAL RESOURCES

RESEARCH REPORT 82

May 1975

THE SHOVELNOSE STURGEON, SCAPHIRYNCHUS PLATORYNCHUS (RAFINESQUE) IN THE RED CEDAR–CHIPPEWA RIVER SYSTEM, WISCONSIN

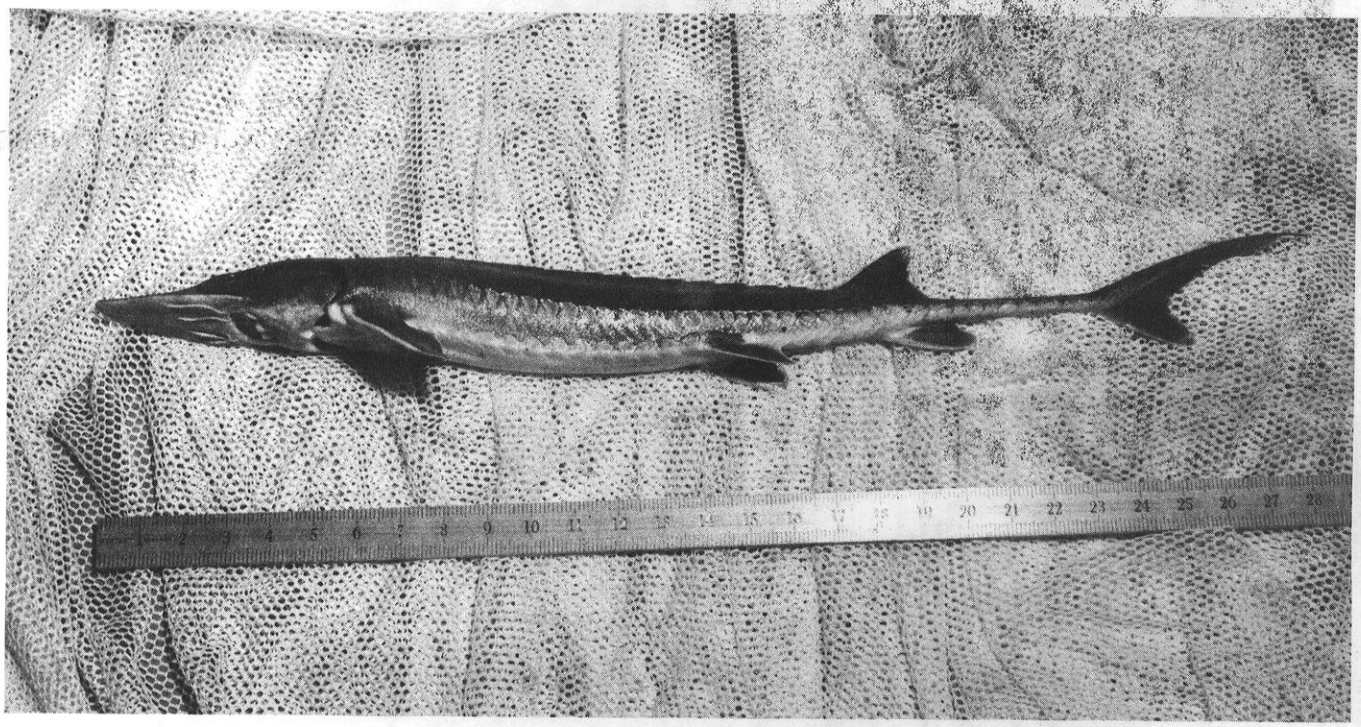
An Interim Report

By Lyle M. Christenson
Bureau of Research, Madison

CONTENTS

INTRODUCTION

The shovelnose sturgeon, Scaphirynchus platorynchus (Rafinesque) is widely distributed throughout the Mississippi River drainage but its life history has been virtually unknown. Early accounts refer primarily to taxonomy and distribution, with only broad generalizations for the most part on life history considerations. Exceptions to the latter are papers on food habits in the Missouri River (Held 1969) and growth in the Mississippi River (Helms 1974). More recently, however, unpublished reports include an M.A. thesis on life history aspects in the Missouri River (Zweiacker 1967), an M.A. thesis on food selectivity in the Missouri River (Modde 1973), a tabulation relating to size at maturity in the Mississippi River (Monson and Greenbank 1947), and two progress reports pertaining to the life history of this species in the Mississippi River (Helms 1972, 1973).



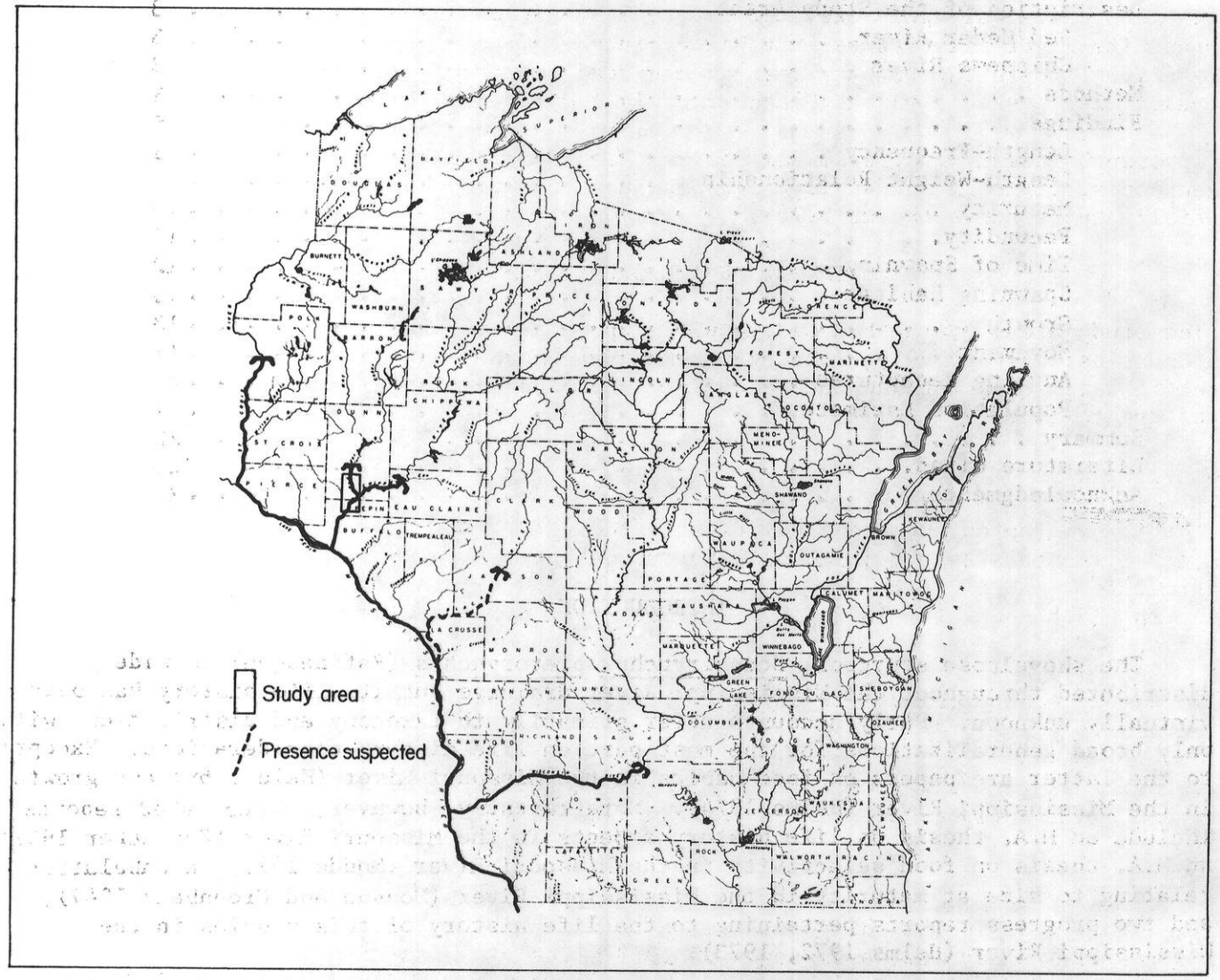


FIGURE 1. Distribution of the shovelnose sturgeon in Wisconsin.

This study is intended to provide a basis for development of improved management strategy. That such information is needed for management decisions is underscored by the diversity of angling regulations applying to this species in Wisconsin. By designated waters, the open season on shovelnose sturgeon varies from none to continuous, the daily bag limit from none to 1, 10, and 25, and the minimum size from none to 40 inches. This diversity is, to a great extent, a reflection of inadequate knowledge.

The lack of sampling gear adequate for collection of fish species inhabiting fast deep waters of large streams and rivers probably accounts, in large measure, for the paucity of information on the shovelnose sturgeon. This situation has changed in recent years due to improvements in boat-mounted electrofishing equipment and adaption of the trawl to freshwater investigations. Only the former has been employed in this study but the use of trawls, as well as gill and trammel nets which have beem employed successfully elsewhere, is contemplated for taking sturgeon in the smaller size ranges which thus far have escaped capture by electrofishing.

Exploratory sampling of shovelnose sturgeon was undertaken on the Red Cedar River, Dunn County, during the period 1967-72 and on the Chippewa River, Dunn and Pepin Counties, in 1972. A formalized study was initiated in 1973, with emphasis on population description, movement, growth, maturity, and spawning characteristics. This report summarizes the findings on both rivers through 30 June 1974.

WISCONSIN DISTRIBUTION

The shovelnose sturgeon has been reported in Wisconsin only in the Mississippi River and its major tributaries--the Wisconsin, Red Cedar-Chippewa, and St. Croix Rivers (Fig. 1). In the tributaries, it has been found only as far upstream as the first dam. Its presence in the Black River is suspected but not documented.

Apparently the navigational dams on the Mississippi River do not prevent movement between pools, at least not during high discharge periods when the dams are essentially inoperative (Helms 1973).

DESCRIPTION OF THE STUDY AREAS

The study areas on the Red Cedar and Chippewa Rivers are in Dunn and Dunn and Pepin Counties, respectively, in northwestern Wisconsin. Water levels in both are subject to daily fluctuations due to operation of upstream power dams and to seasonal changes due to runoff.

Red Cedar River

The study area on the Red Cedar River extends from the Hwy. 29 bridge at Menomonie downstream to the junction with the Chippewa River, a distance of approximately 17 miles (Fig. 2). This portion of the river averages approximately 200 ft. in width and 2 ft. in depth. The long-term average flow at Menomonie is 1,225 cfs.

Bottom types approximate 10 percent bedrock, 40 percent rubble-gravel and 50 percent sand.

Velocity is generally moderate but ranges from fast, especially in the upper half where shallow rapids are common (Fig. 3), to slow in the long deeper pool areas.

Chippewa River

The study area in the Chippewa River extends from the junction of the Red Cedar River downstream to Durand, a distance of 10.3 miles via Nine-Mile Slough and 15.3 total channel miles (Figs. 2, 4). The estimated width of the main channel ranges from

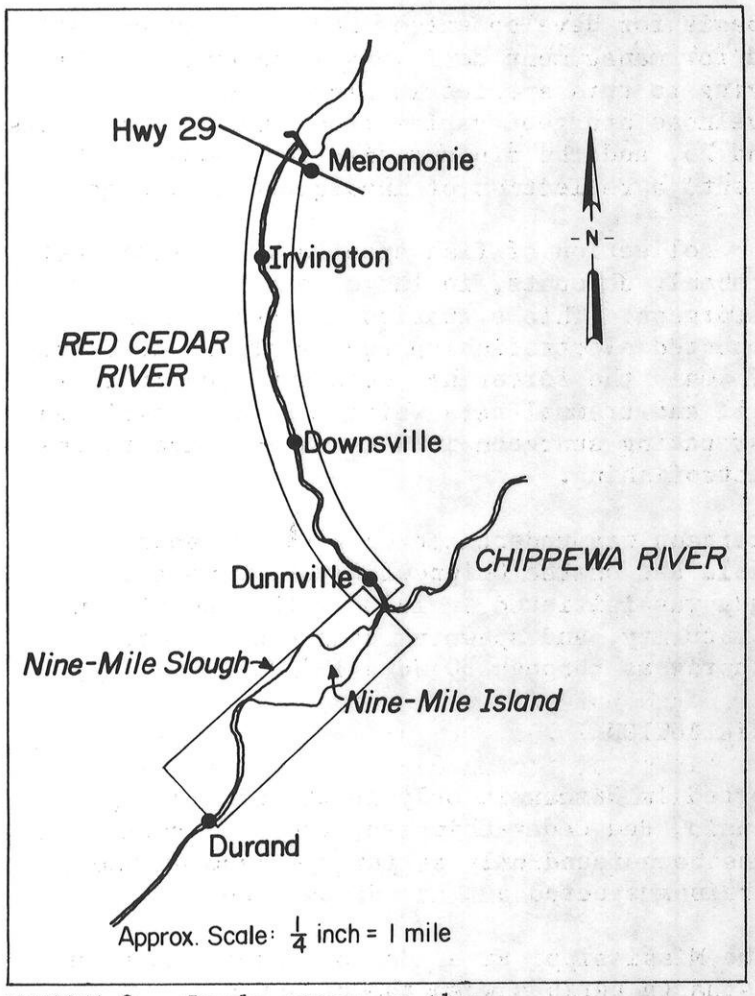


FIGURE 2. Study areas on the Red Cedar and Chippewa Rivers.

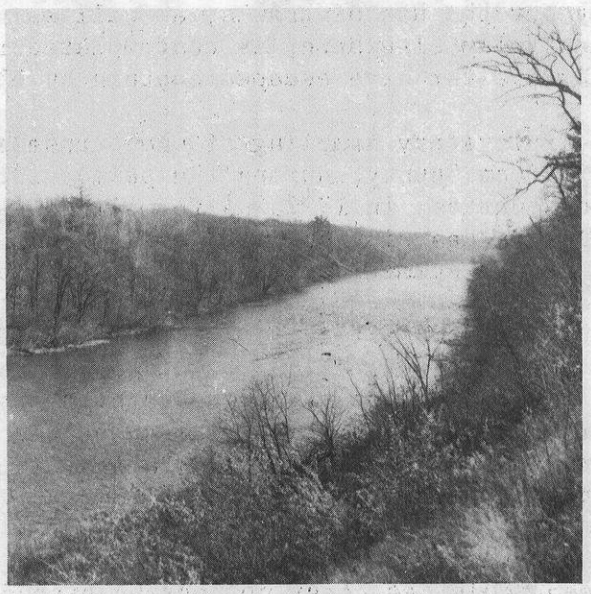


FIGURE 3. View of the Red Cedar River in the upper part of the study area, looking downstream.

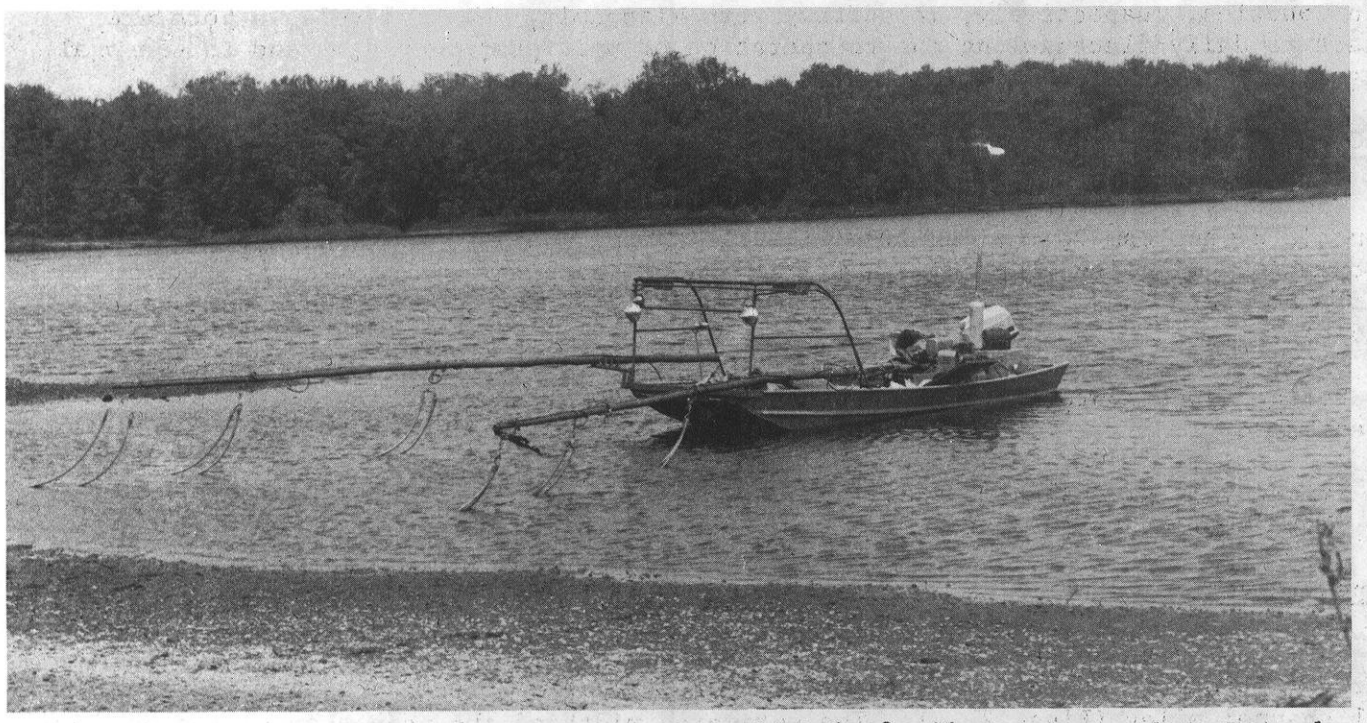


FIGURE 4. View of the Chippewa River, approximately 2 miles upstream from Durand.

600 to 1,000 ft. but where the channel splits around Nine-Mile Island, the width range is much narrower. Depth determinations have not been made. The long-term average flow at Durand is 7,404 cfs.

Velocity is generally moderate throughout the study area but limited stretches of both fast- and slow-moving water are present. A detailed survey of bottom types has not been made but sand and gravel predominate.

METHODS

Shovelnose sturgeon were captured by means of a 230-volt ac boom shocker (Fig. 4), moving primarily in a downstream direction. Fork length was measured to the nearest 0.1 inch. Weight was recorded to the nearest 0.5 ounce and subsequently converted to pounds.

Fish were tagged with a numbered aluminum strap tag encircling the caudal peduncle at the base of the caudal fin (Fig. 5, Table 1). Release and recapture sites were recorded on maps with a scale of 4 inches = 1 mile.

For age determination, a one-inch section of the front rays of a pectoral fin, cut with bone shears as close as possible to the point of articulation, was taken from most Red Cedar River specimens collected during 1967-70. Age determination from fin rays did not prove to be feasible and calculation of growth was subsequently based solely on empirical measurements of recaptured specimens.

No creel census was conducted but to enhance reporting of tagged sturgeon caught by anglers news releases referring to the study were published in the Menomonie and Durand newspapers.

Gonads were taken from weekly samples of up to 20 specimens during the spring of certain years and preserved in 10 percent formalin for subsequent maturity and fecundity determinations.

A population estimate was calculated by a Peterson-type mark-and-recapture method.

Where deemed necessary, amplification of methods employed will be made under the appropriate headings to follow.

FINDINGS

Length-Frequency

Length data were obtained from 465 sturgeon in the Red Cedar River and from 1,024 in the Chippewa River (Table 2). In the former, fork length ranged from the 22.0-22.4 to the 32.0-32.4 inch size interval. The modal length interval was 26.0-26.4 and fish in the 24.5-26.4 interval comprised 52 percent of all specimens measured.

In the Chippewa River, the size intervals ranged from 20.0-20.4 to 31.5-31.9. The modal length interval was 24.5-24.9 and fish in the 24.5-26.4 interval comprised 50 percent of the sample.

Although the maximum length intervals attained and representations in the 24.5-26.4 intervals were approximately the same in both rivers, the proportion of larger fish 26.5 inches and over was appreciably greater in the Red Cedar River (34%) than in the Chippewa River (21%). This length differential is illustrated in Figure 6.

TABLE 1. Summary of shovelnose sturgeon tagged and released in the Red Cedar and Chippewa Rivers.

Year of Release	Number Tagged	Year of Release	Number Tagged
Red Cedar River		Chippewa River	
1967	16	1972	229
1968	115	1973	767
1969	16		
1970	106		
1971	3		
1972	21		
1973	72		
TOTAL	349	TOTAL	996

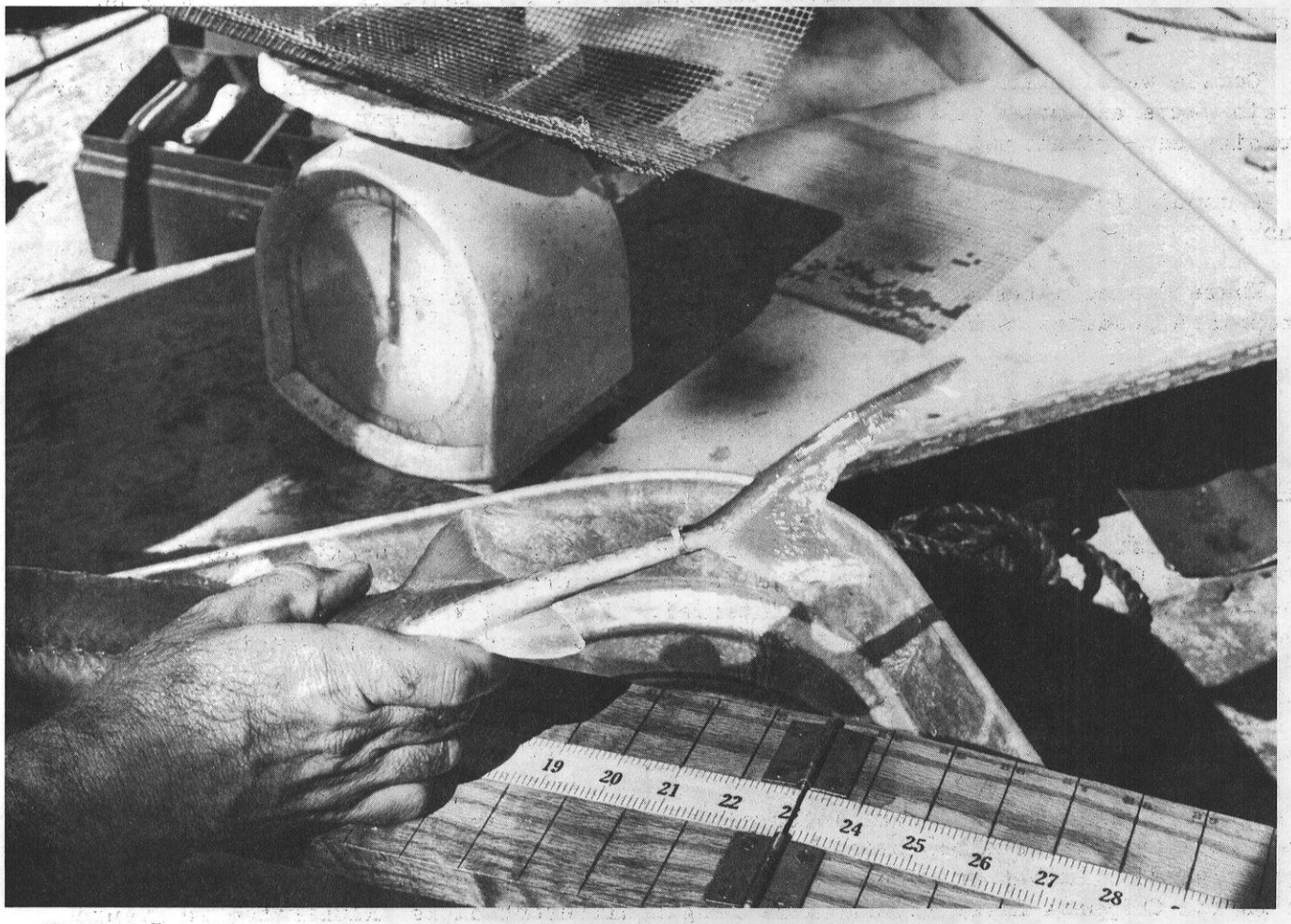


FIGURE 5. Aluminum strap attached to caudal peduncle.

TABLE 2. Length-frequencies (Fork Length in inches) of shovelnose sturgeon in the Red Cedar and Chippewa Rivers collected during the periods April to October, 1967-73 and May to September, 1972-73, respectively.

Size Interval Fork Length (inches)	Red Cedar River Number	Red Cedar River Percent	Chippewa River Number	Chippewa River Percent
20.0 - 20.4			1	0.1
20.5 - 20.9				
21.0 - 21.4				
21.5 - 21.9			1	0.1
22.0 - 22.4	1	0.2	3	0.3
22.5 - 22.9	3	0.6	23	2.2
23.0 - 23.4	8	1.7	56	5.5
23.5 - 23.9	20	4.3	80	7.8
24.0 - 24.4	33	7.1	132	12.9
24.5 - 24.9	48	10.3	141	13.8
25.0 - 25.4	58	12.5	137	13.4
25.5 - 25.9	67	14.4	127	12.4
26.0 - 26.4	68	14.6	107	10.4
26.5 - 26.9	45	9.7	85	8.3
27.0 - 27.4	40	8.6	60	5.9
27.5 - 27.9	38	8.2	33	3.2
28.0 - 28.4	18	3.9	19	1.9
28.5 - 28.9	7	1.5	9	0.9
29.0 - 29.4	5	1.1	7	0.7
29.5 - 29.9	1	0.2	1	0.1
30.0 - 30.4	3	0.6		
30.5 - 30.9				
31.0 - 31.4				
31.5 - 31.9	1	0.2	1	0.1
32.0 - 32.4	1	0.2		
TOTAL	465		1,024	

Length-Weight Relationship

Weights were obtained for 88 sturgeon in the Red Cedar River and 953 in the Chippewa River, for fork lengths ranging from 22.0-22.4 to 29.0-29.4 and 20.0-20.4 to 31.5-31.9 inches, respectively (Table 3). Sample sizes differ from those recorded in Table 2 because (1) the scales used on the Red Cedar River prior to 1971 were later found to be of questionable accuracy in mid-range and (2) all fish taken prior to July in all years were excluded from the calculations to avoid possible bias due to gonadal development.

The weight range within most size intervals in both rivers was so great that a calculated length-weight relationship would be of doubtful value. Nevertheless, the average weights of well-represented size intervals in both rivers were suprisingly close; e.g., for the 25.5-25.9 inch interval, the average weight was 2.19 pounds in the Red Cedar River and 2.22 pounds in the Chippewa River and for the 27.0-27.4 inch interval, the respective average weights were 2.64 and 2.60 pounds.

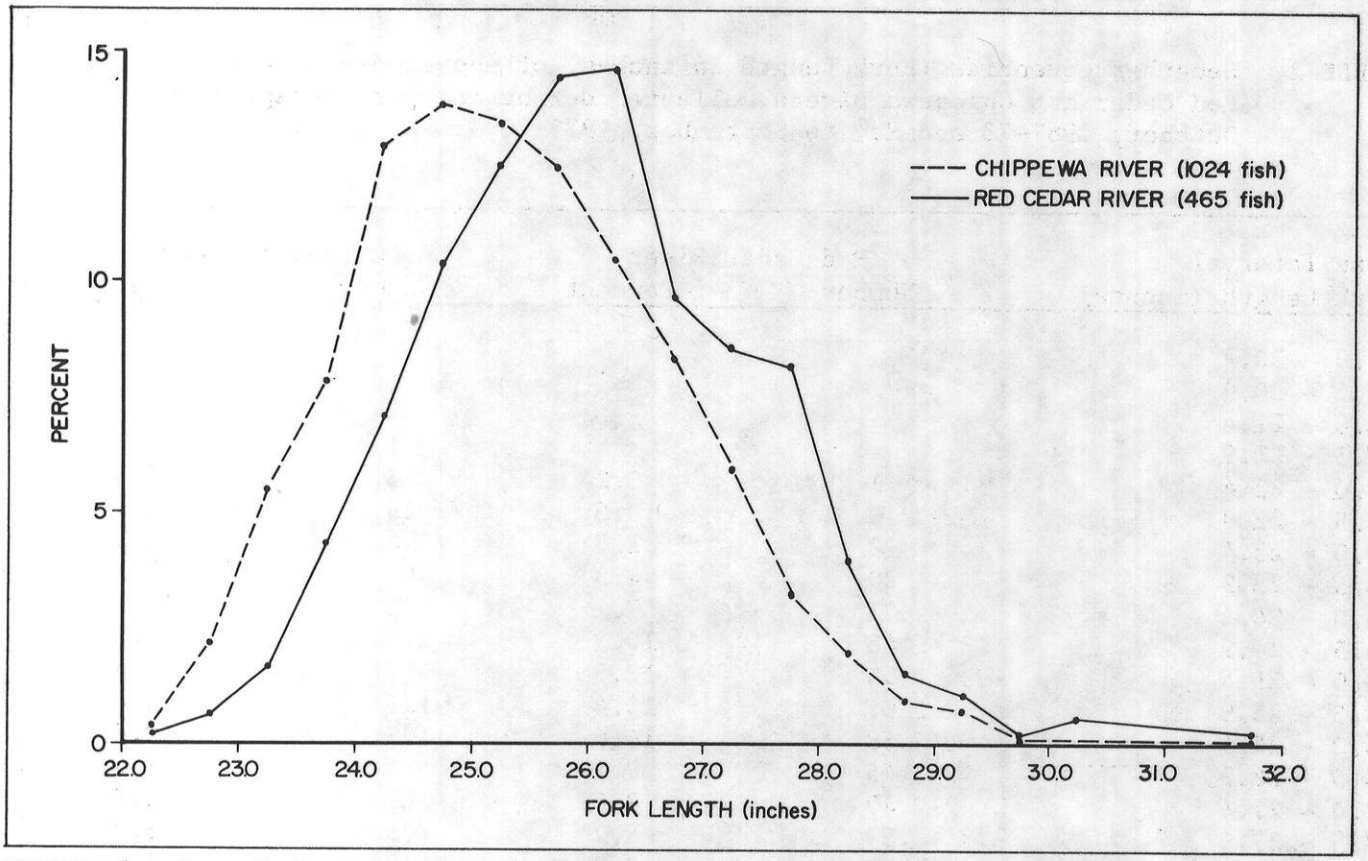


FIGURE 6. Length-frequencies of shovelnose sturgeon in the Red Cedar (1967-73) and Chippewa Rivers (1972-73) expressed as percent of each size interval in the samples.

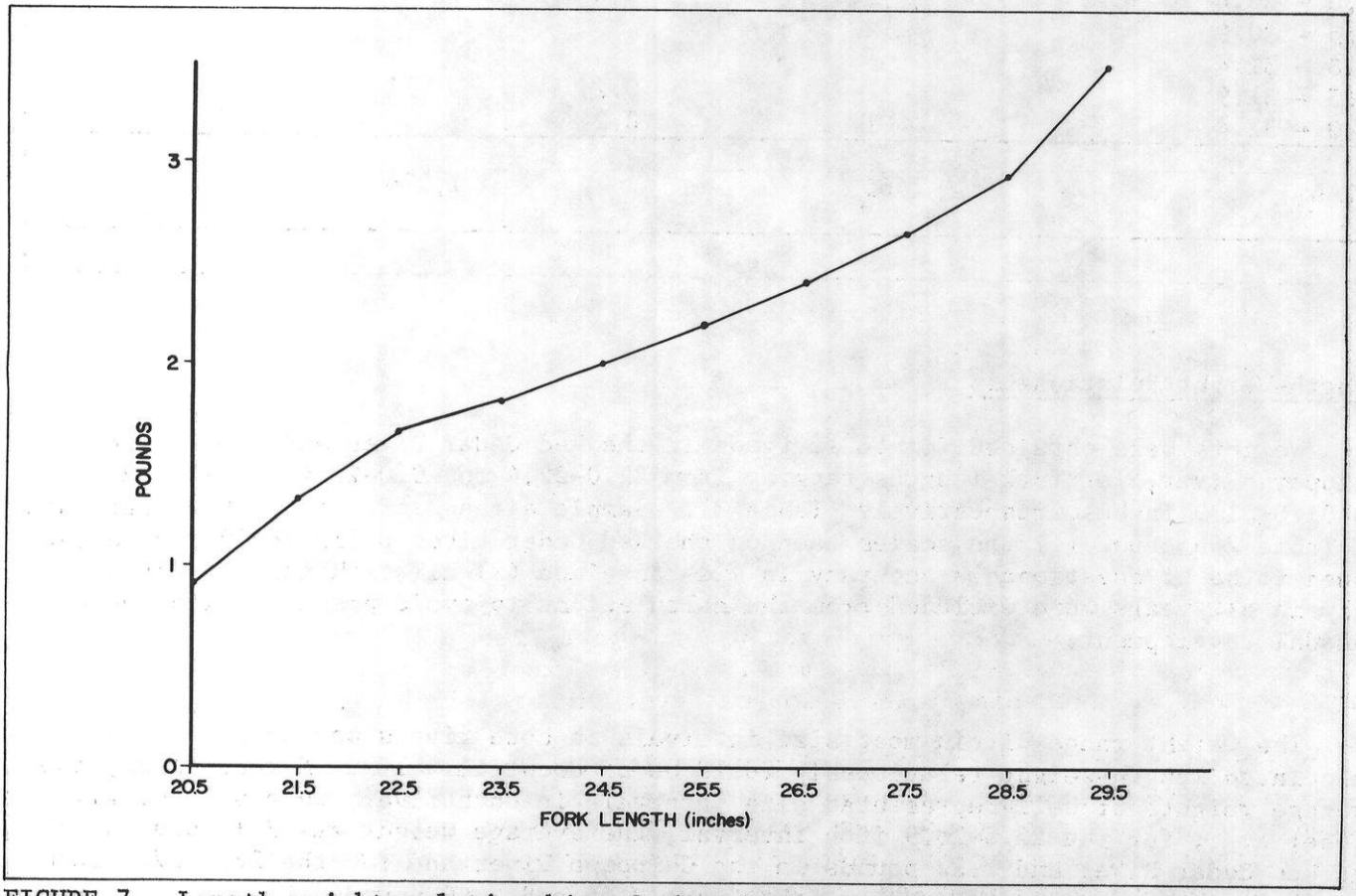


FIGURE 7. Length-weight relationship of shovelnose sturgeon in the Chippewa River (July-September samples only).

TABLE 3. Length-weight relationships of shovelnose sturgeon in the Red Cedar and Chippewa Rivers, collected during the periods July to October, 1971-73 and July to September, 1972-73, respectively.

Size Interval Fork Length (inches)	Red Cedar River				Chippewa River			
	Number	Weight (lb)* Range	Average		Number	Weight (lb)* Range	Average	
20.0 - 20.4					1	---	0.94	
20.5 - 20.9								
21.0 - 21.4								
21.5 - 21.9					2	1.31-1.34	1.33	
22.0 - 22.4	3	1.53-1.88	1.70	1.67	3	1.69-1.88	1.79	1.65
22.5 - 22.9	1	---	1.56		21	1.44-1.97	1.63	
23.0 - 23.4					54	1.44-2.13	1.72	
23.5 - 23.9	6	1.50-1.88	1.76		76	1.47-2.25	1.86	1.80
24.0 - 24.4	3	1.81-2.22	1.96	2.07	126	1.50-2.44	1.96	
24.5 - 24.9	9	1.91-2.47	2.11		135	1.69-2.56	2.04	2.00
25.0 - 25.4	9	1.97-2.47	2.20	2.19	123	1.69-2.69	2.14	
25.5 - 25.9	10	1.88-2.50	2.19		120	1.84-2.91	2.22	2.18
26.0 - 26.4	14	1.97-2.66	2.34	2.47	98	1.95-2.84	2.36	
26.5 - 26.9	9	2.47-2.97	2.67		77	2.06-3.19	2.47	2.41
27.0 - 27.4	11	2.31-2.94	2.64	2.70	54	1.84-3.31	2.60	
27.5 - 27.9	9	2.44-2.94	2.77		29	2.44-3.31	2.77	2.66
28.0 - 28.4	2	2.50-3.09	2.79	2.94	18	2.19-3.38	2.85	
28.5 - 28.9	1	---	3.25		8	2.44-3.44	3.14	2.94
29.0 - 29.4	1	---	2.94		7	3.00-4.16	3.49	
29.5 - 29.9								
30.0 - 30.4								
30.5 - 30.9								
31.0 - 31.4								
31.5 - 31.9					1	---	5.00+**	
TOTAL	88				953			

* Weights taken originally in pounds and ounces and converted to pounds and hundredths.
** Exceeded scale capacity.

Weights of the Red Cedar River sample average 2.34 pounds and ranged from 1.70 to 3.25 pounds. Comparable figures for the Chippewa River were 2.18 pounds and 0.94 to 5.00 plus pounds (weight of the latter specimen exceeded scale capacity). The length-weight relationship of the Chippewa River fish is illustrated in Figure 7.

Not included in Table 3, the maximum weight recorded for Red Cedar River fish was from a 5.69-pound male, 32.4 inches fork length, taken 15 May 1972; the testes accounted for 6 percent of the body weight. The heaviest female from the Red Cedar River weighed 4.88 pounds; this fish, 31.7 inches fork length, was taken 1 May 1972, and the ripening ovary comprised 18 percent of the body weight.

Maturity

Attention to date has been directed primarily to obviously mature females as indicated by the presence of enlarged ovaries containing black eggs (Fig. 8). On that basis, the smallest mature female thus far observed measured 24.7 inches fork length. The smallest mature male, indicated by the presence of running milt when the testis was cut, measures 22.1 inches fork length. Both Monson and Greenbank (1947) and Helms (1973) found that male shovelnose sturgeon mature at a smaller size than females.

To the naked eye, the ovaries appeared to fall into three major color groups: (1) yellow and/or white, (2) white and black ("salt and pepper") (Fig. 9) and (3) black. These groups were all represented throughout most of the size range captured; i.e., at least three stages of egg development occurred essentially irrespective of size. Since the fish were all taken approaching and during the spawning season, the differential development apparent at sizes beyond the minimum size at maturity observed (fork length-24.7 inches) indicate that females do not spawn every year; but the spawning chronology is not readily evident.

Of the preserved gonads on hand, only a few ovaries, selected because of obvious differences, have been examined microscopically (after 20 hours in 10% formalin). In that sample, egg size and color varied considerably between ovaries from different specimens and within ovaries of the same fish. Color variations noted were: (1) yellow and white, (2) white, (3) yellow, white, and black, (4) white and black, and (5) black. In 1-4, at least two sizes of eggs other than black were always present and the smallest were always white. Whether alone or in combination, the largest yellow and white eggs did not exceed 1 mm in diameter and tended to be uniformly spherical (Fig. 10). Black eggs always exceeded 2 mm in diameter and varied from spherical to distinctly ovate (Fig. 11).

Fecundity

Estimated production of mature eggs, i.e., black eggs expected to be spawned in the year collected, was determined for 10 sturgeon from the Red Cedar River (Table 4).

Preserved ovaries were blotted, broken apart, air-dried for approximately 15 minutes and weighed to the nearest 0.001 ounce. Portions were removed from several areas of each ovary, weighed collectively and counted. Total egg production was then calculated on a direct proportion basis. Collective samples ranged from 8.7 to 23.8 percent of the ovary weights and averaged 15.6 percent.

Rough estimates of mature egg diameter were made simply by averaging samples of approximately 20 eggs aligned on a millimeter rule. The average number of eggs per ml was determined by volumetric displacement of samples of 600-700 eggs.

Fork lengths of the fish ranged from 24.7 to 31.7 inches, with an average of 27.7 inches. In that sample, estimated egg production ranged from 10,680 for the smallest fish to 50,971 for the largest, with an average of 24,404. These findings closely parallel those of Helms (1973) for 16 shovelnose sturgeon taken in Iowa waters of the Mississippi River. Within a fork length range of 24.2 to 33.6 inches, his total counts of mature eggs ranged from 13,908 to 51,217 and averaged 24,325.

FIGURE 8. Near-ripe female shovelnose sturgeon, Chippewa River, 29 May 1974 (Fork Length-26.1 inches, Weight-2.25 pounds).

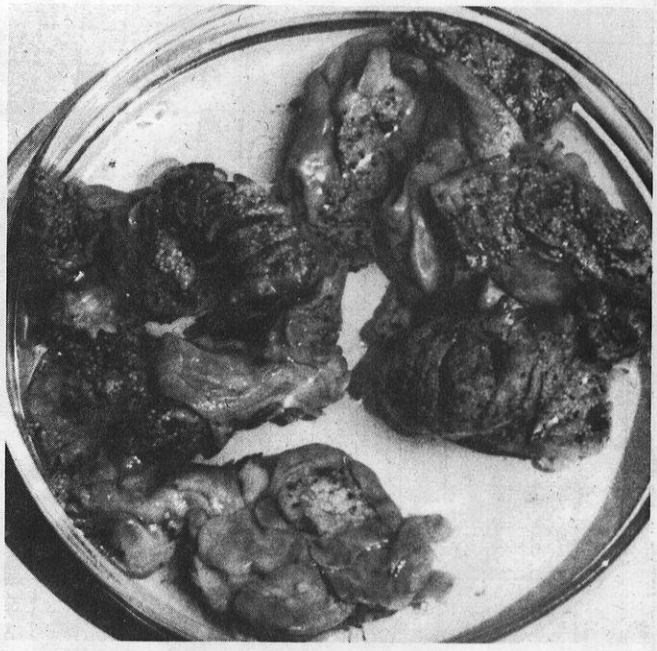


FIGURE 9. Shovelnose sturgeon ovary containing both white and black eggs, 23 May 1972 (Fork Length-27.9 inches, Weight-2.31 pounds).

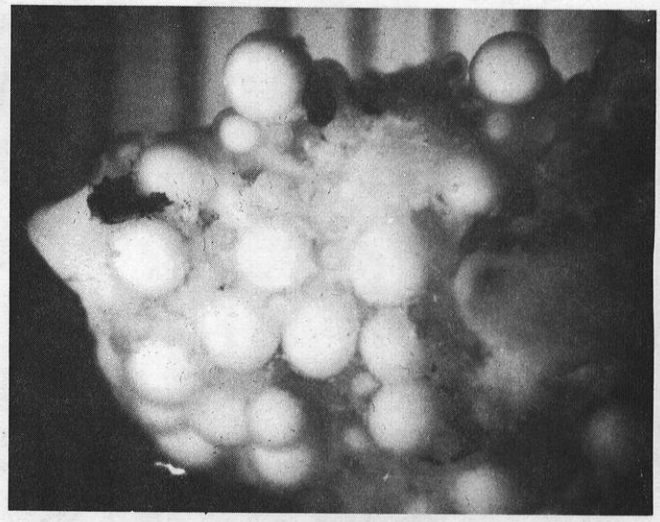


FIGURE 10. Shovelnose sturgeon ovary with white eggs of more than one size (scale in mm).

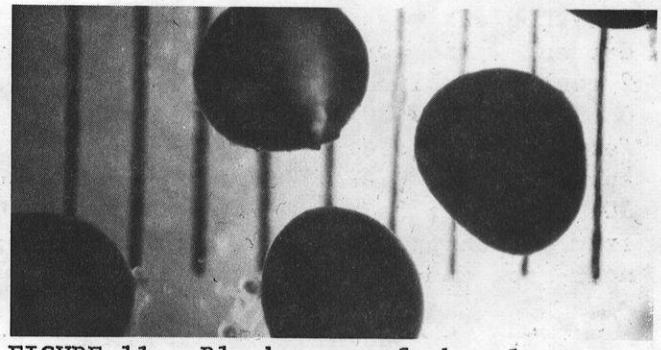


FIGURE 11. Black eggs of shovelnose sturgeon (scale in mm).

TABLE 4. Fecundity of the Shovelnose sturgeon, Red Cedar River.

TABLE 4. Fecundity of the shovelnose sturgeon, Red Cedar River.

Date Captured	Fork Length (Inches)	Weight (lb)	Water Temp. (°F)	Ovary Wt. (g)	Ovary Percent Body Wt.	Percent Ovary Wt. Sampled	No. Eggs/ml.	Avg. Egg Diam. (mm)	Estimated No. Eggs
4 May 71	24.7	1.88	50	94	11.0	19.1	155	2.21	10,680
11 May 71	25.1	2.06	56	100	10.7	23.8	-	-	11,888
18 May 71	26.6	2.63	60	194	16.3	17.0	-	2.36	18,404
4 May 71	27.6	3.00	50	198	14.5	18.2	-	2.43	19,874
11 May 71	27.8	2.75	56	176	14.1	15.6	-	-	17,892
30 May 72	27.9	3.53	68	170	10.6	13.5	219	2.05	23,456
16 Apr 68	27.9	3.84	53	306	11.8	13.5	140	2.27	34,052
23 May 72	28.0	3.88	67	342	19.5	11.9	-	-	36,138
18 May 71	29.4	3.25	60	210	14.2	8.7	130	2.39	20,680
1 May 72	31.7	4.88	52	400	18.1	14.7	169	2.15	50,971
AVG.	27.7	3.17		219	14.1	15.6	163	2.27	24,404

Egg production appeared to be broadly related to fish length, although 2 of the 10 specimens fell outside the ascending length sequence; however, no relationship of egg production to the percent body weight of the ovaries, averaging 14.1 percent and ranging from 10.6 to 19.5 percent, was evident.

Rough estimates of preserved mature egg diameter ranged from 2.05 to 2.43 mm and averaged 2.27 mm.

Time of Spawning

As originally conceived, time of spawning was to be determined from data on the increasing and decreasing body-gonad weight ratio throughout the spawning season. It is now evident that the large sample sizes required preclude the use of this approach. The best alternative would seem to be to establish the chronology of first detection of spawned-out females and last occurrence of ripe females. Ripening and ripe females are easily categorized; but a spawned-out condition has been, because of the limited number thus far encountered, only tentatively ascribed to those fish where the ovary appears as a pinkish or colorless gelatinous mass, with or without some black eggs still remaining.

With that limitation in mind, the 1972 Red Cedar River spring samples roughly circumscribe the spawning season. On 15 May 1972, in a sample of 8 females, only 1 with black eggs was observed. On 23 May, in a sample of 11 females, 3 were spawned-out and 2 had ovaries with black eggs only. On 30 May, in a sample of 5 females, 2 contained black eggs only. On 5 June, in a sample of 4 females, 1 was spawned-out. On 12 June and 20 June, in samples of 3 and 4 females, respectively, no spawned-out females or females with black eggs only were present. Water temperatures (°F at approximately 9 a.m.) during that period were as follows: 15 May - 58°; 23 May - 67°; 30 May - 67°; 5 June - 68°; 12 June - 70°; and 20 June - 70°. Supporting observations from the Chippewa River indicate that of 10 females sampled on 29 May 1974, 1 was near-ripe and 3 were spawned-out.

Thus the spawning season can be tentatively ascribed to approximately the last week in May through the first week in June, at water temperatures in the mid-to-

upper sixties. Helms (1973) in a sample of 20 females from Pool 13, Mississippi River, captured the first spawned-out female on 24 May and the last female with black eggs on 14 June.

Spawning Habitat

Known spawning areas have not been located but several late May areas of sturgeon concentration have been identified in the Chippewa River. If egg deposition is subsequently detected in those areas, bottom type, depth, and velocity will be described.

Growth

Preliminary efforts to determine age and growth of the shovelnose sturgeon, in the size range captured, by the pectoral fin ray cross section method have been unsuccessful. The reason for this became evident when previously tagged and measured specimens were recaptured after varying at-large periods. Empirical growth proved to be virtually nil and hence annulus formation could not be detected.

During the 1967-73 period, 52 previously tagged and measured Red Cedar River sturgeon were recaptured after being at large 7 to 58 months from the date of release (Table 5). Three of these specimens were recaptured a second time. Measured fork length differences between dates of release and of recapture varied from a minus 0.3 inch to a plus 0.4 inch, irrespective of the time at large or the size of the fish. (One specimen exhibited an apparent growth of 1.2 inches over a 21-month period but the preponderance of evidence suggests that this was due to a recording error of 1 inch at either the time of release or of recapture; i.e., the actual difference was probably plus 0.2 inches). Of 19 single recapture fish at large 35 months or more, the recorded average growth of 13 was plus 0.2 inches, of 5 minus 0.2 inches, and one showed no growth.

Empirical growth of tagged sturgeon at large in the Chippewa River for approximately 1 year (Table 6) followed the same pattern as that of the Red Cedar River fish. Here the data on apparent negative and positive growth are evenly balanced; of 31 specimens, 11 exhibited an average growth of plus 0.1 inch, 11 of minus 0.1 inch, and 9 showed no growth.

To determine the degree of precision to be expected in field measurements of fork length, repeated measurements by the same individual were made of 20 specimens held captive over a one-month period (Table 7). In three trials, variation in measurements ranged from 0-0.4 inches, indicating an average expected variation of 0.2 inches in either the positive or negative direction. Viewed in the light of these data, attribution of any growth within the size range sampled to either the Red Cedar or Chippewa River sturgeon over the periods covered must be considered more apparent than real. Helms (1973), citing a personal communication from James Schmulbach, reported a similar growth pattern for tagged sturgeon in the Missouri River.

Average calculated fork lengths of Mississippi River (Pool 13) fish at the end of the first three years of life were 8.2, 14.2, and 18.7 inches (Helms 1974). The oldest specimen in collections of the same investigator from six navigation pools was estimated to be 12 years old and measured 28.2 inches fork length. He attributed reduced growth after the fourth year of life to attainment of sexual maturity. In view of the growth data presented above, it would be difficult to imagine that shovelnose sturgeon in the Red Cedar-Chippewa River system were only 12 years old at approximately 28 inches fork length.

TABLE 5. Empirical growth of the shovelnose sturgeon in the Red Cedar River based on field measurements of tagged recaptures, 1968-73.

Tag Number	Original Release Date	First Recapture: Months at Large	First Recapture: Fork Length (inches) At Release	First Recapture: Fork Length (inches) At Recapture	First Recapture: Length Difference (inches)	Second Recapture: Months at Large*	Second Recapture: Fork Length (inches) At Release	Second Recapture: Fork Length (inches) At Recapture	Second Recapture: Length Difference (inches)
18102	20 Oct 70	7	24.8	25.2	+0.4				
39206	3 Oct 67	10	27.2	27.1	-0.1				
666	6 Aug 69	10	27.4	27.5	+0.1				
779	2 Jul 70	10	26.9	27.1	+0.2				
1438	14 Jul 70	10	26.0	26.2	+0.2				
1278	7 Aug 72	10	27.7	27.8	+0.1				
661	5 Aug 69	11	26.0	26.1	+0.1				
669	6 Aug 69	11	25.2	25.5	+0.3				
860	26 Jun 70	11	24.2	24.5	+0.3				
879	26 Jun 70	11	24.6	24.7	+0.1				
1440	14 Aug 72	11	22.6	22.4	-0.2				
1271	18 Jul 72	12	27.1	27.4	+0.3				
39275	18 Sep 68	21	27.6	28.8	+1.2				
39280**	18 Sep 68	21	27.5	27.4	-0.1	24	27.4	27.4	0.0
39293	18 Sep 68	21	24.4	24.5	+0.1				
18002	19 Sep 68	21	26.3	26.1	-0.2				
18014	19 Sep 68	21	25.9	25.7	-0.2				
888	1 Jul 70	21	28.3	28.1	-0.2				
39214	27 Aug 68	22	27.9	28.3	+0.4				
39248[1]	28 Aug 68	22	26.4	26.4	0.0	24	26.4	26.3	-0.1
18022	19 Aug 68	22	24.4	24.3	-0.1				
1433	14 Jul 70	22	25.7	25.9	+0.2				
39222	27 Aug 68	23	24.1	24.1	0.0				
39230	28 Aug 68	23	25.5	25.5	0.0				
877	2 Jul 70	23	26.4	26.3	-0.1				
872	26 Jun 70	24	25.5	25.3	-0.2				
832	25 Jun 70	24	26.3	26.6	+0.3				
794	2 Jul 70	24	26.5	26.4	-0.1				
882	26 Jun 70	25	27.4	27.4	0.0				
39290	18 Sep 68	32	26.6	26.9	+0.3				
18005	19 Sep 68	32	24.1	24.4	+0.3				
39283	18 Sep 68	32	26.3	26.6	+0.3				
18103	21 Oct 70	33	25.9	26.0	+0.1				
667[2]	6 Aug 69	35	27.2	27.2	0.0	14	27.2	27.4[3]	+0.2
871	26 Jun 70	35	26.3	26.7	+0.4				
844	25 Jun 70	37	25.8	26.0	+0.2				
866	26 Jun 70	37	27.4	27.6	+0.2				
889	1 Jul 70	37	27.7	27.8	+0.1				
782	2 Jul 70	37	24.3	24.6	+0.3				
2760	17 Oct 67	43	24.9	24.7	-0.2				
18017	19 Sep 68	44	26.8	27.0	+0.2				
18012	19 Sep 68	44	27.2	27.6	+0.4				
39224	27 Aug 68	45	23.8	23.9	+0.1				
39245	28 Aug 68	45	25.5	25.8	+0.3				
18011	19 Sep 68	45	25.1	25.0	-0.1				
39253	28 Aug 68	46	24.6	24.7	+0.1				
39252	28 Aug 68	46	24.8	24.9	+0.1				
39242	28 Aug 68	47	27.6	27.4	-0.2				
670	6 Aug 69	47	23.8	23.5	-0.3				
2759	17 Oct 67	56	25.8	25.6	-0.2				
39292	18 Sep 68	58	28.2	28.3	+0.1				
39289[3]	18 Sep 68	58	25.0	25.2	+0.2				

* From date of first recapture.
** Retagged as #838 on 25 Jun 70.
1/ Retagged as #892 on 2 Jul 70.
2/ Retagged as #1263 on 17 Jul 72.
3/ Recaptured in the Chippewa River.

TABLE 6. Empirical growth of the shovelnose sturgeon in the Chippewa River over approximately a one-year period based on field measurements of tagged recaptures, 1972-73.

Tag Number	Original Release Date	Fork Length (inches) At Release	Fork Length (inches) At Recapture	Fork Length (inches) Difference	Weight (lb)* At Release	Weight (lb)* At Recapture	Weight (lb)* Difference
1060	7 Aug 72	23.8	23.6	-0.2	2.00	1.88	-0.12
1297	8 Aug 72	24.0	24.0	0.0	1.53	1.63	+0.10
3350	15 Aug 72	27.0	26.9	-0.1	2.25	2.47	+0.22
3353	15 Aug 72	27.5	27.3	-0.2	2.47	2.69	+0.22
1281	8 Aug 72	24.7	24.8	+0.1	1.78	1.75	-0.03
1300	8 Aug 72	24.1	24.2	+0.1	1.75	1.88	+0.13
3381	15 Aug 72	27.3	27.3	0.0	2.44	2.44	0.00
3336	14 Aug 72	24.5	24.4	-0.1	2.19	2.19	0.00
3343	14 Aug 72	25.8	26.0	+0.2	1.84	1.94	+0.10
3354	15 Aug 72	25.9	25.8	-0.1	2.25	2.19	-0.06
3392	15 Aug 72	24.9	24.8	-0.1	1.84	1.88	+0.03
1010	24 Jul 72	23.7	23.7	0.0	1.78	1.81	+0.03
1012	24 Jul 72	23.2	23.4	+0.2	1.53	1.56	+0.03
1032	25 Jul 72	26.0	26.1	+0.1	2.09	2.00	-0.09
1098	8 Aug 72	24.0	24.1	+0.1	1.81	1.81	0.00
1292	8 Aug 72	24.6	24.5	-0.1	1.88	1.81	-0.07
1297	8 Aug 72	24.0	24.1	+0.1	1.53	1.56	+0.03
3320	14 Aug 72	26.6	26.6	0.0	2.38	2.44	+0.06
1024	25 Jul 72	23.7	23.7	0.0	1.59	1.53	-0.06
1094	8 Aug 72	25.6	25.5	-0.1	2.06	1.94	-0.12
3371	15 Aug 72	26.2	26.3	+0.1	2.38	2.47	+0.09
3373	15 Aug 72	24.9	24.7	-0.2	2.22	2.16	-0.06
3365	15 Aug 72	26.0	26.0	0.0	2.13	2.03	-0.10
1279	8 Aug 72	24.3	24.3	0.0	1.59	1.66	+0.07
1294	8 Aug 72	24.3	24.4	+0.1	1.88	1.78	-0.10
3340	14 Aug 72	24.9	24.8	-0.1	2.00	2.00	0.00
3327	14 Aug 72	26.0	25.8	-0.2	2.28	2.28	0.00
3364	15 Aug 72	24.0	24.0	0.0	1.81	1.69	-0.12
3392	15 Aug 72	24.9	25.0	+0.1	1.84	1.97	+0.13
1081	8 Aug 72	24.8	24.9	+0.1	2.16	2.25	+0.09
1068	7 Aug 72	26.5	26.5	0.0	2.13	2.38	+0.25

* Weights originally recorded as pounds and ounces and converted to pounds and hundreths.

TABLE 7. Repeated measurements by same individual of shovelnose sturgeon held in the Delafield station raceway, 15 May 1973 to 15 June 1973.

Specimen Number	Fork Length (inches) 17 May	Fork Length (inches) 7 June	Fork Length (inches) 15 June	Maximum Variation (Inches)
1	25.5	25.2	25.3	0.3
2	27.9	27.9	27.7	0.2
3	24.0	23.9	23.8	0.2
4	25.1	24.8	24.9	0.3
5	26.9	26.9	26.8	0.1
6	26.1	25.9	26.1	0.1
7	26.4	26.1	26.1	0.3
8	28.1	28.1	28.1	0.0
9	25.5	25.5	25.6	0.1
10	25.8	25.6	25.6	0.2
11	25.6	25.5	25.5	0.1
12	24.6	24.4	24.3	0.3
13	25.5	25.4	25.4	0.1
14	27.2	27.1	27.0	0.2
15	27.4	27.2	27.4	0.2
16	26.6	26.6	26.6	0.0
17	29.2	29.2	29.1	0.1
18	25.6	25.2	25.4	0.4
19	24.2	24.0	24.2	0.2
20	27.1	27.2	27.0	0.2

Jaw tagging has been shown to negatively affect the growth of some fish species, but it does not seem likely that the tagging method employed in this study would have the same effect. If the tagging had retarded growth, a differential in size interval representation between untagged fish caught in 1973 and 1973 recaptures of fish tagged in 1972 could be expected. Visual inspection of the Chippewa River data (Table 8) reveals no such pattern. Some of the recaptures did exhibit varying degrees of physical irritation at the site of tag application but again it is difficult to conceive that this would affect growth. Mississippi River specimens were apparently in good health after loss of the entire caudal peduncle (Fig. 12). That tagging did not affect general mobility of the sturgeon is indicated by movements of tagged fish to be discussed in the next section.

TABLE 8. Comparison of size representation of 1973 untagged shovelnose sturgeon and of recaptures in 1973 of fish tagged in 1972 from the Chippewa River (in percent).

Size Interval Fork Length (Inches)	1973-Untagged		1972 Tagged Fish Recaptured in 1973	
22.0 - 22.4	0.4	2.5		1.4
22.5 - 22.9	2.1		1.4	
23.0 - 23.4	6.2	14.0	2.7	12.2
23.5 - 23.9	7.8		9.5	
24.0 - 24.4	13.4	26.1	20.3	31.1
24.5 - 24.9	12.7		10.8	
25.0 - 25.4	13.4	26.3	12.2	27.1
25.5 - 25.9	12.9		14.9	
26.0 - 26.4	10.6	18.6	12.2	20.3
26.5 - 26.9	8.0		8.1	
27.0 - 27.4	5.6	8.8	4.1	5.5
27.5 - 27.9	3.2		1.4	
28.0 - 28.4	2.0	2.8		1.4
28.5 - 28.9	0.8		1.4	
29.0 - 29.4	0.8	0.9	1.4	1.4
29.5 - 29.9	0.1			
N =	747		74	

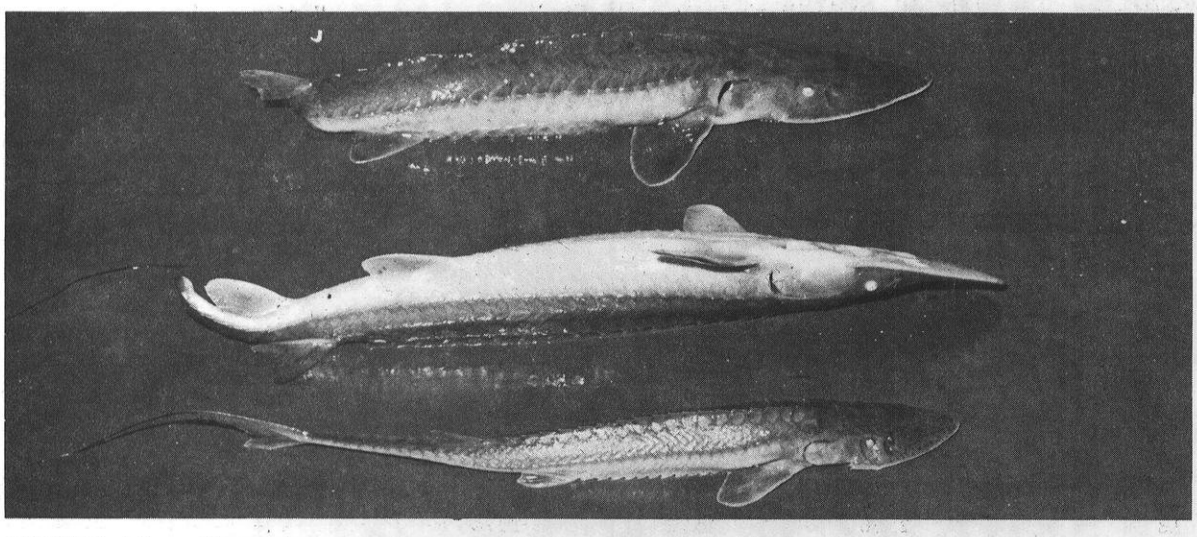


FIGURE 12. Shovelnose sturgeon from the Mississippi River in apparent good health when captured in spite of prior loss of the caudal peduncle.

TABLE 9. Movement of tagged shovelnose sturgeon in the Red Cedar River based on single-recapture by angling and electrofishing, through 1973.

Direction of Movement	Months at Large			
	7-12	21-35	37-58	Combined
Upstream				
No. of fish	10	7	8	25
Mean distance (miles)	2.9	4.5	1.8	3.0
Range (miles)	0.4-6.5	0.4-12.0	0.3-4.3	0.3-12.0
Percent	77	41	57	57
Downstream				
No. of fish	1	10	6	17
Mean distance (miles)	1.8	4.9	4.8	4.7
Range (miles)	-	0.3-10.5	0.4-9.7	0.3-10.5
Percent	7	59	43	39
No Movement*				
No. of fish	2	0	0	2
Percent	15	0	0	5
Total No. of Fish	13	17	14	44

* Recaptured less than 0.1 mile from release site.

Movement

Within Each River. Movement data on single-recapture fish in the Red Cedar River are available for 44 specimens at large for a period of 7 to 58 months. In the combined sample, 57 percent moved upstream a mean distance of 3.0 miles while 39 percent moved downstream an average of 4.7 miles (Table 9). Maximum upstream and downstream distances moved were 12.0 and 10.5 miles, respectively. Two fish (5%) exhibited no movement (recaptured less than 0.1 mile from release site).

The total number of single-recapture fish in the Chippewa River was 95, at large over a period of 1 day to 14 months. In the combined sample 59 percent moved upstream and 28 percent moved downstream (Table 10). Mean and maximum distances moved upstream and downstream were 1.2 and 1.1 miles, and 7.1 and 3.8 miles, respectively. Thirteen percent exhibited no movement.

Because of the differences in time-at-large and sampling distances covered, the two sets of data are not directly comparable; but it is to be noted that the percentages of fish by movement direction category are of approximately the same order of magnitude.

Multiple recaptures of the same fish over a period of time provide added insight on the nature of shovelnose sturgeon movement. Usable data on fish recaptured more than once are available from 4 specimens in the Red Cedar River and 22 in the Chippewa River (Table 11).

TABLE 10. Movement of tagged shovelnose sturgeon in the Chippewa River based on single-recapture by electrofishing only, through 1973.

Direction of Movement	Time at Large			
	1 Day - 3 Weeks	1-4 Months	10-14 Months	Combined
Upstream				
No. of fish	15	19	22	56
Mean distance (miles)	0.5	1.3	1.5	1.2
Range (miles)	0.1-1.5	0.1-4.5	0.1-7.1	0.1-7.1
Percent	52	59	65	59
Downstream				
No. of fish	10	10	7	27
Mean distance (miles)	0.6	1.5	1.2	1.1
Range (miles)	0.1-1.8	0.2-3.8	0.2-2.2	0.1-3.8
Percent	34	31	21	28
No Movement*				
No. of fish	4	3	5	12
Percent	14	9	15	13
Total No. of Fish	29	32	34	95

* Recaptured less than 0.1 mile from release site.

TABLE 11. Movement of shovelnose sturgeon within the Red Cedar and Chippewa Rivers based on multiple recapture by electrofishing, through 1973.

Tag Number	Original Release Date	First Recapture			Second Recapture			Third Recapture		
		Time At Large	Distance Moved (Miles) Up-Stream	Down-Stream	Time At Large*	Distance Moved (Miles) Up-Stream	Down-Stream	Time At Large**	Distance Moved (Miles) Up-Stream	Down-Stream
Red Cedar River										
844[1]	25 Jun 1970	3 week	0.2		36 mon		3.9	2 weeks		4.4
877	26 Jun 1970	1 week	0	0	23 mon	0.5				
39248[2]	26 Aug 1968	22 mon		0.2-0.6	24 mon	0.7				
39280[3]	18 Sep 1968	21 mon		0.3-0.7	24 mon					
Chippewa River										
1012	24 Jul 1972	1 day		0.8	12 mon	0.9				
3318	14 Aug 1972	1 day	1.0		11 mon	1.6				
4050	13 Jul 1973	5 days		0.4	2 mon	3.1				
1069	7 Aug 1972	1 week	2.6		13 mon	0.3-1.1				
4237	31 Jul 1973	9 days	0.0	0.0	1 week		0.2			
4053	13 Jul 1973	2 weeks	0.0	0.0	2 mon	3.4				
4175	30 Jul 1973	2 weeks	0.2		1 mon		0.6-1.9			
4520	16 Aug 1973	1 mon	0.5		1 day		1.0			
4256	3 Jul 1973	2 mon	1.3		2 hr		1.5			
4027	21 May 1973	2 mon		4.8	1 week	0.9				
1090	8 Aug 1972	11 mon	0.2		2 mon	1.4-3.5				
1098	8 Aug 1972	11 mon	0.0	0.0	2 weeks		2.3	9 days	1.6	
3371	15 Aug 1972	11 mon	1.4		2 weeks	0.6				
3373	15 Aug 1972	11 mon	2.4		2 weeks		0.2			
3392	15 Aug 1972	11 mon	1.4		2 weeks	1.3				
1024	25 Jul 1972	12 mon	0.0	0.0	1 mon	0.0	0.0	1 day		5.4
1094	8 Aug 1972	12 mon		0.3	1 week	0.9				
1279	8 Aug 1972	12 mon	0.9		2 mon		1.5-2.2			
1297	8 Aug 1972	12 mon	2.5		1 week		0.3			
1027	25 Jul 1972	13 mon	3.4		1 mon	3.4		1 day		0.2-1.2
1028	25 Jul 1972	13 mon	4.4		1 week		3.9			
3384	15 Aug 1972	13 mon	1.3-2.4		2 hr		1.7			

* From date of first recapture.
** From date of second recapture.
1/ Retagged as #1637 when re-released 13 Jul 1973.
2/ Retagged as #892 when re-released 2 Jul 1970 and as #1259 on 17 Jul 1972.
3/ Retagged as #838 when re-released 25 Jun 1970.
4/ Retagged as #887 when re-released 1 Jul 1970; displaced 1.2 miles downstream before re-release.

Two of the Red Cedar River fish exhibited little or no movement between the date of original release and date of first recapture and approximately 2 years later both were recaptured within 0.7 mile of the release site. In contrast, one specimen after 21 months at large had moved no more than 0.7 mile downstream from the original release site but two years later was recaptured 10.2 miles farther downstream. The fourth specimen had moved 0.2 mile upstream over a 3-week period, was found 3.9 miles downstream 36 months later and two weeks after the second recapture, was taken 4.4 miles farther downstream.

Of the 22 Chippewa River fish at large from 1 day to 13 months, 14 were initially recaptured upstream from the release point, 4 downstream and 4 at the original release point. When recaptured the second time (all within 2 months), 11 were taken upstream, 10 downstream, and one at the original release point. Three of the 22 fish were recaptured a third time: (1) No. 1092 was originally recaptured at the release site after being at large 11 months; 2 weeks later it was taken 2.3 miles downstream, and 9 days later it was recovered 1.6 miles upstream, (2) No. 1024 was recaptured twice at the original release point, after at-large periods of 11 months and 1 month; but one day after the second recapture, it was taken 5.4 miles downstream, and (3) No. 1027 moved upstream 3.4 miles during the first 13-month at-large period, moved an additional 3.4 miles upstream during the next month, and at the time of its third recapture 1 day later, was 0.2-1.2 miles downstream.

These multiple recaptures indicate a random movement not detectable by single recaptures but they also disclose a source of potential bias in the data. Nos. 4256 and 3384 had moved upstream 1.3 and 1.3-2.4 miles during at-large periods of 2 months and 13 months, respectively; but after only 2 hours following their re-release they were recaptured 1.5 and 1.7 miles downstream, respectively. This suggests that physiological stress due to handling may be involved in initial displacement of some specimens rather than simply voluntary movement. That "shock" rather than stimulation seemed to be involved is indicated by the tendency of tagged fish to lie essentially immobile in shallow water after release (Fig. 13). In practice, many released fish were "herded" into deeper water to avoid the possibility of predation, which may have inadvertently abetted involuntary downstream movement. Nevertheless, the preponderance of evidence showing a greater tendency to move upstream suggests that this possible source of bias is not great.

Between the Two Rivers. Six specimens tagged and released in the Red Cedar River were recaptured in the Chippewa River (Table 12). Downstream movement within the Red Cedar River averaged 3.9 miles (range of 1.1 to 9.6 miles) but 4 of the 6 fish had moved very little (0.0-0.2 miles downstream) after they reached the junction. One had moved 0.7 mile downstream and the other 2.6-5.4 miles downstream.

Only one specimen tagged and released in the Chippewa River was later recovered in the Red Cedar River. This fish was originally captured in the Red Cedar River within 1 mile of the junction and released at the confluence. A week later it was recaptured 0.9 mile upstream in the Red Cedar River.

Data on inter-river movement of sturgeon is weak because of the chronological disparity between sampling efforts--primarily 1968 and 1970 in the Red Cedar River and 1972-73 in the Chippewa River--and because of comparatively small numbers tagged in the former and near the confluence in the latter. Nevertheless, that some interchange does occur has been established.

Relative abundance of untagged sturgeon suggests that there may be at least a temporary influx of fish from the Chippewa River into the lower reach of the Red Cedar River during the spring. On three dates in July-August 1972, an average of 6 fish (maximum of 9) were taken in the lower 1.1 mile section; on three dates in July 1973, an average of 2 fish (maximum of 2) were captured there. But on 15, 21,

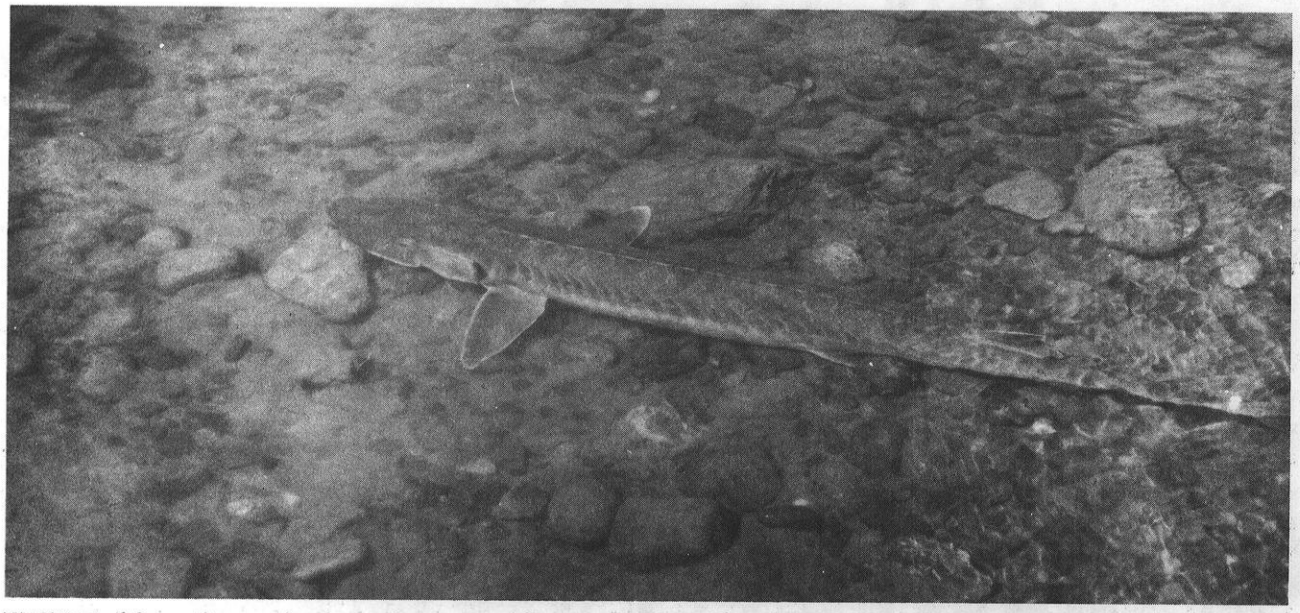


FIGURE 13. Tagged shovelnose sturgeon lying immobile in shallow water after release.

TABLE 12. Movement of shovelnose sturgeon between the Red Cedar and Chippewa Rivers, through 1973.

Tag Number	Original Release Date	First Recapture			Second Recapture		
		Time At Large	Distance Moved (miles) Upstream	Downstream	Time At Large*	Distance Moved (miles) Upstream	Downstream
		From Red Cedar River Downstream Into Chippewa River**					
1649	17 Sep 1973	2 mon		RC: 1.1 C: 2.6-5.4			
794[1/]	2 Jul 1970	25 mon	RC: 0.6		3 weeks		RC: 1.1 C: 0.7
39241	28 Aug 1968	34 mon		RC: 7.1 C: 0.0			
667[2/]	6 Aug 1969	35 mon	RC: 0.6		14 mon		RC: 1.1 C: 0.2
777	2 Jul 1970	37 mon		RC: 3.6 C: 0.2			
39289	18 Sep 1968	58 mon		RC: 9.6 C: 0.2			
		From Chippewa River Upstream Into Red Cedar River					
4019[3/]	21 May 1973	1 week	C: 0.0 RC: 0.9				

* From date of first recapture.
** Distance moved in Red Cedar River (RC) and Chippewa River (C) indicated separately.
1/ Retagged as #1262 on 17 Jul 1972 and re-released 7 Aug 1972 as that number.
2/ Retagged as #1263 on 17 Jul 1972 and re-released 18 Sep 1973 as that number.
3/ Originally captured in Red Cedar River and released at junction with Chippewa River 21 May 1973.

and 29 May 1973, an average of 15 fish (maximum of 20) were taken in that section. The single tagged fish released at the confluence and recaptured 0.9 mile upstream, referred to above, was in the 29 May 1973 sample.

Movement of shovelnose sturgeon can be characterized as multi-directional, random and limited.

Angling Recaptures

Through June 1974, recaptures of only 8 Red Cedar River tagged sturgeon were reported by anglers. With a potential availability of 349 tagged fish, the minimum exploitation for the spring 1968 through spring 1974 period was only 2 percent.

Through June 1974, only 2 of the 996 tagged sturgeon in the Chippewa River were reported caught by anglers.

It is apparent that the shovelnose sturgeon population in the Red Cedar-Chippewa River study area is only lightly exploited.

Population Estimate

The population of shovelnose sturgeon in the Chippewa River study area, within the size range subject to capture by electrofishing, was estimated by the mark and recapture method according to the formula:

$$P = \frac{M(R+U)}{R}$$

Where:
P is the estimated population
M is the number of fish tagged during the marking period
R is the number of tagged fish recovered during the recapture period
U is the number of untagged fish captured during the recapture period

During the marking period, 21 May-16 August 1973, 536 sturgeon were tagged. On 17-18 September, 69 of those tagged fish were recaptured along with 231 untagged fish. Insertion of these figures into the formula yielded an estimated population of 2,330 sturgeon within the study area.

The validity of this figure rests on several assumptions, chief of which are that: (1) no tag loss occurred, (2) tagged fish did not move out of the study area, (3) there was no mortality due to tagging, and (4) there was no recruitment to the catchable portion of the population. Since tagged fish have been recovered after being at large up to 58 months, tag loss during the short period involved in this estimate is highly unlikely. The limited movement of sturgeon discussed previously suggests that any error due to movement is apt to be minimal. Mortality due to tagging cannot be fully evaluated but since many fish were recaptured twice and a few even a third time, an appreciable bias due to tagging mortality is not likely. Since growth has been shown to be very slow at best, recruitment into the catchable segment of the population due to growth during the short time interval involved also seems to be a highly unlikely source of error.

A second estimate of the sturgeon population in the Chippewa River study area was calculated where M was the sum of all fish tagged during 1972 and 1973 through 16 August 1973 (762), where R was the sum of all 17-18 September 1973 recaptures of fish tagged in 1972 and in 1973 through 16 August 1973 (91), and where U was the number of untagged fish caught 17-18 September 1973 (231). These data yielded an estimate of 2,696 sturgeon within the study area.

While the second estimate has the advantage of larger sample sizes, the extended time interval involved could conceivably permit sources of error, especially movement and recruitment, to come into play. But even given those influences, the magnitude of error is not apt to be great. That the sturgeon population in the Chippewa River study area in 1973 approximated 2,300-2,700 (150-176 per mile) is considered to be a valid estimate.

SUMMARY

1. The shovelnose sturgeon is found in Wisconsin only in the Mississippi River and its major tributaries; in the latter it is present only as far upstream as the first dam.

2. Preceded by exploratory sampling during the 1967-72 period, a formalized study of the shovelnose sturgeon in the Chippewa-lower Red Cedar River system was initiated in 1973.

3. Through 30 June 1974, 996 and 349 sturgeon were captured by electrofishing and tagged and released in the Chippewa and lower Red Cedar Rivers, respectively.

4. Sturgeon ranged in fork length intervals from 22.0-22.4 to 32.0-32.4 in the Red Cedar River; the modal length interval was 26.0-26.4 inches. Respective sizes in the Chippewa River were 20.0 to 20.4 to 31.5-31.9 and 24.5-24.9 inches.

5. Sturgeon smaller than approximately 20 inches fork length, presumably present, were not subject to capture by electrofishing.

6. Average weights of the Red Cedar and Chippewa River sturgeon were 2.34 and 2.18 pounds, respectively. The maximum weight was 5.69 pounds, for a male specimen in which the testes accounted for 6 percent of the body weight.

7. The smallest mature male and female specimens measured 22.1 and 24.7 inches fork length, respectively.

8. Based on ovary coloration and egg sizes, at least three stages of egg development were evident in the spring, indicating that females do not spawn every year.

9. Mature eggs were black, varied in shape from spherical to distinctly ovate, and averaged 2.27 mm in diameter.

10. Counts of mature eggs ranged from 10,680 for the smallest mature female (24.7 inches fork length) to 50,971 for the largest (31.7 inches) and averaged 24,404.

11. The spawning period in the Red Cedar River fell roughly within the period extending from the last week in May through the first week in June at temperatures in the mid- to upper 60's (°F).

12. Growth of tagged fish, most of which were sexually mature, at large for periods of up to 58 months was virtually nil; even allowing for the possibility of reduced growth due to tagging, growth within the size range sampled must be characterized as extremely slow.

13. Average upstream and downstream movements within the Red Cedar River were 3.0 and 4.7 miles, respectively, during a period of 7 to 58 months. More fish moved upstream than downstream.

LITERATURE CITED

Held, John W.
1969 Some early summer foods of the shovelnose sturgeon in the Missouri River. Trans. Am. Fish. Soc. 98(3):514-517.

Helms, Don R.
1972 Progress report on first year study of shovelnose sturgeon in the Mississippi River. Proj. 2-156-R-1, Iowa Conserv. Comm., Des Moines, Iowa.

1973 Progress report on the second year study of shovelnose sturgeon in the Mississippi River. Proj. 2-156-R-2, Iowa Conserv. Comm., Des Moines, Iowa.

1974 Age and growth of shovelnose sturgeon, Scaphirynchus platorynchus (Rafinesque), in the Mississippi River. Proc. Iowa Acad. Sci. 81(2):73-75.

Modde, Timothy C.
1973 Food selectivity of the shovelnose sturgeon, Scaphirynchus platorynchus, in the Missouri River. M.A. Thesis, Univ. So. Dak., Vermillion. 109 pp.

Monson, Melvin A. and John Greenbank
1947 Size and maturity of hackleback sturgeon. In Third Prog. Rep., Tech. Comm. For Fish., Upper Miss. River Conserv. Comm.

Zweiacker, Paul L.
1967 Aspects of the life history of the shovelnose sturgeon, Scaphirynchus platorynchus (Rafinesque), in the Missouri River. M.A. Thesis, Univ. So. Dak., Vermillion. 46 pp.

ACKNOWLEDGMENTS

The assistance in this study of Spooner-based fishery research personnel is gratefully acknowledged, especially the Herculean efforts of Ronald Masterjohn. West-Central District fishery personnel made the arrangements for local news releases and they and law enforcement personnel assisted in obtaining tags from anglers. Thanks are extended to Don Helms, Iowa Conservation Commission for field demonstration of trawling and trammel netting techniques, for communications on various aspects of this study, and for permission to cite his unpublished reports. Photo credits: Leon Johnson, Gordon Priegel, and Howard Snow, DNR, and Joseph Hunn, USFWS.

This report constitutes the progress report for Study 215, Project F-83-R-9, D.J. Federal Aid in Fish Restoration Act.

Edited by Ruth L. Hine.

NATURAL RESOURCES BOARD

HAROLD C. JORDAHL, JR., *Chairman*
UW–Madison

THOMAS P. FOX, *Vice-Chairman*
Washburn

MRS. G. L. McCORMICK, *Secretary*
Waukesha

JOHN C. BROGAN
Green Bay

LAWRENCE DAHL
Tigerton

DANIEL T. FLAHERTY
La Crosse

CLIFFORD F. MESSINGER
New Berlin

DEPARTMENT OF NATURAL RESOURCES

L. P. VOIGT
Secretary

JOHN A. BEALE
Deputy Secretary