

The Pallid Sturgeon

**Biology and Annotated Bibliography
Through 1994**

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Technical Bulletin 5, March 1966
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National Biological Service, and the Wildlife Management Institute cooperating

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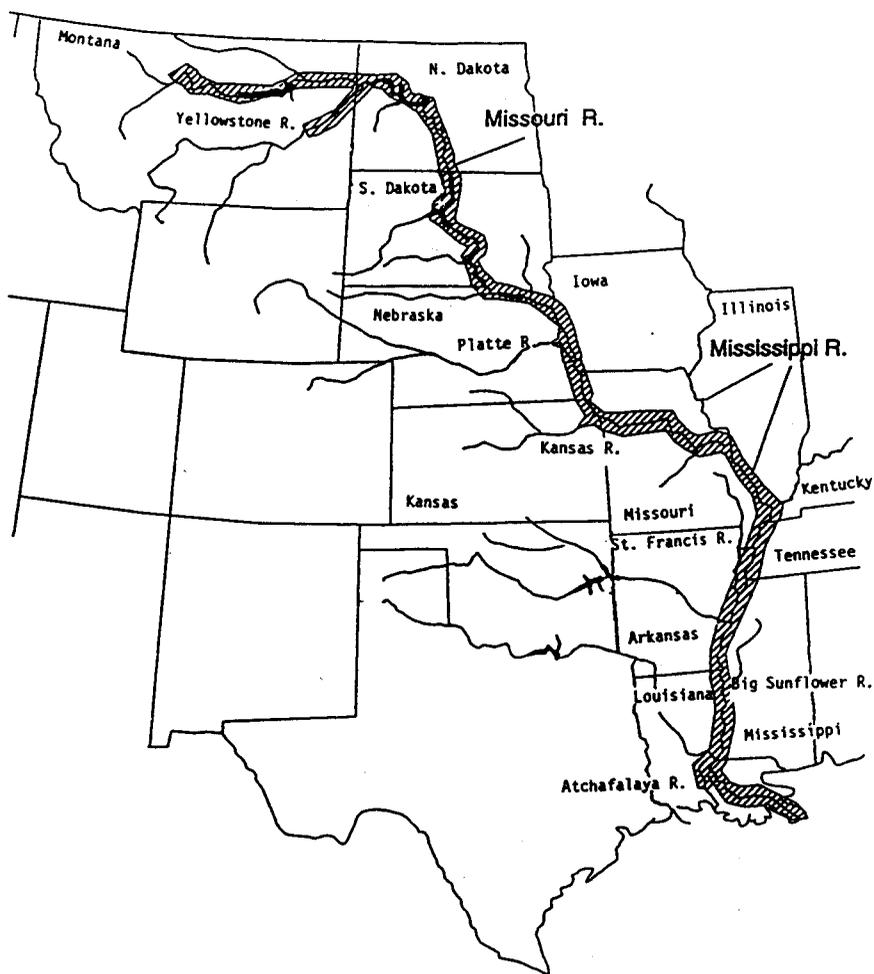


Fig 1. Historical range of the pallid sturgeon — 



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400 copies printed by South Dakota Cooperative Wildlife Research Unit, SDSU, at \$1.45 each. February 1986 WL065

Biology of the Pallid Sturgeon

INTRODUCTION

The pallid sturgeon (*Scaphirhynchus albus* Forbes and Richardson) is one of the largest but least known freshwater fishes of North America. It is a member of an ancient group of fishes whose bodies are covered with bony plates and who possess heterocercal caudal fins and a skeletal structure of mostly cartilage instead of bone.

The pallid sturgeon belongs to a group of sturgeon with flattened snouts and is one of only three members of the genus *Scaphirhynchus*, or shovel-nosed sturgeon. The pallid sturgeon is a "living fossil" that is unique to the few large rivers it occupies. Like other sturgeon, it has a toothless, protrusible mouth under and far behind the nose and four dangling barbels in front of the mouth. It was listed by the federal government in 1990 as "Endangered" throughout its range.

This annotated bibliography on the pallid sturgeon, along with a summation of the biological information presently known about the species, will assist fishery researchers and resource managers in developing preservation plans for this species and

will also assist agency personnel in developing recommendations which may benefit this rare fish when reviewing or approving permit applications. This bibliography contains all known citations about this species through 1994 from both the scientifically reviewed journals and unpublished agency documents. We have annotated these works so others can determine the general substance and nature of the subject material and, thereby, determine whether they desire to obtain a copy of these sometimes rather rare documents.

We are solely responsible for any errors or misinterpretations in the annotations and, since our program limited us to five lines for annotating the citations, users should consult the original sources for pertinent data rather than rely on the limited material contained in the annotations.

Papers included in the bibliography are arranged alphabetically by author. The author-index program will help users to locate annotations keyed to river, state, and, sometimes, general subject material.

TAXONOMY

Class: Osteichthyes
Order: Acipenseriformes
Family: Acipenseridae
Subfamily: Scaphirhynchinae
Species: *Scaphirhynchus albus*
Common names: pallid sturgeon,
white shovelnose, white sturgeon,
white hackleback.

The shovelnose, or Scaphirhynchinae, sturgeon were originally included within the Acipenser genus but separated in 1835 by Heckel

based on a noted absence of spiracles as found in the Acipenserids. Forbes and Richardson (1905) further describe the characteristics that separate the Scaphirhynchinae from the other sturgeon. The closest relatives to the North American shovelnosed sturgeon are a group of Asian sturgeon which were originally called *Scaphirhynchus*. These were later renamed *Pseudoscaphirhynchus* and separated from the North American *Scaphirhynchus* which have a more abbreviated caudal peduncle which is laterally compressed and fully armored.

Forbes and Richardson (1905) are credited with describing the pallid sturgeon. It was originally given the common name of "white sturgeon" and later called "pallid sturgeon" to indicate its light color and so not to confuse it with the white sturgeon from the western coast of North America, *Acipenser transmontanus*.

Forbes and Richardson (1905) originally placed the pallid sturgeon in a separate genus, *Parascaphirhynchus*, based on several noted differences between the pallid and shovelnose sturgeon. These authors noted that pallid sturgeon contained 20 to 22 ribs while the shovelnose sturgeon had only 10 or 11 ribs. The pallid sturgeon also possessed a naked breast and belly while the shovelnose had an abdomen wholly covered with plates. The air bladder was also noted as being relatively smaller in the pallid sturgeon, going into the length of head and body 8 times while the air bladder of the shovelnose sturgeon went only 5 times into length. These authors also recorded differences between the pallid and shovelnose sturgeons in the number of ventral radials, relative

depth of lateral scutes, orbital space size, proportional lengths of inner and outer barbels, mouth width, proportion of head width to head length, and proportion of head length to body length.

Berg (1911) disagreed with placement of the pallid sturgeon into a separate genus and included it in the genus *Scaphirhynchus* while giving the Asiatic forms the genus of *Pseudoscaphirhynchus*. Berg (1932) later suggested that Asian and American shovelnose sturgeons be placed in a subfamily, Scaphirhynchinae, the "shovel-nosed" sturgeons, by themselves.

Bailey and Cross (1954) accepted this classification and suggested that, since the word *Scaphirhynchus* is neuter, the pallid sturgeon should properly have the specific name "album." Bailey later reconsidered (Bailey and Allum 1962), noting that the International Code of Zoological Nomenclature considered generic names ending in *-rhynchus* as masculine gender, making the proper spelling of the specific name "*albus*."

DISTRIBUTION AND NUMBERS

The pallid sturgeon occurs in large rivers of central North America in the Missouri and Mississippi river drainages (Bailey and Cross 1954). A population has also been recently reported from the Atchafalaya River in Louisiana downriver from its connection with the Mississippi River (Keenlyne and Jenkins 1993, Keenlyne and Evenson 1993).

The historic range for this species once included the Mississippi River upstream to Keokuk, Iowa, before the river was converted into a series of locks and dams for commercial navigation (Coker 1930). Present distribution includes the Missouri River to Fort Benton, Montana (3,333 km); the lower Mississippi River from New Orleans to its juncture with the Missouri River (1,863 km); the Atchafalaya River to its

connection with the Mississippi River (139 km); and the lower Yellowstone River from the mouth of the Tongue River to its juncture with the Missouri River (300 km).

Pallid sturgeon have occasionally been reported from the lower sections of large tributaries to the Missouri and Mississippi rivers (Platte River, 34 km; Big Sunflower River, 56 km; St. Francis River, 56 km; and Kansas River, 65 km) (Keenlyne 1989), but tributary collections are rare and usually have been associated with abnormally high river flows (Cross 1967). The total present range of the pallid sturgeon (Figure 1) is 5,635 km (about 3,500 miles).

That pallid sturgeon were better adapted to the muddier Missouri River than the less turbid

Mississippi River was noted by Forbes and Richardson (1905). Several authors report that this species prefers to live in turbid waters where the current is rapid over sand, gravel, or rock bottoms (Forbes and Richardson 1905, Carlson *et al.* 1985, Erickson 1992). Perhaps more importantly, the species avoids areas without turbidity and current (Bailey and Cross 1954, Erickson 1992), which may help explain why pallid sturgeon are no longer found in the upper Mississippi River slackwater pools and the Missouri River reservoirs and have not expanded into other rivers in the Mississippi drainage, even though access is available. Although primarily a freshwater species, pallid sturgeon have been collected from brackish water in the lower Mississippi River near New Orleans and near the mouth of the Atchafalaya River (Keenlyne 1989, Vladykov and Greeley 1963).

Because the pallid sturgeon was not recognized as a distinct species until 1905, it was not listed in early commercial fishery reports, so little is recorded about its historic abundance. Even as late as the mid-1900s, it was common for pallid sturgeon to be tallied in commercial catch records as either shovelnose or lake sturgeon (Keenlyne 1995). Correspondence and notes of researchers suggest, however, that the pallid sturgeon was still fairly common in many parts of the Mississippi and Missouri river systems as late as 1967 (Keenlyne 1989). Review of the literature indicates that declines in populations have occurred in recent years coincidental with development of the Missouri and Mississippi river systems for flood control and navigation (Deacon *et al.* 1979, Keenlyne 1989).

Since 1988, pallid sturgeon researchers have collaborated on studies to gather information about the species including estimates of fish numbers (Keenlyne 1995). This has allowed workers to identify where populations still remain and to obtain rough estimates of present abundance of the species.

Tag and recapture data have allowed researchers to estimate that 50 to 100 pallid stur-

geon remain in the Missouri River above the Fort Peck Dam in Montana and between 200 and 300 pallid sturgeon remain between the Garrison Dam in North Dakota and Fort Peck Dam which also includes the lower Yellowstone River (Steve Krentz, U.S. Fish and Wildlife Service, pers comm). One to five sightings per year have been made on pallid sturgeon between the headwaters of Oahe Reservoir in South Dakota to the Garrison Dam and from the riverine reach in the Missouri River above Gavins Point Dam to the Fort Randall Dam, suggesting that, perhaps, as many as 25 to 50 fish may remain in each of these areas. A small population also exists between Oahe Dam and the Big Bend Dam on the Missouri River in South Dakota with perhaps 50 to 100 fish remaining in this riverine section.

Unfortunately, no evidence has been obtained that any of these upper Missouri River system populations are reproducing, for only large individuals are being reported (Keenlyne 1989).

Obtaining estimates of abundance in the channelized Missouri River downriver from Sioux City, Iowa, to the mouth and the Mississippi River downstream from the mouth of the Missouri River is complicated by the difficulties of sampling rapidly flowing river sections. In general terms, more pallid sturgeon sightings occur in the more turbid lower Missouri River than the Mississippi River.

Pallid sturgeon still are captured in the Mississippi River between the mouth of the Missouri River and the mouth of the Ohio River, but sightings become fewer downriver from the diluting effect of the Ohio River (Keenlyne 1989). Based on tag return and frequency of reports, rough estimates of one to five pallid sturgeon per kilometer of river in the channelized lower Missouri and Mississippi rivers provide an estimate of between 3,175 to 15,850 pallid sturgeon in these river sections.

Recent work in the Atchafalaya River has revealed fish of several age groups, suggesting that some reproduction may occur in the Atchafalaya River.

A high incidence of hybridization with shovelnose sturgeon is also occurring in both the Atchafalaya and Mississippi rivers (Keenlyne *et al.* 1994), however, which makes estimation of the number of pure pallid sturgeon remaining within these river segments difficult. Based on tag returns and telemetry studies, perhaps as many as 20 to 30 pallid sturgeon exist per river kilometer in the Atchafalaya River, providing an estimate of from 2,750 to 4,100 fish in this river section (Glen Constant, Louisiana State University, pers comm).

The best estimate, at present, of the total population of pallid sturgeon is that as few as 6,000 pure pallid sturgeon or as many as 21,000 may still exist throughout the entire range of this species. Numbers are subject to change if upper Missouri River populations gradually die out for continued lack of successful reproduction, or numbers may increase if populations in the Mississippi or Atchafalaya rivers respond well to the high river flows experienced in 1993 and 1995.

BIOLOGY AND LIFE HISTORY

HABITAT

Pallid sturgeon prefer turbid, flowing riverine habitat with rocky or sandy substrate and water depths of 4 to 5 meters (Erickson 1992). Carlson *et al.* (1985) captured pallid sturgeon in the main channels of the Missouri River along sandbars at the inside of river bends and behind wing dikes with deeply scoured trenches. Pallid sturgeon are reported to inhabit areas of swifter water than the closely related but smaller shovelnose sturgeon (Forbes and Richardson 1909; Carlson *et al.* 1985). Fish collected in the Missouri River have been located primarily upstream of reservoirs and show a preference for riverine-like conditions if they exist (Kallemeyn 1983).

Over the years, the habitat of the pallid sturgeon has been dramatically altered. The most obvious change is the series of impoundments on the main stem of the upper Missouri River and channelization of the lower Missouri and Mississippi rivers. The upper Missouri River dams have created physical blockages that prohibit normal migration patterns, alter habitat characteristics, and restrict riverine fish to limited flowing river reaches (Hesse *et al.* 1989). Approximately 51% of the range of the pallid sturgeon has been channelized and 28% impounded. The remaining

21% is affected by upstream impoundments that alter flow regimes and modify both turbidity and water temperatures (Keenlyne 1989).

Alteration of habitat has been a major factor in the decline of this species (Williams *et al.* 1989). Damming of the upper Missouri River has altered river parameters such as current velocity, seasonal flows, turbidity, temperature, nutrient supply, and paths within the food chain (Russell 1986, Unkenholz 1986, Hesse 1987). Channelization of the middle and lower Missouri River has reduced water surface area by half, doubled current velocity, and decreased sediment load (Funk and Robinson 1974). These modifications adversely affect the pallid sturgeon by blocking movements to spawning and/or feeding areas, destroying spawning areas, altering conditions or flows of potential remaining spawning areas, reducing food sources or the ability to obtain food, or otherwise altering conditions necessary for the fish's survival (Keenlyne 1989).

FOOD

The pallid sturgeon is primarily piscivorous (Coker 1930, Carlson *et al.* 1985) with large river cyprinid minnows serving as the primary forage

species (Carlson *et al.* 1985). Pallid sturgeon kept in captivity in state or federal hatcheries or aquaria feed exclusively on minnows, goldfish, or small trout (Darrell Feit, Jerry Hamilton, and Herb Bollig, U.S. Fish and Wildlife Service, pers comm).

REPRODUCTION AND FECUNDITY

Pallid sturgeon do not become sexually mature until several years of age. Males reach sexual maturity at 533 to 584 mm total length (Fogle 1961) and between 5 to 7 years of age while females do not become sexually mature until a length of at least 850 mm (fork length) and an age of 15 years (Keenlyne and Jenkins 1993). Pallid sturgeon may spawn as early as April in the lower portion of their range to early June in the extreme northern portion of their range. Pallid sturgeon have mature reproductive products at times which coincide with natural high river flows in the respective portions of their range (Keenlyne and Jenkins 1993).

Under wild conditions, males do not spawn every year and females may take up to 10 years between spawnings depending on the quality and quantity of food available in their natural habitat

(Keenlyne and Jenkins 1993). Therefore, fecundity of a female may vary considerably, with an individual female spawning only a few times during the normal life span. Keenlyne *et al.* (1992) report that a pallid sturgeon female (17,110 g total weight and 41 years old) contained 1,952 g of eggs (11.4% of her total weight) and 170,000 eggs (87 ova per gram of egg mass).

GROWTH AND LONGEVITY

Pallid sturgeon are one of the largest freshwater fish in North America, attaining a weight of up to 45 kg (Brown 1971). Males live at least to 39 years of age and females to at least 41 years (Ruelle and Keenlyne 1993).

Fogle (1963) calculated that pallid sturgeon collected from the Missouri River averaged 279 mm total length at age one, 378 mm at age 2, 470 mm at age 3, 574 mm at age 4, 638 mm at age 5, 673 mm at age 6, 732 mm at age 7, 790 mm at age 8, 838 mm at age 9, and 881 mm at age 10.

Pallid sturgeon grow more rapidly than shovelnose sturgeon, and length differences continue to increase through at least age 10 (Carlander 1969).

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- #1 Report on second year of study (1992) on Yellowstone River and creel survey results near Fred Robinson Bridge above Fort Peck Reservoir, Missouri River. Authors examined a 138.1-cm pallid sturgeon taken by paddlefish snaggers below the Intake Diversion on June 26, 1992. Fish was tagged and released. Two pallids were caught by 89 bait fishermen near the Fred Robinson Bridge.
- Backes, K.M., W.M. Gardner, and P.A. Stewart.** 1994. Lower Yellowstone River pallid sturgeon study IV and Missouri River pallid sturgeon creel survey. Montana Dept Fish, Wildlife and Parks, Miles City.
- #2 Results of fourth year of study. Four pallid sturgeon were captured in Yellowstone River weighing from 3.8 kg to 18.2 kg and measuring from 981 mm to 1,384 mm FL. Fish were tagged and released back into river. Creel census also performed in relation to paddlefish snagging efforts at Intake Diversion Dam on Yellowstone with report of one pallid sturgeon being snagged and released.
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- #3 General work on fishes of South Dakota. Authors note that the pallid sturgeon is confined to Missouri River and lower parts of major tributaries. Propose that specific name be changed from "album" to "albus" to fit gender ending used in generic name for species. Noted records in Missouri River near mouth of Grand River, mouth of James River, and near Fort Randall Dam.
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- #7 Provides an often-used status table on Missouri River fish species in the reservoir system. The pallid sturgeon is classified as "rare" in Garrison Reservoir in North Dakota and in lakes Oahe, Francis Case, and Lewis and Clark in South Dakota. Author also mentions that most of cyprinid minnows are also declining as a result of reservoirs. (Note: diet of pallid often listed as "cyprinids.")
- Berard, E.** 1973. Management surveys of the Missouri River and its main stem reservoirs in North Dakota. DJ Project F-2-R-20 Report, North Dakota Dept of Game and Fish, Bismarck, 31 pp.
- #8 Summary of 1972 fishery surveys on Missouri River in North Dakota. Reported capturing three pallids in Lake Sakakawea (Garrison Reservoir) in July ranging from 535-840 mm total length and 460-2040 g in weight. Six adult pallids were also captured in the upper reaches of the Oahe Reservoir in North Dakota.
- Berard, E.** 1974. Management surveys of the Missouri River and its main stem reservoirs in North Dakota. DJ Project F-2-R-21 Report, North Dakota Dept of Game and Fish, Bismarck, 33 pp.
- #9 Summarizes fishery surveys on Missouri River in 1973. No pallids were reported for the Garrison Reservoir surveys, but 120 pallid sturgeon were captured from the river and headwaters of Oahe Reservoir in North Dakota. Pallid sturgeon were the most abundant species taken with 119 fish ranging from 510-675 mm total length and from 370-750 g weight netted in 525 hours during June and July.
- Berard, E.** 1975. Management surveys of the Missouri River and its main stem reservoirs in North Dakota. DJ Project F-2-R-22 Report, North Dakota Dep. of Game and Fish, Bismarck, 35 pp.
- #10 Report summarizes fishery survey results on Missouri River in 1974. Four pallid sturgeon were captured in Garrison Reservoir ranging from 630-695 total length and from 680-995 g weight. One adult pallid was also captured in the headwater of Oahe Reservoir in North Dakota.
- Berard, E.** 1978. Ecological investigations of the Missouri main stem reservoirs in North Dakota. DJ Project F-2-R-25 Report, North Dakota Dept of Game and Fish, Bismarck.
- #11 Summary of Missouri River fishery investigations in North Dakota in 1977. The report does not mention the location but does indicate the capture of a specimen in the Garrison Reservoir reach.

- Berard, E.** 1980. Ecological investigations of the Missouri main stem reservoirs in North Dakota. DJ Project F-2-R-26 Report, North Dakota Dept of Game and Fish, Bismarck.
- #12 Summary of Missouri River fishery investigations in North Dakota in 1979. Four pallid sturgeon were reported, with three ranging from 570 to 635 mm total length and from 390 to 950 g in weight. Another individual was also reported as weighing 20,672 g, however, no length measurement was given.
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- #14 Missouri River fishery survey summary for 1982 reported one pallid sturgeon being captured in Lake Sakakawea (Garrison Reservoir) at Wolf Creek, McLean Co., weighing 15,890 g.
- Berard, E.** 1985. Ecological investigations of the Missouri main stem reservoirs in North Dakota. DJ Project F-2-R-31 Report, North Dakota Dept of Game and Fish, Bismarck.
- #15 Fishery investigation summary report for Missouri River studies in 1984. Three pallid sturgeon were reported as being captured: a 825-mm, 2240-g fish taken at White Earth Bay, Mountrail Co., on July 11; a 900-mm total length specimen weighing 3500 g collected at Charging Eagle Bay, Dunn Co., July 17-20; and a 1525-mm total length specimen collected off the face of the dam August 2.
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- #16 Author reports observing four pallid sturgeon during 5 years of study (1975-1979) in the Missouri River above Fort Peck Reservoir. One pallid sturgeon weighing 14.52 kg and measuring 135.1 cm was collected near Coal Banks Landing about 135 RM above the headwaters of Fort Peck Reservoir, one was observed near Cow Island 43 RM above the reservoir, and two were seen near Fort Robinson Bridge 22 RM upstream.
- Berry, C.R.** 1988. Rare fish in the Upper Missouri River Basin. Proc North Dakota Acad Sci 42:3.
- #17 Abstract only. Author lists three rare Missouri River fishes including the pallid sturgeon. Decline of species was attributed to inundation of habitat by reservoirs and change in structure and hydrology of remaining riverine habitats because of regulated flows.

- Bramblett, R.G. and R.G. White.** 1992. Movement and habitat requirements of pallid sturgeon in the Missouri and Yellowstone Rivers, Montana and North Dakota. Montana Coop Fish Res Unit, Montana State University, Bozeman.
- #18 Progress report for studies conducted between February 1 and December 1, 1992. Authors report radio and sonic tagging a 12.7- and a 22-kg pallid sturgeon and obtaining 322 observations during the year. Authors also tagged seven shovelnose sturgeon. Pallid sturgeon chose areas with greater channel width and depth farther downriver and with greater association with sand substrate.
- Bramblett, R.G., and R.G. White.** 1993. Progress report for the period 1 January - 31 December 1993 on movement and habitat requirements of pallid sturgeon in the Missouri and Yellowstone Rivers, Montana and North Dakota. Montana Coop Fish Res Unit, Montana State University, Bozeman. 12 pp.
- #19 Summarizes activities for second season of work on this project and focuses on telemetry results. Researchers followed 20 pallid sturgeon marked in 1992 (7) and 1993 (13) to study habitat use and movements, obtaining 372 relocations. Pallids preferred sandy substrate and avoided clay and gravel, which may be related to food availability. Distribution coincided with sand substrate.
- Brown, C.J.D.** 1955. Record-size pallid sturgeon, *Scaphirhynchus album*, from Montana. Copeia 1955:55.
- #20 Short note on three large specimens of this species from Montana. Corrects identification of a 47-lb specimen reported by Cope in 1879 from near Fort Benton on the Missouri River, a 58-inch specimen weighing 31.5 lb from Fort Peck Reservoir in 1949, and one caught July 24, 1950, weighing 38 lb and measuring 66 inches TL in the mouth of the Tongue River. This is the first report from the Yellowstone River.
- Brown, C.J.D.** 1962. Preliminary list of Montana fishes. Proc Montana Acad Sci 22: 21-26.
- #21 Abbreviated article providing list of fishes in Montana. Pallid sturgeon is listed as being found in Yellowstone and Missouri rivers.
- Brown, C.J.D.** 1971. Fishes of Montana. Montana State University, Bozeman. 207 pp.
- #22 General Montana reference. Author refers to five pallid sightings in Montana, including the three mentioned in his article in Copeia in 1955 and adding a specimen from Fort Peck weighing 40 lb and another specimen from the Yellowstone River near Intake weighing 36 lb. Mention is made of unconfirmed reports of specimens weighing as much as 100 lb.
- Buchanan, T.M.** 1973. Key to the fishes of Arkansas. Arkansas Game and Fish Comm., Little Rock. 68 pp.
- #23 General reference on the fishes of Arkansas. Although no voucher specimens had been obtained, author listed the species as on the Mississippi River and showed on map where specimen had been reported from St. Francis River a short distance from the Mississippi.

Burr, B.M. and M.L. Warren, Jr. 1986. Distributional atlas of Kentucky fishes. Kentucky Nature Pres Sci and Tech Ser 4.

#24 General reference on distribution of fishes in Kentucky. Authors reference one record of a pallid sturgeon taken from the Mississippi River in Hickman Co. in November 1985 and report that commercial fishermen indicate that species not as rare as records suggest. Authors recommend that the species be classified as endangered within the state.

Carlander, K.D. 1969. Handbook of freshwater fishery biology. Iowa State University Press, Ames. 752 pp.

#25 Summarized weight, length, and age data on pallid sturgeon reported from Missouri River by Brown, Bailey and Cross, Fogle, Shields, and Sprague. Species reported as rare on Mississippi River but fairly common on the Missouri River and the newly formed reservoirs on the Missouri. Largest specimen reported was a 30.8-kg fish from North Dakota.

Carlson, D.M. and W.L. Pflieger. 1981. Abundance and life history of the lake, pallid, and shovelnose sturgeons in Missouri. Final Rep, Endangered Species Project SE-1-6, Missouri Dept Cons, Jefferson City.

#26 Summary of information gathered from 2-year sturgeon study conducted by Department personnel. Report information was published in Carlson *et al.* (1985).

Carlson, D.M, W.L. Pflieger, L. Trial, and P.S. Haverland. 1985. Distribution, biology and hybridization of *Scaphirhynchus albus* and *S. platyrhynchus* in the Missouri and Mississippi rivers. In S. Doroshov (ed) Sturgeon Symposium. Environ Biol Fish 14:51-59.

#27 Authors examined 4355 sturgeon from Missouri and Mississippi rivers captured in 1978 and 1979. Eleven pallid and 12 hybrid sturgeon were collected. Pallid sturgeon utilized more fish in diet (primarily cyprinids), were larger, and utilized faster currents than shovelnose sturgeon. First record of hybridization between species attributed to modification of habitats in channelized river.

Carufel, L.H. 1953. Sturgeon. North Dakota Outdoors 1953(May):16-17, 33.

#28 Popular article on sturgeon fishing in the Missouri River. Author used common name "lake sturgeon" for the pallid sturgeon. Two photos accompany article showing large pallid sturgeon taken by Bruce Hoyer of Washburn in which the fish is as long as the car hood. A second pallid taken by Otto Schmittke near Bismarck is as long as the man is tall. Fish were caught commercially or on set lines.

Carufel, L.H. 1958a. Creel census analysis of tailrace fishing area of the Garrison Reservoir. DJ Project F-3-R-5 Report. North Dakota Dept of Game and Fish, Bismarck.

#29 Author reports creel census data taken from Garrison Reservoir tailwaters in 1957. A total of 1777 anglers fished 4254 hours and caught one pallid sturgeon weighing 15 lb.

Carufel, L.H. 1958b. Creel census analysis of tailrace fishing area of Garrison Reservoir. DJ Project F-3-R-6 Report, North Dakota Dept of Game and Fish, Bismarck.

#30 Author reports that 3005 fishermen fished 6659 hours and caught eight pallid sturgeon ranging from 16 to 32 inches in length (ave 24) and weighing between .9 and 15.0 lb (ave 7.9) during the 1958 creel census study below Garrison Dam in North Dakota.

Clancey, P. 1989. Fort Peck pallid sturgeon study. Montana Dept Fish, Wildlife, and Parks, Helena.

#31 Progress report for contract with U.S. Army Corps of Engineers. Author describes preliminary efforts to place telemetry equipment on pallid sturgeons including unique method of obtaining specimens by divers downstream of Fort Peck Dam. Three fish referenced (29, 33, and 53 lb) as used. Two largest fish moved downstream 45 and 105 miles in one month, respectively. Morphometric data provided.

Clancey, P. 1991. Dinosaurs of the deep. *Montana Outdoors* 22(2):19-22.

#32 Popular article in Department magazine. Author portrays species as a remnant from the age of the dinosaurs. Species was once fairly common in Montana but has become depleted within last 50 years. Mentions results of recent studies and concerns about such things as toxins and lack of sufficient reproduction to maintain species. Interesting section on SCUBA diving for sturgeon during winter.

Clancey, P. 1992. Fort Peck pallid sturgeon study. Montana Dept Fish, Wildlife, and Parks, Helena. 34 pp.

#33 Author reports on third year of efforts to fix telemetry equipment to pallid sturgeon. Some fish were obtained by SCUBA diving below Fort Peck Dam during the winter. Angler reports of capturing pallids both at Intake on Yellowstone River and above Fort Peck during paddlefish snagging season not uncommon. Author provides morphologic data on both pallids and shovelnose.

Coker, R.E. 1930. Studies of common fishes of the Mississippi River at Keokuk. *U.S. Bur Fisheries Bull* 45:141-225.

#34 Record of pallid sturgeon on Mississippi River before river modified by lock and dam system. Farthest reference upstream on Mississippi; sighting questioned by Bailey and Cross. Fish reported as 69-cm juvenile weighing 0.75 kg. Collection made on April 21, 1916, at site later eliminated by construction of Keokuk Dam. Called "rare," but local fishermen reported catching them "not infrequently."

Constant, G. 1994. Movement, habitat preference, and current status of pallid sturgeon in the Mississippi, Atchafalaya, and Red Rivers. Progress Rep, Louisiana Coop Fish and Wildl Res Unit, Louisiana State University, Baton Rouge.

#35 Author reports surgically implanting 18 pallid sturgeon with ultrasonic transmitters and attempting to follow movements and obtain information on habitat selection. Fish were collected in outflow channel of Old River Control Structure linking Atchafalaya to Mississippi River. Most fish were obtained using commercial fishermen.

- Conte, F.S., S.I. Doroshov, P.B. Lutes, and E.M. Strange.** 1988. Hatchery manual for the white sturgeon *Acipenser transmontanus* Richardson with application to the North American Acipenseridae. Coop Ext Pub 3322. University of California, Davis. 104 pp.
- #36 Summary of reproductive information published on all North American sturgeon species including age and size at sexual maturity, fecundity, and spawning dates of wild populations. Pallid listed as spawning in spring (June and July) with males reaching sexual maturity at 53.3 to 58.4 cm in length. General treatise on egg development, embryology, and larval development in sturgeon.
- Cook, F.A.** 1959. Freshwater fishes in Mississippi. Mississippi Game and Fish Comm, Jackson. 51 pp.
- #37 General reference to the freshwater fishes of Mississippi. Author indicates that no specimens of this species have been found in the state but that it is known to inhabit the Mississippi River as far south as New Orleans. Reports of specimens weighing up to 25 lb had been received. Author surmised that the species could be present in the Yazoo River since it is a highly muddy river.
- Cross, F.B.** 1967. Handbook of fishes of Kansas. University Kansas Mus Nat Hist Misc Pub 45. Lawrence. 357 pp.
- #38 General account of pallid sturgeon range within Kansas, including sightings on the lower Kansas River during the flood of 1952. The Kansas River specimens contained larval insects and small fishes as food items. The author notes that the limited range of this species, along with late sexual maturity, makes this species more vulnerable to habitat and overfishing threats.
- Cross, F.B. and R.E. Moss.** 1987. Historic changes in fish communities and aquatic habitats in plains streams of Kansas. Pp 155-165 in W.J. Matthews and D.C. Heins (eds.) Community and Evolutionary Ecology of North American Stream Fishes. University Oklahoma Press, Norman.
- #39 Authors review changes in fish communities within state through literature and survey results. Pallid sturgeon no longer in Kansas River and greatly reduced in Missouri River which was its native habitat. Pallid associated with faunal group utilizing shallow streams with fluctuating channels and shifting sand beds. Decline of pallid associated with decline of native cyprinids and dams on river.
- Deacon, J.E., G. Kobetich, J.D. Williams, and S. Contreras.** 1979. Fishes of North America, endangered, threatened, or of special concern. Fisheries 4:29-44.
- #40 Special report by the American Fisheries Society on the status of fishes of North America. Pallid sturgeon was considered "threatened" throughout its range due to present or threatened destruction of its habitat. Species range considered to include states of AR, IA, IL, KS, KY, LA, MO, MS, MT, ND, NE, SD, and TN.

Douglas, N.H. 1974. Freshwater fishes of Louisiana. Louisiana Wildl and Fish Comm., Claitor's Pub, Baton Rouge.

#41 General reference on freshwater fish of Louisiana. Author mentions only two specimens collected in Louisiana from the Mississippi River at Lake Providence from East Carroll Parish. Both specimens were young fish weighing only 0.7 and 1.4 kg. The pallid sturgeon was considered as apparently rare in the state.

Dryer, M.P. and A.J. Sandvol. 1993. Recovery plan for the pallid sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service, Denver. 55 pp.

#42 Official recovery plan for this federally listed endangered species. Provides current information on distribution, abundance, habitat preferences, life history, and reasons for decline. The short-term objective is to avoid extinction through artificial propagation, and the long-term goal is to delist species by 2040 by establishing six naturally self-sustaining populations of the species.

Elstad, S., J.C. Hendrickson, and G. Power. 1992. Sturgeon and their associated habitat in the Missouri and Yellowstone Rivers of North Dakota. Fisheries Inventory Report 4, North Dakota Game and Fish Dept, Bismarck.

#43 Part of North Dakota fisheries investigations series. Authors report that pallid sturgeon are part of native fauna in Missouri and Yellowstone rivers within state, but they failed to capture a single pallid in 582 gill net drift sets for an equivalence of 99.2 miles of river fished in 1992 although 204 shovelnose sturgeon were captured, comprising 57% of the total fish catch.

Erickson, J.D. 1992. Habitat selection and movement of pallid sturgeon in Lake Sharpe, South Dakota. M.S. thesis. South Dakota State University, Brookings. 70 pp.

#44 Unpublished master's thesis. Author studied habitat use by pallid sturgeon through use of telemetry gear from 1989 to 1991. A total of 492 locations were obtained on seven fish. Pallids selected water at a 4-5 meter depth and avoided backwater and areas without current. Small pallids occupied different habitats than larger fish, and shovelnose sturgeon may be a competitor at the smaller sizes.

Fisher, H.J. 1962. Some fishes of the lower Missouri River. Amer Midl Nat 68:424-429.

#45 Results of fishery surveys conducted in lower Missouri River in 1945. Four pallid sturgeon were collected out of 24,664 fish. One pallid was captured near Glasgow in May, one near Lexington in August, and two near St. Joseph in August. Author also obtained a 21.3-inch pallid from a commercial fisherman at Rocheport on October 30 and a 32-inch FL, 4.1-lb fish near Easley on October 25.

Fogle, N.E. 1961. Report of the fisheries investigations during the second year of impoundment of Oahe Reservoir, South Dakota, 1959. DJ Project F-1-R-9 Report, South Dakota Dept of Game, Fish and Parks, Pierre.

#46 Report of fishery investigations on Oahe Reservoir during second year of filling. Author reports capturing four pallid sturgeon in the riverine section as the reservoir filled. One fish was captured on July 7, one on July 27, and two on August 18, 1959. Three fish were 34 inches long, and one was 43. Condition factors were recorded as 12.4 and 12.8. Author thought small mesh prevented more captures.

- Fogle, N.E.** 1961. Report of the fisheries investigations during the third year of impoundment of Oahe Reservoir, South Dakota, 1960. DJ Project F-1-R-10 Report, South Dakota Dept of Game, Fish and Parks, Pierre.
- #47 Oahe Reservoir fishery investigations in 1960. Tailwater harvest of fish was estimated at 547, including 20 pallid sturgeon. Reservoir studies netted 22 pallids representing 0.5% of all catches. Average condition factor for 17 males was 9.8 and for 5 females 10.8, which was down from 12.5 and 12.8 for previous year. Lengths were from 18 to 45 inches; males matured at 21 to 23 inches.
- Fogle, N.E.** 1963. Report of the fisheries investigations during the fourth year of impoundment of Oahe Reservoir, South Dakota, 1961. DJ Project F-1-R-11 Report, South Dakota Dept of Game, Fish and Parks, Pierre.
- #48 Results of fishery surveys on Oahe Reservoir in 1961 and for the tailrace fishery. Author reported capturing a 30-inch male on June 27 with a condition factor of 10.3. The fish weighed 3.1 lb. The tailrace fishery was estimated to have taken 34 pallid sturgeon weighing 532 lb, or 2.9 lb per surface acre of fishing area.
- Fogle, N.E.** 1963. Report of the fisheries investigations during the fourth year of impoundment of Oahe Reservoir, South Dakota, 1962. DJ Project F-1-R-12 Report, South Dakota Dept of Game, Fish and Parks, Pierre.
- #49 Author summarizes fishery studies in Oahe Reservoir and the tailwater creel survey results for 1962. Title should have been ""during fifth year of filling." Gill netting yielded 1613 fish including 20 pallid sturgeon ranging from 26 to 42 inches and 1.8 to 9.25 lb. The tailwater fishery yielded seven pallid sturgeon weighing 27 lb. Author provides growth table from backdating on six fish.
- Fogle, N.E.** 1964. Summation of four years of creel census, July 1959 through June 1963, on Oahe tailwater. DJ Project F-1-R-13 Report, South Dakota Dept. of Game, Fish and Parks, Pierre.
- #50 Tailwater creel harvest below Oahe Dam on Missouri River for first 4 years after dam was closed. Pallid sturgeon were creeled for 2 of 3 years until water diverted through power plant facilities in fourth year. Largest pallid sturgeon creeled was 23 lb.
- Forbes, S.A., and R.E. Richardson.** 1905. On a new shovelnose sturgeon from the Mississippi River. Bull Illinois State Lab of Nat Hist 7:37-44.
- #51 Original description of this species from nine specimens collected by commercial fishermen on the Mississippi River near Grafton, Illinois. Authors report that about one in 500 sturgeon at Grafton (mouth of Illinois River upstream from Missouri River) were this "white" sturgeon while one in five were this species near West Alton (mouth of Missouri River). Named *Parascaphirhynchus albus*.
- Forbes, S.A., and R.E. Richardson.** 1909. Fishes of Illinois. Illinois Nat Hist Surv 3:1-357.
- #52 Authors included species in *Parascaphirhynchus* and provided commonly known name of white sturgeon. Provided data on comparative morphometric features between this species and the shovelnose sturgeon. Reported species as rare on the Mississippi River but more common on the lower Missouri River. Spawning season was reported to be between June 1 and August 1, according to commercial fishermen.

- Gabel, J.A.** 1974. Species and age composition of trap net catches in Lake Oahe, South Dakota, 1963-67. Tech Paper 75, U.S. Fish and Wildlife Service, Washington, DC. 13 pp.
- #53 Results of trap net catches in Oahe Reservoir from 1963 to 1967 as the reservoir completed filling. Three pallid sturgeon were reported in the catch in 1399 days of trap netting. All three fish were captured in 1964.
- Gardner, W.M. and P.A. Stewart.** 1987. Fishery of the lower Missouri River, Montana. DJ Project FW-2-R Report, Montana Dept of Fish, Wildl and Parks, Helena.
- #54 Report of studies on Missouri River, with mention that pallid sturgeon were caught but with no records.
- Gardner, W.M.** 1990. Missouri River pallid sturgeon inventory. DJ Project F-46-R-3 Report, Montana Dept of Fish, Wild and Parks, Helena.
- #55 Results of first year of study, including interviews of 50 people who fished or lived along the river upstream of Fort Peck Reservoir, regarding pallid sturgeon observations. A total of 35 observations were recorded. Recorded weights ranged from 17 to 62 lb. Of 22 captures, 8 were by setlines, 7 while snagging for paddlefish, 4 in gillnets, and 3 by electroshocking.
- Gardner, W.M.** 1991. Missouri River pallid sturgeon inventory. DJ Project Report, Montana Dept of Fish, Wildl and Parks, Helena.
- #56 Report of second year of study above Fort Peck Reservoir. Five pallids and 382 shovelnose sturgeon were captured on setlines and in trammel nets. The five pallids ranged from 30.0 to 50.0 lb and from 50.0 to 60.0 cm FL. Two pallid sturgeon were fitted externally with radio transmitters in attempts to gather information on movements and habitat selection.
- Gardner, W.M.** 1992. Missouri River pallid sturgeon inventory. DJ Project F-46-R-5 Report, Montana Dept of Fish, Wildl and Parks, Helena.
- #57 Results of third year of study above Fort Peck Reservoir. Author reports capture of two pallids weighing 30.0 and 38.0 lb and measuring 50.3 and 55.0 inches FL. One pallid captured the previous year was recaptured. Pallid sturgeon were captured in pools on downstream end of islands. One fish moved 69 and another 37 miles. Authors captured two pallids and 624 shovelnose in trammel nets.
- Gardner, W.M.** 1993. Missouri River pallid sturgeon inventory. DJ Project F-46-R-6 Report, Montana Dept of Fish, Wildl and Parks, Helena.
- #58 Summary of fourth year of study in Missouri River above Fort Peck Reservoir. Fifteen captured pallid sturgeon during 1992, 11 "new" fish and 4 recaptures. Six pallids were fitted with transmitters. Weights of the new fish ranged from 17.5 to 41.0 lb and lengths from 42.7 to 56.5 inches FL. A total of 147 radio relocations were obtained. Morphometric measurements provided.

- Gardner, W.M.** 1994. Missouri River pallid sturgeon inventory. DJ Project F-46-R-7 Report, Montana Dept of Fish, Wildl and Parks, Helena.
- #59 Author summarizes 5 years of study including results of 1993 field season where 6 "new" and 3 recaptured pallids were taken. A total of 24 pallids had been observed during the 5 years of study ranging from 13.2 to 50.0 lb and averaging 33.4 lb. All pallids were caught in the lower 60 miles of the study area above the headwaters of Fort Peck Reservoir in pool areas with sandy substrate.
- Gasaway, C.R.** 1970. Changes in the fish population in Lake Francis Case in South Dakota in the first 16 years of impoundment. Tech Pap 56, U.S. Fish and Wildlife Service, Washington, DC.
- #60 Reports on commercial harvest of several species after Lake Francis Case formed on Missouri River (Fort Randall Dam), including 328 sturgeon, between 1959 and 1968. Most of these sturgeon were presumed to be pallid sturgeon since the average weight of sturgeon was about 15 lb and too large to be shovelnose sturgeon. Peak year was 1962 when 78 sturgeon, weighing 1,170 lb, were taken.
- 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. South Dakota State University, Brookings. 76 pp.
- #61 Status of the species throughout its known range. Authors identify habitat alteration, possible hybridization with the more common shovelnose sturgeon, river operations, and possible overuse as threats to the species' continued existence. The species was protected by all states on the Missouri River but by no state along the Mississippi River. Compiles known data.
- Gould, G. and J. Schmulbach.** 1975. Relative abundance and distribution of fishes in the Missouri River, Gavins Point Dam to Rulo, Nebraska. Missouri River Envir Inventory. University of South Dakota, Vermillion. 59 pp.
- #62 Summary of studies in Missouri River from 1968 to 1973. Only one pallid sturgeon was captured to 6392 shovelnose sturgeon. The pallid was captured in the unchannelized river section (now Wild and Scenic River section) below Gavins Point Dam.
- Gowanloch, J.N.** 1933. Fishes and fishing in Louisiana. Bull 23, Louisiana Dept Cons, New Orleans.
- #63 Author considers the "white shovelnose" as one of the least known of all sturgeons. No site data or captures are referenced, but a key is provided to enlist help of fishermen in obtaining data on this species. Generic name listed as "*Paraschaphirhynchus*" as originally described by Forbes and Richardson, and one of distinguishing characteristics is 20 to 21 ribs (10 to 11 ribs for shovelnose).

- Graham, K. and 10 others.** 1993. MICRA paddlefish/sturgeon committee strategic plan. Mississippi Interstate Cooperative Resource Agreement, Columbia, MO.
- #64 Strategic plan for sturgeon and paddlefish as developed by the paddlefish/sturgeon committee working under the auspices of the Mississippi Interstate Cooperative Resource Agreement. Organization is a cooperative and coordinating group involved with interjurisdictional fishery resources within the Mississippi drainage basin. Brief species accounts are provided as well as goals for the committee.
- Haddix, M.H., and C.C. Estes.** 1976. Lower Yellowstone River fishery study final report. Montana Dept Fish, Wildl and Parks, Helena.
- #65 Final report for a fishery survey of the Yellowstone River conducted for the Bureau of Reclamation. Authors report capturing a 52.0-inch pallid sturgeon weighing 24.5 lb while electroshocking below the Intake Diversion structure on the Yellowstone River in 1975.
- Harlan, J.R. and E.B. Speaker.** 1956. Iowa fish and fishing. Iowa Cons Comm, Des Moines.
- #66 General reference on fishes in Iowa. Pallid sturgeon reference short, giving the common names of white sturgeon or hackleback. Mentions specimen by Coker and probable credence of sighting since fish was collected prior to Keokuk locks. Authors believed species likely in Missouri River, although no specimens were verified from Missouri River in Iowa waters.
- Harlan, J.R., E.B. Speaker, and J. Mayhew.** 1987. Iowa fish and fishing. Iowa Dept Nat Resources, Des Moines. 323 pp.
- #67 General reference on fish and fishing in Iowa. Authors indicate historic range along both eastern and western borders of Iowa in Mississippi and Missouri rivers. Species presently rare and classified as "endangered" in Iowa and protected. Pallid sturgeon presently confined to Missouri River only and considered to be rare.
- Heckman, W.H.** 1952. By "Steamboat Bill." Missouri Conservationist 13(12):11.
- #68 Author is a steamboat captain responding to an article on sturgeon in the October issue of the Conservationist. Mentions catching a 24-lb pallid near Herman, also seeing a 35-lb pallid near Herman, and a 65-lb pallid taken in 1910. Claimed pallid sturgeon (i.e. "white" sturgeon) are about a fourth of sturgeon in river. Bite only during cool weather in fall and spring. Setlines used.
- Henry, C.J. and R. Ruelle.** 1992. Study of pallid sturgeon and shovelnose sturgeon reproduction. U.S. Fish and Wildlife Service, Pierre. 19 pp.
- #69 Reproductive data on 12 pallid sturgeon (3 Illinois, 9 Louisiana) from Mississippi River compared with data from 11 shovelnose from Nebraska. Hybrid female had GSI of 23.9 while three immature pallid females had GSIs of 7.2, 9.0, and 10.5. The GSI of male pallids ranged from 1.3 to 7.6. Female pallids over 700 mm FL showed developing eggs and at 900 mm appeared mature.

Hill, W.J. 1966. Progress and job completion report, test netting survey of Garrison Reservoir, Missouri River, and Oahe Reservoir investigations, Snake Creek Reservoir, commercial fishing in Garrison Reservoir. DJ Project F-2-R-13 Report, North Dakota Dept of Game and Fish, Bismarck.

#70 Summary of Garrison Reservoir fishery surveys for 1965. Author reports capturing one pallid sturgeon at the Deepwater Creek station weighing 14 lb, 4 oz and measuring 48 inches long. Fish was caught in a gill net in 91 hours of fishing.

Hill, W.J. 1968. Management surveys of the Missouri River and its main stem reservoirs in North Dakota. DJ Project F-2-R-15 Report, North Dakota Dept of Game and Fish, Bismarck. ND D-J Report.

#71 Missouri River fishery survey results for 1967. Author reported gill netting pallid sturgeon in the Van Hook Arm station of Lake Sakakawea (Garrison Reservoir) in August (25.8 inches long and 2 lb, 6 oz), one at Fort Yates (2 lb, 8 oz, 28.0 inches long in 133 hours), and two in Porcupine Bay (6 lb, 6 oz, 39.3 inches; 7 lb, 0 oz, 41.4 inches; 87 hours) in the Oahe Reservoir headwaters.

June, F.C. 1976. Changes in young-of-year fish stocks during and after filling of Lake Oahe, an upper Missouri River storage reservoir, 1966-74. Tech Pap 87, U.S. Fish and Wildlife Service, Washington, DC. 25 pp.

#72 Success of spawning in Oahe Reservoir from seventh to sixteenth year after initiation of filling. Even though adults persisted, no reproduction of several large river fish, including the pallid and shovelnose sturgeons, paddlefish, blue catfish, and channel catfish, was found. Twelve of 45 species previously in this section of the Missouri River were no longer found.

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. FWS/OBS-77/25, U.S. Fish and Wildlife Service, Columbia, MO.

#73 Authors report capturing one pallid sturgeon in a gill net in the riverine section of the Missouri River downstream of the Fort Randall Dam in 1976.

Kallemeyn, L.W. 1983. Status of the pallid sturgeon (*Scaphirhynchus albus*). Fisheries 8:3-9.

#74 Reported 250 sightings of pallid sturgeon; 76% of them from Missouri River in Montana and North and South Dakota. Of 13 states representing species range, nine classify it as rare, endangered, or of special concern. Discusses distribution, abundance, habitat, food, harvest, and reproduction. Length-weight formula of $\log W = -7.311 + 3.664 \log L$ developed for Missouri River population.

Keenlyne, K.D. 1989. Report on the pallid sturgeon. MRC-89-1, U.S. Fish and Wildlife Service, Pierre, SD.

#75 Report summarizes status of pallid sturgeon throughout its range and examines threats through review of the literature. Author also summarizes sighting data on species from scientific literature, gray literature, and Heritage Program data. Report contains appendix of all known sightings, by river section and by river mile along with several historic photos of large pallid sturgeon.

- Keenlyne, K.D., E.M. Grossman, and L.G. Jenkins.** 1992. Fecundity of the pallid sturgeon. *Trans Amer Fish Soc* 121:139-140.
- #76 Authors report on fecundity of a 41-year-old fish collected from the Missouri River in North Dakota. The ripe female weighed 17.1 kg and was 140.4 cm FL. Egg mass represented 11.4% of total weight. Sampling provided an average of 87 eggs/g for a total fecundity estimate of 170,000 eggs. This is the oldest pallid reported in the literature but not the largest, meaning fish may get much older.
- Keenlyne, K.D. and S.J. Maxwell.** 1993. Length conversions and length-weight relations for pallid sturgeon. *NA Jour Fish Mgmt* 13:395-397.
- #77 Authors developed conversion formulae for SL to FL, SL to TL, and FL to TL, based on 30 pallid sturgeon collected from the Missouri River in Nebraska, South and North Dakota, and Montana. Length-weight formulae were also calculated for each of the length measurements that have been commonly used for the species. Weight and length data for the 30 specimens are included in the paper.
- Keenlyne, K.D. and L.G. Jenkins.** 1993. Age at sexual maturity of the pallid sturgeon. *Trans Amer Fish Soc* 122:393-396.
- #78 Authors report reproductive information for five males and nine females. Males became sexually mature at ages 5-7. Females began egg development at ages 9-12 and first spawned at age 15. GSI data is included for developmental stages of both males and females along with ages based on sections from pectoral fin rays. Paper includes specimens from the Atchafalaya River, a new site location.
- Keenlyne, K.D. and P.D. Evenson.** 1993. Standard and relative weight for the pallid sturgeon, *Scaphirhynchus albus*. *Proc South Dakota Acad Sci* 72:41-49.
- #79 Authors developed standard and relative weight formulae from weight-length data obtained from 214 pallid sturgeon collected from throughout the species range. The weight to length formula of $\log W = -6.378 + 3.357 \log L$ provided an r-square value of 0.974. A length-specific standard weight formula was also calculated as $Ws = 4.18$ to the 7th power times L to the 3.357th power.
- Keenlyne, K.D., C.J. Henry, A. Tews, and P. Clancey.** 1994. Morphometric comparisons of upper Missouri River sturgeons. *Trans Amer Fish Soc* 123:779-785.
- #80 Authors took morphometric measurements from 89 pallid and 204 shovelnose sturgeon from three populations on the upper Missouri River. Pallid sturgeon showed morphometric changes in populations toward the headwaters while shovelnose did not follow this trend. Morphometric ratios commonly used to distinguish between the species did not remain mutually exclusive with this larger sample size.

Kreil, R. 1990. Old man, the old fish and tomorrow. *North Dakota Outdoors* 52(4): 25-27.

#81 Popularized fictional article on catching pallid sturgeon. Author uses article to educate public about life history and habitat needs of pallid sturgeon and what has happened to habitat in North Dakota to cause additional restrictions on capturing the species. Article describes new restrictions placed in North Dakota on harvest of sturgeon where it became illegal to harvest any sturgeon species.

Kreil, R. and G. Power. 1991. Preliminary status investigation of the pallid sturgeon in North Dakota. Endangered Species Project SE-1 Report, North Dakota Game and Fish Dept, Bismarck.

#82 Primarily a proposal for obtaining Section 6 study funding under the Endangered Species Act. Provides summary of management activities recently performed in North Dakota to benefit pallid sturgeon including information and education activities and changes in regulations to protect both the pallid sturgeon and the shovelnose sturgeon.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer. 1980. Atlas of North American freshwater fishes. North Carolina State Mus Nat Hist, Raleigh.

#83 General reference on range and distribution of freshwater fishes in North America. Pallid sturgeon listed as one of two genera in subfamily and one of two or three in genus. Range given as main channels of Missouri and lower half of Mississippi rivers. Habitat preference is excessively turbid waters in strong current over firm bottom. Considered one of most poorly known fishes in North America.

Lopinot, A.C. and P.W. Smith. 1973. Rare and endangered fish of Illinois. Illinois Dept of Conservation, Div of Fisheries, Champaign.

#84 General reference on rare and endangered fishes of Illinois. Authors list the pallid sturgeon as occurring in the Mississippi River in Illinois below the confluence with the Missouri River. The authors recommended that the pallid sturgeon be classified as "rare" in Illinois and placed under the state's endangered species code.

Madsen, T. I. 1985. The status and distribution of the uncommon fishes of Nebraska. M. A. thesis, University of Nebraska, Omaha. 97 pp.

#85 Author summarizes life history and capture data on rare fishes of Nebraska. Pallid sturgeon is listed as having been caught in the Missouri and the lower 30 km of the Platte River in Nebraska. A total of 25 fish are referenced as having been caught in Nebraska waters.

Metcalf, A.L. 1966. Fishes of the Kansas River system in relation to zoogeography of the Great Plains. University Kansas Museum of Nat Hist 17:23-189.

#86 Author looks at ancestral development of fish species in relation to zoogeographics of Kansas and the Great Plains. Author indicates that no pallid sturgeon have been found in the Kansas River since the large flood of 1952 when several specimens presumably entered from the Missouri River. Author suggests pallid developed in preglacial Hudson Bay drainage, becoming sympatric with shovelnose later.

- Mississippi Power and Light Company.** 1973. Environmental field measurements programs final report. Mississippi Power and Light Company.
- #87 Mimeographed environmental report for the Grand Gulf Nuclear Station between June 1972 and August 1973. Report references capture of a pallid sturgeon in the Mississippi River with subsequent vouchering of the specimen in the Museum of Zoology, University of Michigan. Specimen served as a distributional record of the species.
- Morris, J., L. Morris, and L. Witt.** 1972. Fishes of Nebraska. Nebraska Game and Parks Comm, Lincoln. 98 pp.
- #88 General treatise on the fishes of Nebraska. Authors mention that pallid sturgeon weighing from 10 to 12 lb are taken immediately below the Gavins Point Dam. Pallid sturgeon and lake sturgeon both considered to be rare in state. Pallid sturgeon mentioned as seeming to prefer muddy water.
- Nebraska Game and Parks Commission.** 1977. Nebraska's endangered and threatened wildlife. Nebraska Game and Parks Commission, Lincoln.
- #89 General public document on threatened and endangered fauna of Nebraska. Pallid sturgeon is classified as "threatened" due to destruction of spawning and feeding grounds, pollution, and siltation. Species is fully protected in Nebraska.
- Nelson, W.R.** 1962. Report of fisheries investigations during the seventh year of impoundment of Gavins Point Reservoir South Dakota, 1961. DJ Project F-1-R-11 Report, South Dakota Dept of Game, Fish and Parks, Pierre.
- #90 Summary of fishery studies in Gavins Point Reservoir during seventh year of impoundment. Author reports three pallid sturgeon being captured in the reservoir headwaters in 36 gill net sets. Fish collected June 26-28 and July 10-12 in 1961 averaged 31 inches in length and 3.7 lb, having condition factors during the two periods of 13.8 (2) and 9.2 (1), respectively.
- Pflieger, W.L.** 1975. Fishes of Missouri. Missouri Cons Dept, Jefferson City. 343 pp.
- #91 A general work on the fishes of Missouri. Key provided to separate pallid from shovelnose sturgeon, noting differences in relative length of inner barbel and a general lack of scutation on abdomen of pallid sturgeon. Although once abundant, overharvest during early 1900s had seriously reduced numbers of pallid sturgeon. Overfishing, pollution, dams, and channelization were considered threats.
- Pflieger, W.L. and T.B. Grace.** 1987. Changes in the fish fauna of the lower Missouri River, 1940-1983. Pp 166-77 in W.J. Matthews and D.C. Heins (eds) Community and Evolutionary Ecology of North American Stream Fishes. University Oklahoma Press, Norman.
- #92 Authors analyzed changes in the fish community of lower Missouri River from sampling at about 20-year intervals. Pallid sturgeon and flathead chub had declined markedly, and authors postulated competition with other more generalist species. Reduced habitat diversity may no longer permit survival of two sturgeon species in the river, with loss of pallid sturgeon the likely result.

- Phelps, S.R., and F.W. Allendorf.** 1983. Genetic identity of pallid and shovelnose sturgeon (*Scaphirhynchus albus* and *S. platyrhynchus*). *Copeia* 1983:696-700.
- #93 Examined fish collected by Carlson *et al.* (1985) electrophoretically at 37 loci. Two species shared same allele at 34 monomorphic loci and had similar allelic frequencies at three polymorphic loci. Close genetic similarity attributed to recent or incomplete reproductive isolation accompanied by rapid morphological differentiation or recent divergence.
- Power, G.J., J.C. Hendrickson, J.D. Lee, and F. Ryckman, F.** 1994. Missouri River system fishery reference and operational management document. Fisheries Inv Rep 10, North Dakota Game and Fish Dept, Bismarck.
- #94 Authors summarize fishery data on the Missouri River as part of the North Dakota Game and Fish "Fisheries Investigations" series. Data on commercial harvest of sturgeon from Lake Sakakawea (Garrison Reservoir) are included. In 1953, 256 sturgeon (3.6 lb ave) were harvested, 186 in 1954 (ave 6.8 lb), 116 in 1955 (ave 7.2 lb) and 322 in 1957 (ave 5.9 lb). Size suggests some were pallids.
- Power, G. and R. Kreil.** 1992. Preliminary status investigation of the pallid sturgeon in North Dakota. End Species Project SE-1 Report, North Dakota Game and Fish Dept, Bismarck.
- #95 Report describes work intended to be performed by agency in relation to pallid sturgeon. It summarizes management activities recently initiated, including review of catch data obtained by Department, information and education efforts, new regulations to prohibit capture of pallid sturgeons, and development of a cooperative study agreement with Montana for interjurisdictional populations.
- Riis, J.** 1993. Pallid sturgeon. *South Dakota Conservation Digest* 60 (July/August):16-19.
- #96 Popular article on the pallid sturgeon alerting sportsmen about the species and about changing regulations prohibiting the harvest of both the pallid sturgeon and shovelnose sturgeon within the state. Several photos including one of 68-lb pallid sturgeon caught by Bruce Hoyer in North Dakota in 1956. Article discusses recovery plan for species, recent telemetry studies, and asks fishermen for sighting information.
- Robison, H. W.** 1974. Threatened fishes of Arkansas. *Arkansas Acad of Sci Proc* 27:59-64.
- #97 General article on the rare and threatened fishes of Arkansas, listing the pallid sturgeon as "rare." Author gave Arkansas distribution of this species as the Mississippi and St. Francis rivers and noted general lack of availability of voucher specimens within the state.
- Ruelle, R. and K.D. Keenlyne.** 1992. Contaminants in Missouri River sturgeon. SD-FWE-93-01, U.S. Fish and Wildlife Service, Pierre. 12 pp.
- #98 Data on contaminant loads in liver, kidney, muscle, and reproductive tissue of two pallid sturgeon from North Dakota and one from Nebraska. Analysis was made for 23 elements and organochlorines. Cadmium, mercury, and selenium were elevated in all tissues. Isomers of DDT, PCBs, and chlordanes were relatively high in reproductive tissues and may be related to reproduction problem.

Ruelle, R. and K.D. Keenlyne. 1993. Contaminants in Missouri River pallid sturgeon. *Bull Environ Contam Toxicol* 50:898-906.

#99 Authors identified several contaminants of concern which may cause adverse effects to pallid sturgeon and especially to sturgeon reproduction. Contaminants of greatest concern were three heavy metals (mercury, cadmium, and selenium) and four organic compounds (PCBs, chlordane, dieldrin, and DDT and isomers). Late maturation and periodic reproduction makes this species vulnerable to contaminants.

Ryckman, F. 1985. Missouri River relic—pallid sturgeon. *North Dakota Outdoors* 47(4): 37-39.

#100 Popular article on pallid sturgeons in North Dakota. Author provides life history information, how to identify species, and capture information for Departmental studies. Photos include one taken from a Williston newspaper showing six pallid sturgeon caught by a setline fisherman near Williston. The largest specimen reportedly weighed 85 lb and measured 66 inches in length.

Schuckman, J. 1989. Nebraska's sturgeon. *Nebraskaland* 67(7):50.

#101 General article on sturgeon in a popularized format. Informational article for fishermen advising them that it is illegal to keep pallid sturgeon in Nebraska and showing how to distinguish between Nebraska sturgeon species. Author indicates that most pallid sturgeon caught in Nebraska are approximately 3 feet long and weigh from 6 to 8 lb.

Shields, J.T. 1957. Report of the fisheries investigations during the second year of impoundment of Gavins Point Reservoir, 1956. D-J Project F-1-R-6 Report, South Dakota Dept of Game, Fish and Parks, Pierre.

#102 Author indicates that reservoir conditions are not suitable for sturgeon. All specimens caught were from the upper portion of the reservoir where riverine conditions existed.

Shields, T.J. 1958. Report of fisheries investigations during the third year of impoundment of Gavins Point Reservoir, South Dakota, 1957. D-J Project F-1-R-7 Report, South Dakota Dept Game, Fish and Parks, Pierre.

#103 Report of fishery survey results for Gavins Point Reservoir during 1957. Author reports capturing nine pallid sturgeon in gill nets that ranged in size from 26 to 51 inches total length and from 3.5 to 18.75 lb in weight. Individual condition factors ranged from 9.7 to 15.2, generally increasing with increasing fish length. Pallids noted to use upstream section of reservoir.

Smith, P.W. 1979. *Fishes of Illinois*. University of Illinois Press, Urbana. 314 pp.

#104 General reference on fishes of Illinois. Author mentions that most pallid sturgeon enter the Mississippi River out of the Missouri River and are primarily found between the mouth of the Missouri and the mouth of the Ohio River in the Mississippi. Species is considered rare in the Mississippi River, and previous report of a specimen found upriver near Keokuk, Iowa, is considered an error.

- Snyder, D.E.** 1994. Morphological development and identification of pallid, shovelnose, and hybrid sturgeon larvae. Contribution 71, Colorado State University Larval Fish Lab, Ft. Collins.
- #105 Larvae from shovelnose sturgeon adults collected in Montana and pallid and hybrid sturgeon collected in Missouri were studied to develop a morphologic key for larvae and protolarvae. Protolarvae could be differentiated using inner and outer barbel length ratios (61-70% I:O pallids; 77-109% shovelnose). For larvae, turns of the hindgut spiral valve was best criterion (5-6 pallid; 6-8 shovelnose).
- Sprague, J.W.** 1959. Report of fisheries investigations during the fourth year of impoundment of Gavins Point Reservoir, South Dakota, 1958. DJ Project F-1-R-8 Report, South Dakota Dept Game, Fish and Parks, Pierre.
- #106 Summarizes fishery studies for Gavins Point Reservoir for 1958. Author reports capturing three pallid sturgeon ranging from 36 to 50 inches in length and from 6 to 16.25 lb with individual condition factors ranging from 11.0 to 13.0. Reported that sport fishermen occasionally catch pallid sturgeon on hook and line. Pallid sturgeon represented 2.8% of catch by weight.
- Sprague, J. W.** 1960. Report of fisheries investigations during the fifth year of impoundment of Gavins Point Reservoir South Dakota, 1959. DJ Project F-1-R-9 Report, South Dakota Dept Game, Fish and Parks, Pierre.
- #107 Summary of fishery investigations on Gavins Point Reservoir during 1959. Author reports capturing two pallid sturgeon in gill nets which averaged 37 inches and 5.5 lb. The average condition factor was 10.7, lower than that recorded in 1958. Author also mentions that commercial netting operations took 36 pallid sturgeon averaging 20 pounds in one 24-hour period.
- Sprague, J.W.** 1964. Test netting survey of Garrison Reservoir, creel census of Garrison tailrace, pre-impoundment survey of the Missouri River Snake Creek Reservoir, commercial fishing in Garrison Reservoir. DJ Project F-2-R-11 Report, North Dakota Game and Fish Dept, Bismarck.
- #108 Summarizes results of fishery surveys on Garrison Reservoir on the Missouri River for 1963. Author reports capturing one pallid sturgeon weighing 14 lb, 8 oz and measuring 49.5 inches in 1426 hours of gill net fishing.
- Swain, D.P., A.J. Derksen, and J.S. Loch.** 1980. A literature review of life histories of some species of fish that may be introduced into the Hudson Bay Watershed from the Missouri River Watershed as a result of the Garrison Diversion. MS Rep. 80-37:92-110, Manitoba Dept Nat Resources, Winnipeg.
- #109 Life history data on several Missouri River fish species that could be introduced into Canada by diversion of water from the Missouri River into basins draining northward through the proposed Garrison Irrigation Unit in North Dakota. This section contains life histories of the shovelnose and pallid sturgeon.

- Tews, A.** 1994. Pallid sturgeon and shovelnose sturgeon in the Missouri River from Fort Peck Dam to Lake Sakakawea and in the Yellowstone from Intake to its mouth. Final Rep, Montana Dept Fish, Wildlife, and Parks, Helena. 87 pp.
- #110 Fifty-five different pallid sturgeon were caught, ranging from 1090-1566 mm FL. Drift netting for 123 hours yielded 0.4 pallids/hr. All pallids caught in nets were in the lower Yellowstone or below its confluence in the Missouri. One fish moved 300 km in a 9-month period.
- Tews, A. and P. Clancey.** 1993. Fort Peck pallid sturgeon study. Montana Dept Fish, Wildlife, and Parks, Helena. 70 pp.
- #111 This the final report under contract to the Corps of Engineers for the 1992 field season. In 38 hr of drift netting, 35 pallid and 402 shovelnose sturgeon were captured. One pallid was from the Yellowstone, the rest were from below the confluence of the Yellowstone and Missouri rivers. Pallids were usually found in narrow channels along sandbars at an average depth of 3.1 m and at velocity of 0.5 m/s. Weights were from 15 to 54 lb.
- U. S. Fish and Wildlife Service.** 1965. A documentation of 1963-64 activities and findings. Bureau of Commercial Fisheries, Mobridge, SD. 74 pp.
- #112 Mimeographed report on results of test netting of commercial fishing gear on Oahe Reservoir by Bureau of Commercial Fishery staff located in Mobridge. Reports harvest of 106 lb of pallid sturgeon in the upper reaches of reservoir with up to 0.2 lb/trap net/day. Also mentions tagging and releasing 13 pallid sturgeon (8 fin clip, 5 dart tags). Pallids noted in upper reservoir only.
- Van Wyhe, G.L.** 1960. Test netting survey of the Garrison Reservoir. DJ Project F-3-R-7 Report, North Dakota Game and Fish Dept, Bismarck.
- #113 Results of test netting in Garrison Reservoir for 1959. Author reports catching six pallid sturgeon in 1083 hours of fishing with a variegated gill net. Lengths ranged from 16.0 to 26.5 inches and averaged 23.5, and weights ranged from 0.5 to 2.4 lb and averaged 1.4 lb.
- Vladykov, V.D. and J.R. Greeley.** 1963. Order Acipenseroidei. Pp 24-60 in Y.H. Olsen (ed), Fishes of the western North Atlantic, part 3. Sears Foundation for Marine Research, Yale University, New Haven, CT.
- #114 Authors list in a footnote the capture of a pallid sturgeon that measured 532 mm FL and weighed 553 g in the brackish water of Vermillion Bay at Cypremont Point, Louisiana, by a shrimp fisherman in a trawl on May 10, 1954. This sighting would be after some large flooding on the Mississippi River and not a great distance from one of the outlets to the Atchafalaya River where pallids were found.
- Walburg, C.H.** 1964. Fish population studies, Lewis and Clark Lake, Missouri River, 1956-1962. Spec Fish Rep 482, U.S. Fish and Wildlife Service, Washington, DC. 27 pp.
- #115 Documents decline of most fish species in Lewis and Clark Lake (Gavins Point Dam) during the first 7 years after impoundment. Nine pallid sturgeon were captured in 1957, 3 in 1958, 2 in 1959, and 3 in 1961. Lengths ranged from 26 to 51 inches and weights from 3.5 to 18.8 lb. Growth rates of many species also declined, leaving the author to conclude rapid water exchange harmed fish.

- Walburg, C.H., G.L. Kaiser, and P.L. Hudson.** 1971. Lewis and Clark Lake tailwater biota and some relations of the tailwater and reservoir fish populations. Pp 449-467 in *Reservoir Fisheries and Limnology, Spec Pub 8*, Amer Fish Soc, Bethesda, MD.
- #116 Authors studied fish dynamics of Lewis and Clark Lake (Gavins Point Dam) on Missouri River from February 1968 to April 1969, 13 and 14 years after enclosure. Only one pallid sturgeon was captured out of 5486 fish in 61 gill net sets below the reservoir in the tailwater area.
- Walburg, C.H.** 1976. Changes in the fish population of Lewis and Clark Lake, 1956-1974, and their relation to water management and the environment. Research Rep 79, U.S. Fish and Wildlife Service, Washington, DC. 34 pp.
- #117 References to captured pallid sturgeon during first 19 years after the impoundment of Lewis and Clark Lake (Gavins Point Dam) on the Missouri River. No specific data on pallid sturgeon is provided; however, the decline of sympatric species such as shovelnose sturgeon and silvery minnows is indicated.
- Walburg, C.H.** 1977. Lake Francis Case, a Missouri River Reservoir: changes in fish population in 1954-75, and suggestions for management. Tech Paper 95, U.S. Fish and Wildlife Service, Washington, DC. 12 pp.
- #118 Frequently used reference on status of pallid sturgeon. Author provides a list of fish species and their apparent trends in Lake Francis Case (Gavins Point Dam Reservoir) on the Missouri River over a 22-year study period. The pallid sturgeon is classified as "rare" with "no trend" on population numbers. Also termed "rare" are three sunfish species, black bass, flathead chub, silvery minnows, and other species.
- Walker, C. R.** 1952. Sturgeon. *Missouri Conservationist* 13(10):16
- #119 Popular article on sturgeon in Missouri. Mentions pallid, or white sturgeon, as one of three Missouri sturgeons and explains how to identify between the species. Author also mentions that commercial sturgeon harvest in Missouri has been between 6000 and 13,000 lb with most of these being shovelnose. Fish are eaten smoked, the eggs used as caviar, and the skin as leather. Trammel nets are used in harvesting.
- Warren, M.L., Jr., B.M. Burr, and B.R. Kuhajda.** 1986. Mississippi River sturgeons: new Kentucky records and comments on status. *Trans Kentucky Acad Sci* 47(1-2):52-53.
- #120 Authors report first vouchered specimen of pallid sturgeon in Kentucky. Specimen was obtained November 5, 1985, from the Mississippi River about 9 km south of Columbus, Hickman Co. Fish was a 685-mm SL female weighing 1.8 kg, captured with six shovelnose sturgeon on a setline baited with worms. Authors note that commercial fishermen find species less common than shovelnose.
- Warren, M.L. Jr. and 14 others.** 1986. Endangered, threatened, and rare plants and animals of Kentucky. *Trans Kentucky Acad Sci* 47(3-4):83-98.
- #121 Authors are the Endangered Species Committee for the Kentucky Academy of Science and the Kentucky Nature Preserves Commission. Report updates rare animal and plant list. Pallid sturgeon listed as "endangered" in state.

Watson, J.H. and P.A. Stewart. 1991. Lower Yellowstone River pallid sturgeon study. Montana Dept Fish Wildlife and Parks, Helena.

#122 Covers work for Bureau of Reclamation on Yellowstone River. Authors report capturing one pallid sturgeon on July 19, 1991, in a trammel net near RM 129.3 near the town of Fallon. Specimen weighed 11.34 kg and was 134.0 cm FL. Authors captured 724 fish, including the pallid sturgeon and 349 shovelnose sturgeon.

Zuerlein, G. 1993. Nebraska's threatened and endangered species; pallid and lake sturgeons. *Nebraskaland Magazine*. 1993 (Oct.).

#123 Popular article on the lake sturgeon and pallid sturgeon giving fishermen information on how to distinguish between the species, life history information, and status. Article includes map showing location of reports received since 1970, which are 15 locations on the Missouri River and two sites on the lower Platte River.

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