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Larry W. Hesse
Nebraska Game and Parks Commission

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THE STATUS OF NEBRASKA FISHES IN THE MISSOURI RIVER.

6. SAUGER (PERCIDAE: *STIZOSTEDION CANADENSE*)

Larry W. Hesse

Nebraska Game and Parks Commission
Box 934, Norfolk, Nebraska 68702

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ABSTRACT

Saugers were once common representatives of the Missouri River fish assemblage. Prior to channelization and impoundment, they comprised from 10 to 65% of the main channel big-river fish group. They utilized the slower side channels and backwaters seasonally for feeding, resting, and maturing, but the main channel was important for breeding habitat. Since the onset of channelization and impoundment, saugers have been reduced by as much as 98% in some areas, and the trend toward extirpation continues unabated today. Recovery of native sauger stocks will require a complete cessation of harvest, recovery of the natural hydrograph, recovery of sediment transport, recovery of snags and organic matter dynamics, and re-connection of cut-off side channel morphology.

† † †

> A few years ago the sauger was, to the few elect who knew where to find it, the choicest game-fish of the lower Wabash River, and we knew a minister who always went saugering when he failed in other ways to get the proper inspiration for his next Sunday's sermon. Starting at the Vandalia bridge, he would direct his oarsman to get out into the current, then row slowly up stream, even to old Fort Harrison and beyond, perhaps to Durkee's Ferry, then, turning, slowly drift with the current home again. Meanwhile, with a small, silvery minnow at the end of 50 feet of line, trolling through the quiet ripples and over the deep pools, he patiently waits for the sauger's strike. While waiting, his eyes take in the beauties of the river, the shore, and the sky. Ideas come readily, his thoughts fall together in logical sequence, and when Sunday comes, the sermon that he preaches is filled with sunshine, and love, and faith in humanity, and his flock know that their pastor has spent a day upon the river, saugering.

This quotation was first written by David Starr Jordan and Barton Warren Evermann on April the 10th, 1902, and was first published in 1923 (Jordan and Evermann, 1969). By Jordan's time the native fish populations of the Wabash River in Indiana had already been extensively altered, and since then the sauger and other game fish have been significantly reduced due to channel alterations, draining of riparian wetlands, damming, and heavy pollution. Most recently some improvement has been documented, but the sauger still makes up only a small fraction of the fish assemblage (Gammon, 1993). It appears that the minister's "faith in humanity" was overzealous.

Saugers were common in many parts of Nebraska before 1900, according to Jones (1963), who reported on early collections by Seth Meek and others from the Platte River all the way to the Nebraska-Wyoming border, and from the Blue, Loup, Elkhorn, and Niobrara rivers. But the Missouri River was the stronghold for this animal, and Jones (1963) reported its range was reduced then to the lower reaches of their streams in Nebraska and to the entire Missouri River. Few stockings of saugers occurred in the period prior to Jones' report—Lake McConaughy on the Platte River and the Middle Loup River received limited numbers of sauger. Since 1963, 123,082 saugers were stocked into mainstem reservoirs on the Missouri River, but only 7,333 were stocked in Nebraska's portion of the Missouri River (Hesse et al., 1989). There is strong evidence that such stockings have failed to survive (Hesse, 1983).

Cross (1967) stated that saugers occurred commonly in the Missouri River in Kansas and rarely in the Kansas River Basin westward to the Blue River. He also recounted historical evidence of saugers in the Marais des Cygnes and Neosho river drainages in Kansas. Pflieger (1975) noted that saugers were more restricted in their distribution in Missouri than walleyes. The former are found principally in large turbid streams, such as the Missouri and Mississippi, and the latter are found elsewhere in Missouri. Bailey and

Allum (1962) stated that saugers were common throughout the Missouri River in South Dakota and occurred in the lower ends of some tributaries. They were found in oxbow lakes along the Missouri River but not in natural lakes in South Dakota.

Identification

The sauger and the walleye are closely related and thus often confused by anglers. Both fish have sharp teeth and very sharp and strong spinous dorsal-fin rays. Their bodies feel rough to the touch, and they both have the defensive habit of closing their mouths tightly and raising their gill covers and spinous dorsal fin when held.

Saugers are easily distinguished from walleyes, when both are unhybridized, by the dark spots on the membranous webbing of the spinous dorsal fin. Walleyes have only one dark patch at the posterior base of this fin. Saugers are typically hues of black and brown, with dark blotches extending below the lateral line, while walleyes are often hues of yellow, light brown to golden, and light olivaceous on the sides and back, with less distinct blotches that do not extend below the lateral line. The walleye has a large white patch that encompasses the entire lower lobe of the tail; the sauger lacks this white marking.

Internally, saugers possess 5 to 8 pyloric caeca (fingerlike projections near the junction of the stomach and intestine), which are shorter than the stomach, while walleyes have three caeca which are about as long as the stomach (Pflieger, 1975).

These characteristics are somewhat jumbled in the hybrid. Saugers and walleyes will hybridize in nature, and the frequency of hybrids in the wild may increase because man-made hybrids, called saugeyes, have been planted in various lakes in Nebraska and adjacent states (Bannick, 1974). The opportunity for escape into the Missouri River is high. The hybrid was created because it was found that it was easier to raise in hatcheries, suffered less mortality, and seemed to survive better in turbid reservoirs than the parents (Knox, 1990). Johnson et al. (1988) stated that the hybrid was fertile. This may pose a serious problem for the native sauger in altered natural habitats because of the potential that the saugeye can cross-breed with saugers more readily than walleyes, because they inhabit areas where saugers may wish to live.

The sauger is native to Nebraska's streams, while the evidence suggests that the walleye was introduced in the late 1800s (Jones, 1963). O'Brien (1888) noted that though the walleye was found in a few streams in the state, it was not found generally in the streams and ponds of Nebraska until after stockings began in 1884.

Spawning requirements

Prior to dam construction on the mainstem of the Missouri River, saugers likely spawned in March and April, when water temperature was optimum at 7.2–10.0°C. Deep-release reservoir water has created cooler water temperatures later in tailwater areas, and as a result saugers spawn now as late as the end of May (Hesse et al., 1993).

Spawning fish are most active in early evening. Groups of males move into shallow water to await single females ready to spawn. Eggs and sperm are scattered at random over rock/rubble bottoms. Fertilized eggs hatch in about two weeks. Spent adults do not provide care for hatched young (J. Morris et al., 1974).

Habitat preferences

Kallemeyn and Novotny (1977) collected saugers from the main channel, main channel border, sandbar pool, backwater, and chute habitats of the unchannelized Missouri River downstream from Gavins Point Dam. They also collected them from spur dikes (wing dikes), notched spur dikes, and notched revetments in the channelized section of the Missouri River. The only place they were not found was deep in marshes among monoculture cattail beds. Crance (1987) conducted a Delphi exercise with a panel of 17 experts to prepare habitat-suitability index curves for sauger. Velocity at spawning sites reportedly ranged from 42 to 144 cm/s. Sauger eggs require some current to provide adequate aeration for successful incubation, and Saylor et al. (1983) determined that sauger eggs adhere to rocks up to velocities of 33.5 cm/s.

Spawning depth has been shown to range from 0.6 to 3.7 m in the Missouri River (Graham and Penkal, 1978, unpublished report, Montana Department of Fish and Game). Delphi panelists agreed that optimal depth was > 1 m (Crance, 1987). Turbidity was considered to be an important component of instream cover for the sauger, with some panelists suggesting the optimum was when Secchi disk transparency readings were < 1 m (Crance, 1987).

Spawning substrates were listed as rubble, coarse sand, gravel, cobble and pebble. Substrate was considered not important for juveniles and adults, except that saugers were likely associated with substrates that produced the greatest amounts of the most desirable foods (Crance, 1987).

Saugers are mesothermal, based on spawning requirements. Outside limits for successful spawning are as low as 5.6°C (Nelson, 1969) and as high as 16°C (Fletcher, 1977). However, optimum growth was shown to occur at 26°C (Hokanson and Koenst, 1986), which

suggests that saugers are more typical of eurythermal species.

Evidence from the earliest collections of saugers in the Missouri River north of Omaha at about the time this reach was being channelized suggested that backwaters were used seasonally, as was the main channel. Both were essential components of successful sauger survival (Miller, 1964).

Feeding Behavior.

Saugers feed on zooplankton and aquatic insect larvae when they are small (< 50 mm) (McBride, 1982; Priegal, 1969). McBride found fish composed 99.7% of the food items (by weight) in the stomachs of saugers measuring 150 to 400 mm total length (TL). Hesse and Wallace (1976) examined 165 sauger stomachs during 1974-1975 from the channelized Missouri River in the length range from 100 to 500 mm TL . Based on frequency of occurrence, fish (80%), aquatic insects (40%), and crustaceans (5%) were consumed. By weight, however, fish were most important. Gizzard shad, emerald shiner, freshwater drum, and channel catfish in that order were dominant in stomach contents of 550 Ohio River saugers (Wahl and Nielsen, 1983). These prey species are common in the Missouri and undoubtedly are important in the diet of Missouri River saugers as well.

The objective of this paper is to summarize the status of the sauger in Nebraska's portion of the Missouri River during 1974–1993. Wherever possible, these collections will be compared with collections made previously, dating back to about the late 1950s.

METHODS

Saugers were highlighted in collections made with electrofishing and gill netting equipment prior to 1970. The gear used then differed somewhat from that used in more recent studies. For that reason statistical testing between the very earliest collections and those most recently collected is minimal.

Saugers were collected incidental to the collection of other species from channelized and unchannelized Missouri River collection sites during the period of 1974 through 1993. Electrofishing was used extensively in the earliest collections and also during the recent period (1974–1993). However, standard electrofishing results are not easily quantified because the method has evolved from 1950 to 1993. Some collections were made with alternating current (AC), while others were made with pulsed direct current (PDC). These differences might be reflected in different catch per unit effort (CPUE) estimates because of differences in collection efficiency. For that reason the best comparisons may be species composition of multi-species catches. However, CPUE will be presented in many cases because the differences are often large.

Gill nets have been used in off-channel habitats prior to channelization and then afterward in remnant unchannelized reaches. Gill nets have not been standard sized through the period (1950–1993), but they were standardized during specific studies. Species composition is a good way to display the changing status of the sauger, but wherever possible CPUE will be displayed as well. Unless otherwise stated, the standard gill net used was experimental multifilament nylon, with six equal-length panels ranging from 12.4 mm to 76.4 mm square measure mesh. Nets were 91.4 × 2.4 m and were fished in a stationary fashion. A unit of effort was one net fished from one afternoon to the next morning.

Larval saugers were captured with large plankton nets called drift nets. Flowmeters were not available in the earliest studies. Some innovation was necessary to quantify volume filtered from timed samplings. Recent drift net studies have employed nets with 560-micron nylon mesh and mechanical flow meters.

The sauger has always been an important sport fish in the Missouri River. For this reason, angler surveys have been conducted periodically to document their harvest.

RESULTS

Channelized-reach electrofishing

Two-hundred eighty-eight (288) hours of AC and PDC electrofishing was carried out in 1971, 1974, and 1975 (Hesse and Wallace, 1976). These collections were made weekly beginning in April and continuing through November at one site north of Omaha, Nebraska, on the channelized Missouri River (Blair, Nebraska), and one site south of Omaha (Brownville) (Fig. 1). The effort resulted in the capture of 702 saugers (2.44/hr). All of the sampling during this project was done in revetment habitat. Revetments are continuous rock sheaths along the cutting bank of the channel. Saugers represented 2.38% of the total assemblage (29,493 fish), which included at least 43 different species. In addition, NALCO Environmental Sciences electrofished for 45.5 hours in the pool habitat associated with wing dikes (perpendicular hard points along the filling bank) in the same area in 1974 and 1975 (Szmania, 1975; Szmania and Johnson, 1976). They were able to collect 2,712 fish, including 68 saugers (2.51%, 1.49/hr).

Hesse and Wallace (1976) electrofished during February and March in 1974 and 1975 in wing-dike habitat. The percent composition of sauger was somewhat

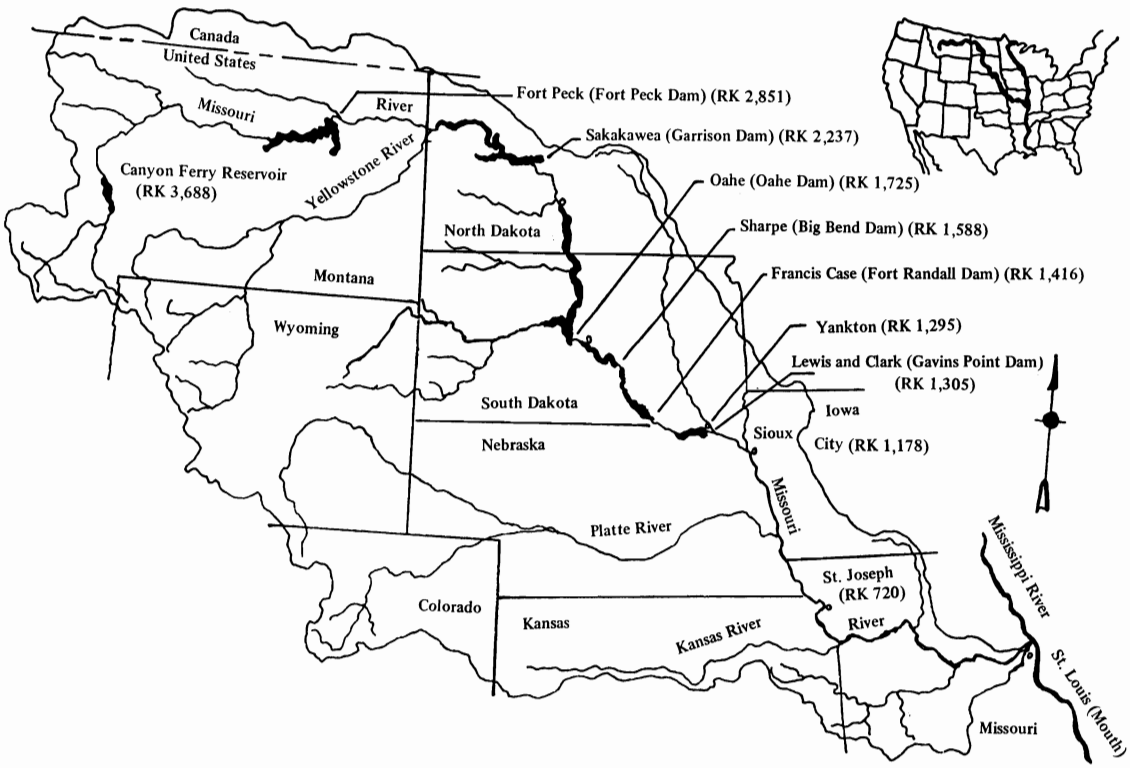

Figure 1. Map of the Missouri River basin.

higher than during the April–November period (i.e., 61 saugers among 1,785 fish, 3.42%). Winter collections in the channelized reach were repeated during the period 1979–1986. By 1979 the percent of sauger in the winter catch had dropped to 0.6% (32 among 5,357). In 1980 it was down to 0.11% (12 among 10,584) (Hesse and Newcomb, 1982). Newcomb (1989) collected only 2 saugers among 1,857 fish (0.11%) in the winter of 1983, 7 among 3,501 (0.20%) in 1985, 7 among 5,234 (0.13%) in 1986, and 7 among 1,695 (0.41%) in 1984.

April–November collections were repeated in the channelized reach during 1986–1990. In 1986 3 saugers were among 393 fish (0.76%, 0.35/hr, 8.52 hours). The other years were as follows: 1987, 3 saugers among 783 fish (0.38%, 0.18/hr, 16.45 hours); 1988, 1 sauger among 748 fish (0.13%, 0.08/hr, 12.4 hours); 1989, 4 saugers among 392 fish (1.02%, 0.87/hr, 4.6 hours; 1990, 3 saugers among 624 fish (0.48%, 0.29/hr, 10.05 hours).

The sauger, during April–November in 1974-1975, in revetment habitat was 2.38% of all fish collected, and the CPUE was 2.44/hr. By 1986–90, the percent of sauger in the total catch had dropped by 84% to 0.39%, and the CPUE dropped by 91% to 0.21/hr. The winter collection data tied these two periods together. The percentage of sauger in the winter 1974-75 period was 3.42%, and the percentage in the winter 1979–86 was 0.24%, down by 93%. Kallemeyn and Novotny (1977) in April–November, 1976, in the same channelized reach. They collected 28 saugers among 3,601 fish (0.78%). These data support the findings of our studies. The Bank Stabilization and Navigation Project between Sioux City and Kansas City was about 88% completed by 1965 (U.S. Fish and Wildlife Service, 1980). Missouri River saugers survived to about six years of age (Hesse and Wallace, 1976; Walburg, 1964). It appears that the impact of the finality of channelization was fully realized by about 1974.

Channelization north of Omaha had begun in the 1930s but without the flow control provided by the mainstem dams, which were not completed until 1954, the early channelization efforts in this reach were not completely successful. Large floods often reclaimed the channel and its erosion zone. The dams controlled these high flows in such a way that channel and bank stabilization was possible. The earliest complete cutoff of wide sections occurred about 1960. Desoto Bend was one of the first to be completely closed on both upstream and downstream ends (1961). Upper Decatur Bend had been closed previously, however a notch was cut in the levee large enough for boats to enter from the main channel in 1963. Middle Decatur, Snyder, and Omadi bends had only been closed at the upper end and the lower end was still wide open to the river in 1963.

Catches of saugers along the main channel during the construction of dikes and revetments were limited. Robinson (1958) was able to collect 134 saugers among

1,984 fish (6.8%) during 27.5 hours (4.87/hr) of sampling in 1958. These collections were made in the channel where he noted velocities as high as 313 cm/s, which made collection difficult. Moreover, at this time backwaters and side channels were still attached and backwater electrofishing data was unavailable. Gill nets were used to collect in these habitats, but Welker (1963a) noted that saugers were not as readily captured with gill nets as with electrofishing. The fact that many saugers were living in off-channel areas seasonally would make main channel collections less comparable with the data available after 1965 because fish were confined to the main channel by then, and the main channel collections represented all of the fish in the river.

Welker (1963b) conducted a 4-hour electrofishing survey of the main channel of the Missouri River at locations between Omaha and Sioux City, Iowa. He collected along the banks were the velocity was slower, but not in the backwaters or developing cut-offs. The gizzard shad was the most numerous fish collected, and his report did not list the number captured. However, 144 other fish including 36 carpsuckers, 6 carp, 2 shovelnose sturgeon, 2 blue suckers, 6 catfish, 4 largemouth bass, 1 white bass, 5 sunfish, and 4 walleyes in addition to 78 saugers were collected. If shad are excluded, saugers comprised 54% of the catch, and the catch rate was 19.6/hr. It is important to remember that electrofishing methods have evolved throughout the entire period of 1950–1990. The collections may reflect these changes, but collection efficiency should have improved, not degraded, therefore the densities may be even higher than was determined by the earliest collections.

L. Morris (1965) electrofished the revetment habitats in this same reach during 1964. Saugers represented 10.0% of the total catch and he collected them at a rate of 10.0/hr. By 1974-75 the sauger percent and catch rate had already dropped 76%, respectively.

Figure 2 graphically depicts the decline in sauger abundance from the channelized section of the river during the period 1963–1990 based on electrofishing catches.

Unchannelized-reach electrofishing

A variety of habitats were electrofished in the unchannelized section of the river during 1983–1990. Representative habitats were visited equally each year, so data have been combined to reflect total changes in sauger density during the period. The annual collections were as follows: 1983, 67 saugers among 504 fish (13.3%, 2.82/hr, 23.8 hours); 1984, 73 saugers among 433 fish (16.9%, 4.01/hr, 18.2 hours); 1985, 20 saugers among 164 fish (12.2%, 1.20/hr, 16.7 hours); 1986, 15 saugers among 336 fish (4.5%, 1.74/hr, 8.6 hours);1987, 10 saugers among 358 fish (2.8%, 1.14/hr, 8.8 hours); 1988, 32 saugers among 840 fish (3.8%, 2.88/hr, 11.1 hours); 1989, 4 saugers among 581 fish (0.7%, 0.44/hr, 9.2 hours); 1990, zero saugers among 239 fish (0.0%, 0.0/hr, 6.6 hours). Saugers were once a very important component of the species assemblage living in unchannelized sections, but the percent of sauger declined dramatically beginning in 1985, as did the CPUE, with 1988 a notable exception.

The Missouri River exposed a deposit of glacial till along the south bank of the river in Boyd County, Nebraska, which lies at the intersection of the state

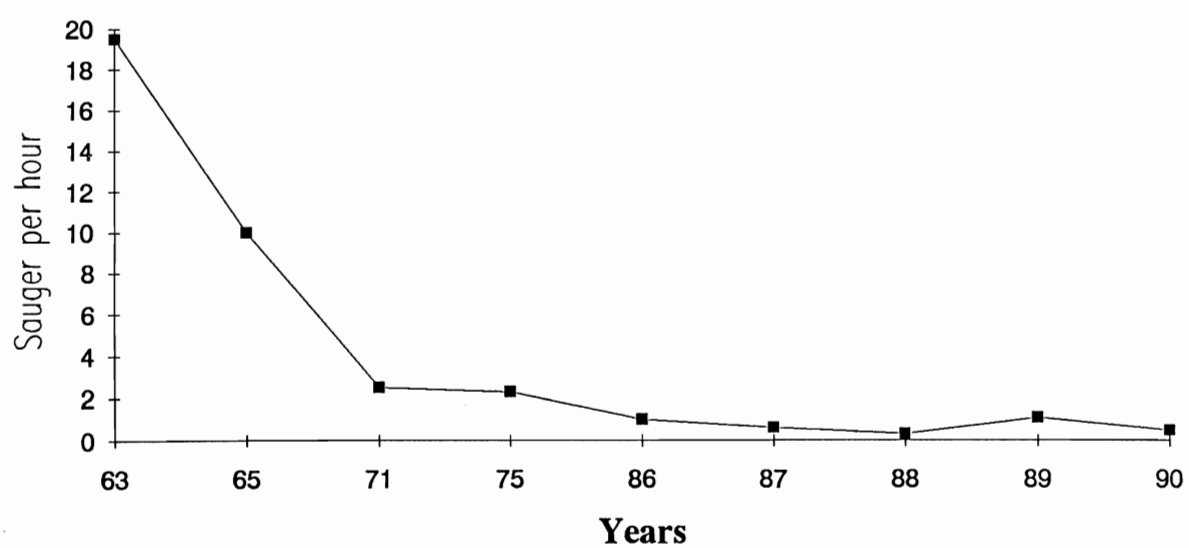

Figure 2. CPUE of sauger by electrofishing from the channelized Missouri River in Nebraska 1963 to 1990.

boundaries of Nebraska and South Dakota. This rock and rubble substrate was known to be used by saugers as a spawning area. Nelson (1969) periodically night-electrofished this bankline during the sauger breeding season. The maximum observed catch rate during the period 1963–1965 was 36/hr. We attempted to duplicate his effort during 1982–1989. Mean peak catch was 3.7/hr, down by 90%.

Unchannelized reach gill netting

The sauger was one of 22 species collected with experimental gill nets in off-channel habitat in the unchannelized reach of the Missouri River upstream from Lewis and Clark Lake (Gavins Point Dam) (Table 1). Sauger CPUE declined steadily during the period, as did 16 other species. The species that showed an increase were able to utilize the altered conditions which occurred in this reach after the dam was created. Some of the differences in mean CPUE were determined to be significant (Prob > T < 0.05) as shown in Table 2. The sauger differences were highly significant. The percent of the total assemblage made up by saugers declined throughout the period, as well (Table 3).

I have been unable to find representative gill-net effort from these same areas prior to 1983. Extensive gill-net work was done by Walburg (1976) and other researchers during the early years after Gavins Point Dam was constructed. South Dakota Game, Fish and Parks has periodically conducted gill net surveys in Lewis and Clark Lake. However, these data do not show any trend in the status of the sauger. Saugers may live in Lewis and Clark Lake for part of the year, but the riverine reach was essential for reproduction and nursery, and use of the riverine reach has clearly decayed to almost nothing.

The importance of river habitat for saugers was first postulated by Welker (1964). He was able to determine that larger saugers left the side channels, backwaters, and open oxbows, and moved into the main channel during part of each year to breed. Welker (1964) reported the catch of saugers from four open oxbow lakes was 12.5/gill net night in 1963, which was nearly three times higher than we found in 1983 in the unchannelized remnant upstream from Lewis and Clark Lake (Table 1). Miller (1964) reported a catch rate of

Table 1. Results (CPUE) of experimental gillnetting in the unchannelized Missouri River near Niobrara, Nebraska, 1983–1991.

Species	Status	1983	1984	1985	1986	1987	1988	1989	1990	1991
Shortnose gar	D	1.2	0.7	1.1	1.1	0.3	0.5	0.5	1.3	0.4
Gizzard shad	D	1.9	0.1	1.9	0.0	0.0	0.1	0.0	0.0	0.1
Goldeye	I	0.1	0.0	0.1	0.0	0.0	1.4	0.0	0.0	0.4
Northern pike	I	0.8	0.5	0.8	0.8	0.8	0.9	1.5	1.8	1.2
Carp	D	2.1	3.3	3.1	3.5	0.0	0.8	2.0	1.0	0.3
River carpsucker	I	2.8	3.3	2.6	4.6	0.8	8.9	2.0	12.3	1.9
White sucker	D	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth buffalo	D	4.6	6.1	1.1	2.7	1.0	3.0	4.5	2.2	0.2
Bigmouth buffalo	D	0.5	0.4	0.2	0.2	0.0	0.1	1.0	0.2	0.0
Shorthead redhorse	I	0.4	0.4	0.2	0.9	2.0	2.2	0.0	5.3	1.7
Black bullhead	D	0.0	0.3	0.8	3.7	0.0	0.3	1.0	0.5	0.1
Channel catfish	D	0.5	1.4	1.2	5.4	0.8	1.5	4.0	1.8	0.2
White bass	D	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Rock bass	D	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Largemouth bass	D	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.1
Smallmouth bass	I	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.2	0.1
Black crappie	D	0.2	0.3	0.8	0.5	0.0	0.1	0.0	0.2	0.0
White crappie	D	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Yellow perch	D	0.0	0.1	0.2	0.1	0.0	0.2	0.0	0.0	0.0
Sauger	D	4.5	3.3	2.8	2.0	0.8	0.2	0.0	0.0	0.3
Walleye	D	2.0	0.7	1.0	1.9	0.5	0.5	2.0	0.2	0.4
Freshwater drum	D	0.2	0.4	0.8	0.3	0.0	0.1	0.5	0.2	0.0
Net-nights		17	18	29	10	4	23	2	7	21
Mean CPUE		23.3	21.8	19.2	28.0	6.8	20.8	19.0	27.3	7.6

Status: I = increasing, D = decreasing

Table 2. Significance of *t*-test comparisons of mean gillnet CPUE among years for the unchannelized Missouri River near Niobrara, Nebraska, 1983–1991.

Period 1:	**1983**	**1983–84**	**1983–95**	**1983–86**	**1983–87**	**1983–88**	**1983–89**	**1983–90**
Period 2:	**1984–91**	**1985–91**	**1986–91**	**1987–91**	**1988–91**	**1989–91**	**1990–91**	**1991**
Shortnose gar	-	-	-	-	-	-	-	-
Gizzard shad	-	-	-	-	-	-	-	-
Goldeye	-	-	*1	*1	*1	-	-	-
Northern pike	-	-	-	-	-	-	-	-
Carp	-	-	*2	*2	*2	*2	*2	*2
River carpsucker	-	-	*1	-	*1	-	-	-
White sucker	-	-	*2	-	-	-	-	-
Smallmouth buffalo	-	*2	-	-	-	-	-	-
Bigmouth buffalo	-	-	-	-	-	-	-	-
Shorthead redhorse	-	-	*1	*1	*1	*1	*1	-
Black bullhead	-	*2	-	-	-	-	-	-
Channel catfish	*1	-	-	-	-	-	-	-
White bass	-	-	*2	-	-	-	-	*2
Rock bass	-	-	-	-	-	-	-	-
Largemouth bass	-	-	-	-	-	-	-	-
Small mouth bass	-	-	*1	*1	*1	-	-	-
Black crappie	-	-	-	*2	*2	-	-	-
White crappie	*2	*2	*2	*2	-	-	-	-
Yellow perch	-	-	-	-	-	-	-	-
Sauger	*2	*2	*2	*2	*2	*2	*2	*2
Walleye	*2	-	-	*2	*2	*2	*2	*2
Freshwater drum	-	-	*2	*2	-	-	-	-

- = Not significant
*1 = Period 1 mean was smaller
*2 = Period 2 mean was smaller

11.3 saugers per gill net night from these same cutoffs.

The best example of the density of saugers, based on gill netting, and the impact of completely cutting off an old wide bend is presented in a report by Robinson (1966). Desoto Bend was cut off completely in 1961; the catch of saugers in 1961 was 30/net-night; by 1963 it dropped to 14/net-night; in 1964 it was 7/net-night; and in 1965 it was 2/net-night.

Larval saugers

More than 112,000 larval fish have been collected from the Missouri River in Nebraska since 1983 (Table 4). Larval sauger density varied from 0.1 to 2.2/1,000 m^3 ($\bar{x}$ = 0.9/1,000 m^3) in the upper unchannelized reach. Nelson (1969) reported larval sauger density in this same reach was 10.6/1,000 m^3 in 1965. Mean larval-sauger density in the channelized reach was 1.1/1,000 m^3 for the period 1986–91.

Saugers represented 15.8% of all larvae in 1985 in the unchannelized reaches, but then they declined sharply (1.5% in 1986, 5.2% in 1987, 1% in 1988, 3.9% in 1989, 0.3% in 1990, 0.2% in 1991). Channelized-reach sauger larvae accounted for 0.2% in 1986, 0.4% in 1987, 0.5% in 1988, 2.1% in 1989, 0.1% in 1990, and 0.06% in 1991. The mean percent composition of sauger larvae among all larvae for 1985–1991 was 1.8% in the upper unchannelized reach, 0.7% in the lower unchannelized reach, and 0.2% in the channelized reach. Sauger larvae represented 3.0% of all fish larvae collected from the channelized reach in 1974 (Harrow et al. 1975), representing a decline of 93%.

Year-class relationships

Hesse and Mestl (1987) used a method developed by El-Zarka (1959) to create a year-class index for adult saugers collected from the Missouri River. This index was subsequently correlated with the density of sauger larvae drifting in the unchannelized sections. The density of sauger larvae was determined to be positively correlated with adult year-class index. High larval density produced larger year-classes, and low larval sauger density was correlated with highly fluctuating discharge from Fort Randall Dam and low mean annual volume discharge during the months of April–

Table 3. Results (percent composition) of experimental gillnetting in the unchannelized Missouri River near Niobrara, Nebraska, 1983–1991.

Species	Status	1983	1984	1985	1986	1987	1988	1989	1990	1991
Shortnose gar	I	5.3	3.3	5.7	3.9	3.7	2.6	2.6	4.8	5.1
Gizzard shad	D	8.3	0.5	9.7	0.0	0.0	0.4	0.0	0.0	1.5
Goldeye	I	0.3	0.0	0.4	0.0	0.0	6.8	0.0	0.0	5.1
Northern pike	I	3.3	2.3	3.9	2.8	11.1	4.2	7.9	6.6	16.2
Carp	D	8.8	15.0	16.3	12.5	0.0	3.8	10.5	3.6	4.4
River carpsucker	I	12.1	15.0	13.6	16.4	11.1	42.8	10.5	45.1	25.8
White sucker	D	0.3	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth buffalo	D	20.0	28.0	5.9	9.6	14.8	12.5	23.7	7.9	2.9
Bigmouth buffalo	D	2.3	2.0	0.9	0.7	0.0	0.6	5.3	0.6	0.0
Shorthead redhorse	I	1.5	1.8	0.9	3.2	29.6	10.2	0.0	19.5	22.8
Black bullhead	D	0.0	1.5	3.9	13.2	0.0	1.2	5.3	1.8	1.5
Channel catfish	I	2.3	6.6	6.1	19.3	11.1	7.2	21.1	6.7	2.9
White bass	D	0.5	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Rock bass	D	0.3	0.3	0.2	0.7	0.0	0.2	0.0	0.0	0.0
Largemouth bass	D	1.0	0.0	1.3	0.0	0.0	0.0	0.0	0.6	0.7
Smallmouth bass	I	0.0	0.0	0.0	0.4	0.0	0.6	0.0	0.6	0.7
Black crappie	D	0.8	1.5	4.1	1.8	0.0	0.4	0.0	0.6	0.0
White crappie	D	4.0	1.5	0.7	0.0	0.0	0.0	0.0	0.0	0.7
Yellow perch	D	0.0	0.3	1.3	0.4	0.0	0.8	0.0	0.0	0.0
Sauger	D	19.4	15.0	14.5	7.0	11.1	1.1	0.0	0.0	4.4
Walleye	D	8.8	3.1	5.4	6.8	7.4	2.2	10.5	0.6	5.1
Freshwater drum	D	1.0	1.8	4.1	1.1	0.0	0.4	2.6	0.6	0.0
Others	I	0.5	0.3	0.2	1.4	12.9	0.2	0.0	2.4	22.7
Net-nights		17	18	29	10	4	23	2	7	21
Total fish		396	393	558	280	27	500	38	164	136

Status: I = increasing, D = decreasing

Table 4. Total larval fish density (no./1,000 m^3), and sauger density for three sections of the Missouri River, Nebraska.

	Upper unchannelized		Lower unchannelized		Channelized	
	Total	Sauger	Total	Sauger	Total	Sauger
1983	23.5	0.0	109.3	0.0		
1984	21.4	0.2	170.6	0.0		
1985	3.8	0.1	82.1	0.0		
1986	22.4	1.4	32.4	0.8	134.8	0.2
1987	139.4	0.8	337.2	4.8	139.0	1.0
1988	96.8	2.4	338.3	5.0	780.1	2.4
1989	84.2	0.6	172.1	6.9	117.2	1.9
1990	22.0	2.2	364.0	1.8	690.5	0.5
1991	31.4	0.8	1,234.8	1.1	1,372.0	0.3
Mean	49.4	0.9	315.6	2.3	538.9	1.1
Total fish	3,944		40,854		67,242	
Total volume filtered (m^3)	79,838		129,449		124,776	

Table 5. Estimated harvest of fish by sport fishers in the Gavins Point Dam tailwaters in 1956, 1957 and 1958. (1956 and 1957 data are not expanded.)

Species	1956*		1957*		1958**	
	No.	%	No.	%	No.	%
Sauger	403	26.7	472	27.1	73,542	30.4
Crappie	7	0.5	104	2.3	47,415	19.6
Channel catfish	255	16.9	1,108	24.3	43,786	18.1
Freshwater drum	427	28.2	944	20.7	30,239	12.5
Carp	253	16.7	1,235	27.1	18,627	7.7
Goldeye	15	1.0	203	4.5	5,564	2.3
Burbot	77	5.1	0	0.0	4,838	2.0
Walleye	4	0.3	3	<0.1	3,629	1.5
Yellow perch	17	1.1	44	0.1	3,387	1.4
Shorthead redhorse	3	0.2	32	0.1	3,145	1.3
Largemouth bass	3	0.2	181	4.0	2,177	0.9
Bullhead	1	<0.1	110	2.4	2,176	0.9
Gar	3	0.2	4	<0.1	725	0.3
Flathead catfish	0	0.0	5	<0.1	484	0.2
Sturgeon	42	2.8	11	<0.1	242	0.1
Other	2	0.1	103	2.3		
Total fish	1,512		4,559		239,976	
Fish per hour	0.50		0.37		0.15	

*Carlson, 1957
**Orr, 1958

June. Fluctuations in flow at Fort Randall result from electrical power-peaking management, while seasonal volume discharge is related to flood-control storage in the upstream reservoirs. When heavy precipitation occurs in the lower basin, run-off is stored in the reservoirs, often dewatering the unchannelized reaches adjacent to Nebraska for weeks or even months in the critical spring spawning season.

Harvest statistics

Gavins Point Dam was closed in July of 1955, and Lewis and Clark Lake began to fill. South Dakota and Nebraska fish and game personnel expected that the reservoir and tailwater would become attractive sport fisheries, and therefore an effort was made to census anglers after the dam was completed.

Percent Stock Density (PSD), Relative Stock Density for angler preferred size (RSD-P) and mean length can be used to evaluate changes in year-class strength (Gabelhouse, 1984) (Fig. 3). The evidence suggests that recruitment has declined between 1970 and 1992. Moreover, lower PSD and RSD-P values (indicating a strong year-class) occurred one year after high discharge from Fort Randall Dam (Fig. 4), and the highest values were from 1977–82 when no discharge peaks occurred.

It was estimated that fishers spent 9,000 fishing days in the area just upstream from the developing reservoir in the riverine habitat between Niobrara, Nebraska and Springfield, South Dakota (Carlson, 1957) during the period of January through December of 1956. However, these users were not formally surveyed. Saugers, catfish, carp, bullheads, largemouth bass, crappies, and bluegills, in that order, were reported to be dominant in the harvest.

It was estimated that 37,400 fishing days were spent in the tailwater in 1956. This fishing effort was estimated to have resulted in the harvest of 42,006 fish. The percentage composition of the catch is shown in Table 5. The total harvest continued to increase during 1957 and 1958, as did the percent that saugers represented of total harvest (Table 5).

Gavins Point Dam tailwater harvest peaked in 1962 (Table 6). The sauger component began to decline already in 1961. By 1992, sauger harvest has almost disappeared from the tailwater. It is important to note that the extraordinary sport fishing represented in Tables 5 and 6 was based on native, wild fish. Large stockings were made into Lewis and Clark Lake as it was filling, but few of these plantations succeeded and fishes such as sauger, drum, bass, crappie, perch, stur-

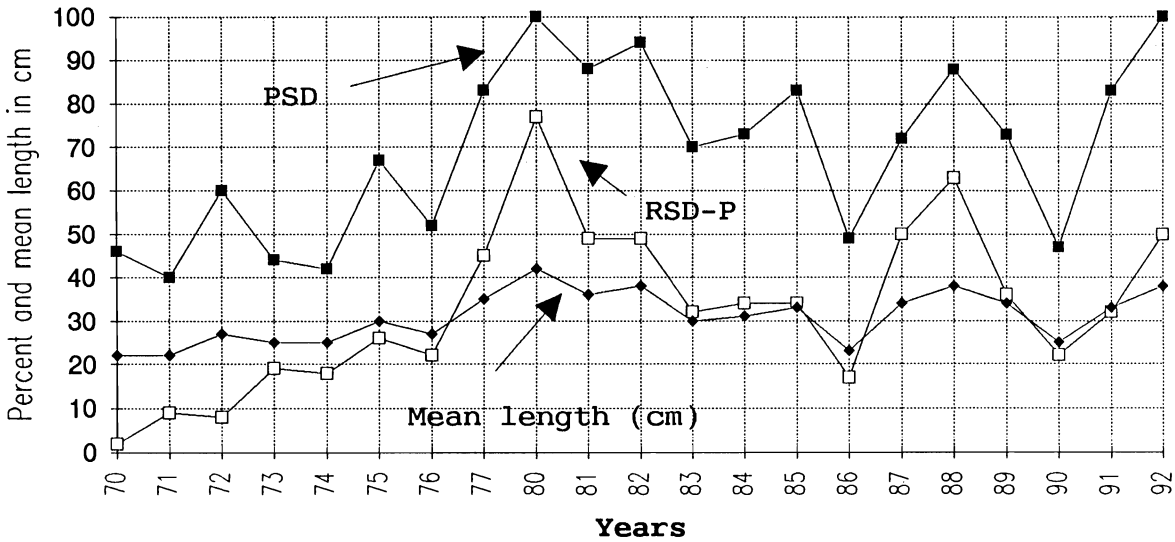

Figure 3. PSD, RSD-P, and mean length for sauger from the Missouri River, Nebraska, between 1970 and 1992.

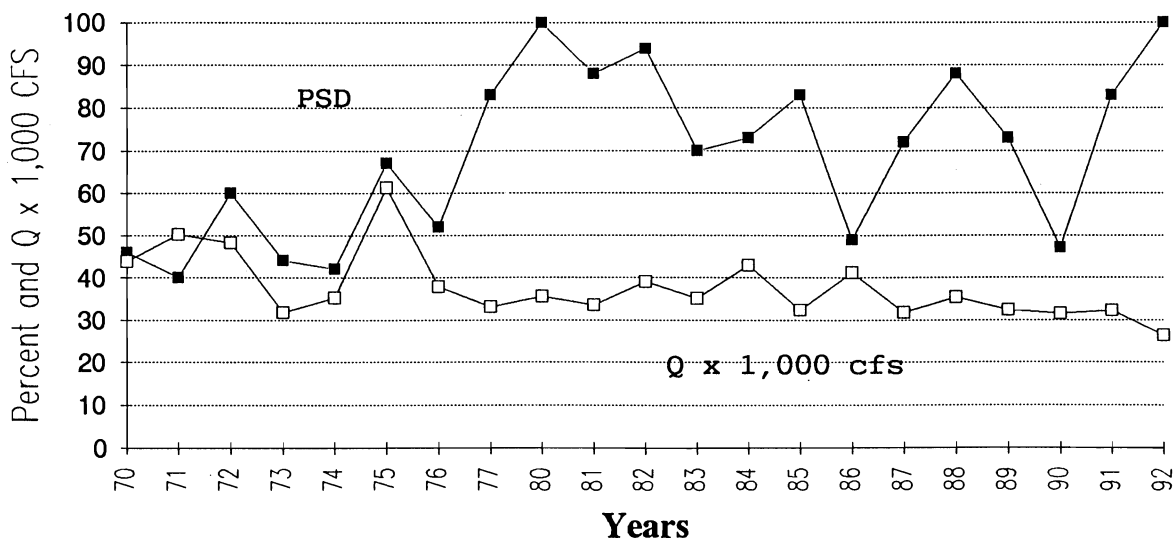

Figure 4. Annual peak inflow into Lewis and Clark Lake and PSD for sauger from the Missouri River in Nebraska.

geon or catfish were not stocked in significant numbers, if at all.

The tailwater quickly became a well-known destination for sport anglers, and the sauger was one of the premier attractions. In some ways this newly available fishing resource overshadowed the real source of the resource supplying the fish (i.e., the Missouri River).

The river downstream as well as upstream from the dam and reservoir had a following of dedicated anglers. Robinson (1959a) surveyed ice fishers using Decatur cut-off about the time it was first separated from the main channel. He reported that "early winter catches were almost exclusively sauger with many limit catches. As the season progressed, crappies and largemouth bass were more frequently encountered as well."; 209 fishers were interviewed from December 1958 through March 1959. They had caught 569 fish of which 64.3% was sauger (366). The overall catch rate was 1.67 fish/hr of fishing, which is quite remarkable. However, many fishers told the clerk that, as good as the fishing was the previous winter had been even better, "with a greater take of sauger."

Fishers were interviewed from April through November 1959, using the main channel of the Missouri River between Sioux City, Iowa and Omaha, Nebraska; 724 fishers were contacted, They had 1,194 fish, sauger (44) represented 4% of the catch. Total catch rate was 0.7 fish/hr (Robinson 1959b). The lower number of saugers was not unexpected, since only 4% of the an-

Table 6. Sport fishing harvest of sauger from the Missouri River in the Gavins Point Dam tailwater, 1956 through 1992.

			Sauger	
Year	**All harvest**	**Rate**	**No. caught**	**%**
1956	10,000	1.6	2,700	27.0
1958	239,000	1.6	71,700	30.0
1961	539,000	1.4	264,110	49.0
1962	710,000	1.4	284,156	40.0
1972	18,441	0.4	830	4.5
1978	29,294	0.1	3,808	13.0
1984	45,101	0.6	4,143	9.0
1992	51,523	0.5	106	0.2

glers were interested in saugers. Most fishers expressed an interest in fishing for carp, catfish, and crappies (95%). This was reflected in the catch which was 83% carp, catfish, and crappies. Robinson (1960) found a similar lack of interest in "game fish" when he interviewed 430 additional anglers in 1960 in this same area. Saugers, however, made up 6% of the reported catch from these main channel sites. In 1961, fisher surveys of the riverine reaches of the Missouri adjacent to Nebraska resulted in an estimate of 12.4% saugers among 1,093 fish inspected, while at the same time the harvest of saugers was already declining in the new reservoir (5.6%) (Orr, 1961). The small number of saugers caught in the Gavins Point Dam tailwater in 1992 was just 0.2% of the total fish harvested that summer (Hesse et al., 1992).

FINAL COMMENTS

Heavy spring precipitation in the lower Missouri River basin during 1983–1985 was met with stringent flood control actions, during which the discharge downstream from these dams was curtailed dramatically for extended periods during spring and early summer. Not only was spawning jeopardized, but off-channel habitat was dewatered, causing severe damage to macroinvertebrate communities, threatening the base of the food supply for saugers and other native fishes, and eliminating essential nursery habitat in the remnant unchannelized sections. During this same time a late summer drought began to expand, and by 1987 had expanded to the entire year. This was also met with reduced spring discharge as navigation seasons were shortened on either end in order to maintain higher discharges during the heart of the navigation season. Unchannelized sections experienced low spring and winter discharge but high summer and fall discharge, which is exactly opposite the natural hydrograph. The impact on the sauger in the unchannelized reaches is most likely reflective of these management practices. Moreover, a series of ineffective discharge schemes was tested in an effort to improve the hatching and fledging success of the threatened piping plover and the endangered least tern. This included a rapid rise in stage downstream from these dams every third day during spring, and up to the onset of nesting in late May, followed by a decline in discharge, and then a steady stage continually until the birds had fledged in August. These fluctuations were in addition to those already inflicted by electrical power peaking, which creates daily stage variations of as much as a meter. Unnatural fluctuations in stage were most likely very hard on fish eggs laid in shallow water, which characterizes the sauger's breeding habits, among others.

There have been numerous observations reported by anglers of a large density of y-o-y saugers during 1993 in the unchannelized reach downstream from Gavins Point Dam. If these reports are true, the strong year-class may have resulted from the flood conditions which affected this reach during 1993. Reduced discharge at Fort Randall Dam was used to abate downstream flooding in 1993; however, this time some of the tributaries just downstream from Gavins Point flooded as well. Since this flooding was not controllable, the erosion zone experienced some limited overbank flows which may contribute to higher survival of the saugers which hatched in 1993. Since saugers are not fully recruited to gill nets until they are several years old, we will not know if this flood actually improved conditions for the Missouri River sauger for another year or so.

Channelized-reach sauger density has declined due to channelization. Off-channel habitat was essential in the annual habits of saugers. Reduced flooding has eliminated organic matter and snags, which supply food and substrate for essential aquatic insects. Aquatic insects were essential in the first year survival of saugers, and thereafter, as food for small fish which then became prey for saugers.

The sauger is in desperate need of help. It is on a very slippery slope toward extirpation. The animal should be listed immediately as endangered in Nebraska. Although it is conceivable that a small number of sauger may be considered surplus to the stock under conditions of low carrying capacity, in my view continued harvest sends the wrong message to anglers. Moreover, it would be difficult to determine what size harvest quota to adopt, and the small quota would be impossible to enforce. I believe all harvest should be stopped in place of other alternatives. Several steps can be taken to remediate the decline, including: recovery of a semblance of the natural hydrograph at Fort Randall Dam, recovery of sediment transport at Fort Randall and Gavins Point dams, replacement of snags into the unchannelized channels and into the mitigation restoration sites along the channelized reach, re-

covery of organic matter supplies by overbank flooding and insertion of "yard waste," and most importantly by re-connection of most cut-off bends along the channelized reach.

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