Preliminary Report on the Status of the Pallid Sturgeon, *Scaphirhynchus albus*, a Candidate Endangered Species

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ABSTRACT

The pallid sturgeon (Scaphirhynchus albus), a "living fossil", is one of the larger (unofficial world record of 85 lbs, 38.5 kg) and lesser known North American freshwater fish. Its historic habitat is the Missouri River and the Mississippi River downstream from the confluence of the Missouri, but most records are from the Missouri River. The pallid sturgeon has never been common, but circumstantial evidence indicates that it is becoming more rare, and reproduction has not been recently documented. The decline of the species is probably due to habitat loss and the fish's inability to adapt to the changed Missouri River environment. Other possible threats are hybridization with the common shovelnose sturgeon (S. platorynchus), unintentional capture by anglers, and lack of information about the species. The fish is listed by the U.S. Fish and Wildlife Service as a Category 2 taxon, which does not receive substantive or procedural protection pursuant to the Endangered Species Act of 1973. However, the Service encourages federal agencies and other appropriate parties to take these taxa into account in environmental planning. Category 2 comprises taxa for which information now in possession indicates that proposing to list as endangered or threatened is possibly appropriate. All states in the Missouri basin protect the species; none in the Mississippi basin do. This report is a summary of published and unpublished information, and opinions of knowledgeable biologists. The report is organized according to guidelines for preparation of status reports (Henifin et al. 1981). A draft was reviewed by individuals representing agencies listed in the back of the report.

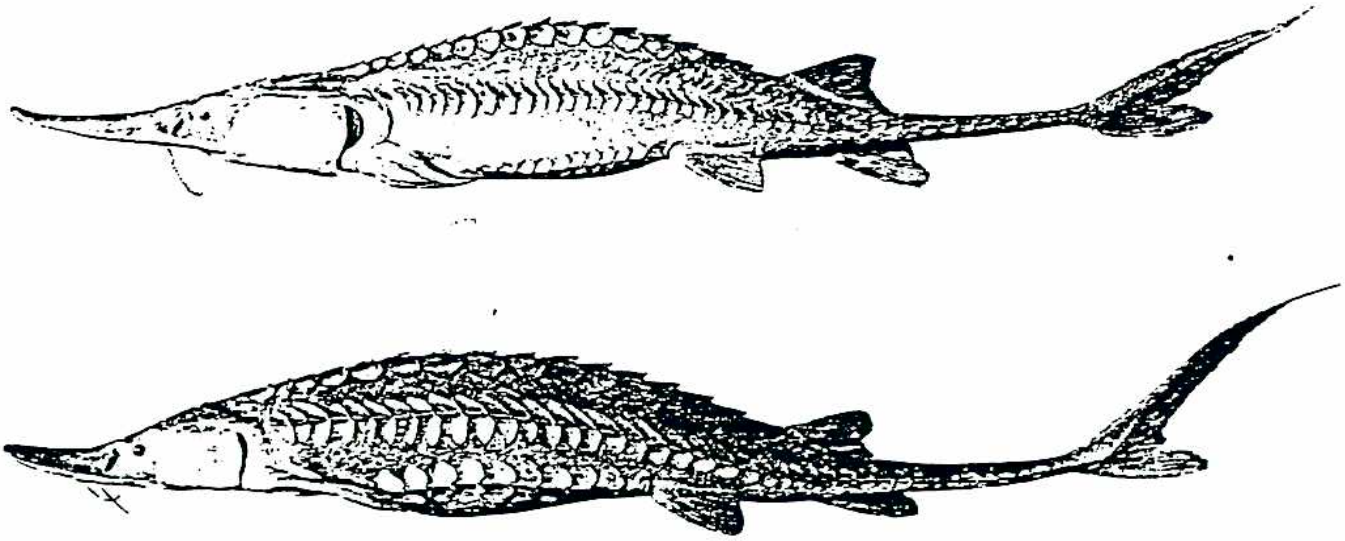
Scientific name of taxon: Scaphirhynchus albus (Forbes and Richardson).

Common name of taxon: Pallid sturgeon.

Family: Acipenseridae.

States where species occurs: Arkansas, Iowa, Illinois, Kansas, Kentucky, Louisiana, Missouri, Mississippi, Montana, North Dakota, Nebraska, South Dakota, and Tennessee, USA.

Current federal status: Category 2 (U.S. Department of the Interior 1985).



Pallid sturgeon (upper) and shovelnose sturgeon (lower). The figure is from Forbs and Richardson (1920) who reported that commercial fishermen caught what was believed to be "a distinct sturgeon, known to the fishermen of the locality as the white sturgeon---among the catches of the common shovelnose locally called the switchtail ... ." Seven specimens of the white sturgeon were sent to Forbs, all taken in fykenets at or near Grafton, Illinois. Fishermen reported that "the fish is more abundant along the Missouri---a fifth of the number were this species."

CONTENTS

I. Species Information.

1. Classification and nomenclature.

A. Species.

a. Binomial. Scaphirhynchus albus (Forbes and Richardson) (Pflieger 1975, American Fisheries Society 1980).

b. Full bibliographic citation. Parascaphirhynchus albus Forbes, S. A., and R. E. Richardson 1905. On a new shovelnose sturgeon from the Mississippi River. Bulletin of the Illinois State Laboratory of Natural History 7:37-44. Berg (1911) did not support the P. albus decision and placed albus in Scaphirhynchus (Berg, L. S. 1911). These taxonomic troubles are discussed by Bailey and Cross (1954).

c. Type specimen(s). Illinois Natural History Survey has five of the original nine specimens collected by Forbes and Richardson (1905) from the Mississippi River at or near Grafton, Illinois. Bailey and Cross (1954) described specimens located at the Museum of Natural History, University of Kansas; Department of Zoology, Tulane University; Museum of Zoology, University of Michigan; and the United States National Museum, Washington, D.C.

Additional specimens.

Ak-sar-ben Aquarium, Gretna, Nebraska has one 3.3 kg. pallid sturgeon in captivity which was caught in the Missouri River near Plattsmouth, Nebraska, and one 4.3 kg mounted specimen on display.

South Dakota State University has three preserved juvenile specimens and one frozen 17 kg specimen collected from the Missouri River at Bismarck, North Dakota.

South Dakota Department of Game, Fish and Parks has one 116 cm, 10 kg mounted pallid sturgeon, which was collected on the Missouri River near Farm Island, on display at Bluedog State Fish Hatchery.

Eleven Scaphirhynchus albus and 12 presumed hybrids analyzed by Carlson et al. (1985) are housed at the Missouri Department of Conservation research facility in Columbia, Missouri.

University of Kansas - one adult.

University of South Dakota - three adults.

Montana State University - One complete adult and one head from a large specimen collected at Intake, Montana in 1955 (William R. Gould, Assistant leader, Montana Cooperative Fishery Research Unit, Montana State University, Bozeman, MT pers. comm.).

2. **Pertinent synonym.** None.

3. **Common names.** Pallid sturgoen, white sturgeon, white shovelnose, white hackleback (Kallemeyn 1983), and rock

sturgeon (Bailey and Cross 1954).

4. **Taxon codes.** Not applicable.

5. **Size of genus.** Two; occurs with the shovelnose sturgeon, Scaphirhynchus platorynchus Rafinesque.

B. Family Classification.

1. **Family name.** Acipenseridae.

2. **Pertinent synonyms.** None.

3. **Common name for family.** Sturgeon.

C. Major group. Primitive cartilaginous fishes (Order Acipenseriformes). Members of the genus Acipenser are also called sturgeons; these include shortnose (A. brevirostrum), lake (A. fulvescens), green (A. medirostris), Atlantic (A. oxyrhynchus), and white sturgeon (A. transmontanus). The biology and management of selected sturgeons were recently reviewed at a symposium (American Fisheries Society, Annual meeting 1983, Milwaukee, Wisconsin). Symposium results were published in Environmental Biology of Fishes, Volume 14(1), 1985. Deas (1961) discussed the life history, behavior, protection, capture, and value of sturgeons.

D. History of knowledge of the taxon. See Bailey and Cross (1954). Original collection was made in the Mississippi River at or near Grafton, Illinois (Forbes and Richardson 1905). The earliest published record of the species was a 21.3 kg fish from the Missouri River at Fort Benton, Montana. Although identified as a shovelnose sturgeon by Cope (1879), specimen size indicated it was a pallid sturgeon.

E. Comments on current alternative taxonomic treatments.

Kallemeyn (1983) discussed historical application of the name. Shovelnose and pallid sturgeon were indistinguishable at 37 loci examined by electrophoresis (Phelps and Allendorf 1983). The similarity at such a large number of loci suggests a close genetic relationship between these two species. Carlson et al. (1985), using principal components analysis, confirmed separation of the pallid and shovelnose sturgeon based on phenotypic variation.

2. Present legal or other formal status.

A. International.

1. Present designated or proposed legal protection or regulation. None.

B. National.

1. United States.

a. Present designated or proposed legal protection or regulation. No official listing proposed for this species (U.S. Fish and Wildlife Service 1986), but it has been labeled a Category 2 taxon, which does not receive protection; however the Category 2 designation suggests that federal and other agencies consider the pallid sturgeon in environmental planning.

C. State. The status and regulations for the pallid sturgeon in each state are summarized in Table 1.

3. Description.

A. General nontechnical description. The pallid sturgeon is

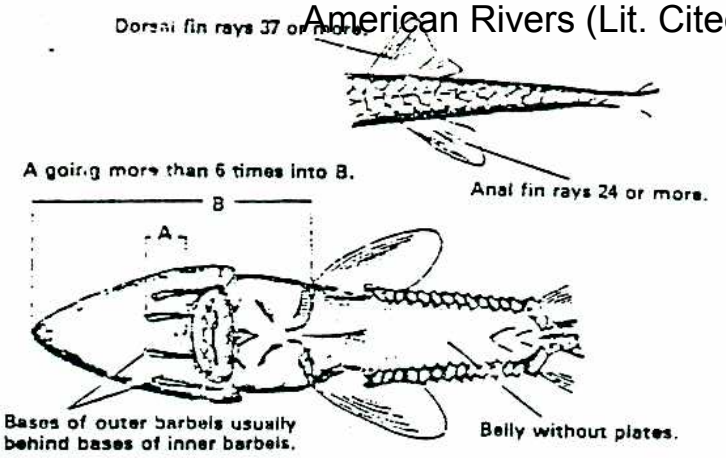
characterized by a flattened, shovel-shaped snout and long, slender tail with prolonged upper lobe completely covered with bony plates. Most of the skeletal structure is cartilage rather than bone. The toothless, protrusible mouth is under and far behind the nose. Four barbels are in front of the mouth; the two outside are longer than the two inner barbels. Pallid sturgeons are usually light brown on the back and white on the belly. Weight and length can exceed 27 kg and 1.5 m although weights less than 9 kg are presently more common.

Table 1. Status and regulation of the pallid sturgeon (Scaphirhynchus albus) in each state; updated from Miller (1972) and Kallemeyn (1983).

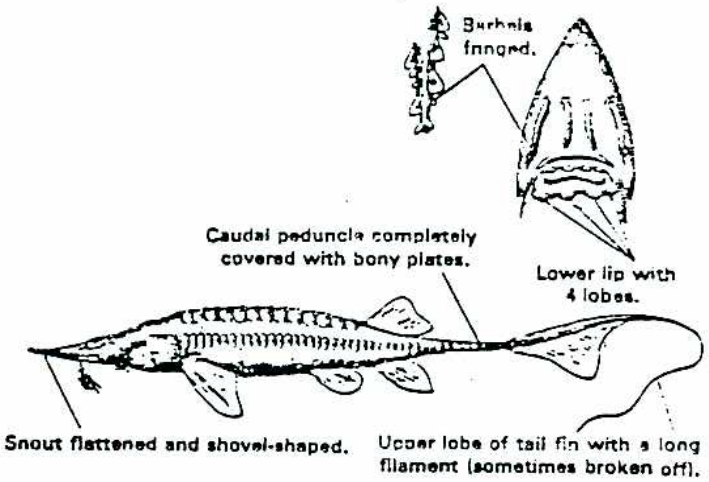
State	Classification	Regulation	Citation
Arkansas	None	---	
Iowa	Endangered	Must release	
Illinois	Rare	---	
Kansas	Endangered	Must release	KS Fish & Game Comm. (1986)
Kentucky	Endangered	---	
Louisiana	Rare	---	
Missouri	Endangered	Must release	
Montana	Special Concern	Must release if > 16 lbs.	Holton (1980)
Nebraska	Endangered	Must release	Ryckman (1985)
North Dakota	Threatened	Must release if > 36 in.	
South Dakota	Threatened	Must release	Houtcooper et al. (1985)
Tennessee	Wildlife in need of management	---	

B. Technical description. The genus Scaphirhynchus is characterized by a long, tapering, extremely depressed, broad and shovel-like snout (Fig. 1). The body is long and subcylindrical and the flat ventral surface is usually white. The darker lateral and dorsal surfaces are armored with five longitudinal rows of large bony shields or scutes. The carinate (ridged) scutes are strongly spined in young sturgeon but dull with age and may become completely embedded within the skin in older fish. The head is protected by bony plates joined at sutures; the skeleton is mainly cartilage with a persistent notochord. A traverse row of four barbels is located anterior to the subterminal protractile mouth. The anal and dorsal fins are placed far back on the body, posterior to the abdominal pelvic fins. The pectoral fins are relatively large and situated near the ventrolateral border just behind the gill opening. The upper lobe of the heterocercal (Nikolsky 1963) caudal fin sometimes terminates in a filament (Moos 1978).

Head length is at least 30.5 percent of the standard length (Bailey and Cross 1954). The snout is pointed and long, at least 17.4 percent of the standard length. Orbit length is about 250 mm. Mouth width is more than 8.9 percent of body length. The outer barbels are placed behind the inner barbels; the line through their bases is convex forward. The ratio "snout tip to outer barbel: mouth to inner barbel" is 2.29 to 3.26. Length of the inner barbel is 3.7 to 5.0 percent of the standard lenth. The outer barbel is 8.7 percent of standard



Pallid



Shovelnose

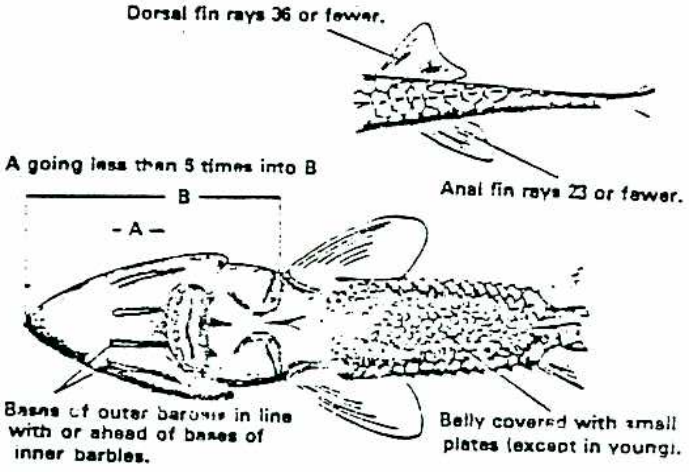


Figure 1. Distinguishing characteristics of shovelnose (Scaphirhynchus platorynchus) and pallid (S. albus) sturgeon (from Pflieger 1975).

length. The tip of the outer barbel reaches or exceeds the sharp angle of the suborbital. The ratio between the lengths of inner to outer barbels is 1.64 to 2.41. The shorter inner barbel is slender, with a basal diameter about one half as great as that of the outer barbel. Fringing (papillae) of the barbel is poorly developed. The two dorsal series of papillae are better developed than the ventral file. Fringing on the longer barbels is usually stronger than on the shorter ones. The anal fin base varies from 4.7 to 5.5 percent of the length. Lesser dermal ossifications are mostly small spicules. Most of the belly is naked at all ages. The strip between the lateral plates and the midventral plating usually extends back about as far as the origin of the anal fin. Average total length is 533-838 mm; maximum standard length is 1100 mm (Lee et al. 1980). Most morphological features distinguishing the species have been determined on adult fish; little work has been conducted on larval specimens. Pigmentation, size, and total myomere counts are important for distinguishing lake and shovelnose sturgeon, but cannot separate shovelnose and pallid sturgeon (Carlson 1983).

Fogle (1961) reported that male pallid sturgeon matured at three or four years of age and 533-584 mm total length. The age and size at maturity for females is unknown. Fogle (1963), Brown (1971), and Carlson et al. (1985) presented annual growth data (Table 2). June (1981) reported that a 27-year-old pallid sturgeon was caught in a gill net in Lake Sharpe, South Dakota.

Table 2. Pallid sturgeon (Scaphirhynchus albus) lengths at various ages.

Age	Montana Brown (1971) length (mm)	Lake Oahe Fogle (1963) from Carlander (1969) length (mm)	Missouri River Carlson et al. (1985) length (mm)
1	279	279	
2	406	378	
3	457	470	
4	559	574	480
5	635	638	530
6		673	
7		732	
8		790	640
9		838	690
10		881	
11			620
12			
13			890
14			750

C. Local field characters. Carlson et al. (1985) found that the length of the pallid was significantly greater than that of the shovelnose sturgeon for each age group compared (age determined by pectoral fin ray sectioning). In life the pallid is much more pale than the shovelnose sturgeon. The primary morphological characteristics that separate the two species are head length, inner barbel length, the distance from the snout tip to the outer barbel, and the height of the tenth lateral plate (Fig. 1). Pallid sturgeon have 24 or more anal fin rays and 37 or more dorsal fin rays (Phelps and Allendorf 1983). Differences in structural features such as swim bladder size, belly plates and gill rakers are also apparent. Bailey and Cross (1954) presented comparisons of various body measurements separating adult pallid and shovelnose sturgeons.

D. Identifying characteristics of material which is in interstate or international trade or commerce. Eggs (caviar) are brown or black compared to the yellowish or orange eggs of many fish species. Scaphirhynchus were traditionally smoked by commercial fishermen (Coker 1930) and others (Helms 1974).

E. Photographs and/or line drawings.

Brown (1955) - photograph of Montana state record North Dakota Outdoors (1956) - black and white photograph.

North Dakota Outdoors (April-May 1985) fishermen with pallid sturgeon (Ryckman 1985).

North Dakota Outdoors (August, 1986) fisherman with sturgeon.

U.S. Fish and Wildlife Service, Ecological Services, Pierre, South Dakota - Six 35 mm slides of pallid sturgeon from various body angles.

Ak-sar-ben Aquarium - 35 mm color slides of their captive specimen.

4. Significance.

A. Natural. The difficulties of studying the life history and population dynamics of sturgeon are enormous (Ragotzkie 1985). Sturgeons other than Scaphirynchus spp. are anadromous, widely distributed freshwater fishes of the northern hemisphere. Known from the Upper Cretaceous, sturgeons represent a relic form of a fish group that was dominant in early geological history. The family includes 23 species in 4 genera: Huso, 2 species, Pliocene to Recent; Acipenser, 16 species, Upper Cretaceous to Recent; Scaphirhynchus, 2 species; and Pseudoscaphirhynchus, 3

species (Scott and Crossman 1973). Among the many endemic genera of North American freshwater fishes, one of the most distinctive is Scaphirhynchus (Bailey and Cross 1954). Except for the two species of Scaphirhynchus, the only living "shovelnose" sturgeons occupy tributaries of the Aral Sea, north of Afghanistan (Cross and Collins 1975). The pallid sturgeon ranks among the largest of the freshwater fishes (Pflieger 1975). Among the fish species considered rare on the Missouri River, the pallid sturgeon is one of the few true riverine inhabitants (Schmulbach et al. 1975).

Peculiar adaptations or structures. Scaphirhynchus, from Greek, means "spade snout." The heterocercal caudal fin and slender caudal peduncle facilitate upward movement (Nikolsky 1963). Several longitudinal rows of bony plates cover the body instead of scales. The genus is very tolerant of high turbidity (Pflieger 1975) because the barbels aid in food identification in turbid waters where visibility is limited. The highly protrusible lips are adapted for sucking (Cross 1967). Dean Rosenthal (Biologist, Nebraska Game and Parks Commission, Gretna, NE, pers. comm.), observing the feeding habits of the pallid sturgeon at the Ak-sar-ben Aquarium, reported that food items (fathead minnows and goldfish) touching the outer two barbels would cause no feeding response. However, food items touching the inner barbels would elicit protrusion of the mouth, suction, and ingestion. The body is flattened dorsoventrally and streamlined for life at the bottom of swift flowing rivers.

The abrasive effect of waterborne mud and sand are reduced by the tough hide and small eyes (Cross and Collins 1975).

Disjunction or endemism in range. Pallid sturgeons were restricted to the large, turbid, free-flowing Missouri and Mississippi river drainages. Six dams on the middle Missouri River have caused disjunction of riverine habitat, habitat loss, and reduced migration.

The type specimen was taken in the Mississippi at the mouth of the Illinois River. Collections of pallid sturgeons from tributaries of the Missouri and Mississippi rivers have been limited to the Yellowstone, Little Missouri, Platte, Kansas, and St. Francis rivers.

Taxonomic uniqueness. Scaphirhynchus is unique to the Acipenseridae due to the absence of a spiracle and possession of a fully armored caudal peduncle. The pallid sturgeon is unique to the genus due to larger maximum size than the shovelnose sturgeon (Carlson et al. 1985).

Obligate relationships with other species. There are no known obligate relationships with other species. The sicklefin chub, Hybopsis meeki Jordan and Evermann, has a similar habitat preference and distributional pattern (Bailey and Cross 1954). The sicklefin chub is also considered a rare species.

Pallid and shovelnose sturgeon habitat may overlap, particularly where reproduction occurs (Carlson et al. 1985). Hybrids of pallid and shovelnose sturgeon have been collected in the Missouri and Mississippi rivers in the state of Missouri.

B. Significance to Humans. When sturgeon were harvested commercially in the Missouri and Mississippi rivers, pallid sturgeon may have been a prize catch because of their size. Both the flesh and roe (eggs) were prized by the public. Commercial aquaculture of the white sturgeon is expanding in California and similar successes with the pallid sturgeon are possible if a broodstock could be found. Pallid sturgeons are of interest to anglers because of their unique appearance and large size. They are of biological interest because they represent a primitive species.

5. Geographical Distribution.

A. Geographical range. Pallid sturgeons have been found in 13 states within the United States.

B. Precise occurrences.

North Dakota: Missouri River throughout the state and the lower Yellowstone River (Hankinson 1928, McKenna and Seabloom 1976).

South Dakota: Missouri River throughout the state (Bailey and Allum 1962).

Nebraska: Missouri River, Platte River at the confluence with the Missouri River, Platte River at the Interstate 80 bridge.

Missouri: Missouri and lower Mississippi River, penetrating only a few miles into the Mississippi River upstream from the confluence of the Missouri River (Pflieger 1975, Missouri Dept. of Conservation, 1984).

Occurrences in other states have been less frequent and

widely distributed. Precise locations are shown in Figure 2 a-f.

C. Status and location of presently cultivated material. The only living specimen in captivity is on display at Ak-sar-ben Aquarium, Gretna, Nebraska.

D. Biogeographical and phylogenetic history. These ancient fish evolved over 200 million years ago (Binkowski and Doroshov 1985). The extinct family Chondrosteidae is known from the Lower Jurassic to the Lower Cretaceous (Scott and Crossman 1973). A shovelnose sturgeon from the Upper Cretaceous was found 24 miles southeast of Fort Peck, Montana. Scaphirhynchus had assumed its most distinctive structural features by the Cretaceous (Moore 1950, Bailey and Cross 1954). The pallid and shovelnose sturgeons are phylogenetically similar (Phelps and Allendorf 1983).

6. General environment and habitat description.

A. Concise statement of general environment and habitat. Pallid sturgeons require large, turbid, free-flowing riverine habitat with a rocky or sandy substrate. They prefer main channel pools below sandbars (Kallemeyn and Novotny 1977). When found in reservoirs, they have been captured from the headwaters of the reservoirs where conditions are riverine-like (Kallemeyn 1983). Joseph (1977) listed numerous unpublished studies of the fisheries of the Missouri River reservoirs in which the pallid sturgeon is mentioned.

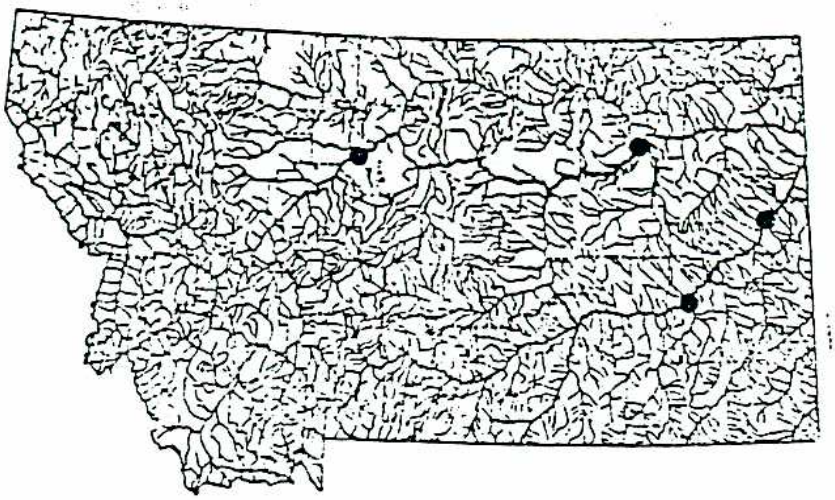


Figure 2a. Montana (Brown 1971): Missouri River below Marias River and the Yellowstone River downstream from the Tongue River.

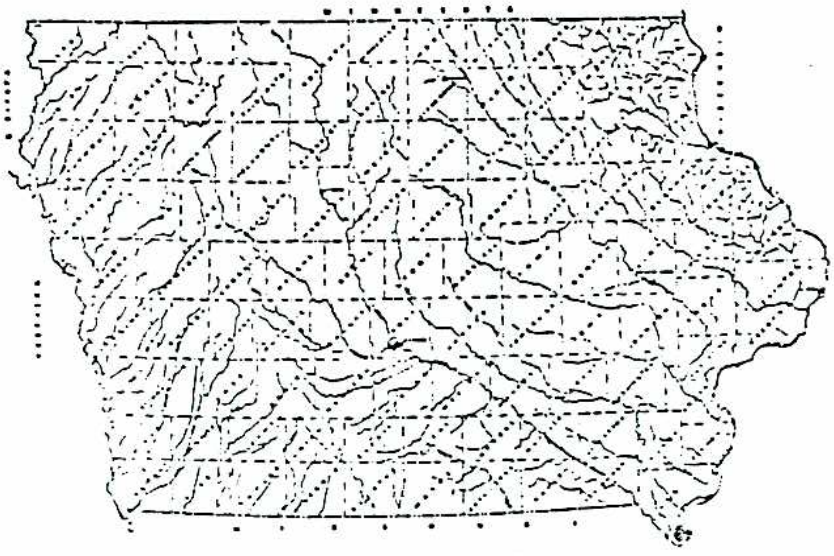


Figure 2b. Iowa (Harlan and Speaker 1969): Missouri and Mississippi rivers. Only a single specimen reported for the Mississippi River (Coker 1930) before construction of the Keokuk locks.

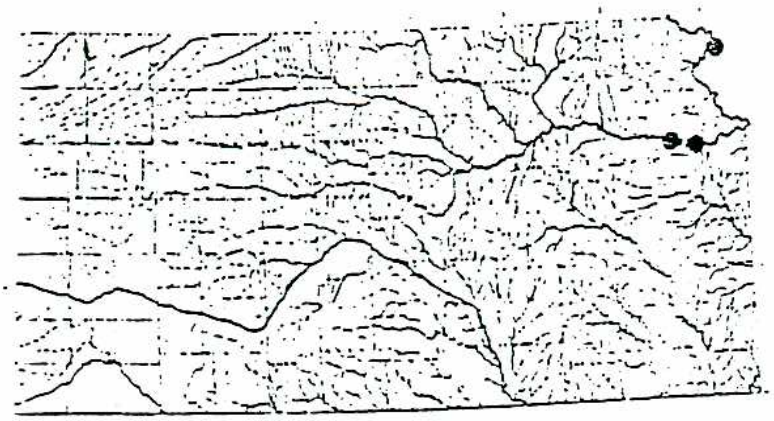


Figure 2c. Kansas (Cross 1967): mainstream of the Missouri River and lower Kansas River (only in years of exceptionally high water).

Figure 2d. Illinois (Smith 1979): mouth of Missouri River (Barnickol and Starrett 1951), and Mississippi River (Jackson County).

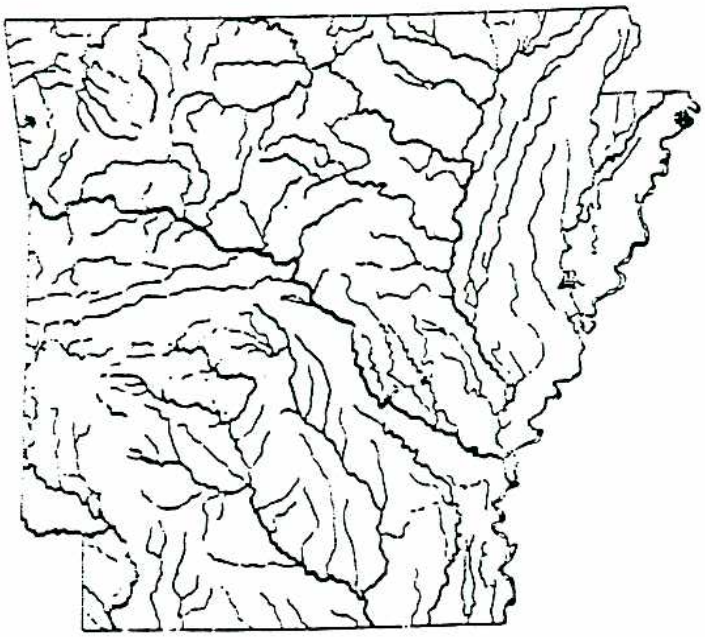


Figure 2e. Arkansas (Buchanan 1974): the Mississippi and lower St. Francis rivers.

Figure 2f. Louisiana (Douglas 1974): East Carroll Parish, Mississippi River at Lake Providence.

B. Physical characteristics.

1. Climate.

a. Koppen Climate Classification. Not applicable.

b. Regional macroclimate. The Middle Missouri and Mississippi rivers are contained in the Great Plains. The climate of this region is continental, typified by low rainfall and extreme seasonal temperature variations. Reigh (1978) and Slizeski et al. (1982) provide a detailed description of the regional climate.

2. Water quality requirements. Specific water quality requirements are unknown but in general pallid sturgeons are restricted to freshwater (Moos 1978) and are adapted to turbid rivers. Flooded tributaries may be utilized seasonally; the only report of pallid sturgeon in the Kansas River was when the river was at flood stage (Cross 1967).

If water quality characteristics of the unaltered Missouri River are the pallid sturgeon's preference, then development has altered its habitat significantly. Damming has changed riverine water quality features such as current velocity, seasonal flow, turbidity, temperature, and possibly carbon inputs (Russell 1986, Unkenholz 1986, Hesse 1987). Present water quality in the middle Missouri is discussed by Todd and Bender (1982). Channelization has reduced the surface area of the Missouri River by about one-half; yet the velocity has nearly doubled (Funk and Robinson 1974). Sediment load,

especially in the winter, is noticeably smaller (Funk and Robinson 1974, Kallemeyn and Novotny 1977) in the Missouri section of the Missouri River than that described by Ellis (1936) before impoundment.

3. **Physiographic province.** Not applicable.
4. **Physiographic and topographic characteristics.** Because the lower and middle Missouri River appears to be in the center of pallid sturgeon range, most physiographic information included here deals with glaciation of the northcentral plains. Wisconsin glaciation altered flow of the Missouri River from northeast to southeast, dissecting many eastward-flowing rivers in the Great Plains and creating western tributaries (Reigh 1978). The glaciated area immediately east of the Missouri River is the coteau, typified by rolling, poorly drained topography and a thin mantle of glacial till. Unglaciated areas to the west display a mature, heavily dissected topography. Easily erodible strata west of the Missouri River causes extremely high turbidity in western tributaries, which are also highly alkaline due to runoff from alkaline soils formed from ancient marine deposits. Differences in physiography, climate, and soils cause tributary streams east of the Missouri River to have a different fauna than those to the west.
5. **Edaphic factors.** Soils in the Missouri River drainage are sandy-loam; the bed of the river was historically unconsolidated sand. Frank Cross (Curator of Fishes,

University of Kansas, Lawrence, KS, pers. comm.) suggested that reservoir construction has reduced high flows necessary to wash larger sand particles downstream. The fine sand which is now deposited results in a more consolidated, firmly packed substrate. The sediment loading characteristics of the Missouri River are discussed by Slizeski et al. (1982). Average suspended sediment concentrations range from 200 to 1,500 mg/l during normal navigation flows, to 5,000 mg/l during floods. Suspended sediment is mostly sand with approximately equal amounts of silt and clay (Slizeski et al. 1982).

6. **Dependence on dynamic aspects.** The erosional nature of a river system that deposits silt and fine sands downstream may be significant for this taxon. In addition, periodic flooding and low water conditions deposit sand bars, which are important features of the pallid sturgeon's preferred habitat (Schmulbach et al. 1975). Pallid sturgeon were captured in the Kansas River in 1952, following unprecedented flooding (Cross 1967). Extensive dam-building in that drainage has reduced the probability of extreme flood situations; no pallid sturgeons have been captured in the Kansas River since 1952. Damming of the Missouri River has resulted in large slack water pools, thus minimizing the free-flowing spawning areas. Seasonal flow differences may trigger sturgeon spawning migrations in free-flowing rivers (Zakharyan 1972, Peterman 1977a). The spring high water

surge also helps form and maintain the river channel. High flows are necessary to start the river gravels (collectively called bedload) moving to form islands, gravel bars, and shoal areas (Peterman 1977b).

7. **Other unusual physical features of environment and habitat.** None known.

C. **Biological characteristics.**

1. **Community structure.** Pallid sturgeon are a component of the warmwater, riverine community.

2. **Regional vegetation type.** The Missouri and Mississippi river drainages are contained in the Great Plains short grass prairie, tall grass prairie, Aspen Parkland, eastern deciduous forest, outer coastal plain forest and southeastern mixed forest provinces (Bailey 1980).

The free-flowing sections of the Missouri River provide a variety of riparian and riverine habitat types that have been lost on much of the channelized and impounded stretches. Major riparian habitat types include cottonwood-dogwood (Populus deltoides-Cornus stolonifera), cottonwood-willow (P. deltoides-Salix spp.), and elm-oak (Ulmus americana-Quercus macrocarpa) forest (Clapp 1977). Riverine habitat includes sandbars, islands, and a variety of wetlands. About 15% of the unchannelized river is cattail (Typha angustifolia) marsh that support a higher fish standing crop and diversity than sand bar habitat (Kozel and Schmulbach 1976).

Channelization has eliminated over 100,000 acres of

aquatic habitat and 374,000 acres of wetland and terrestrial habitat from the natural river and its floodplain in the reach from Sioux City, Iowa to the mouth at St. Louis, Missouri (U.S. Fish and Wildlife Service 1980). Extensive development following channelization, including row-crop agriculture and urban and industrial encroachment, has dramatically changed the composition of the natural plant communities which formerly colonized the floodplain.

3. **Frequently associated species.** Bailey and Cross (1954) stated that the sicklefin chub, Hybopsis meeki Jordan and Evermann, seemed most closely associated with pallid sturgeon, both in habitat preference and distributional pattern. Pallid sturgeon coinhabit free-flowing rivers with shovelnose sturgeon but prefer more turbid water (Lee et al. 1980) and possibly swifter current (Carlson et al. 1985).
4. **Dominance and frequency.** Although one of the largest species in the Missouri-Mississippi river system, pallid sturgeon were considered present in low densities throughout their range in the 1950's (Bailey and Cross 1954). Pallid sturgeon were outnumbered by shovelnose sturgeon 1:20 to 1:6392 (Table 3). However, they are not routinely captured.
5. **Successional phenomena.** Allogenic succession (driven by external factors) typifies succesional phenomena of the Missouri River fish community, but nothing is known about the sturgeon's successional ecology. It is a long-lived species and hence would resist short-term, sublethal habitat change.

6. **Dependence on dynamic biotic features.** The abundance and distribution of fish forage is a biotic feature that is highly dynamic in riverine systems; however, the effects on pallid sturgeon are unknown.

7. **Other endangered species.** The sicklefin chub and the sturgeon chub, Hybopsis gelida, were historically present with the pallid sturgeon. Sicklefin chubs are now classified as endangered in Kansas (Kansas Fish and Game Commission 1986), rare in Missouri (Missouri Department of Conservation 1984) and North Dakota (Kreil 1986), a "species of special concern" in Montana (Holton 1980), and threatened in South Dakota (Houtcooper et al. 1985). Their disappearance in the middle Missouri River apparently coincided with the reduction in pallid sturgeon captures.

   The sturgeon chub inhabits the open channels of large, silty rivers such as the Missouri River and occurs in the swift current over a bottom of sand or fine gravel (Cross 1967, Pfleiger 1975). A single sturgeon chub was collected in the middle Missouri River during extensive sampling by Hesse et al. (1982).

7. Population biology.

A. General summary. Pallid sturgeon are long lived, slow growing, and mature at an unknown but probably advanced age (males 3-4 years, females perhaps 5-6 years). Reproduction is believed to occur from June 1 to August 1 but has not been well documented. Hybridization of pallid and shovelnose sturgeon

has occurred in the Missouri and Mississippi rivers in the state of Missouri in the last 20 to 30 years (Carlson et al. 1985). Lock and dam construction may have created subpopulations of pallid sturgeons that are associated with each impoundment and tail water. In addition, there are populations in the free-flowing Yellowstone and upper and lower Missouri rivers.

B. Demography.

1. Known populations. This species is potentially present in the Missouri River from Great Falls, Montana to the mouth, and in the Mississippi River from the confluence of the Illinois River to New Orleans. Due to the extreme rarity of the species, no population estimates have been made.

H. L. Ashlock (Forbes and Richardson 1905) stated that the pallid sturgeon was more abundant in the lower Missouri than the Mississippi River, based on its occurrence in commercial catches and ratio to the abundant shovelnose in both rivers (Table 3). Others have also used the pallid:shovelnose ratio when reporting pallid sturgeon densities. Kallemeyn (1983) presented circumstantial evidence, based on commercial landings, that pallid sturgeon densities had declined in the Missouri, Kansas and South Dakota sections of the Missouri River.

Table 3. Ratio of pallid (Scaphirhynchus albus) to shovelnose (S.platorynchus) sturgeon in the Missouri and Mississippi rivers.

Missouri River	Mississippi River	Citation
1:5	1:500	Forbes and Richardson (1905)
	1:300	" " (1920)
1:20 - 1:6392		Kallemeyn (1983)
1:200	1:181	Carlson et al. (1985)
1:4801		Moos (1978)

2. **Demographic details.** Pallid sturgeon reports were subdivided by drainage and Missouri River impoundment.

a. Upper Missouri River:

1. Area. Missouri River from Great Falls to Fort Peck Dam.

2. Number and size of fish. The first reported pallid sturgeon in Montana was a 21.3 kg fish taken at Fort Benton by Cope (1879).

3. Density. Unknown.

4. Evidence of reproduction. None.

5. Evidence of expansion/contraction. Unknown.

b. Lower Yellowstone River:

1. Area. Yellowstone River below Forsyth or Cartersville, Montana, from the diversion structure to mouth.

2. Number and size of fish. A 17 kg fish was taken at the mouth of the Tongue River in 1950 (Brown 1955). Haddix and Estes (1976) reported capturing a 11.3 kg pallid sturgeon while electrofishing below Intake, Montana, in

1975. The Montana state record, 27.2 kg, was taken in 1979 on a setline near Sidney.

3. **Density.** Pallid sturgeons are rare, occasionally taken at the mouth of the Tongue River and below the intake diversion structure (Haddix and Estes 1976). Pallid sturgeons were taken by electrofishing from Fairview, North Dakota, to the mouth during a paddlefish cooperative study with Montana in 1977 and 1978 (Greg Power, Fisheries Research Biologist, North Dakota Game and Fish Department, Riverdale, ND, 1987 correspondence). Seldom are more than one to three pallid sturgeons reported annually from the Yellowstone River in Montana (Peterman and Haddix 1975).
4. **Evidence of reproduction.** None reported.
5. **Evidence of expansion/contraction.** The irrigation diversion structure that was constructed at Forsyth, Montana, in 1904 probably blocked upstream movement of shovelnose and, presumably, pallid sturgeon (Graham et al. 1979).

c. **Fort Peck Dam tailrace to Garrison Dam:**

1. **Area.** Missouri River from Fort Peck Dam downstream to Garrison Dam, North Dakota.
2. **Number and size of fish.** The unofficial world record, 38.5 kg, was taken from the Missouri River at Williston, North Dakota (Ryckman 1985). One possible albino (pure white), approximately 2.2 kg, was taken near Mallard Island, Lake Sakakawea, in 1981, in water less than 100

feet deep.

3. **Density.** Not known.

4. **Evidence of reproduction.** None reported.

5. **Evidence of expansion/contraction.** Since 1956, at least one pallid sturgeon has been netted during population sampling studies in Lake Sakakawea, from the mouth of the Yellowstone River to Garrison Dam, in 14 of 23 years sampled (Berard 1984).

d. **Garrison Dam tailrace to Oahe Dam:**

1. **Area.** Missouri River from Garrison Dam downstream to Oahe Dam, South Dakota.

2. **Number and size of fish.** The world record pallid sturgeon, 36.8 kg was taken near Washburn, North Dakota, in 1956 (North Dakota Outdoors 1956). The North Dakota state record, 22.6 kg was caught on hook and line in 1984. South Dakota Natural Heritage Database has the following sites and dates listed for collections of individual fish on this river stretch: Lake Oahe (1971), Grand River mouth (1952), and Okobojo Creek (1985) (George Vandel, Assistant Director, Wildlife Division, South Dakota Department of Game, Fish and Parks, Pierre, SD, pers. comm.).

3. **Density.** There was a reasonably good population in 1967, based on unspecified catches during test netting (Dale Henegar, Fisheries Division Chief, North Dakota Game and Fish Department, Bismarck, ND, 1967 memorandum). Since

1956, population studies have resulted in the collection of at least one pallid sturgeon during 7 of 22 years sampled in that portion of the Missouri River, between Bismarck, ND, and the South Dakota border (Oahe Reservoir) (Greg Power, 1987 correspondance).

4. **Evidence of reproduction.** Fred June (Fisheries Biologist, U.S. Fish and Wildlife Service, Pierre, SD, 1967 memorandum) reported no young-of-year pallid sturgeon taken in extensive trawling and seining in Oahe Reservoir and Lake Sharpe.

5. **Evidence of expansion/contraction.** Not known.

e. **Oahe Dam tailrace to Big Bend Dam:**

1. **Area.** Missouri River from Oahe Dam downstream to Big Bend Dam, South Dakota.

2. **Number and size of fish.** Art Talsma (Director, Division of Wildlife, South Dakota Department of Game, Fish and Parks, Pierre, SD, pers. comm.) saw one pallid sturgeon caught on hook and line in the tailrace below Oahe Dam. Scuba divers have reported large pallid sturgeon in the same area. In 1979, 2 pallid sturgeons averaging 104 cm and 4.7 kg were captured. In 1985, 1 pallid sturgeon approximately 121 cm and 9-13 kg was captured in Lake Sharpe (Robert Krumm, Fisheries Biologist, South Dakota Department of Game, Fish and Parks, Mobridge, SD, pers. comm.). South Dakota Natural Heritage Database has the following sites and dates listed for collections of

individual fish on this river stretch: Lake Sharpe (1975), Antelope Creek (Lake Sharp) (1983), and Stony Point, south of Medicine Knoll Creek mouth (Lake Sharpe) (1983) (George Vandel, Assistant Director, Wildlife Division, South Dakota Department of Game, Fish and Parks, Pierre, SD, pers. comm.). One pallid sturgeon was captured during 1986 test netting in Lake Sharpe (Jim Riis, Fisheries Biologist, South Dakota Department of Game, Fish and Parks, Pierre, SD, pers. comm.).

3. **Density.** Not known.

4. **Evidence of reproduction.** None reported.

5. **Evidence of expansion/contraction.** Not known.

f. Big Bend Dam tailrace to Fort Randall Dam:

1. **Area.** Missouri River from Big Bend Dam downstream to Fort Randall Dam, South Dakota.

2. **Number and size of fish.** Robert Krumm (1967 memorandum) reported that 954 fish averaging 7-9 kg were caught between 1959 and 1965 at the upper end of Lake Francis Case (Fort Randall Reservoir). Gasaway (1970) reported as many as 78 sturgeon, presumably pallids, taken yearly by commercial fishermen from 1959 to 1968.

3. **Density.** Unknown.

4. **Evidence of reproduction.** None reported.

5. **Evidence of expansion/contraction.** None.

g. Fort Randall Dam tailrace to Gavins Point Dam:

1. **Area.** Missouri River from Fort Randall Dam downstream to

Gavins Point Dam.

2. **Number and size of fish.** Robert Krumm (1967 memorandum) reported 9 pallid sturgeon, ranging from 1.6 to 8.8 kg, taken in the Springfield area downstream to Bon Homme Colony, 1957. Kallemeyn and Novotny (1977) reported one pallid sturgeon taken in this area in 1976. Mike Avery (Biologist, Nebraska Game and Parks Commission, Ak-sar-ben Aquarium, Gretna, NE, pers. comm.) caught an 45-50 cm, pallid sturgeon on hook and line near the Sunshine Bottom area in 1986. Larry Hesse (Biologist, Nebraska Game and Parks Commission, Norfolk, NE, pers. comm.) reported a 22.5 kg pallid sturgeon caught at the mouth of the Niobrara River.
3. **Density.** Unknown.
4. **Evidence of reproduction.** None reported in the Missouri River. The Niobrara, a major tributary of the Missouri River, may offer a better spawning and nursery environment than the Missouri River-Lewis and Clark Lake (Gavins Point Reservoir) system. However, no Scaphirhynchus young were captured during extensive sampling in 1976 and 1977 (Hesse et al. 1979).
5. **Evidence of expansion/contraction.** Habitat degradation threatens to destroy possible reproductive habitat in the remaining unchannelized river below Fort Randall Dam (Hesse and Newcomb 1982).

h. Gavins Point Dam tailrace to mouth:

1. **Area.** Missouri River from Gavins Point Dam downstream to the mouth at St. Louis, Missouri.

2. **Number and size of fish.** Moos (1978) reported considerable movement of shovelnose sturgeon in this river section. Pallid sturgeon are frequently captured by fishermen, using "green worms" dug from riverbanks and hook and line fishing in the Platte and at the mouth of the Platte River, Schilling Wildlife Management Area, Plattsmouth, Nebraska. Since 1979, six or seven fish weighing approximately 4.5 kg each have been taken by anglers to Ak-sar-ben Aquarium for identification (Dean Rosenthal, pers. comm.). South Dakota Natural Heritage Database has the following sites and dates listed for collections of individual fish on this river stretch: 15 km west of Vermillion on the Missouri River (1970), tailwaters of Gavins Point Dam (1976), Missouri River at and 8 km east of Yankton (1952), and the Missouri River about 2 mi below Gavins Point Dam (1952) (George Vandel, Assistant Director, Wildlife Division, South Dakota Department of Game, Fish and Parks, Pierre, SD, pers. comm.).

3. **Density.** Researchers must look at thousands of shovelnose sturgeon to find one pallid sturgeon (Carlson and Pfleiger 1981). Since 1940 the density of shovelnose sturgeon has not changed much in this section of the river (Pflieger and Grace 1987). Like most riverine species, shovelnose

(and presumably pallid) sturgeon are better able to tolerate habitat change in areas that remain riverine even though somewhat affected by reservoir construction, compared to areas more directly affected by inundation or dam releases.

4. **Evidence of reproduction.** No young-of-year pallid sturgeon have been collected in the Missouri River below Gavins Point Dam using electrofishing, selective toxicants,

and seine nets (Kozel 1974, Schmulbach et al. 1975). Moos (1978) reported one larval sturgeon captured by a plankton net in the Missouri River National Recreation River (MNRR) stretch (Gavins Point Dam to Ponca, Nebraska) in 1969. No pallid sturgeon were among some 68,000 larvae collected from middle Missouri River (Hergenrader et al. 1982).

5. **Evidence of expansion/contraction.** Three captures in the MNRR in the past 20 years have been recorded (James Schmulbach, Fisheries Professor, University of South Dakota, Vermillion, SD, pers. comm.). No pallid sturgeon have been captured by Nebraska biologists since 1979 (Larry Hesse, Fisheries Biologist, Nebraska Game and Parks Commission, Norfolk, NE, pers. comm.). None were among some 90,000 adult fish collected by Hesse et al. (1982) over a five year period from the Missouri River (Nebraska). Extensive netting in the lower Missouri and Mississippi rivers by Carlson et al. (1985) produced 4355

sturgeons: 11 (0.2%) were pallid sturgeons and 12 (0.3%) were pallid-shovelnose hybrids. The pallid to shovelnose ratio (Table 3) was substantially lower than that found earlier by Fisher (1962). Pflieger and Grace (1986) predicted that the pallid sturgeon could disappear from the lower Missouri River. Funk and Robinson (1974) reported a steady decline in the total sturgeon catch between 1894 and 1970 in the lower Missouri River. Shovelnose sturgeon have also become more rare. Kallemeyn and Novotny (1977) found no shovelnose sturgeon in channelized portions of the river. Schmulbach et al. (1975) found decreased densities of shovelnose sturgeon in the channelized river below Ponca State Park, Nebraska.

i. Mississippi River.

1. **Area.** Mississippi River downstream from its confluence with the Missouri River mouth.
2. **Number and size of fish.** Not known.
3. **Density.** Not known.
4. **Evidence of reproduction.** None reported.
5. **Evidence of expansion/contraction.** Pallid sturgeon are assumed to be distributed throughout lower sections of the river but are captured only infrequently. This is possibly due to inefficiency of capture systems in large rivers (Kallemeyn 1983). Construction of Keokuk Dam created a barrier to upstream migration of shovelnose and possibly pallid sturgeon in the Mississippi River

(Carlander 1954).

C. Phenology.

1. Patterns. Spawning occurs between June 1 and August 1 (Forbes and Richardson 1920). Spawning chronology among sturgeon species depends on temperature preferences (Zakharyan 1972) and other sturgeons do not spawn annually (Roussow 1957, Moos 1978). Shovelnose and pallid sturgeon have similar spawning times, temperatures, and habitats, as evidenced by hybridization between the two species (Carlson et al. 1985). Larval drift of sturgeon occurs at specific intervals during the summer and is dependent on water temperature and flow regime of riverine systems (e.g., Hergenrader et al. 1982).

2. Relation to climate and microclimate. Spawning depends on water temperature. Peterman and Haddix (1975) noted that spawning runs of shovelnose sturgeon in the Powder River (Montana) slowed when spring storms lowered river water temperatures. Scaphirhynchus species were reported 80 km above the mouth of the Little Missouri River during high water in the spring 1950 (Personius and Eddy 1955). Shovelnose sturgeons also spawn earlier in streams (Peterman and Haddix 1985) than in reservoirs (June 1977).

D. Reproductive ecology.

1. Types of reproduction. The reproductive biology of the pallid sturgeon is unknown but in general is probably similar

to that of other sturgeons. Breeding habits of the sturgeons appear to be quite uniform; all species spawn in the early spring and are multiple spawners, i.e., release eggs at intervals (Breder and Rosen 1966, Doroshov et al. 1983). Adhesive eggs are deposited at breeding sites in deep channels or rapids and left unattended. Reproductive modes are more similar to those of modern-day fishes than those of ancient groups. Acipenser spp. migrate upstream to spawn (Zakharyan 1972) as do shovelnose sturgeon (Peterman and Haddix 1985).

Acipenseridae have no evident external secondary sex characteristics, except perhaps body shape and color. Females are generally larger than males, whereas males are generally more slender and have brighter colors than females.

Stages in egg development described for Canada's eastern lake sturgeon (Roussow 1957) and the shovelnose sturgeon (June 1977) probably apply to the pallid sturgeon.

2. Dispersal.

a. General mechanisms. Pallid sturgeon movement patterns are unknown. S. platorynchus moved 107 km in 5 years in the Missouri River and showed no tendency to return to the capture location (Moos 1978). In the Upper Mississippi River, shovelnose sturgeons were mostly sedentary but sometimes moved up to 11.7 km/day. Most movements occurred in May and July and fewest in April and June (Hurley et al. 1987). Larval Acipenser spp. drift

downstream in late summer with falling water levels and the warmest seasonal water temperatures (Zakharyan 1972).

b. Responses of mechanisms. Unknown.

7. Overall assessment of reproductive success. No reproduction has been documented in recent years other than the report of one larvae captured in a net in 1969 (Moos 1978). Impoundment of the majority of the middle Missouri River may impede reproduction (Held 1969). June (1977) attributed the unusually high incidence of atretic ovarys (reabsorbing unspawned eggs) in shovelnose sturgeon to adverse reproductive conditions in Lake Oahe, South Dakota. Reproductive success is probably poor because 1) numbers are low, 2) modified habitat may cause those present to hold eggs, 3) the fish probably matures at an advanced age, and 4) it may not spawn every year. No larvae or young fish have been collected in the last ten years.

8. Population Ecology.

A. General summary. Pallid sturgeons occur in low densities in deep water channels of large rivers in association with shovelnose sturgeons.

B. Positive and neutral interactions. None known.

C. Negative interactions.

1. Herbivores, predators, pests, parasites and diseases. Nothing is known of potential negative interactions except for the general increase in piscivorous fishes. Increases

in the number of large predators in the Missouri River system, such as white bass, (Morone chrysops), goldeye, (Hiodon alosoides), and walleye (Stizostedion vitreum), may have increased mortality of young pallid sturgeon because of predation (Frank Cross, pers. comm.). Skipjack herring (Alosa chrysochloris) and white bass, both piscivorous sight feeders adapted to relatively clear waters, were not reported in the lower Missouri River until recently (Funk and Robinson 1974). Salmonids have also been recently stocked in Missouri River waters.

2. **Competition.**

   a. **Intraspecific.** Low densities of this species throughout its range probably preclude this type of competition.

   b. **Interspecific.** Due to habitat modifications in the Missouri River, Carlson et al. (1985) speculated that ecological segregation of the pallid and shovelnose sturgeon has decreased because of channel degradation. Competition for spawning sites may be indicated by the hybridization between the two species (Pflieger and Grace 1986).

D. **Hybridization.**

1. **Naturally occurring.** Fish species hybridize in nature, at times in considerable frequency (Hubbs 1955). Carlson et al. (1985) determined that 12 sturgeon (0.3% of total catch) taken in the Missouri River in Missouri were

pallid-shovelnose sturgeon hybrid females, which suggests that an unbalanced sex ratio may exist. Phelps and Allendorf (1983) determined the two Scaphirhynchus species to be genetically identical at 37 loci.

2. **Artificially induced.** None known.

3. **Potential in cultivation.** Cultivation of pallid sturgeon has not been attempted; however the cultural requirements of sturgeons is fairly well known. (See Symposium on the biology and management of sturgeon, Environmental Biology of Fishes, Volume 14).

E. Other factors of population ecology. Pallid sturgeons have never been as numerous as shovelnose sturgeons.

9. Current land ownership and management responsibility.

A. General nature of ownership. Land adjacent to the Missouri and Yellowstone rivers is a mixture of state, federal, and predominantly private ownership.

B. Specific landowner. Specific landowners may be important if critical habitat areas are found.

C. Management responsibility.

1. Missouri River from Fort Benton to Robinson Bridge, Montana (National Wild and Scenic River System): management responsibility is assigned to the Bureau of Land Management (U.S. Department of the Interior 1978).

2. Charles M. Russell National Wildlife Refuge: federal ownership, administered by the U.S. Fish and Wildlife Service.

3. Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point Reservoirs: shoreline is administered by the U.S. Army Corps of Engineers.

4. Missouri National Recreational River (MNRR) from Gavins Point Dam to Ponca State Park, Nebraska: administered by the National Park Service and U.S. Army Corps of Engineers (U.S. Department of the Interior 1979). Although there is an authorization for MNRR, no lands have been acquired either in fee title or easement under this authorization.

10. Management practices and experience.

A. Habitat management.

1. Review of past management and land-use experiences. Numerous civil works (reviewed by Branyan 1974) have resulted in the following changes to the Missouri River: 67 percent of its length is either impounded or channelized; 75 percent of the remaining 1,241 km lies in the headwaters, leaving only remnants (about 288 km) of "natural" river downstream, which is the hypothesized center of the pallid sturgeon range; the natural river remnants are affected by reservoir releases. The civil works projects have benefited commerce but like other water projects were carried out without adequate consideration of environmental damage (NRC 1966). The extensive siltation of riverine habitat has probably been unfavorable to the pallid sturgeon; however, this is speculation because of the lack of knowledge about its specific habitat needs.

Fishing regulations in Missouri, South Dakota, and Nebraska protect all pallid sturgeons. Regulations in North Dakota protect those over 91 cm. Regulations in Montana protect those over 7.2 kg.

b. Related Taxa. The commonly encountered shovelnose sturgeon is considered a game fish and creel limits vary from unlimited possession (North Dakota, Montana) to a maximum of 20 fish in possession (South Dakota, Nebraska) or a maximum possession of 22 kg (Missouri). The lake sturgeon (A. fulrescens) receives protection similar to the pallid sturgeon.

c. Other ecologically similar taxa.

2. **Performance under changed conditions.** Pallid sturgeon have been captured in mainstem Missouri River reservoirs in greater density than in the river proper (Kallemeyn 1983), perhaps because of greater sampling effort in reservoirs than the river. Evidence of natural reproduction has not been obtained in the last 10 years.
3. **Current management policies and actions.** The system regulation is directed by the Reservoir Control Center in Omaha, Nebraska. Input into system regulation is obtained at semi-annual public meetings attended by concerned citizens, special interest groups, and state, local, and federal agencies. The system is presently operated with consideration of the reservoir sport fisheries during spawning (Fig. 3). One or more reservoirs are selected each year and water levels controlled to enhance spawning.

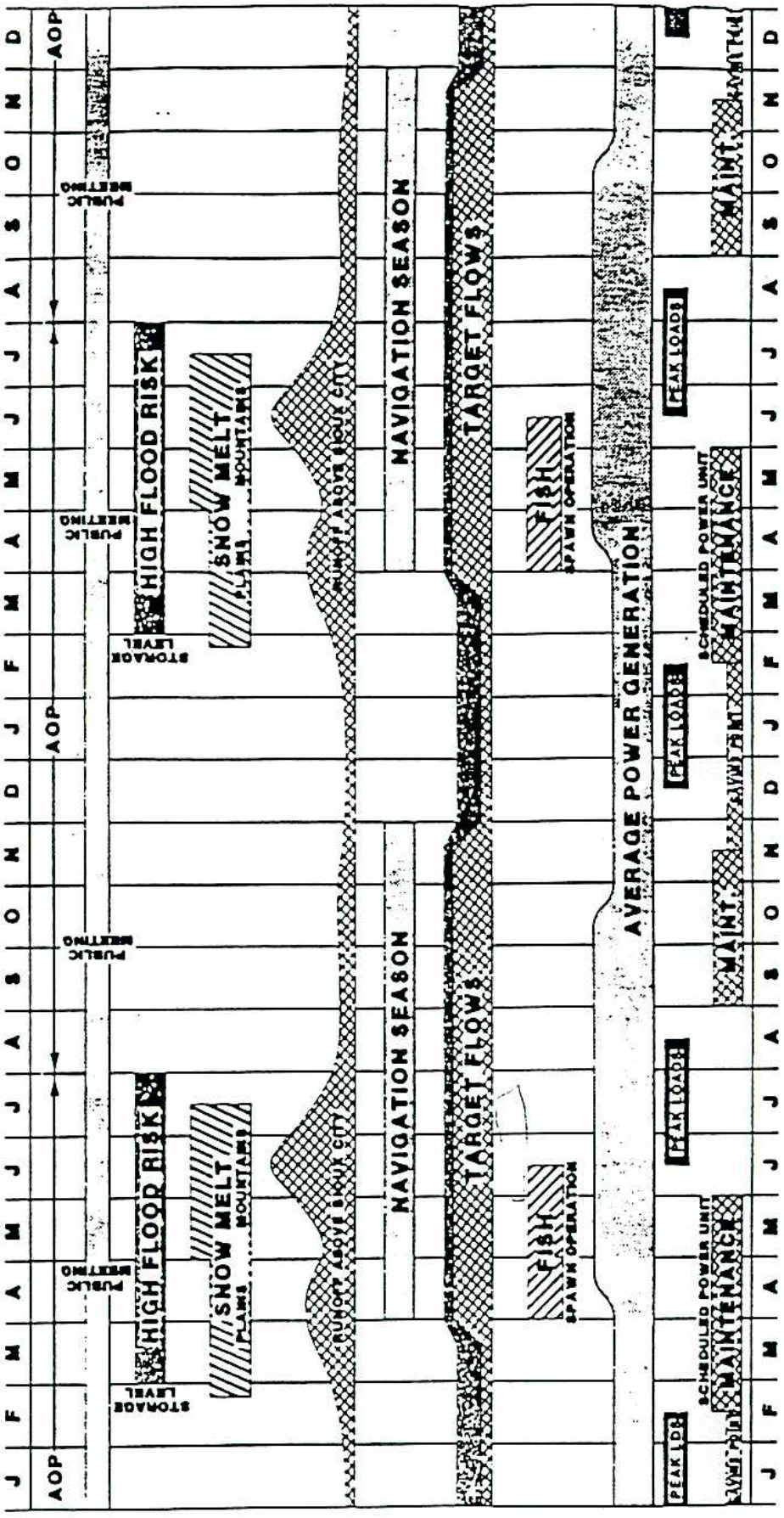


Figure 3. Water control calendar of events for the Missouri River showing months when fish spawning is enhanced on selected reservoirs by stabilizing water levels.

Reservoir releases are also being experimentally adjusted to accomodate nesting of rare birds (least tern, Sterna antillarum; piping plover, Charadrius melodus).

Formation of a Missouri River Natural Resource Committee occurred in December 1986. This committee, headed by the Missouri River Coordinator, is composed of technical wildlife personnel representing Wildlife Conservation Agency Directors from the seven states in the Missouri River drainage. Committee functions are varied, but a major task is to provide the Reservoir Control Center a consensus annual recommendation concerning reservoir releases and pool operating levels.

Each state fish and game agency provides fisheries management (monitoring, stocking, enforcement) the length of the river. Most of this effort is expended on reservoirs and in dam tailraces.

4. **Future river use.** Dewatering and flow regime regulation in the upper Missouri and Yellowstone rivers is probable because of coal and other energy development (Gardner and Berg 1982). In Montana, a Yellowstone moratorium went into effect in 1974 as a result of growing concern over large industrial filings for water. The board regulating permits fully agreed with the legitimacy and necessity of assuring adequate water to maintain fish, wildlife, water quality, and recreational values. However, balancing those requests against the requests for diversion of

water by cities and irrigation applicants is difficult (Lord et al. 1975, Clark 1979). In the middle and lower Missouri River, agriculture will continue to be a major water use (90% of the consumptive use). Hence, irrigation projects such as Garrison Diversion or CENDAK may have major cumulative impacts on the Missouri River. Other uses of the river are navigation, public water supply, electric power production, and outdoor recreation. In the MNRR below Gavins Point Dam, land purchase or easements obtained for protection of MNRR values (Keenlyne et al. 1986) may coincidentally provide protection to important pallid sturgeon habitat areas.

B. Cultivation.

1. Controlled propagation techniques. The idea of using hatcheries to augment wild sturgeon populations is not a new one (Marx 1986). Aquaculture is successfully being used to supplement natural reproduction of Atlantic, shortnose, white, and lake sturgeons (Table 4). The breeding habits of sturgeons appear to be quite uniform (Breder and Rosen 1966); therefore, investigations of Acipenser culture techniques could be useful for Scaphirhynchus culture. The Atlantic sturgeon and shortnose sturgeon (federally listed as endangered species) are being cultured in South Carolina (Smith et al. 1980). Adults are captured from lotic systems, spawned, and returned to the wild; no brood stock is held.

Shortnose sturgeon exhibit specific food preferences while confined (Edward Dingley, Fish Culturist, U.S. Fish and Wildlife Service, Orangeburg, SC, pers. comm.). Artificial spawning of shortnose sturgeon was also reported by Buckley and Kynard (1981). Eggs from the white sturgeon are surgically removed and are then fertilized and hatched using methods that are routine for other fish. Eggs hatch in 12 days and fry are reared on commercial trout chow (Marx 1986).

Table 4. Sturgeon culture locations in the United States.

Species	Hatchery	Contact Person	Phone #
White Green	Univ. Calif. (Davis)	Serge Doroshov	(916) 752-7603
Lake	Univ. Wisconsin Center for Great Lakes Studies	Fred Binkowski	(414) 224-3000
Lake	Missouri Department of Conservation, Blind Pony Hatchery	Kim Graham	(314) 449-3761
Shortnose Atlantic	U.S. Fish & Wildlife Service, National Fish Hatchery, Orangeburg, SC	Edward Dingley	(803) 534-4828
Shortnose	Mass. Coop. Fishery Unit, Univ. Mass.	Boyd Kynard	(413) 545-2011
Shovelnose	U.S. Fish & Wildlife Service, Gavins Point National Fish Hatchery, SD	Roger Copper	(605) 665-3352

Rinne et al. (1986) cautioned that "(endangered) species may be readily propagated in the hatchery, but

without suitable sites for their re-introduction into the wild, the role of hatcheries in endangered species management is reduced to that of providing refugia."

2. **Ease of transplanting.** Dean Rosenthal (pers. comm.) reported that pallid sturgeon were difficult to hold in captivity at Ak-sar-ben Aquarium, Nebraska. Moos (1978) felt that adult shovelnose sturgeon were hardy and withstood handling and temperature shock well.

3. **Pertinent knowledge concerning ecologically similar taxa.** Paddlefish propagation is successful in Missouri (Purkett 1963, U.S. Fish and Wildlife Service 1984), North Dakota (Gregg Power, 1987 pers. comm.), South Dakota (Graham et al. 1986), Alabama, and Tennessee (Semmens and Shelton 1986). Research at Auburn University coupled paddlefish spawning methods with those for white sturgeon described by Doroshov et al. (1983).

11. Evidence of threats to survival.

A. Present or threatened destruction, modification, or curtailment of habitat or range.

1. **Past threats.** Pallid sturgeons were reported by Forbes and Richardson (1905) to compose a small portion of the sturgeon catch in the Mississippi River but a much larger portion of the catch in the lower Missouri River. Cross (1967) cited wasteful fishing practices, probably in conjunction with netting shovelnose sturgeon, as a possible threat to pallid sturgeon survival. Moos (1978)

stated that shovelnose sturgeon, not differentiated from pallid sturgeon, were considered a nuisance by commercial fishermen in the late 1800's and were intentionally destroyed. Barnickol and Starrett (1951) reported a decrease in the shovelnose sturgeon catch from 84,825 to 13,600 kg from 1899 to 1946, which may have included some pallid sturgeon. Types of developments (agriculture, energy, urban growth, etc.) requiring water allocation decisions were covered by Lord et al. (1975).

2. **Existing threats.** Existing threats are primarily related to the decrease in riverine habitat in which the pallid sturgeon evolved. Eighty percent of the middle Missouri River has been altered from a meandering large river to a series of lakes and a barge canal (reviewed by Hesse 1987, Pfieger and Grace 1987). Six reservoirs on the middle Missouri River are used to control main stem flooding. Low discharge in the spring may conflict with the pallid sturgeon's hypothesized need for high spring flows to initiate a yearly spawning run.

   The lower Missouri River has been shortened by over 8 percent (Funk and Robinson 1974). Formerly, the river featured sandbars, islands (many dominated by cottonwoods and dogwoods), and a variety of wetlands (Keenlyne et al. 1986). Islands have been virtually eliminated. The chutes or sloughs which separated the islands from the shore are gone, along with other forms of backwater

habitat. Snags, once abundant in the river, have been removed. The full volume of the river's flow is confined within a relatively narrow channel of rather uniform width and a strong, swift current. This was done to stabilize the river and improve conditions for navigation, and it was accomplished by the use of revetments to stabilize banks and wing dikes to direct the current and cut off chutes and sloughs. These changes have apparently afffected shovelnose sturgeon abundance and reproductive success (Schmalbach 1974, Moos 1978). The same hydrological changes have probably been detrimental to pallid sturgeon populations.

Dam construction restricts pallid sturgeon movements in the Missouri-Mississippi drainage, resulting in a series of fragmented populations in place of formerly contiguous ones. The blockage of such movements has been shown to theoretically increase the probability of extinction (Molles 1980).

3. **Potential threats.** Increased hybridization of pallid sturgeon with shovelnose sturgeon may decrease genetic integrity.

Additional power plant (pumped storage) facilities could cause rapid daily fluctuations in discharge (Unkenholz et al. 1984) and further impact habitat. Power plant and water supply intakes may entrain or impinge fish, but no pallid sturgeon were found on screens of the

Fort Cahoun and Cooper Nuclear Stations for several years after start-up (Hergenrader et al. 1982).

The feasibility of more impoundments on the Upper Missouri River in Montana is being studied (Gardner and Berg 1982). A plan to divert flow from the headwaters at Yellowstone Lake across the continental divide to the Green and Colorado rivers (Galbraith 1986) could affect the hydrology of the system.

B. **Overutilization for commercial, sporting, scientific, or educational use.** Potential problems arise from the inability of sport and commercial harvestors to distinguish shovelnose from pallid sturgeons. Sturgeon have historically been considered a nuisance and dumped on sandbars in some locations (Carlander 1954); in others, the flesh was used as food to such an extent that the species became depleted (Churchill and Over 1938). Sturgeon values more than doubled in the period from 1954 to 1974 (Helms 1974). The demand for caviar since the Iranian crisis has greatly increased commercialization of paddlefish eggs and pallid sturgeon eggs would also be highly prized (U.S. Fish and Wildlife Service 1984). Sturgeon poaching has been an enforcement problem in California (Marx 1986). Sport harvest regulations in most states do not fully protect small pallid sturgeon.

C. **Disease, predation, or grazing.** None known. Introduced piscivorous game fish are more common than in the past.

D. **Inadequacy of existing regulatory mechanisms.**

1. **Past threats.** Provisions were not made to exclude pallid sturgeon from the commercial catch.
2. **Existing threats.** There is a lack of conformity in state regulations concerning the pallid sturgeon. No sturgeon regulations exist in Arkansas, Illinois, Kentucky, Louisiana, Mississippi, or Tennessee. All pallid sturgeon must be released in Iowa, Kansas, Missouri, Nebraska, and South Dakota. This requires anglers to recognize the difference between pallid and shovelnose sturgeons. Nebraska anglers have misidentified 7 or 8 pallid sturgeons in the past decade and brought them to Game and Parks facilities for documentation as new state record shovelnose sturgeons (Dean Rosenthal, pers. comm.). The fish is included on the Nebraska list of endangered and threatened wildlife (NGPC 1977). Size regulations in Montana and North Dakota prohibit possession of large sturgeons; this generally means that pallid sturgeons, which are larger than shovelnose, are released (Ryckman 1985) but small pallid sturgeons are not protected.

   Lack of knowledge about the status and ecology of the pallid sturgeon prevents regulations from being made that might preserve or manipulate habitat to benefit existing stocks. Additionally, lack of a captive "colony" prevents research on artificial propagation.
3. **Potential threats.** The major threat is lack of knowledge about the needs of the pallid sturgeon so that it can be

adequately considered in future plans for allocation of Missouri River water. Also, allocation of water to uses that have higher priority with the public than preservation of rare fish is a potential threat.

E. Other natural or manmade factors. Unknown.

II. Summary and Recommendations.

12. General assessment of vigor, trends, and status. There is documentation that the pallid sturgeon has never been commonly found and is more scarce now than in the past. No significant recruitment is occurring; thus the vigor of the population is low. The fish's designation as a Category 2 animal indicates federal concern for its status, a concern shared by state agencies and fishery biologists interested in the Missouri River. There have been so few documented catches of the pallid sturgeon in the past 10 years that it may be threatened or endangered. The American Fisheries Society has listed it as threatened due to destruction of habitat (Deacon et al. 1979). The fish could be extirpated from the lower Missouri River if trends continue (Pflieger and Grace 1987).

The decline of the species has probably been because of habitat loss and inability to adapt to the changed environment. Other possible threats are hybridization with the shovelnose sturgeon and the possibility of misidentification by fishermen seeking the common shovelnose sturgeon. Lack of knowledge about the fish's habitat needs prevents useful input into water planning efforts. Lack of captive adults prevents research on artificial propagation.

13. Priority of listing or status change.

A. Recommendation to U.S. Fish and Wildlife Service. The Service should begin efforts to enhance the pallid sturgeon population. If initial efforts reveal that the fish is as scarce as many believe, then the species should be considered "endangered" because of low population numbers, significant habitat loss, and possible reproductive failure throughout much of its range. An updated inventory of its range needs to be completed. The feasibility of culturing the species should be investigated in further detail. The greatest difficulty in culturing pallid sturgeon could be obtaining broodstock. Norman Benson, (Biologist, North Central Reservoir Investigations, U.S. Fish and Wildlife Service, Yankton, SD, 1967, memorandum) doubted that enough specimens could ever be obtained for a complete life history study.

B. Recommendations to other U.S. Federal agencies. The Corps of Engineers, National Park Service, Bureau of Reclamation, and appropriate state agencies should join with the Fish and Wildlife Service to begin efforts to recover the species. Until more information on habitat needs is obtained, policy makers cannot consider the pallid sturgeon in water control plans.

C. Other status recommendations.

1. Counties and local areas. None.

2. State. Fishing regulations between states should be standardized to provide protection for all size classes of the pallid sturgeon.

3. **Other Nations.** The pallid sturgeon is not present outside the United States.

4. **International.** Not applicable.

14. Recommended critical habitat.

A. Concise statement. Critical habitat, as defined in section 4(a)(3) of the Endangered Species Act (U.S. Congress 1983), has not been determined by the U.S. Department of the Interior, Fish and Wildlife Service, for the pallid sturgeon. Critical habitat recommendations can be made only in a general way because of lack of information. Diverse riverine habitat including sandbars, sloughs, chutes, backwaters, cutoff lakes, braided channels and deep pools, a native riparian and aquatic plant community, and a fluctuating seasonal hydrology would certainly be found in the critical habitat. The Kansas Fish and Game Commission has designated the Missouri River mainstem in Kansas as critical habitat for pallid sturgeon (Dr. Bill Layher, Kansas Fish and Game Commission, Pratt, KS, pers. comm.).

B. Legal description of boundaries. Too little is known about distribution and habitat needs to suggest critical habitat boundaries; however, certain areas are of special interest:

1. Yellowstone River from Tongue River to mouth. This reach represents an important free-flowing habitat for pallid sturgeons.

2. Missouri River above Fort Peck Reservoir. (Cow Island vicinity downstream to headwaters of the reservoir). This 80 km section of the Missouri River represents one of the last free-flowing

stretches with pallid sturgeon habitat and lies within a 352 km stretch of free-flowing upper Missouri River. Three sitings of pallids have been noted here along with one capture 120 km upstream from this area. Also, this is an area where sicklefin chubs are found.

3. Missouri River below Fort Peck Dam to Garrison Reservoir. (Big Muddy Creek to headwaters of the reservoir). No pallid sturgeon have been found in this river stretch although one was captured 192 km upstream. Sicklefin chubs have been found in this section, which lies within a 304 km stretch of free-flowing river.
4. Missouri National Recreational River. (Gavins Point Dam to Ponca, Nebraska). This stretch should be maintained in a natural condition, providing a 90 km long sanctuary. Low numbers of pallid sturgeon could be supplemented by stocking. Fish might be reared at the Gavins Point National Fish Hatchery which is located on this stretch of river. Several universities (South Dakota State University, University of South Dakota) are also near this stretch of river, and university fisheries faculty could evaluate stocking success.
5. Mouth of the Platte River (Nebraska). A wing dam where 7 pallid sturgeon have been captured by recreational fishermen may be a concentration point to obtain a broodstock.
6. Lower Missouri and Mississsippi Rivers in Missouri. Carlson et al. (1985) captured 11 pallid sturgeon and 12 pallid-shovelnose sturgeon hybrids in this river stretch.

Within these areas, micro-habitat occupied by the pallid sturgeon might be similar to that occupied by the shovelnose. [For example, during high-river stages, downstream from wing or closing dams, or at the border of the main channel; during low-river stages, close to or in the main channel or on the upstream side of wing or closing dams (Harley et al. 1987)]. Shovelnose sturgeons were frequently located where currents were 20-40 cm/sec at the bottom and 40-70 cm/sec at the surface.

C. Latitude and longitude. Specific critical habitat locations can not be defined at this time.

D. Publicity - sensitivity of critical habitat area. Management of the Missouri River is a sensitive issue. Opinions will be presented to the Corps of Engineers from municipalities, irrigation districts, bank stabilization associations, power production and user interest groups, riparian associations, barge lines, and sportsmens groups.

15. Conservation/recovery recommendations.

A. General conservation recommendations. Recommendations are tentative and few because of the lack of information.

1. Recommendations regarding present or anticipated activities.

1. Water management. Adjusting reservoir water releases in free-flowing reaches to simulate natural river conditions before impoundment may help initiate spawning runs and provide suitable habitat for spawning (Risotto and Turner 1985). Where possible, warmer water from the upper layers of the reservoirs should be released. Providing water to

backwater areas may provide habitat for important food organisms and increase overall river productivity.

2. Culture. The feasibility of pallid sturgeon culture should be assessed, perhaps by first perfecting techniques with shovelnose sturgeon. The most immediate mitigation effort may be propagation and release below impounded sections of the Missouri River to establish better age-class distributions.
3. Public relations. Increased public information should be provided to educate anglers about the differences between shovelnose and pallid sturgeon and the need for and importance of protecting this rare species.
4. Define critical habitat. Initial data could be gathered using biotelemetry on adults (providing adults can be captured). Poddubny (1976) presented a detailed discussion of sturgeon movements within an impounded river system in Russia.
5. Survey and Inventory. A coordinated effort among fishery biologists throughout the river should be conducted specifically to find pallid sturgeons. Sampling should be concentrated in areas where probability of capture is highest. The actual sampling should be conducted in concert with a public information program to alert commercial fishermen and recreational fishermen who might also find pallid sturgeons.

2. **Areas recommended for protection.** Remaining free-flowing

stretches of major rivers in the fish's range should be protected from impoundment.

3. **Habitat management and recommendations.** Shovelnose sturgeon prefer intermediate currents found in pools behind sandbars and open water areas adjacent to a main channel. A few collections have been made below irrigation diversion dams, so the benefits of "hard points," rip-rap areas, sand bars, and tailraces of dams should be investigated.
4. **Publicity sensitivity.** Publicity might 1) promote anglers to release snagged or mouth-hooked pallid sturgeon, and 2) possibly foster a greater willingness of the public to consider rare wildlife in general when planning the management of the Missouri's waters.
5. **Other recommendations.** None.

B. **Monitoring activities and further studies recommended.**

Research needs identified for endangered species in the early 1970's are still needed today. Lord et al. (1975) placed endangered species of the Upper Missouri River in a research needs catagory labeled "Top Priority, Short Term Research." They felt that endangered species research was top priority with high urgency and importance and had a medium probability of success and medium cost.

1. The Fish and Wildlife Service has Cooperative Fish and Wildlife Research Units in Montana, South Dakota, Iowa, Missouri, Tennessee, and Alabama. The geographical distribution of these research entities is ideal for the study of such a widely

distributed species.

2. A survey should determine the fish's current range, concentrating on areas where the fish is most likely to be found, as well as sections of the former range where sightings are limited.
3. In areas where a spawning population may exist (e.g., the Yellowstone River) the spawning habitat and evidence of natural reproduction should be evaluted.
4. Determine critical habitat, especially spawning habitat, of both the pallid and shovelnose sturgeon because reproduction has not been documented in any area of the range.
5. The sturgeon culture expertise and facilities in Missouri River state and federal hatcheries should be inventoried.

16. Interested Parties:

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Division of Ecological Services
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U.S. Fish and Wildlife Service
Division of Ecological Services
(Attn: Kent Keenlyne)
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Pierre, South Dakota 57501

U.S. Fish and Wildlife Service
Office of Endangered Species
Washington, D.C. 20240
Director: (Attn: John L. Spinks, Jr.)
Listing Branch: (Attn: Jim Williams, Ichthyologist)

Bureau of Land Management
U.S. Department of the Interior
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North Dakota Natural Heritage Survey
North Dakota Game and Fish Department
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100 North Bismarck Expressway
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South Dakota Department of Game, Fish & Parks
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Missouri River Public Water Supplies Association
St. Louis Co. Water Co.
535 North New Ballas Rd
St. Louis, MO 63141

Department of the Army
Missouri River Division
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Missouri Basin States Association
10834 Old Mill Road, Suite 1
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III. Information Sources.

17. Sources of information.

A. Publications.

1. References cited in report. List appended.

2. Other technical publications. Various Dingell-Johnson reports may contain records of occasional captures in the Missouri and Mississippi Rivers.

B. Museum collections consulted.

1. Ak-sar-ben Aquarium: one live adult.

2. South Dakota State University: several preserved juvenile specimens, and one frozen adult.

C. Fieldwork. No fieldwork directly aimed at capture of pallid sturgeons was conducted during preparation of this report.

D. Knowledgeable individuals.

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E. Other information sources. Publications cited in this report are on file at the South Dakota Cooperative Fish and Wildlife Research Unit, South Dakota State University, Brookings, SD.

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