Habitat use by shovelnose sturgeon in the channelized Missouri River and selected tributary confluences

by

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This thesis is dedicated to my children, Rachel, Adam, Joe, Martha, and especially my wife Becky for enduring this process.

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GENERAL INTRODUCTION

A study on habitat use by shovelnose sturgeon (*Scaphirhynchus platorynchus*) was done in the channelized Missouri River, Iowa - Nebraska. I evaluated conditions and utilization of the tributary confluence zone, a habitat type not yet investigated.

The shovelnose sturgeon is the smallest North American sturgeon and is restricted to Missouri, Mississippi, Rio Grande and Mobile rivers and their major tributaries in central North America (Lee et al. 1980). This lotic species prefers moderate to high water velocities and is a benthic feeder whose diet is dominated by aquatic arthropods (Modde and Schmulbach 1977). Spawning is thought to take place over gravel areas in the main channel as noted in the Missouri River (Moos 1978) or on submerged wing-dams, as seen in the Mississippi River (Helms 1974).

Previous investigators have reported on the habitat associations of various fish species in the Missouri River, Iowa - Nebraska (Schmulbach et al. 1975; Kallemeyn and Novotny 1977; Atchison et al. 1986). However, little sampling has been done in the channelized Missouri River with gear known to be effective in capturing sturgeon. Shovelnose sturgeon habitat use patterns have not been determined for the channelized reach of this river. Previous workers have not documented the local concentration of sturgeon at the mouth of the Platte River or characterized the tributary habitat. The preliminary report on the status of the pallid sturgeon (Gilbraith et al. 1988) recommended identifying critical habitat, especially spawning habitat for both the pallid and shovelnose sturgeon.

The goal of this research was to assess the utilization of different habitats by shovelnose sturgeon in the channelized Missouri River including mouths of three tributaries (Little Sioux, Platte, and Nishnabotna Rivers). The first objective was to compare abundance of shovelnose sturgeon in the tributary habitats with those of the main river habitats. The second objective was to compare abundance of shovelnose sturgeon at the mouth of the Platte River with catches from two other major tributary confluences. The third objective was to determine if the abundance of shovelnose sturgeon in the different habitats is related to velocity, depth, temperature, turbidity and time of year.

Explanation of Thesis Format

This thesis is composed of two papers. A general introduction explains the objectives of the research. Paper I is a paper accepted for publication in the Proceedings of the Second International Symposium on the Sturgeon, Moscow, Russia, 1993. The style of Paper I follows that of the Proceedings editors. Paper II will be submitted for publication in a scientific journal. The style follows that of the North American Journal of Fisheries Management. A summary and references cited in the general introduction follows Paper II. Additional information is included in the appendix.

PAPER I. SELECTION OF TRIBUTARY CONFLUENCE HABITAT BY SHOVELNOSE STURGEON IN THE CHANNELIZED MISSOURI RIVER

Douglas C. Latka, John S. Ramsey, Joseph E. Morris

ABSTRACT

We monitored abundance and habitat selection in a marginal population of shovelnose sturgeon (*Scaphirhynchus platorynchus*) in the channelized Missouri River, Iowa-Nebraska, over a 1-year period. Randomized drift-net sampling of available riverine habitats was conducted at five sites, including the confluences of three large tributaries (Little Sioux, Platte, and Nishnabotna Rivers) and two sites removed from the influence of tributaries. Together, 378 gill-net drifts yielded 113 shovelnose sturgeon (but no pallid sturgeon, *S. albus*). During the winter nonnavigation period, an interval of low river discharge (November 1990 through March 1991), catch per unit of effort was greater in the main channel and main channel border. In stark contrast, shovelnose sturgeon were virtually absent in samples from main channel and main channel border habitat during the navigation period (April-October 1990), an interval of augmented discharge. Instead, catch rates were greater in tributary mouths, higher even than in main channel border and wing-dike habitats--a departure from trends observed in populations elsewhere. The confluences of large tributaries may provide important

seasonal habitat for marginal populations of river sturgeons (*Scaphirhynchus* spp) that survive in entrained navigational channels throughout their ranges.

INTRODUCTION

Maps that depict records of distribution of shovelnose sturgeon (*Scaphirhynchus platorynchus*) virtually define the limits of large rivers in the central United States. The species is absent in headwater streams (Lee 1980) and, in less turbid rivers, rarely penetrates into upper main channel habitat (Trautman 1981). Furthermore, telemetry investigations in the upper Mississippi River never have shown shovelnose sturgeon to enter tributary streams or even approach the mouths of tributaries (Hurley et al. 1987; Curtis 1990). Therefore, biologists have presumed that efficient sampling for river sturgeons (including pallid sturgeon, *S. albus*, and Alabama sturgeon, *S. suttkusi*) should exclude the tributary confluence habitat (e.g., Burke and Ramsey 1985; Carlson et al. 1985).

We came across a previously undocumented sport fishery for shovelnose sturgeon in the Platte River, Nebraska, at its confluence with the Missouri River (D. C. Latka, personal observation). To date, shovelnose sturgeon are caught regularly on baited hooks fished at and immediately below the mouth of the Platte River. We found that the fishery, though popular among local anglers, had escaped notice in news media and sport fishery literature alike, e.g., Groen and Schmulbach 1979. The substantial size of the fishery was unexpected, since the middle Missouri River is regarded as of poor habitat quality for turbid-water fishes (Pflieger and Grace 1987).

We suspected that the relatively large sturgeon population in the Missouri - lower Platte River vicinity might also contain pallid sturgeon, recently recognized as an endangered species (U.S. Fish and Wildlife Service 1990). The pallid sturgeon used to be recorded from both the lower Platte and middle Missouri rivers (Kallemeyn 1983; Gilbraith et al. 1988). Its status in the area remained undetermined and of much concern to conservation managers.

Therefore, we designed a sampling program to assess seasonality and intensity of use of tributary confluences by shovelnose sturgeon and pallid sturgeon populations in otherwise marginal large river habitat. Our objective was to document sturgeon abundance in the channelized middle Missouri River and three major tributary confluences during two seasonal regimes of river discharge.

STUDY AREA

The middle Missouri River is channelized at and below the level of Sioux City, Iowa (Fig. 1). The fish fauna, previously adapted to life in a large, turbid river, is dominated by pelagic planktivores and sight-feeding carnivores, forms more typical of conditions of low turbidity (Pflieger and Grace 1987). The previously wide (610 - 1,830 m), braided river channel now is forced into a uniform width of 180 m; a series of dike fields accumulate sediments and entrain the river flow in one narrowly confined channel (Slizeski et al. 1982). Moreover, starting in 1937, six large mainstream dams (Fig. 1) were completed on the upper Missouri River (Sveum 1988). Of the 3,768-km length of the main channel, the reservoirs impounded 1,233 km (Hesse et al. 1989), drastically affecting discharge, flow pattern, water quality, and channel morphology downstream.

Missouri river discharge today is closely controlled, predominantly to support warm-season commercial navigation between Sioux City, Iowa and St. Louis, Missouri but also for flood control and other purposes. A monthly average discharge of about 1,200 m^3/s is maintained during the navigation

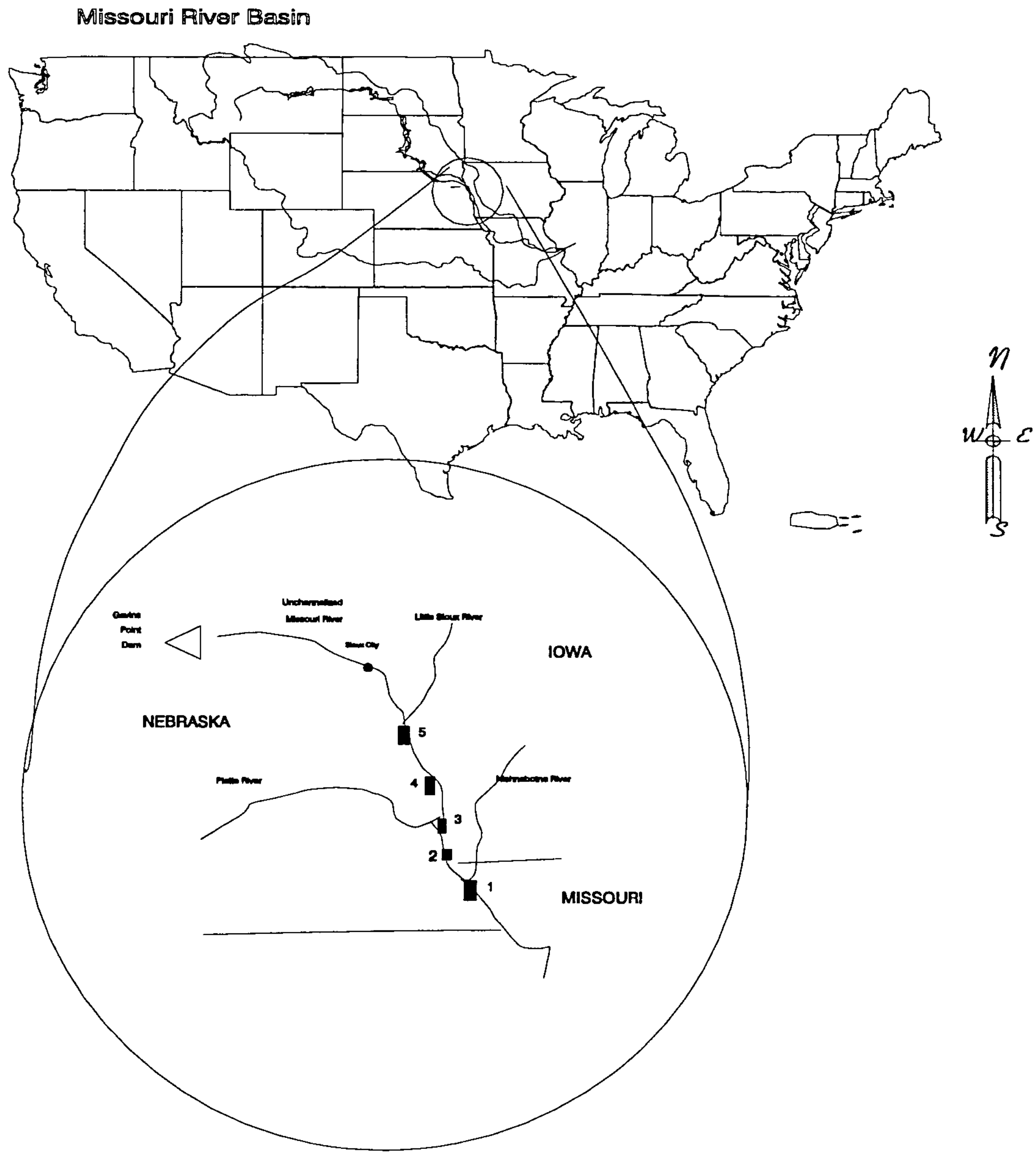

Figure 1. Location of study area in relation to Missouri River basin, April 1990 - March 1991.

season, which in the area usually extends from April 1 through early December (Fig. 2).

Our work fell during a 6-year period of drought in central North America, so navigation discharge ended one month early. Except for two periods of high water, average weekly discharge during the 1990 navigation season (April through October) usually ranged from 800 to 1,000 m^3/s (Fig. 2). Average weekly discharge dropped to 300 - 600 m^3/s during our sampling in the nonnavigation season (November 1990 through March 1991), a volume well below the 550 - 900-m^3 average monthly nonnavigation discharge gauged in the Missouri River over the previous quarter-century.

Preliminary exploration showed three broad macrohabitats to occur in riverine portions of the study area, i.e., excluding tributary confluence macrohabitats. We defined the main Missouri River habitats based on a combination of features summarized by Fremling et al. (1989) for upper and lower reaches of the Mississippi River. In the middle Missouri River, the "main channel" habitat was the swiftest, deepest part of the main river cross-section (usually to about 6 m deep); like the other riverine macrohabitats in the Missouri

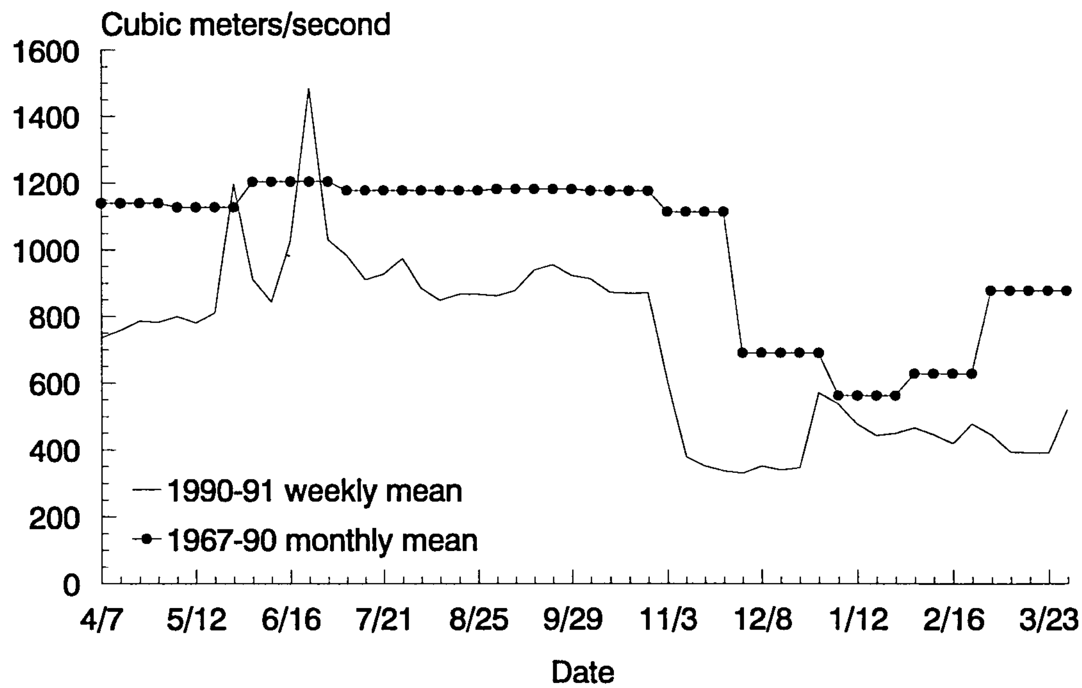

Figure 2. Long term average monthly discharge (m^3/s) for the Missouri River near the Platte River confluence compared with the average weekly discharge for the same location, April 1990 - March 1991.

River, main channel substrate consisted almost entirely of shifting sand; main channel edges usually were indicated by permanent navigational buoys and markers, and its course meandered between stabilized, often revetted river banks. The "main channel border" habitat was a transitional zone between the main channel and shoreline or dike fields; current velocity and water depth were less than in the main channel. The "wing dike habitat", located in series (dike fields) along the Missouri River opposite the main channel, consisted of a series of rock jetties, spaced 245 m apart that jutted outward from the bank and forced water back toward the navigational channel. The outer edge of the eddy current around the wing dike separated the main channel border from the wing dike habitat; depth and current velocity in the wing dike zone usually were less than in the other habitats, but deeper, often debris-filled scour holes occurred behind the outer ends of wing dikes in swift current.

We defined two new habitat types for the Missouri River, based on conditions observed at the confluences of three large tributaries. The "tributary mouth" habitat extended from the geometric line of confluence of the tributary and the Missouri

River into the slightly ponded reach of the tributary extending above the confluence; depths were variable but always deeper within the tributary mouth (to 4 m) than at the line of confluence, across which a sill of loose sand was deposited parallel to the river shoreline to within 1 m of the surface. Finally, the "near mouth habitat" was defined in the Missouri River just below the tributary mouth and along the contiguous river shoreline for about 0.8 km downstream of the tributary mouth. Near mouth habitat was conspicuously influenced by tributary discharge, especially when highly turbid; during low main river discharge, a ridge of loose sand deposited parallel to the shoreline sometimes physically partitioned flows of the main river and near mouth habitats.

We established five sites for sampling stations on the main Missouri River, Iowa - Nebraska, including three sites at the mouths of tributaries and two sites randomly selected as intermediate reaches remote from tributary rivers (Fig. 1). Sampling efforts extended over an average 4.8 km of Missouri River length at the tributary sites and an average 3.2 km at the main river sites remote from tributary confluences.

Site 1.--Missouri River and the mouth of the Nishnabotna River east of Peru, Nebraska. The Nishnabotna River drains highly erodible loess soils of western Iowa; it carries an immense suspended sediment load for its size -- an average 12.6 million metric tons per year in 1939 - 1951, almost as much sediment as the much larger Platte River (Slizeski et al. 1982). The Nishnabotna River is 50 m wide at the mouth, with an average annual discharge of 32.0 m^3/s. Rainfall runoff peaked in late June and early August of 1990.

Site 2.--Missouri River west of Bartlett, Iowa, ca. 12 km south-southwest of Glenwood, Iowa.

Site 3.--Missouri River and the mouth of the Platte River ca. 20 km south of Omaha, Nebraska. The turbid Platte River, draining the Rocky Mountains of northern Colorado and Wyoming and a substantial area of Great Plains and prairie, a much larger tributary than the other two, is 250 m wide at the mouth, with an average annual discharge of 185.0 m^3/s. Runoff peaks recorded were similar in timing to those in the Little Sioux River, regardless of origin as rainfall, plains snow melt, or mountain snow melt.

Site 4.--Missouri River west of Modale, Iowa, ca. 17 km northwest of Missouri Valley, Iowa.

Site 5.--Missouri River and the mouth of the Little Sioux River west of River Sioux, Iowa. The Little Sioux River is a typically turbid prairie stream, 50 m wide at the mouth, with an average annual discharge of 39.0 m^3/s; snowmelt runoff peaked in early March of 1991 and rainfall runoff peaked in late June of 1990 (stream discharges and trends are from hydrographic data files, U.S. Army Corps of Engineers, Omaha, Nebraska). Missouri River discharges during navigation and nonnavigation seasons over the period of our study are summarized in Fig. 2.

METHODS

We selected a repeated measures experimental sampling design to detect differences in sturgeon abundance among habitats and tributary sites. A numbered sampling grid overlay was created on a map of each site by drawing lines between the major habitat types, below tributary mouths, and across the river at each wing dike. The order in which the sites were sampled was selected based on random numbering, as were grid segments representing each habitat type.

We deployed sinking drift nets constructed of nylon multifilament gill netting fitted with foam core float line and heavy lead line. Each net was 1.75 m deep with four panels of mesh consisting of two mesh sizes (bar measurement 2.5 and 5.1 cm). Original net lengths were 15.2, 30.5, and 45.7 m (50, 100, and 150 feet); we adjusted net length data as needed to account for breakage and availability.

Nets were drifted with the current along the bottom for a distance of 245 m, which is the approximate distance interval between wing dikes in a dike field. Drifts were completed in three random units per habitat type per site per sampling interval. An exception to random procedure was observed for the tributary mouth habitat category, in which we drifted only one net per month. Drifts in tributary mouths started from a point 245 m upstream, progressed downward in midchannel, and ended at the barrier sill formed at the confluence. If sections of net were torn, the length of the net remaining was recorded for each drift (and for subsequent gear reuse). If a net became snagged, it was retrieved and reset at the point of the snag to complete the drift.

We attempted to conduct monthly samples in all habitats at each site during April 1990 through March 1991. During routine sampling we usually visited all sites within the same 7-day interval. However, high flows, suspended debris, or ice conditions prevented sampling in May (all but 10 drifts at site 3, which were removed from statistical comparison), December, and January. Moreover, equipment losses forced us to halt all September sampling and work at sites 2 and 4 in October and November.

We report standardized catch data for statistical comparison: catch per unit of effort (CPUE) is the number of sturgeon captured per 30.5-m length of net per drift. Monthly sample results are averaged for each habitat category at each site.

Analysis of variance comparisons (SAS Institute 1985) were applied to detect differences in sturgeon CPUE among (1) main channel, main channel border, and wing dike habitats at all five sites, (2) all five habitats (including mouth and near mouth categories) at the three tributary sites, (3) navigation season (high discharge) and nonnavigation season (low discharge). All CPUE data were transformed for statistical comparison by the square root of (CPUE + 1) to incorporate effort for unsuccessful (CPUE = 0) drifts. The null hypothesis of no difference was rejected based on a probability level of $\underline{P} \leq 0.05$ for all statistical tests.

RESULTS

Nets of various lengths were drifted successfully 378 times during random sampling (Table 1). Total drifts completed included 244 in the navigation season and 134 in the nonnavigation season. Successful samples at main river sites 1 - 5, included 58, 41, 75, 51, and 65 drifts respectively. There were 25, 33, and 30 total drifts completed at tributary confluence sites 1, 3, and 5.

No pallid sturgeon specimens were taken. Neither randomized nor nonrandomized netting effort yielded records of this endangered species in tributary confluence or main river habitats.

We captured a total of 113 shovelnose sturgeon in random sampling, or an overall general catch (not CPUE) of 0.30 sturgeon per randomized drift, regardless of net length (Table 1). Of the total, 62 were caught during the navigation season and 51 during the nonnavigation season. The sturgeon were 20 - 70 cm in fork length ($\overline{x}$ = 54 cm) and weighed 70 - 1,400 g ($\overline{x}$ = 569 g. Another 347 shovelnose sturgeon were taken in nonrandom net hauls in tributary confluences during the navigation season; the latter were processed and released but

Table 1. Shovelnose sturgeon captured by gill nets drifted in the middle Missouri River and tributary confluences, Iowa - Nebraska, during navigation (augmented flow) and nonnavigation (low flow) seasons, April 1990 - March 1991.

Season and month[a]	No. drifts[b]	No. sturgeon	Sturgeon/ drift[c]
Navigation			
April	51	25	0.49
May[d]	10	4	0.40
June	43	6	0.14
July	54	16	0.30
August	59	8	0.14
October	27	3	0.11
Total navigation	244	62	0.25
Nonnavigation			
November	37	13	0.35
February	15	0	0.00
March	82	38	0.46
Total nonnavigation	134	51	0.38
Total	378	113	0.30

[a]No samples were completed in September and December 1990 and January 1991.

[b]Lengths of gill nets drifted ranged from 12.2 m (40 feet) to 45.7 m (150 feet); nets of 15.2 m (50 feet)and 30.5 m (100 feet) were deployed most frequently (152 and 149 drifts, respectively).

[c]Catch per drift regardless of net length.

[d]Data for site 3 only, excluded from statistical comparisons of CPUE-transformed data.

are not included in the random catch analysis.

There was a significant difference ($\underline{P} < 0.05$) in sturgeon CPUE among the different habitats at the tributary sites during the navigation season (Table 2). Sturgeon were found almost exclusively in the tributary mouth and wing dike habitats. However, during the nonnavigation season, there was no significant difference in habitats used. During the nonnavigation season the CPUE increased in the main channel and main channel border habitats and decreased in the tributary mouth habitat.

There was a significant difference in CPUE among the main river habitats (all five study sites, excluding the tributary confluence habitats) during the navigation season (Table 3). Sturgeon CPUE then was highest in the wing dike habitat. In contrast, there was no significant difference in main river occurrence demonstrated during the nonnavigation season.

Table 2. Mean catch per unit of effort (CPUE) and standard error (SE) of shovelnose sturgeon in all five habitat types at the three tributary sites in the middle Missouri River and tributary confluences, Iowa - Nebraska, during the navigation (augmented flow) and nonnavigation (low flow) seasons, April 1990 - March 1991.

Habitat type	Navigation Mean CPUE[a,b]	SE	Nonnavigation Mean CPUE	SE
Main channel	0.00	0.00	0.58	0.35
Main channel border	0.03	0.03	0.36	0.14
Wing dike	0.39	0.13	0.43	0.28
Mouth	4.48	2.75	0.33	0.24
Near mouth	0.13	0.10	0.30	0.19

[a]Mean CPUE is the mean no. of sturgeon per 30.5 m of net drifted 245 m along the river bottom in each habitat.

[b]Significant difference ($\underline{P} < 0.05$) in CPUE among the different habitats.

Table 3. Mean catch per unit of effort (CPUE)and standard error (SE) of shovelnose sturgeon in the main river habitats (excluding mouth and near mouth habitats) at all five sites in the middle Missouri River, Iowa - Nebraska, during the navigation (augmented flow) and nonnavigation (low flow) seasons, April 1990 - March 1991.

Habitat type	Navigation Mean CPUE[ab]	SE	Nonnavigation Mean CPUE	SE
Main channel	0.02	0.02	0.61	0.26
Main channel border	0.02	0.02	0.31	0.11
Wing dike	0.29	0.09	0.30	0.21

[a]Mean CPUE is the mean no. of sturgeon per 30.5 m of net drifted 245 m along the river bottom.
[b]Significant difference ($\underline{P} < 0.05$) in CPUE among the different habitats.

DISCUSSION

Our results clearly show that shovelnose sturgeon in the channelized Missouri River select tributary confluences over main river habitat during the navigation season. The tributary mouth habitat yielded far greater CPUE ($\bar{x}$ = 4.48 ± 2.8 [SE] sturgeon) than any other, including habitats in main river divisions (Table 2). In contrast, CPUE in tributary mouth habitat decreased greatly during the nonnavigation season.

Besides fish taken by regular sampling during the navigation season, we also caught many other sturgeon from large concentrations chanced upon in tributary mouths (i.e., by repeated net hauls at times of high availability). Although excluded from statistical analyses, the large side catches further support strong attraction of tributary confluences to sturgeon in the reaches sampled.

Physical data collected in each habitat type are currently being analyzed to determine what factors may be influencing habitat selection by sturgeon. Water temperature, turbidity, water velocity and bottom topography are thought to play a role in the sturgeon habitat use we observed.

Tributary confluence areas were observed to have a particular habitat configuration that was characterized by a deep pool with slow water velocities behind a shallow sandbar. During the navigation season this habitat configuration existed only in the tributary confluence areas and to a lesser extent in the wing dike habitat. The lack of pool areas and high velocities probably prevented the other habitats from being used because of the inability of these areas to concentrate benthic invertebrates. During the navigation season tributary confluence areas provide the only suitable area for sturgeon to congregate. Buckley and Kynard (1985) believed that shortnose sturgeon in the Connecticut River used discrete areas during the summer because of the availability of food. During the navigation season, tributary confluence areas probably function in the same way in this study area.

During the nonnavigation season this habitat configuration existed in all habitats. This probably played a role in increased use of these habitats by sturgeon. The habitat configuration observed during this study should be further investigated to determine its importance to sturgeon life history requirements.

Our data indicate tributary confluence areas provide important habitat in a highly modified, degraded river system, especially during augmented, high flow periods. Other highly modified river systems throughout the shovelnose sturgeon range may have tributary confluence areas that provide important habitat. These areas should be identified and described so that adequate protection measures can be undertaken.

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This study was funded by the U.S. Army Corps of Engineers, Omaha District. We thank Dick Gorton and Mark Harberg for insuring adequate resources were available to complete the investigation. Special thanks to Mark Mills for his field assistance throughout the study. D. Cox, Mark Harberg, P. Hinz and J. Schmulbach provided valuable advice and criticism.

REFERENCES

Buckley, J., and B. Kynard. 1985. Yearly movements of shortnose sturgeon in the Connecticut River. Transactions of the American Fisheries Society 114:813-820.

Burke, J. S., and J. S. Ramsey. 1985. Status survey on the Alabama shovelnose sturgeon (*Scaphirhynchus* sp. cf. *platorynchus*) in the Mobile Bay drainage. U.S. Fish and Wildlife Service, Jackson, Mississippi, USA. 61 pp.

Carlson, D. M., W. L. Pflieger, L. Trial, and P. S. Haverland. 1985. Distribution, biology and hybridization of *Scaphirhynchus albus* and *S. platorynchus* in the Missouri and Mississippi rivers. Environmental Biology of Fishes 14:51-59.

Curtis, G. L. 1990. Habitat use by shovelnose sturgeon in pool 13, upper Mississippi River, Iowa. M.S. thesis, Iowa State University, Ames, Iowa, USA.

Fremling, C. R., J. L. Rasmussen, R. E. Sparks, S. P. Cobb, C. F. Bryan, T. O. Claflin. 1989. Mississippi river fisheries: A case history. Canadian Special Publication of Fisheries and Aquatic Sciences 106:309-351

Gilbraith, D. M., M. J. Schwalbach, and C. R. Berry. 1988. Preliminary report on the status of the pallid sturgeon, *Scaphirhynchus albus*, a candidate endangered species. Cooperative Fish and Wildlife Research Unit, South Dakota State University, Brookings, South Dakota. 73 pp.

Groen, C. L. and J. C. Schmulbach. 1979. The sport fishery of the unchannelized and channelized middle Missouri river. Transactions of the American Fisheries Society 107:412-418

Hesse, L. W., J. C. Schmulbach, J. M. Carr, K. D. Keenlyne, D. G. Unkenholz, J. W. Robinson, and G. E. Mestl. 1989. Missouri river fishery resources in relation to past, present, and future stresses. Canadian Special Publications of Fish and Aquatic Sciences 106:352-371.

Hurley, S. T., W. A. Hubert, and J. G. Nickum. 1987. Habitats and movements of shovelnose sturgeons in the upper Mississippi river. Transactions of the American Fisheries Society 116:655-663.

Kallemeyn, L. 1983. Status of the pallid sturgeon. Fisheries 8:3-9.

Lee, D. S. 1980. *Scaphirhynchus platorynchus* (Rafinesque), shovelnose sturgeon. Page 44 *in* D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr., editors. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, North Carolina, USA.

Pflieger, W. L. and T. B. Grace. 1987. Changes in the fish fauna of the lower Missouri River, 1940-1983. Pages 166-177 *in* W.J. Matthews and D.C. Heins, editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman, Oklahoma, USA.

SAS Institute Inc. 1985. SAS language guide for personal computers, release 6.03 edition. Cary, North Carolina: SAS Institute Inc., 558 pp.

Slizeski, J. J., J. L. Andersen, and W. G. Dorough. 1982. Hydrologic setting, system operation, present and future stresses. Pages 15-37 *in* L.W. Hesse, editor. The middle Missouri river: A collection of papers on the biology with special reference to power station effects. The Missouri River Study Group, Norfolk, Nebraska, USA.

Sveum, D. J. 1988. Regulation of the Missouri river main stem reservoirs. Pages 51-66 *in* N.G. Benson, editor. The Missouri river: the resources, their uses and values. American Fisheries Society, North Central Division, Special Publication No. 8.

Trautman, M. B. 1981. The fishes of Ohio, revised edition. Ohio State University Press, Columbus, Ohio, USA. 782 pp.

U. S. Fish and Wildlife Service. 1990. Determination of endangered status for the pallid sturgeon. Federal Register Vol. 55, No. 173. 36641-36647, September 6, 1990.

PAPER II. CHARACTERISTICS OF HABITATS USED BY SHOVELNOSE STURGEON IN THE CHANNELIZED MISSOURI RIVER

Douglas C. Latka, Joseph E. Morris, John S. Ramsey

ABSTRACT

We evaluated the physical characteristics of habitats where gill net drifts for shovelnose sturgeon (*Scaphirhynchus platorynchus*) revealed marked differences in habitat utilization between navigation and nonnavigation seasons (augmented and low flow periods respectively) in the channelized Missouri River, Iowa - Nebraska from April 1990 to March 1991. Bottom and mean column velocity, turbidity, temperature and channel topography were measured in five habitats at five sites to determine if differences existed between habitats and seasons. Differences in velocity between habitats during the navigation season were observed. Habitats utilized by sturgeon were characterized by relatively low velocities and sandbar pool bottom topography. These characteristics were found only in tributary confluence and wing dike areas.

Unused habitats had higher velocities and a flat bottom topography. In contrast to the navigation season, there were no differences in velocities between habitats during the nonnavigation season. Bottom topography changed during the nonnavigation season at three of the five study sites to

resemble areas used by sturgeon during the navigation season. Velocity of areas not used during the navigation season decreased during the nonnavigation season; there were no significant differences in velocity between habitats. Suitable velocities and a unique bottom topography appeared to influence the areas used by sturgeon. These characteristics are restricted to the tributary confluence and wing dike areas during the navigation season. These limited areas provide important seasonal habitat for sturgeon.

INTRODUCTION

Historically the Missouri River was a wide, braided river with a diversity of habitat types. Channelization has resulted in a narrow, single, sinuous channel with a width that various from 183 - 335 m (Sveum 1988). Dikes, built in series and perpendicular to the bank (wing dikes), help constrict flow to the main channel where boats navigate. The area between the main channel and the dike field is called the main channel border. In addition to these main habitat types, there are tributary confluence areas that provide different physical conditions than those found in the main river. The transition between the confluence area and the main river is the near mouth habitat.

The flow in the river is controlled by upstream reservoirs to insure adequate water depths for navigation. The controlled flows result in two hydrologic seasons along the Iowa - Nebraska portion of the river. The navigation season is the high flow season generally from April through November and the nonnavigation season is the low flow season from December through March.

Catch data revealed that shovelnose sturgeon used primarily tributary confluence areas and, to a lesser extent, the wing dike habitat during the navigation season (see Section I). In contrast to the navigation season, during the nonnavigation season there was no significant difference in sturgeon abundance between the five habitat types. During this low flow period, sturgeon were found in the main channel and main channel habitats in the same abundance as other habitats.

Velocity, depth, temperature, turbidity and channel configuration were monitored at study site locations where sturgeon drift net sampling was done. This paper will quantify these factors and investigate how they changed between seasons. They may influence sturgeon use of different habitats in the highly modified Missouri River along the Iowa - Nebraska border.

This study also describes physical characteristics of the tributary confluence habitat, an important seasonal habitat for shovelnose sturgeon. The apparent restriction of sturgeon to tributary confluence areas and, to a lesser extent, the dike fields during spring, summer, and fall makes it important to understand the physical characteristics of these habitat types. Proposed water management changes and habitat restoration efforts as well as dredging and maintenance of the navigation channel have the potential to affect shovelnose sturgeon habitat. Understanding the physical characteristics of preferred shovelnose sturgeon habitats will help quantify these effects.

STUDY AREA

The middle Missouri River is channelized at and below the level of Sioux City, IA (Fig. 1). The previously wide (610 - 1,830 m), braided river channel now is forced into a uniform width of 180 m. A series of dike fields accumulate sediments and entrain the river flow in one narrowly confined channel (Slizeski et al. 1982). Moreover, starting in 1937, six large mainstream dams were completed on the upper Missouri River (Sveum 1988). Of the 3,768-km length of the main channel, reservoirs impounded 1,233 km (Hesse et al. 1989), drastically affecting discharge, flow pattern, water quality, and channel morphology downstream.

Missouri River discharge today is closely controlled, predominantly to support warm-season commercial navigation between Sioux City, Iowa and St. Louis, Missouri but also for flood control and other purposes. A monthly average discharge of about 1,200 m^3/s is maintained during the navigation season, which in our study area usually extends from April 1 through early December (Fig. 2). Our work fell during a 6-year period of drought in central North America, so navigation discharge was terminated one month early. Except for two

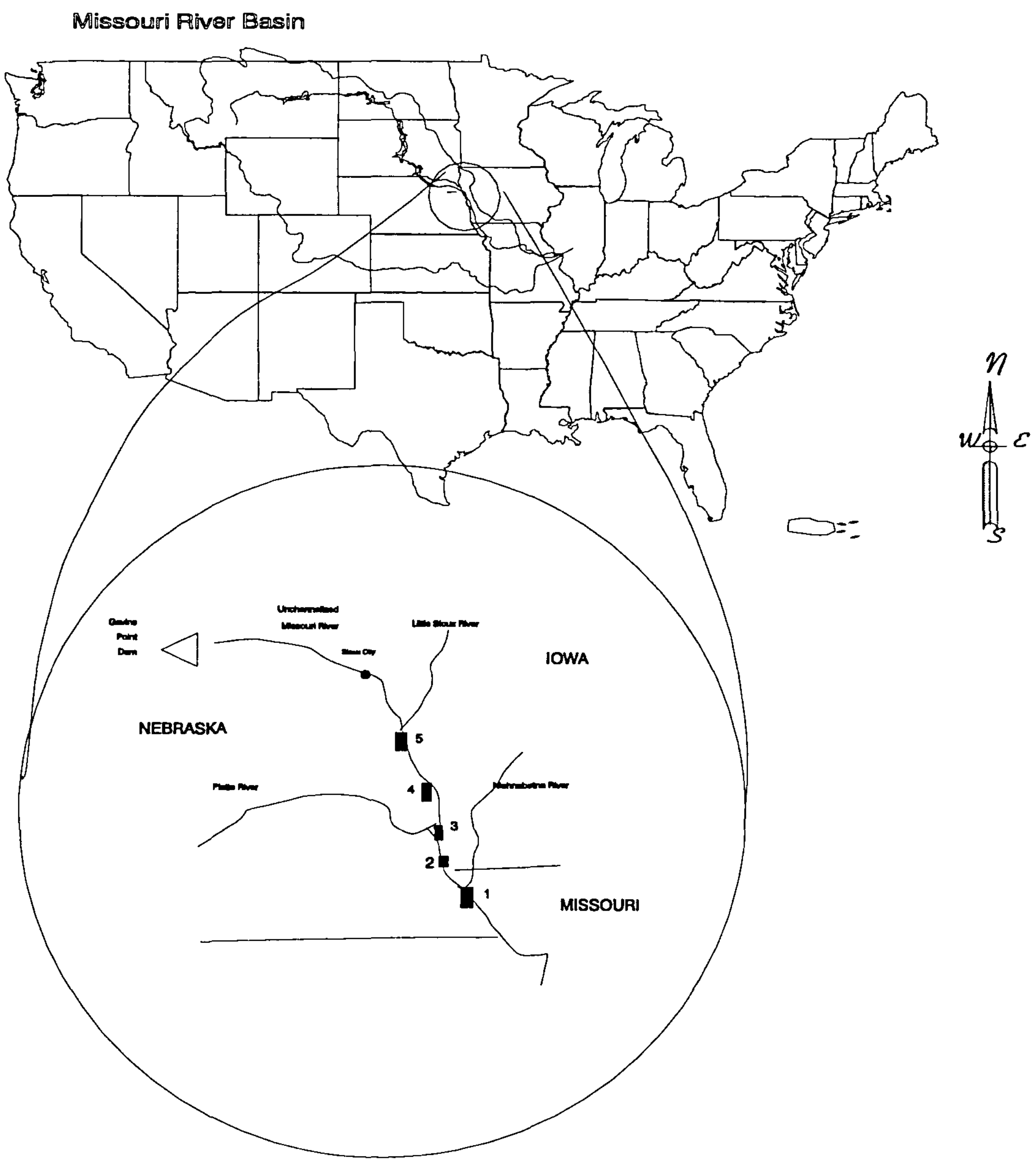


Figure 1. Location of study area in relation to Missouri River basin, April 1990 - March 1991.

periods of high water, average weekly discharge during the 1990 navigation season (April through October) usually ranged from 800 to 1,000 m^3/s. Average weekly discharge dropped to 300 - 600 m^3/s during our sampling in the nonnavigation season (November 1990 through March 1991), a volume well below the 550 - 900 m^3 average monthly nonnavigation discharge gauged in the Missouri River over the previous quarter-century (Fig. 2).

Preliminary exploration showed three broad macrohabitats occur in riverine portions of the study area, i.e., excluding tributary confluence macrohabitats. We defined the main Missouri River habitats based on a combination of features summarized by Fremling et al. (1989) for upper and lower reaches of the Mississippi River. In the middle Missouri River, the "main channel" habitat was the swiftest, deepest part of the main river cross-section (usually to about 6 m deep). Like the other riverine macrohabitats in the Missouri River, main channel substrate consisted almost entirely of shifting sand. Main channel edges usually were indicated by permanent navigational buoys and markers and its course meandered between stabilized, often revetted river banks. The

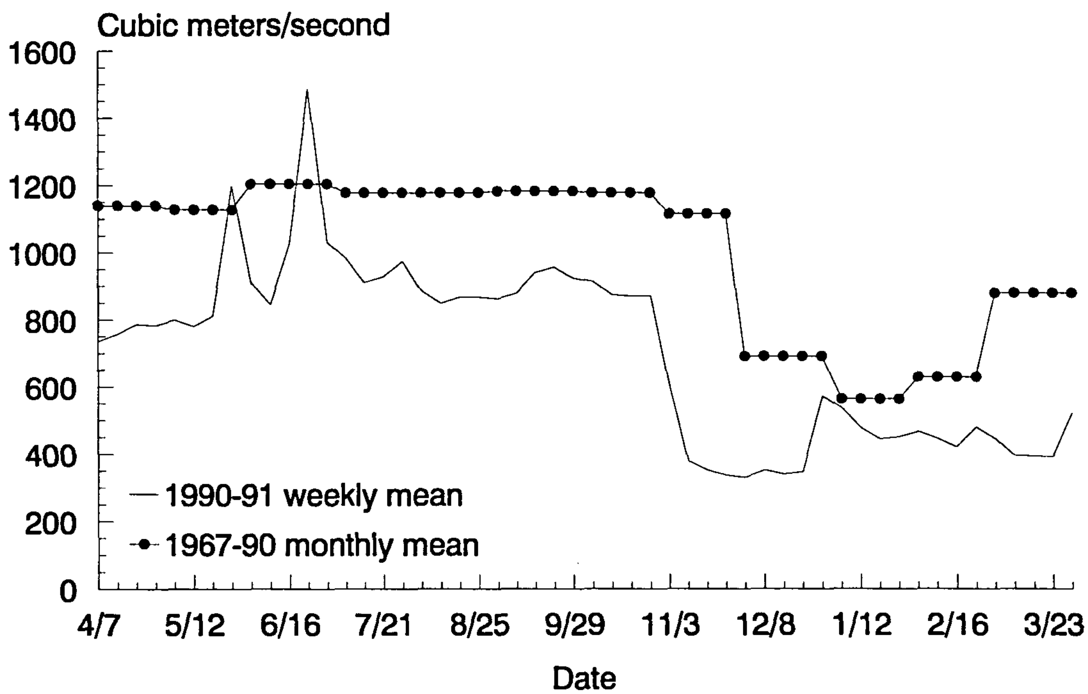


Figure 2. Long term average monthly discharge (cubic meters/second) for the Missouri River near the Platte River confluence compared with the average weekly discharge for the same location during the study period, April 1990 - March 1991.

"main channel border" habitat was a transitional zone between the main channel and shoreline or dike fields. Current velocity and water depth were less than in the main channel. The "wing dike" habitat, located in series (dike fields) along the Missouri River opposite the main channel, consisted of a series of rock jetties, spaced 245 m apart, that jutted outward from the bank and forced water back toward the navigational channel. The outer edge of the eddy current around the wing dike separated the main channel border from the wing dike habitat. Depth and current velocity in the wing dike zone usually were less than in the other habitats, but deeper, often debris-filled scour holes occurred behind the outer ends of wing dikes in swift current.

We defined two new habitat types for the Missouri River, based on conditions observed at the confluences of three large tributaries (Nishnabotna, Little Sioux, and Platte Rivers). The "tributary mouth" habitat extended from the geometric line of confluence of the tributary and the Missouri River into the slightly ponded (caused by the backwater effect of the Missouri River) reach of the tributary extending above the confluence. Depths were variable but always deeper within the tributary mouth (to 4 m deep) than at the line of confluence, across which a sill of loose sand was deposited parallel to the river shoreline to within 1 m of the surface. Finally, the "near mouth" habitat was defined in the Missouri River just below the tributary mouth and along the contiguous river shoreline for about 0.8 km downstream of the tributary mouth. Near mouth habitat was conspicuously influenced by tributary discharge, especially when highly turbid. During low main river discharge, a ridge of loose sand deposited parallel to the shoreline sometimes physically partitioned flows of the main river and near mouth habitats.

We established five sites for sampling stations on the main Missouri River, Iowa - Nebraska. Three sites located at the mouths of large tributaries and two sites arbitrarily selected as intermediate reaches remote from large tributaries (Fig. 3). Sampling efforts extended over an average 4.8 km of Missouri River length at the tributary sites and an average 3.2 km at the main river sites remote from tributary confluences.

Site 1.--Missouri River and the mouth of the Nishnabotna River east of Peru, Nebraska. The Nishnabotna River drains

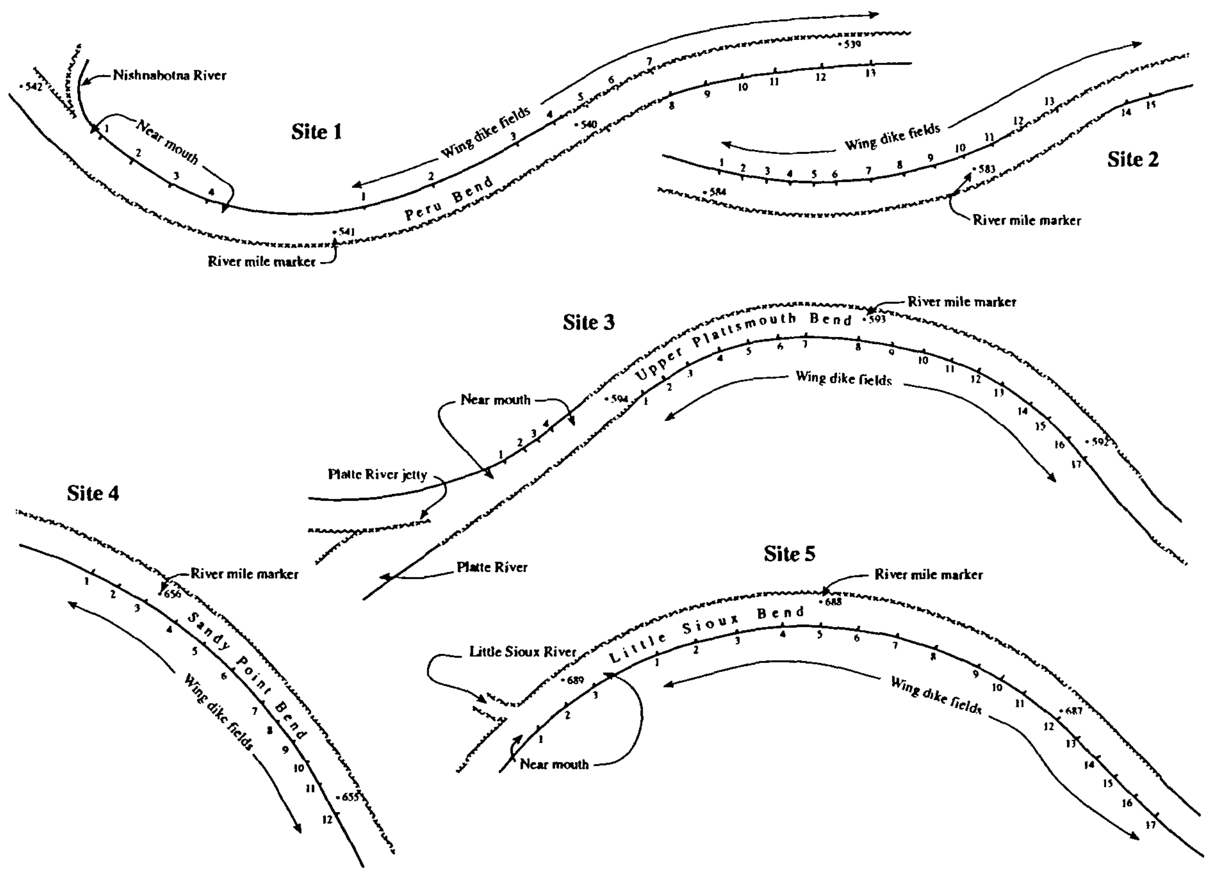


Figure 3. Study sites sampled April 1990 - March 1991, Missouri River, Iowa - Nebraska. Wing dikes are numbered and were used to select random sampling locations.

highly erodible loess soils of western Iowa; it carries an immense suspended sediment load for its size -- an average 12.6 million metric tons per year in 1939 - 1951, almost as much sediment as the much larger Platte River (Slizeski et al. 1982). The Nishnabotna River is 50 m wide at the mouth, with an average annual discharge of 32.0 m^3/s. Rainfall runoff peaked in late June and early August of 1990.

Site 2.--Missouri River west of Bartlett, Iowa, ca. 12 km south-southwest of Glenwood, Iowa.

Site 3.--Missouri River and the mouth of the Platte River south of Omaha, Nebraska. The turbid Platte River drains the Rocky Mountains of northern Colorado and Wyoming and a substantial area of Great Plains and prairie, and is a much larger tributary than the other two. It is 250 m wide at the mouth, with an average annual discharge of 185.0 m^3/s. Runoff peaks recorded were similar in timing to those in the Little Sioux River, regardless of origin as rainfall, plains snowmelt, or mountain snowmelt.

Site 4.--Missouri River west of Modale, Iowa, 17 km northwest of Missouri Valley, Iowa.

Site 5.--Missouri River and the mouth of the Little Sioux River west of River Sioux, Iowa. The Little Sioux River is a typically turbid prairie stream, 50 m wide at the mouth, with an average annual discharge of 39.0 m^3/s; snowmelt runoff peaked in early March of 1991 and rainfall runoff peaked in late June of 1990 (stream discharges and trends are from hydrographic data files, U.S. Army Corps of Engineers, Omaha, Nebraska). Missouri River discharges during navigation and nonnavigation seasons over the period of our study are summarized in Fig. 2.

METHODS

We selected a repeated measures experimental sampling design to detect differences in depths, bottom and mean column velocity among habitats. A numbered sampling grid overlay was created on a map of each site by drawing lines between the major habitat types, below tributary mouths, and across the river at each wing dike. The order in which the sites were sampled was selected based on random numbering, as were grid segments representing each habitat type. Gill net drifts were completed in three random units per habitat type/ site/ sampling interval to determine sturgeon for each season (see Paper I). Due to the time involved in taking the physical measurements, depths, bottom velocity, average velocity, temperature and turbidity samples were only taken at the midpoint of the first random unit sampled for sturgeon abundance in each habitat at each site. The first unit was sampled regardless of sturgeon catch. If time permitted, additional depth and velocity measurements were taken at subsequent random units and averaged to obtain the sample for the habitat at that site for that sampling period.

Velocities were measured using a Price AA type current meter (unknown manufacture) suspended on a cable mounted on a United States Geological Survey (USGS) B-56 reel (USGS 1982). A 22.7 kg weight was attached to the bottom of the current meter. The weight and meter assembly were lowered to the bottom and depths were read from the depth gauge mounted on the reel. Bottom velocities were measured with the weight on the bottom. Mean column velocities were determined by taking the measurement at 0.6 of the distance from the surface when depths were 1.5 m or less and averaging measurements taken 0.2 and 0.8 of the distance from the surface when the depth exceeded 1.5 m (USGS 1982).

A water sample and temperature were taken from the surface at the same locations velocities were measured. Turbidity of the water samples was measured in nephelometric turbidity units (NTU) using a Hach Turbidimeter (Model no. 2100A, Loveland, CO).

An exception to random procedure occurred in the tributary mouth habitat category, in which we drifted only one net per month at each site. Depth, bottom velocity, mean column velocity temperature and turbidity were taken at the midpoint of these drifts.

We attempted to conduct monthly samples in all habitats at each site during April 1990 through March 1991. During routine sampling we usually visited all sites within the same 7-day interval. However, high flows, suspended debris, or ice conditions prevented sampling in May, December, and January. Moreover, equipment losses forced us to halt all September sampling and work at sites 2 and 4 in October and November.

Analysis of variance comparisons (SAS Institute 1985) were applied to detect differences in both bottom velocity and mean column velocity among (1) main channel, main channel border, and wing dike habitats at all five study sites (2) all five habitats (including mouth and near mouth categories) at three tributary sites (3) navigation season (high discharge) and nonnavigation season (low discharge). The Mann-Whitney-Wilcoxon two sample non-parametric test (Slauson 1988) was applied to the velocity samples where sturgeon were caught to detect differences in velocities used between the navigation season and the nonnavigation season. The null hypothesis was rejected based on a probability level of $\underline{P} \leq 0.05$ for all statistical tests. Temperature and turbidity values were qualitatively evaluated for seasonal trends.

Bottom topography was obtained at each tributary confluence area. A recording fathometer (model no. DE719 Ratheyen Co. East Providence, RI during the navigation season, and Eagle Model Mach 1 portable fathometer (Eagle Electronics, Catoosa, OK) during the nonnavigation season were used to trace the river bottom along transacts across the tributary confluence areas. A longitudinal trace was made from the confluence area upstream into the tributary. A theadolite (Leitz model "red mini" no current address) and an electronic distance meter (Leitz model no. DT 5A) were used to scale the depth traces during the navigation season.

Landmarks were used during the nonnavigation season. The bottom of the other habitats was monitored with a non recording fish finder (Lowrance unknown model no., Lowrance Electronics, Tulsa, OK). A longitudinal bottom topography trace was also obtained from each study site during the nonnavigation season by traveling from the downstream boundary to the upstream boundary along the main channel border. The longitudinal bottom topography traces were compared between tributary confluence areas and main channel border of the main river sites.

RESULTS

There were significant differences in both bottom and mean column velocities between the main river habitats (all five study sites excluding the mouth and near mouth habitats) during the navigation season (Tables 1 and 2) . The highest velocities were found in the main channel and main channel border habitats and the lowest velocities were in wing dike habitats.

No significant differences were found in bottom velocity or mean column velocity between habitats during the nonnavigation season. (Tables 1 and 2). Bottom and mean column velocities decreased in the main channel, main channel border habitats between the two seasons.

There was also a significant difference in mean column velocity between all habitats at the tributary sites during the navigation season (Table 3). Highest velocities were in the main channel, main channel border, and near mouth habitats. No significant differences were found during the nonnavigation season. During the nonnavigation season velocities decreased in the main channel and main channel border habitats.

Table 1. Average mean column water velocity (m/s) and standard error (SE) at the midpoint of random drift locations in the main river habitats (excluding mouth and near mouth habitats) at all five sites in the middle Missouri River, Iowa - Nebraska, during the navigation (high flow) and nonnavigation (low flow) seasons, April 1990 - March 1991.

Habitat type	Navigation season velocity[a]	SE	N	Nonnavigation season velocity	SE	N
Main channel	1.30	0.04	14	0.90	0.04	9
Main channel border	1.17	0.03	17	0.85	0.06	11
Wing dike	0.75	0.03	18	0.75	0.08	11

[a]At $\underline{P} < 0.05$, Average mean column water velocity in habitats are significantly different.

Table 2. Mean bottom water velocity (m/s) and standard error (SE) measured at the midpoint of random drift locations in the main river habitats (excluding mouth and near mouth habitats) at all five sites in the middle Missouri River, Iowa - Nebraska, during the navigation (high flow) and nonnavigation (low flow) seasons, April 1990 - March 1991.

Habitat type	Navigation season velocity[a]	SE	N	Nonnavigation season velocity	SE	N
Main channel	0.78	0.07	14	0.64	0.04	12
Main channel border	0.84	0.03	17	0.61	0.05	11
Wing dike	0.56	0.02	18	0.57	0.05	11

[a]At $\underline{P} < 0.05$, Mean bottom water velocity in habitats are significantly different.

Table 3. Average mean column water velocity (m/s) and standard error (SE) measured at the midpoint of random drift locations in all five habitat types at the three tributary sites in the middle Missouri River and tributary confluences, Iowa - Nebraska, during the navigation (high flow) and nonnavigation (low flow) seasons, April 1990 - March 1991.

Habitat	Navigation season			Nonnavigation season		
type	velocity[a]	SE	N	velocity	SE	N
Main channel	1.30	0.06	9	0.89	0.04	6
Main channel border	1.17	0.05	11	0.93	0.03	8
Wing dike	0.75	0.05	12	0.87	0.06	7
Mouth	0.70	0.09	10	0.70	0.13	6
Near mouth	1.14	0.06	4	0.69	0.00	1

[a]At $P < 0.05$, Average mean column water velocity in habitats are significantly different.

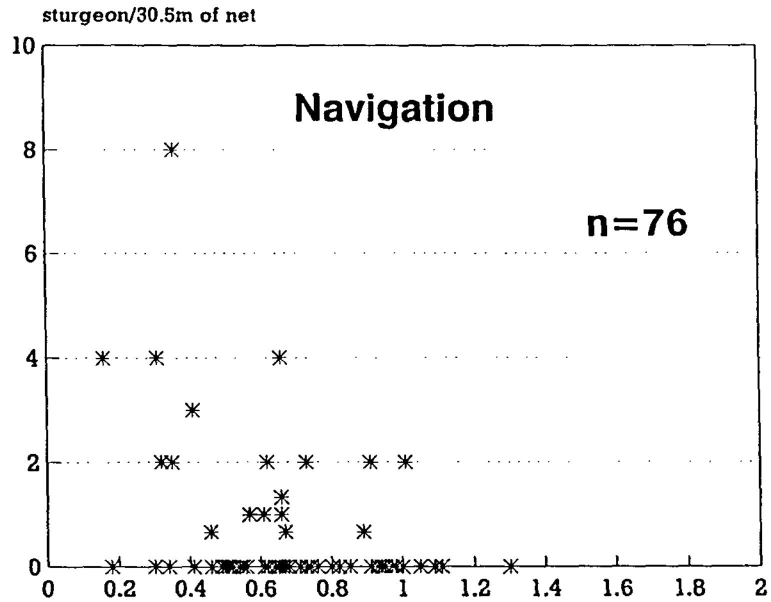
Bottom velocities were also higher in the main channel, main channel border and near mouth habitats at the tributary sites during the navigation season but the differences were not significant (Table 4). There were no significant differences in bottom velocity at the tributary sites during the nonnavigation season (Table 4).

At locations where velocities were measured, sturgeon CPUE was highest when bottom velocities were between 0.2 and 0.6 m/s during the navigation season and 0.3 and 0.7 m/s during the nonnavigation season (Fig. 4). Sturgeon CPUE was highest where mean column velocities were 0.3 - 0.9 m/s during the navigation season and 0.5 - 1.0 m/s during the nonnavigation season (Fig. 5). The Mann-Whitney-Wilcoxon test did not reveal significant differences in velocities used by sturgeon between the two seasons for either bottom or mean column velocities.

Tributaries were more turbid than the main river during the navigation season. The habitat on the side of the river where the tributary enters had higher turbidity levels than habitats on the opposite side (Fig. 6). Tributaries warm faster in the spring and cool faster in the fall than the main

Table 4. Mean bottom water velocity (m/s) and standard error (SE) measured at the midpoint of random drift locations in all five habitat types at the three tributary sites in the middle Missouri River and tributary confluences, Iowa - Nebraska, during the navigation (high flow) and nonnavigation (low flow) seasons, April 1990 - March 1991.

Habitat type	Navigation season velocity	SE	N	Nonnavigation season velocity	SE	N
Main channel	0.75	0.08	9	0.61	0.04	8
Main channel border	0.84	0.04	11	0.69	0.03	8
Wing dike	0.52	0.03	12	0.62	0.03	7
Mouth	0.56	0.08	10	0.65	0.11	7
Near mouth	0.68	0.02	4	0.67	0.00	1



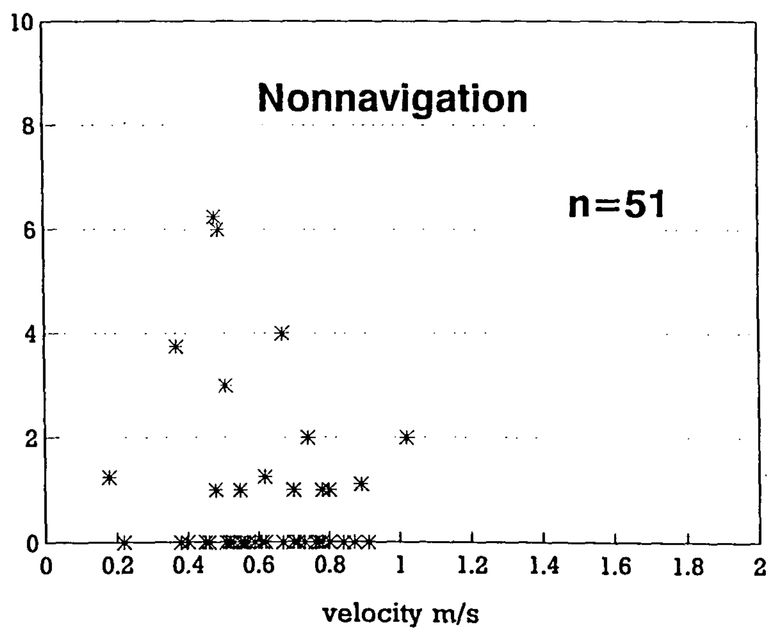


Figure 4. Number of sturgeon per 30.5 m of net at locations where bottom velocities were measured, Missouri River Iowa-Nebraska, April 1990-March 1991.

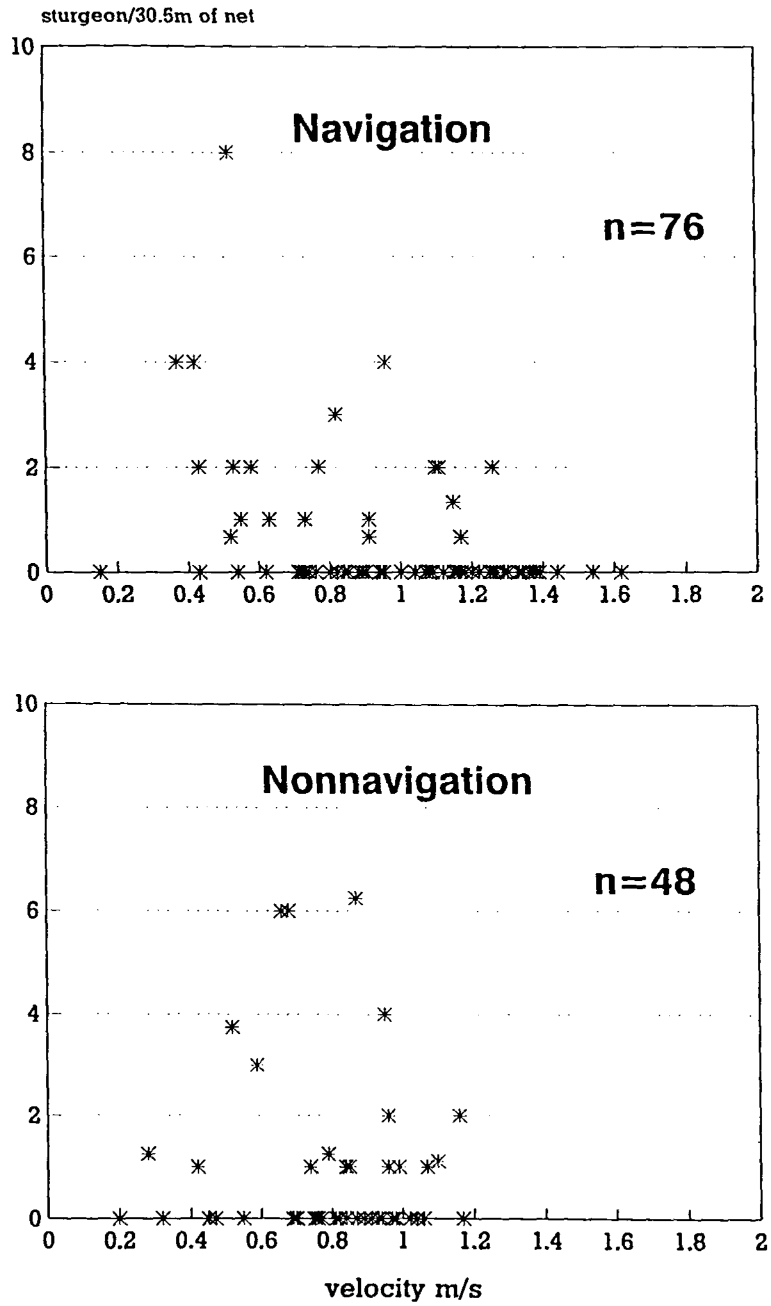
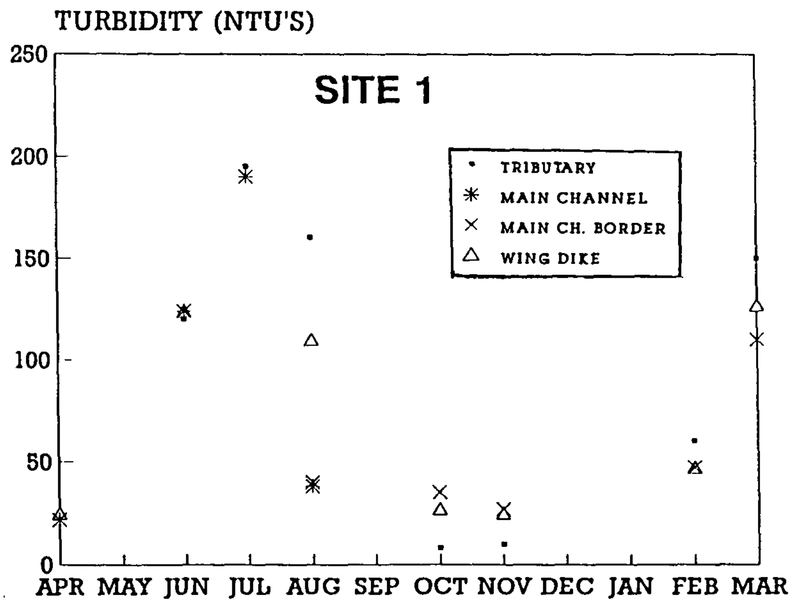


Figure 5. Number of sturgeon per 30.5 m of net at locations where mean column velocities were measured, Missouri River Iowa-Nebraska, April 1990-March 1991.



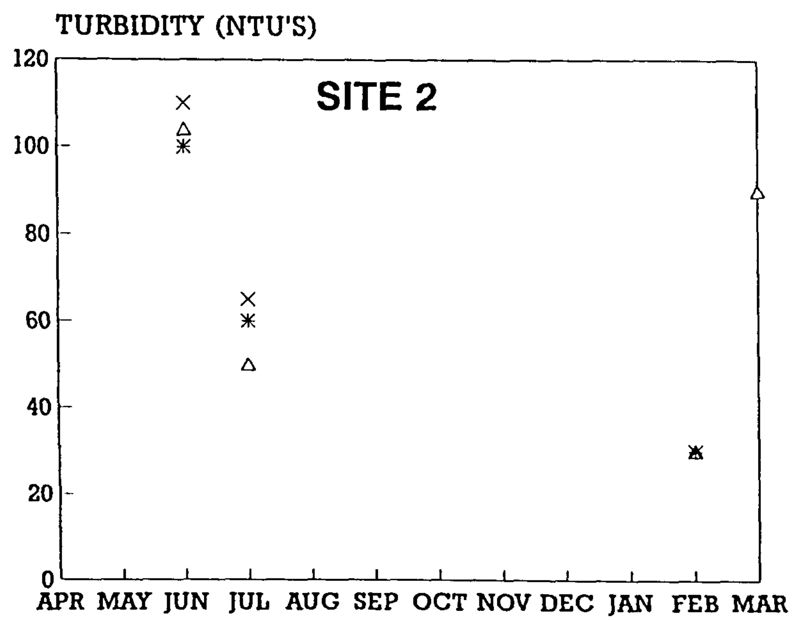
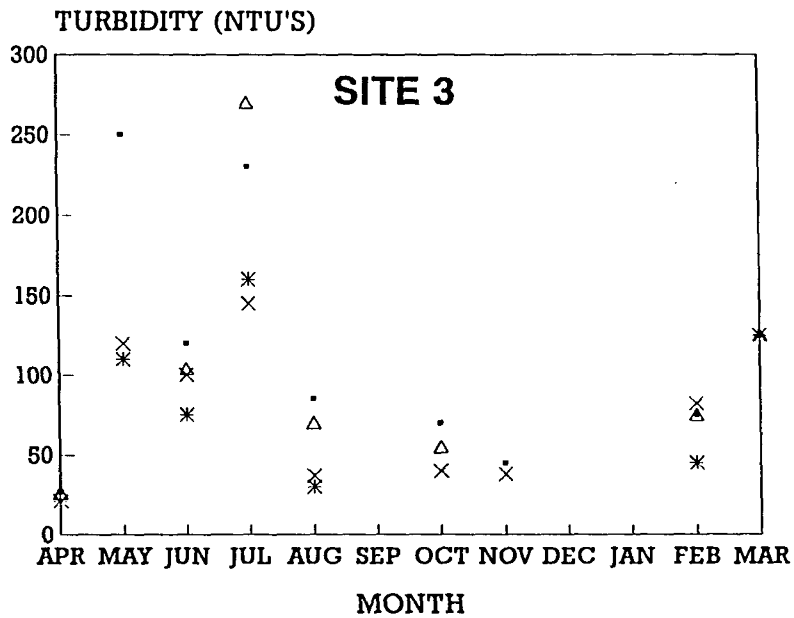
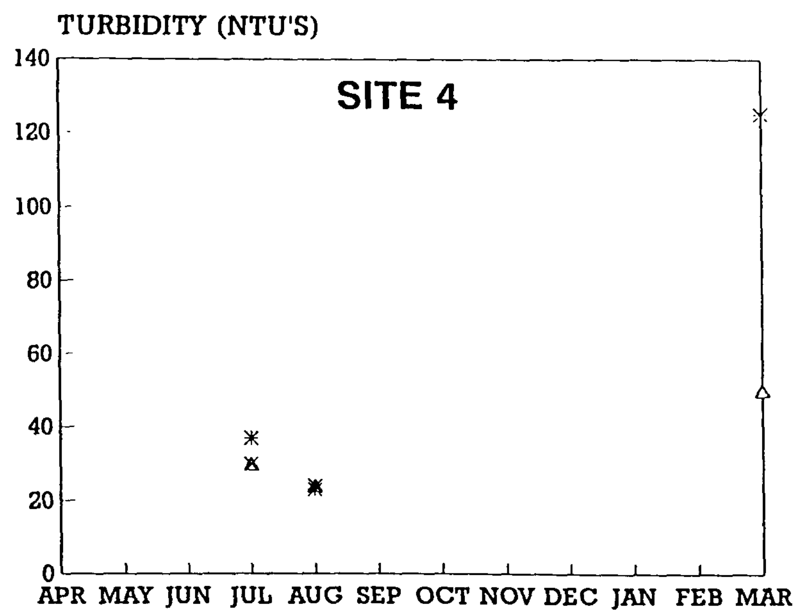


Figure 6. Individual turbidity values by habitat and month for each study site, Missouri River, Iowa-Nebraska, April 1990-March 1991.





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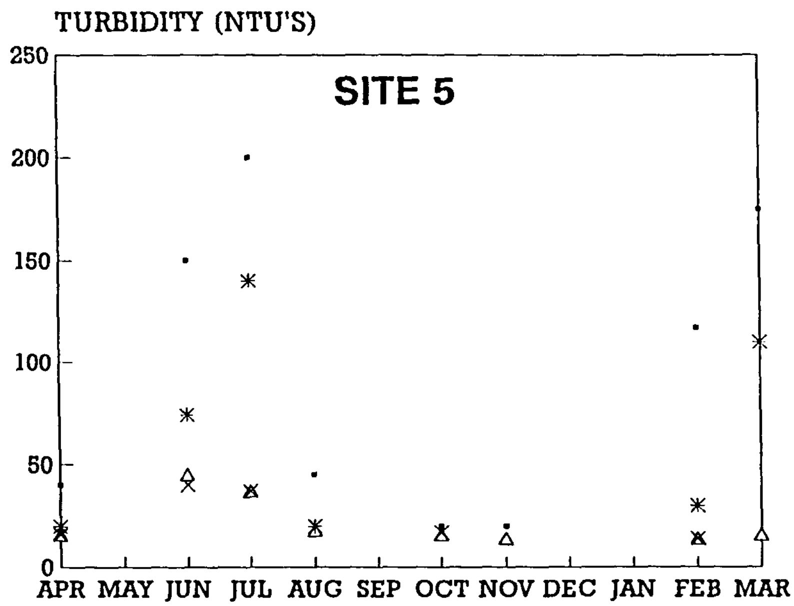
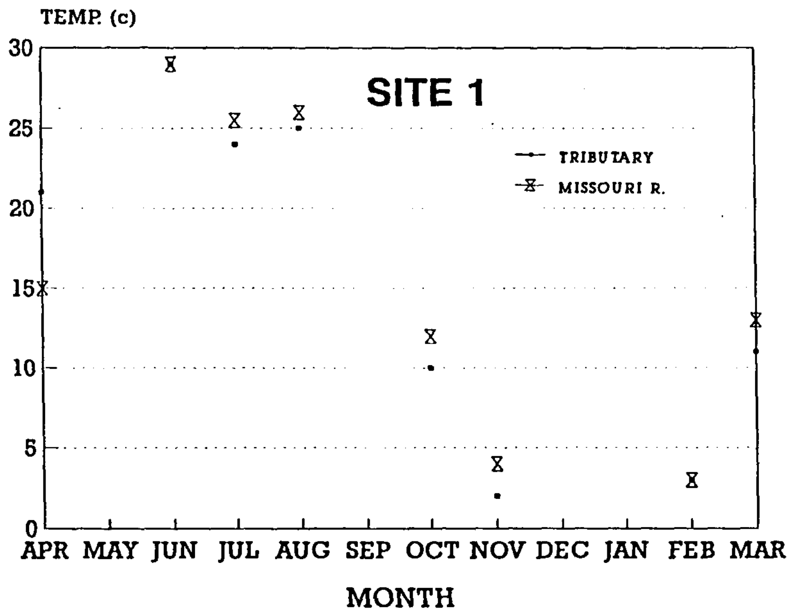


Figure 6. (continued)

river (Fig. 7).

Tributary mouth habitats had unique bottom configurations consisting of a deep pool behind a steep faced sandbar during both seasons.(Fig. 8). During the nonnavigation season, the main channel and main channel border habitats at the three upstream study sites had a configuration similar to the tributary mouth habitat (Fig. 9). This configuration was not noted through monitoring with the nonrecording fish finder during the navigation season.



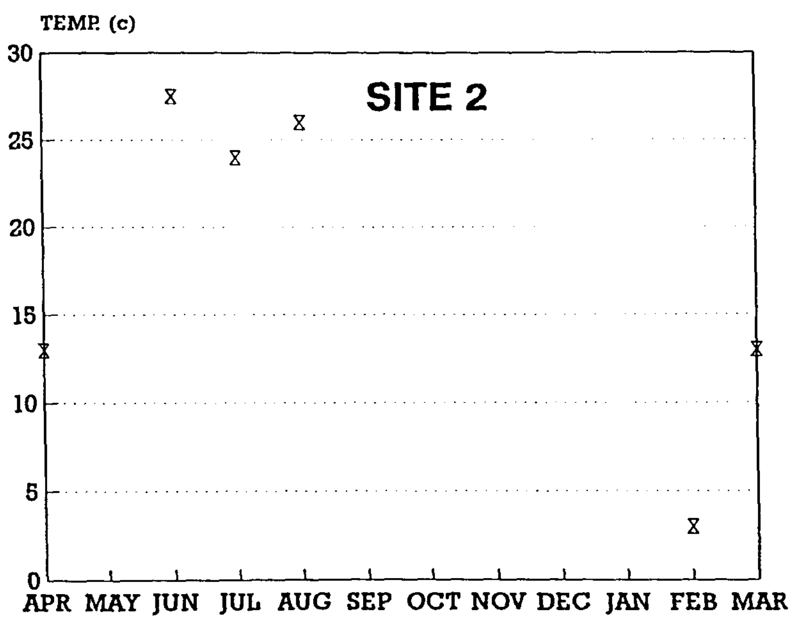
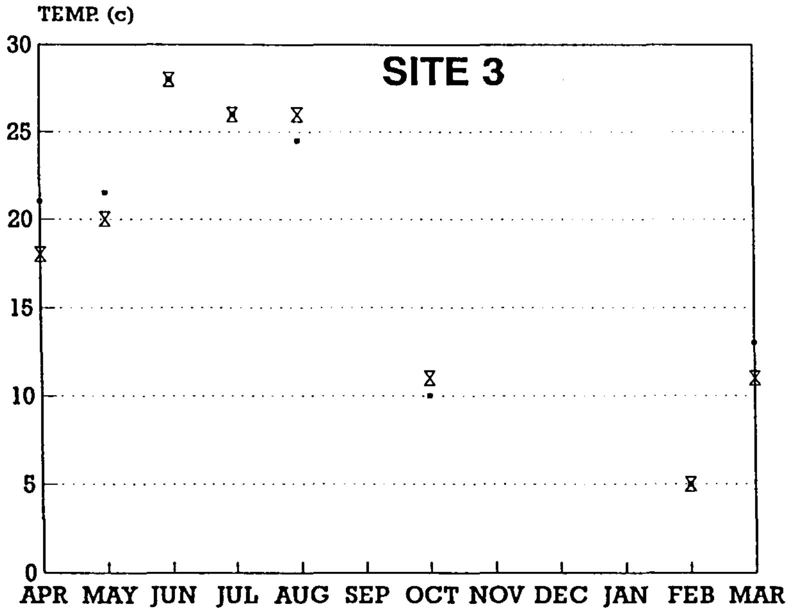
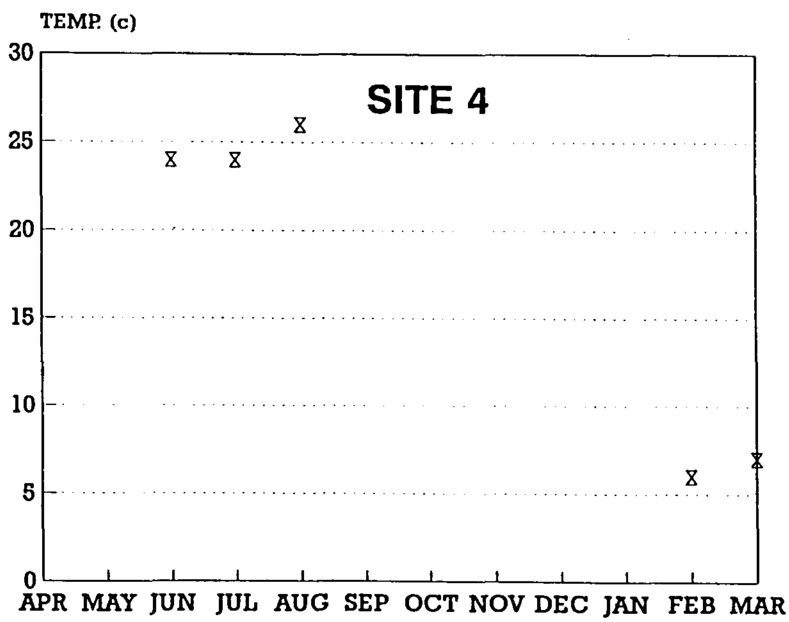


Figure 7. Monthly temperature values for tributary rivers and the Missouri River, Iowa - Nebraska, April 1990 - March 1991. Missouri River values are averages for all main river habitats, tributary values are single measurements.





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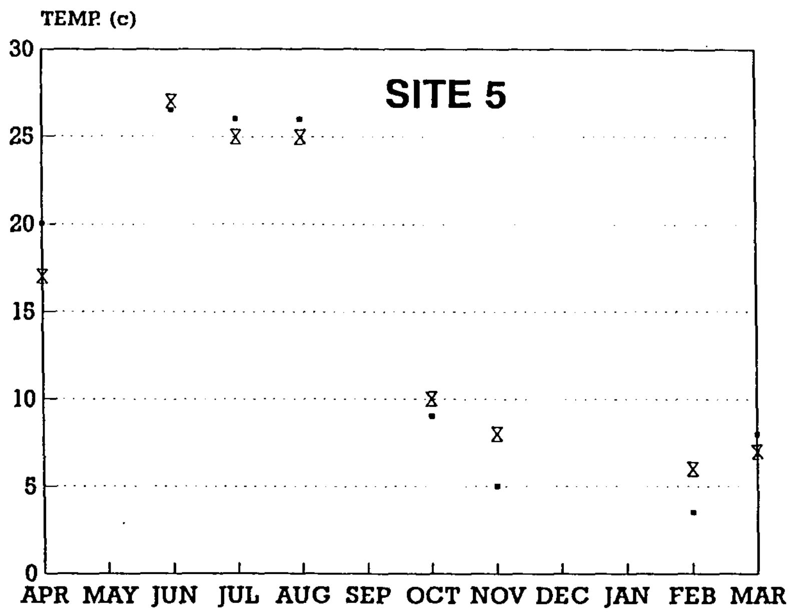

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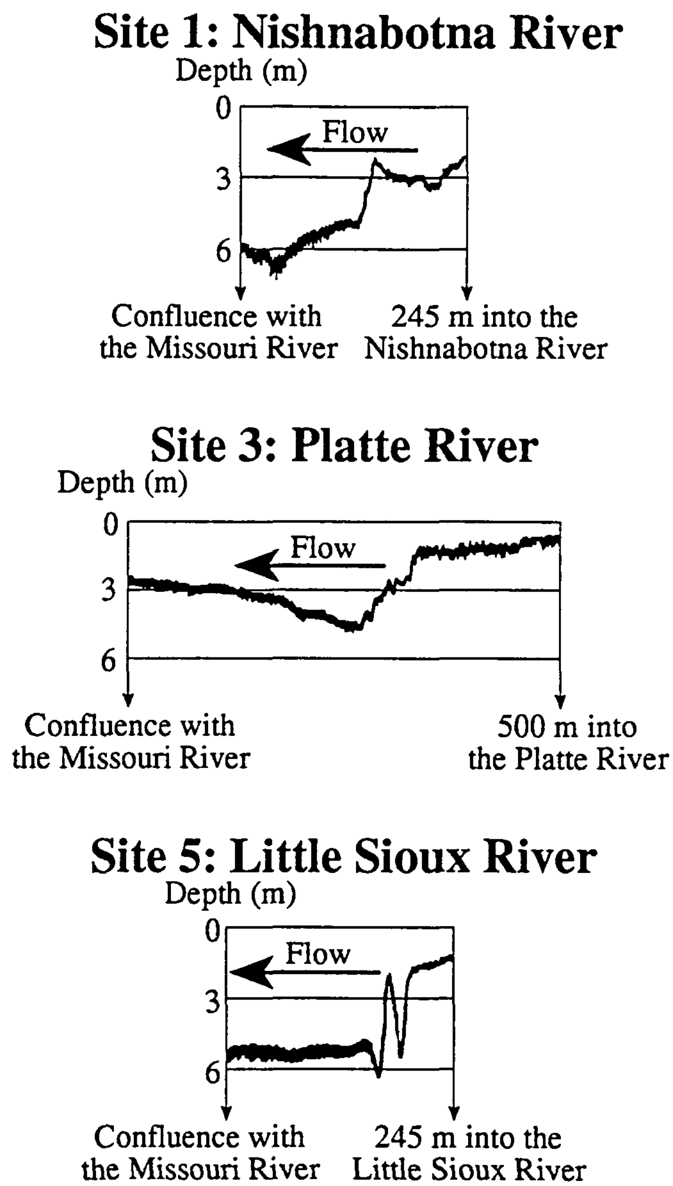

Figure 8. Longitudinal depth soundings starting at the confluence of the tributaries and the Missouri River proceeding upstream in the tributary at study sites 1, 3, 5, May and August 1990.

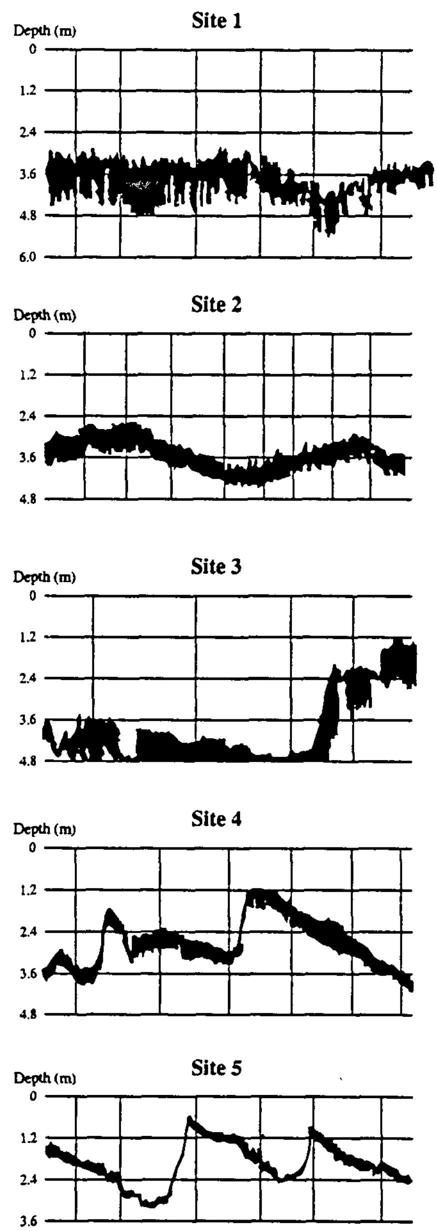

Figure 9. Longitudinal depth soundings made in the main channel of the Missouri River downstream to upstream at all five study sites during the nonnavigation season. Vertical lines show approximately when the boat passed a wing dike.

DISCUSSION

This study has shown that habitats used by shovelnose sturgeon are characterized by a unique bottom topography with a defined water velocity range. Physical characteristics of habitats used by sturgeon in this study were similar to those reported by others. Hurley et al. 1987 determined that velocity and a high profile bottom structure probably influenced the distribution of sturgeon in their study. Changes in velocity and bottom profile between the navigation and nonnavigation seasons appear to account for the change in sturgeon distribution documented in Paper I.

Hurley et al. 1987 and Curtis 1990 found sturgeon in the upper Mississippi River in velocities slightly lower than what we found in this study. This suggests if lower velocities were available in our study area, they would have been used. In this study, sturgeon were found in habitats that had the lowest velocities available during the navigation season. The tributary mouth habitat and the wing dike habitat were the only habitats with velocities close to those found by Hurley et al. 1987 or Curtis 1990.

During the nonnavigation season sturgeon utilized all habitats when there were no significant differences in velocities between habitats. The velocities utilized by sturgeon were not significantly different between seasons, which suggests sturgeon use of the main channel and main channel border habitats during the nonnavigation season was in response to more favorable velocities there. Hurley et al. 1987 reported sturgeon shifting habitat use in the Mississippi River in response to a shift in velocities.

Modde and Schmulbach 1977 speculated that increasing velocities in sandbar pools in the unchannelized Missouri River near Vermillion, South Dakota, increased the mobility of sturgeon food organisms. This resulted in reduced concentrations of food, causing sturgeon to disperse. In our study, velocities in the Missouri River during the navigation season are probably too high to concentrate food organisms.

Tributaries of the Missouri River have a higher content of coarse particulate organic matter (CPOM) than the main river (Hesse 1989). Low velocities in pools in tributary mouths may help concentrate this matter and associated benthic invertebrates providing food for sturgeon.

Schmulbach et al. 1975, and Moose 1978, found sturgeon to be abundant in pools behind sandbars. Hurley 1987 speculated sturgeon use submerged wing dams in the upper Mississippi River because they provide similar habitat as sandbar pools described by Schmulbach et al. 1975 and Moose 1978. During the navigation season, the tributary mouth habitat and, to a lesser extent, the wing dike habitat were the only habitats with sandbar pool conditions similar to those reported by these authors. The unique channel configuration coupled with adequate velocities provide important habitat for shovelnose sturgeon during the navigation season. These sandbar pools, characterized by slower velocities and a high profile sandbar face on the upstream side of the pool, became available in all habitats during the nonnavigation season. We believe these two factors explain the distribution of shovelnose sturgeon reported in Paper I.

Jaeggi 1989 described the formation of alternate sandbars during low flows on the Alpine Rhine River in Europe. Formation of bars and pools in the Alpine Rhine contributed to a diversity of depths and velocities. The limits of the bar formation are a function of river width, sediment grain size, and water slope. It is possible that formation of these bars and pools in the main channel and main channel border habitats during this study was related to a change in one or all of these parameters in response to lower than normal flows (drought conditions). If this is the case, normal flows will change the channel configuration to eliminate these bars. Hence shovelnose sturgeon will be restricted to tributary confluence and wing dike habitats during the nonnavigation season as well.

Although it is possible these bars were present during the navigation season, they were not prominent enough to be noticed on the fish finder. Numerous longitudinal bottom traces taken by the U.S. Army Corps of Engineers (USACOE) during past navigation seasons do not show these bars (USACOE 1969). Also, Jaegi 1989 states the riffle-pool like sequence caused by these bars becomes apparent at low flows. Low flows in this study occurred during the nonnavigation season. Shovelnose sturgeon would not be restricted to tributary confluences and wing dike habitats when sandbar pool complexes are available during the navigation season in the main Missouri River.

The warmer, more turbid tributaries in the spring and early summer may be factors in the greater abundance of sturgeon being found there. Also, temperature and turbidity in habitats on the same side of the main river as the tributary confluence were influenced by tributary waters. With spawning temperatures occurring first in the tributaries the sturgeon might congregate and spawn there first. However, this does not explain the continued use of these areas later in the navigation season when temperatures and turbidity were the same in tributaries and the main river.

Further sampling for shovelnose sturgeon in the lower channelized Missouri River in Missouri should be done to document whether sturgeon are less restricted in habitat utilization than was found in this study. We expect habitat usage would be dependent on availability of suitable velocities and channel configuration described in this paper.

REFERENCES

Curtis, G. L. 1990. Habitat use by shovelnose sturgeon in pool 13, upper Mississippi River, Iowa. M.S. thesis, Iowa State University, Ames, Iowa, USA.

Fremling, C. R., J. L. Rasmussen, R. E. Sparks, S. P. Cobb, C. F. Bryan, T. O. Claflin. 1989. Mississippi river fisheries: A case history. Canadian Special Publication of Fisheries and Aquatic Sciences 106:309-351.

Hesse, L. W., G. E. Mestl and M. J. Rohrke. 1989. Chemical and physical characteristics of the Missouri River, Nebraska. Proceedings of the Nebraska Academy of Sciences 17:103-109.

Hesse, L. W., J. C. Schmulbach, J. M. Carr, K. D. Keenlyne, D.G. Unkenholz, J. W. Robinson, and G. E. Mestl. 1989. Missouri river fishery resources in relation to past, present, and future stresses. Canadian Special Publications of Fish and Aquatic Sciences 106:352-371.

Hurley, S. T., W. A. Hubert, and J. G. Nickum. 1987. Habitats and movements of shovelnose sturgeons in the upper Mississippi river. Transactions of the American Fisheries Society 116:655-663.

Jaeggi, M. N. R. 1989. Channel engineering and erosion control. Pages 163-183 *in* J.A. Gore and G.E. Petts, editors. Alternatives in Regulated River Management. CRC Press, Inc.,Boca Raton, Florida.

Modde, T. and J. C. Schmulbach. 1977. Food and feeding behavior of the shovelnose sturgeon, *Scaphirhynchus platorynchus*, in the unchannelized Missouri river. Transactions of the American Fisheries Society 106: 602-608.

Moos, R. E. 1978. Movement and reproduction of shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the Missouri river in South Dakota. Doctoral dissertation, University of South Dakota, Vermillion.

Rantz, S. E. 1982. Measurement and computation of streamflow. Geological Survey Water-Supply Paper 2175, Washington D.C.

SAS Institute Inc. 1985. SAS language guide for personal computers, release 6.03 edition. Cary, North Carolina: SAS Institute Inc., 558 pp.

Schmulbach, J. C., G. Gould, and C. L. Groen. 1975. Relative abundance and distribution of fishes in the Missouri River, Gavins Point Dam to Rulo, Nebraska. Proceedings of the South Dakota Academy of Sciences 54:194-222.

Slizeski, J. J., J. L. Andersen, and W. G. Dorough. 1982. Hydrologic setting, system operation, present and future stresses. Pages 15-37 *in* L.W. Hesse, editor. The middle Missouri river: A collection of papers on the biology with special reference to power station effects. The Missouri River Study Group, Norfolk, Nebraska, USA.

Slauson, W. L. 1988. Graphical and statistical procedures for comparing habitat suitability data. U. S. Fish and Wildlife Service Biological Report 89 (6), Washington D.C.

Sveum, D. J. 1988. Regulation of the Missouri river main stem reservoirs. Pages 51-66 *in* N.G. Benson, editor. The Missouri river: the resources, their uses and values. American Fisheries Society, North Central Division, Special Publication No. 8.

U.S. Army Corps of Engineers, U.S. Army Engineer District, Omaha. 1969. Missouri River channel regime studies. M.R.D. Sediment Series No. 13 B. Omaha, Nebraska.

SUMMARY

I monitored abundance of shovelnose sturgeon in habitats of the channelized Missouri River, Iowa - Nebraska and three tributary areas during a period of drought (April 1990 - March 1991). Sturgeon used different habitats between the navigation and nonnavigation seasons. Catch data demonstrated tributary confluence areas provide important habitat for shovelnose sturgeon during the navigation season. Sturgeon were absent from the main channel and main channel border habitats. Sturgeon were widely distributed in all habitats during the nonnavigation season.

Physical characteristics of habitats also changed between seasons. Velocity and channel configuration changed in the main channel and main channel border habitats to those reported to be more favored by shovelnose sturgeon. These characteristics were restricted to the tributary confluence areas and wing dike fields during the navigation season but were broadly dispersed during the nonnavigation season.

Other areas of the Missouri River should be investigated to determine the availability of velocities and a channel configuration preferred by shovelnose sturgeon. Their

distribution and abundance are hypothesized to be dependant on the availability of preferred velocities and channel configuration described here. Also, sturgeon food availability and use should be studied to determine if preferred physical characteristics concentrate food organisms as suggested by Modde and Schmulbach 1977.

The present study should be repeated when flows return to normal (closer to the long term average) to determine if the preferred physical characteristics are still widely available in all habitats during the nonnavigation season. If more normal flows preclude development of preferred physical characteristics, sturgeon may be restricted to tributary confluence areas during the nonnavigation season as well.

The process precipitating the occurrence of main channel sandbars should also be investigated. Changing flow patterns and sediment transport are known to affect velocity and channel configuration (Jaeggi 1989).

Understanding these processes will help in designing channel restoration projects under consideration as well as evaluating alternative flow regimes from upstream reservoirs for the benefit of shovelnose sturgeon and other endemic

Missouri River fishes. This thesis demonstrates the need for a multidisciplinary approach to river restoration work.

REFERENCES

Atchison, G.J., R.W. Bachmann, J.G. Nickum, J.B. Barnum, and M.B. Sandheinrich. Aquatic biota associated with channel stabilization structures and abandoned channels in the middle Missouri river. U.S. Army Corps of Engineers. Waterways Exper. Sta. Techn. Rep. E-86-6. 53p.

Gilbraith, D. M., M. J. Schwalbach, and C. R. Berry. 1988. Preliminary report on the status of the pallid sturgeon, (*Scaphirhynchus albus*), Cooperative Fish and Wildlife Research Unit, South Dakota State University, Brookings, South Dakota. 73 pp.

Helms, D. 1974. Shovelnose sturgeon, (*Scaphirhynchus platorynchus*)(*Rafinesque*), in the navigational impoundments of the upper Mississippi river. Technical series. Iowa State Conserv. Comm. 74-3 68 p.

Jaeggi, M. N. R. 1989. Channel engineering and erosion control. Pages 163-183 *in* J.A. Gore and G.E. Petts, editors. Alternatives in Regulated River Management. CRC Press, Inc.,Boca Raton, Florida.

Kallemeyn, L.W. and J.F. Novotny. 1977. Fish and fish food organisms in various habitats of the Missouri river in South Dakota, Nebraska, and Iowa, U. S.Fish and Wildlife Service. FWS/OBS-77/25. 100p.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh.

Modde, T. and J.C. Schmulbach. 1977. Food and feeding behavior of the shovelnose sturgeon, (*Scaphirhynchus platorynchus*), in the unchannelized Missouri river. Transactions of the American Fisheries Society. 106:602-608.

Moos, R. E. 1978. Movement and reproduction of shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the Missouri river in South Dakota. Ph.D. dissertation, University of South Dakota, Vermillion.

Schmulbach, J. C., G. Gould, and C. L. Groen. 1975. Relative abundance and distribution of fishes in the Missouri River, Gavins Point Dam to Rulo, Nebraska. Proceedings of the South Dakota Academy of Sciences 54:194-222.

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APPENDIX

Species composition

Shovelnose sturgeon was the most abundant species in the catch followed by blue suckers (*Cycleptus elongatus*)and channel catfish (*Ictaluras punctatus*)(Table 1). Most channel catfish were caught during the fall and winter once water temperature dropped below 15° C. Blue suckers were caught throughout the study period but never in a tributary mouth.

Length frequency

Shovelnose sturgeon ranged in size from 20 - 70 cm fork length (FL) with an average of 54 cm FL. The length frequency distribution is shown in Table 1. Sturgeon caught in this study covered a wider range of lengths than those reported by authors cited in Papers I and II who worked on the unchannelized Missouri River.

Table 1. Species composition obtained by drifting sinking gill nets in the Missouri River, Iowa - Nebraska, and three tributary confluence areas, April, 1990 - March 1991.

Species	No.
shovelnose sturgeon	460
blue sucker	53
channel catfish	53
goldeye	21
drum	9
carp	7
smallmouth buffalo	5
river carpsucker	4
longnose gar	4
sauger	4
flathead catfish	2
other	3

Table 2. Length-frequency (cm) for shovelnose sturgeon caught in sinking gillnets in the Missouri River, Iowa - Nebraska, April 1990 - March 1991.

Fork Length Class (cm)	No. Sturgeon	Percent of Total
21-25	2	<1
26-30	3	<1
31-35	8	2
36-40	17	4
41-45	33	7
46-50	58	13
51-55	106	23
56-60	146	32
61-65	71	15
66-70	13	3