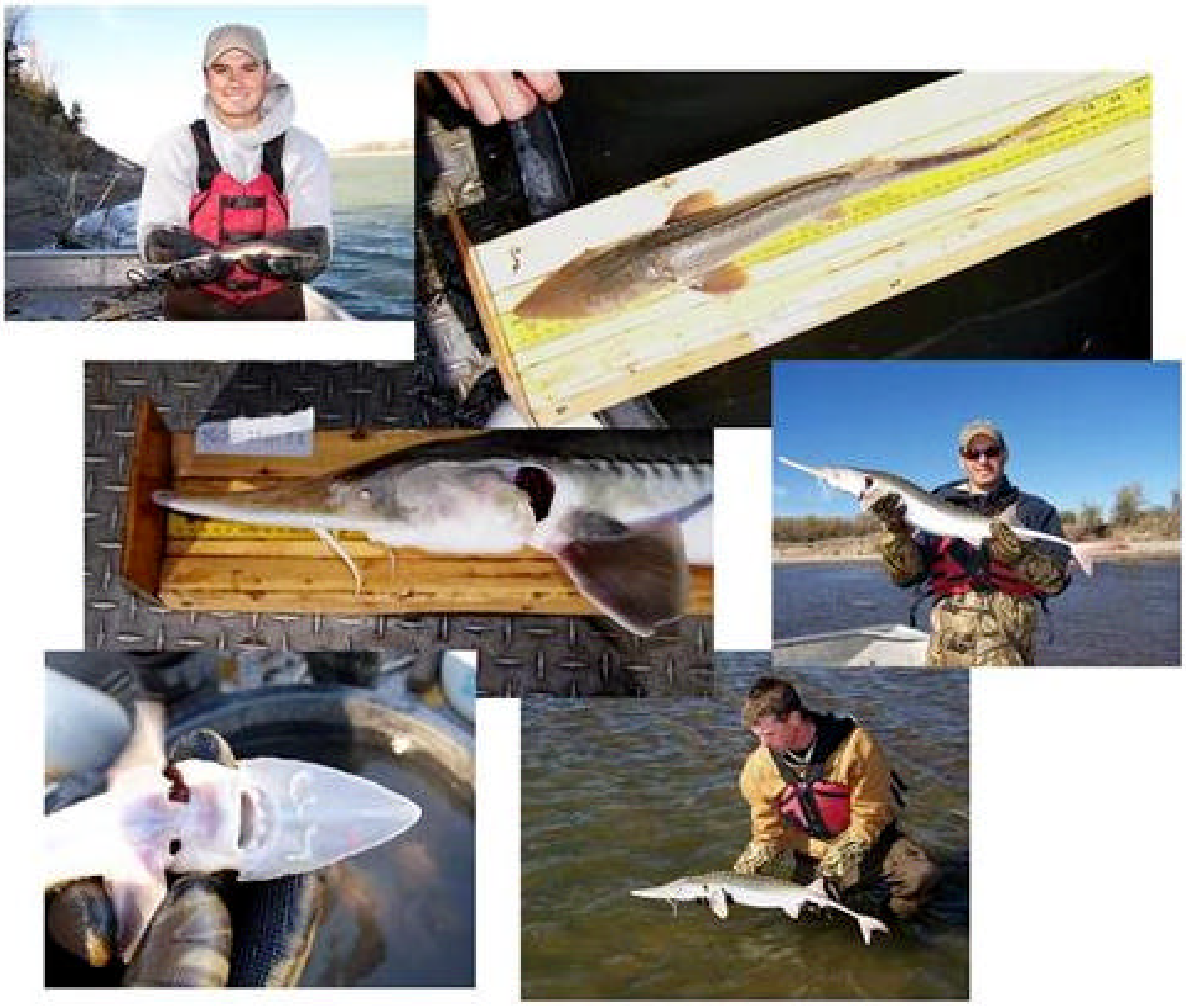
Draft: Last updated March 9, 2006

South Dakota
Pallid Sturgeon (*Scaphirhynchus albus*)
Management Plan



South Dakota Department of Game Fish and Parks
Pierre, SD
2006
Wildlife Division Report 2006-01

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South Dakota
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Management Plan

Approved/Date ______________________________________

Secretary, Department of Game, Fish and Parks

DISCLAIMER
This is the completed South Dakota Pallid Sturgeon Management Plan. It does not necessarily represent the views nor the official position or approval of any individuals or agencies involved in the plan formulation, other than South Dakota Game, Fish and Parks.

ACKNOWLEDGEMENTS
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EXECUTIVE SUMMARY

As a part of the Water Resources Development Act of 1999, approximately 91,178 acres along the Missouri River and reservoirs in South Dakota will transfer from the U.S. Army Corps of Engineers (USACE) to the state for wildlife and recreation purposes. This pallid sturgeon management plan has been developed, in part, to ensure that the state's activities on the transferred lands have an overall net benefit on pallid sturgeon. Ultimately, South Dakota would like the pallid sturgeon population to become self-sustaining in the wild. To this end, we will continue to work with agencies responsible for the Missouri River to manage the system so that conditions are suitable for pallid spawning and fry survival.

A summary of South Dakota Game, Fish and Parks' (SDGFP) planned activities to benefit the pallid sturgeon over the next several years is below. Because of the nature of the Missouri River system, with numerous agencies working together to make management decisions, many of these tasks involve cooperators.

Monitoring and Research:

- Participate in a river-wide pallid sturgeon monitoring project funded by the USACE. A crew of three SDGFP biologists work on the riverine stretch below Gavins Point Dam. This work is contracted with the USACE through September 2009.
- Help fund a research project in cooperation with the U.S. Fish and Wildlife Service (USFWS) and the Cooperative Fish and Wildlife Research Unit in the Department of Wildlife and Fisheries at SDSU to model feeding and growth rates in juvenile pallid sturgeon.

Broodstock Recovery

- In coordination with a team from the USFWS, will provide a team to spend at least one week attempting to capture pallid sturgeon from Lake Sharpe to augment the broodstock available for stocking.

Interagency Cooperation:

- Work with the USFWS to coordinate pallid sturgeon stocking.
- Participate in the Missouri River Natural Resources Committee, Mississippi Interstate Cooperative Resources Association, Great Plains Fisheries Workers Association, Missouri River Restoration Program/Task Force, a part of the Missouri River Trust; Missouri River Association of States and tribes (MORAST), Upper and Middle Basin Workgroups and in development of the Missouri River Recovery Implementation Committee (MRRIC).
- Provide input on the Corps' Annual Operating Plan (AOP) and other planning documents.

Public Outreach:

- Increase public knowledge and interest in pallid sturgeon using news releases. Two fisheries biologists have been identified as the primary contacts: Jim Riis and Sam Stukel.
- Include information, including images, in the South Dakota Fishing Handbook that the sturgeon season is closed.
- Post and maintain signs at boat ramps from Fort Randall Dam to the South Dakota state line (on the South Dakota side) to alert anglers that the sturgeon season is closed.

- Fund a position to work with private landowners on conservation opportunities in cooperation with the Missouri River Futures, an organization of federal and state entities with the goal of improving habitat along the Missouri River.

Reconnecting the Floodplain:

- Identify and work to reconnect low areas of the floodplain which could be flooded periodically without damage to other property owners.

ACRONYMS

AOP	Annual Operating Plan
BO	Biological Opinion
CFS	Cubic Feet per Second
DENR	Department of Environment and Natural Resources
ESA	Endangered Species Act
MOA	Memorandum of Agreement
MORAST	Missouri River Association of States and Tribes
MRRIC	Missouri River Recovery Implementation Committee
msl	mean sea level
NFH	National Fish Hatchery
NPS	National Park Service
NRCS	Natural Resources Conservation Service
SDGFP	South Dakota Game, Fish and Parks
SDSU	South Dakota State University
USACE	U.S. Army Corps of Engineers
USFWS	US Fish and Wildlife Service

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1 INTRODUCTION

With its pale color and armored body, the pallid sturgeon (*Scaphirhynchus albus*) is often referred to as a modern day dinosaur. The species evolved in the turbid river systems of the Missouri, Yellowstone, and Mississippi rivers, with meandering channels and low current velocities (Dryer and Sandvol 1993). Dam construction on the Missouri and Mississippi and channelization on all of these river systems have created conditions in which the pallid sturgeon rarely reproduces in the wild. While wild born pallid sturgeon that spawned before the dams were built are dying out, a number of partners are cooperating to raise fish in hatcheries until changes in river management promote natural pallid sturgeon spawning and juvenile survival.

In this plan, we identify goals to promote the survival and eventual recovery of the pallid sturgeon in the wild. South Dakota recognizes that recovering imperiled species such as the pallid sturgeon requires a cooperative effort to be successful, and we are committed to retaining this piece of South Dakota's natural heritage. SDGFP is dedicated to on-going protection and to participating in management actions to protect the pallid sturgeon. The plan is intended to be a flexible "living" document that will help managers make decisions to promote recovery. As we learn more about the species and the Missouri River, this plan may change to reflect this new information.

1.1 Purpose and Need

1.1.1 Federal Land Transfer

There are six major dams on the Missouri River, four of which are in South Dakota (Oahe, which creates Lake Oahe, Big Bend, which creates Lake Sharpe, Fort Randall, which creates Lake Francis Case, and Gavins Point, which creates Lewis and Clark Lake) (Figure 1). The resulting reservoirs are flanked by lands that the federal government took ownership of during construction of the dams and filling of the reservoirs. The US Army Corps of Engineers (USACE) was given jurisdiction over these lands. The Water Resources Development Act of 1999 (Public Law 106-53, August 17, 1999) required the USACE to transfer lands and recreation areas along Lake Oahe, Lake Sharpe, Lewis and Clark Lake, and Lake Francis Case to participating entities which include the State of South Dakota, the Cheyenne River Sioux Tribe, and the Lower Brule Sioux Tribe. This transfer may eventually include a total of 91,178 acres managed by the State of South Dakota: 49,585 acres along Lake Oahe region, 4,709 acres along Lake Sharpe, 31,078 acres along Lake Francis Case, and 5,806 acres along Lewis and Clark Lake (Figure 2). To date (2004), only the recreation areas have been

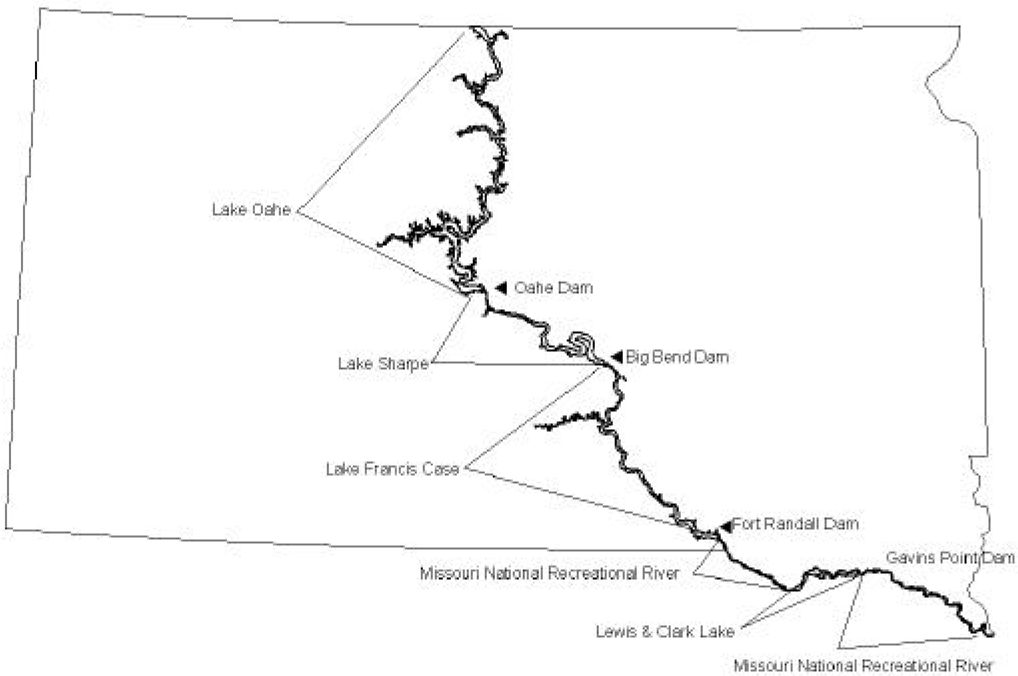

FIGURE 1. Map of Missouri River in South Dakota

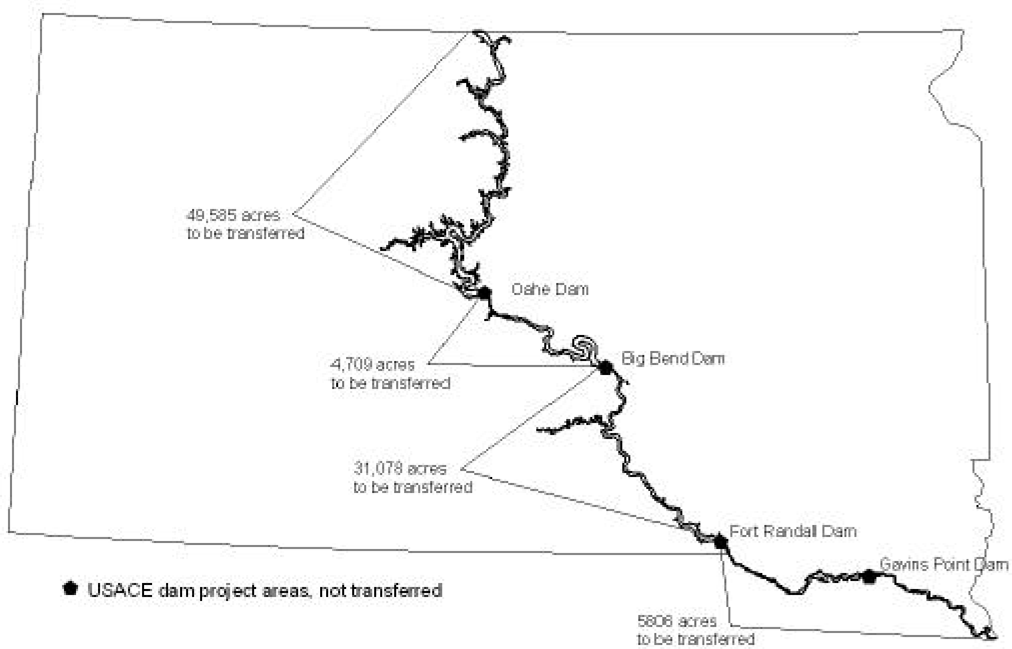

FIGURE 2. Lands to be transferred to South Dakota

transferred to the state. This includes 12,375 acres that have been transferred and 1,659 acres leased to the state.

Once the lands are transferred to South Dakota, state environmental laws apply (USACE 2001). To ensure that federally threatened and endangered species continue to be protected, SDGFP, the USFWS, and the USACE entered into a Memorandum of Agreement (MOA) in 2001. The National Park Service (NPS), which manages two stretches of designated National Recreational River along the southern border of South Dakota, joined the MOA in 2005. The MOA ensures continued protection and active management of the bald eagle, least tern, piping plover, and pallid sturgeon. This state management plan for the pallid sturgeon was written as a component of the MOA. The MOA can be viewed in Appendix A.

1.2 General Species Account

The pallid sturgeon evolved from a group of bony fishes (subclass Paleopterygii) dominant during the Paleozoic Era (570 to 248 million years ago). Most members of the group became extinct sometime during the Mesozoic Era (65 to 248 million years ago), with only the paddlefish (family Polyodontidae) and eight species of sturgeon (family Acipenseridae) still extant in North America today (Dryer and Sandvol 1993).

Pallid sturgeon have a flattened, shovel-shaped snout and a long, completely armored peduncle (the part of the body just in front of the tail fin). The mouth is toothless and protrusible (capable of extending forward) and positioned under the snout. Pallid sturgeon can be easily mistaken for the more common shovelnose sturgeon. In fact, the two species were not differentiated until 1905 (Forbes and Richardson 1905).

Pallid sturgeon tend to be paler than shovelnose sturgeon, although this is not a consistent, reliable indicator (Dryer and Sandvol 1993). Both the pallid and shovelnose sturgeon have four barbels (fleshy protrusions located above the mouth on the ventral side). The position and relationship of these barbels is probably the most reliable method of differentiating the two species in the field (Figure 3). In the pallid sturgeon, the two innermost barbels are approximately half the length of the outer pair, and are not long enough to reach the mouth. In the shovelnose sturgeon, the inner pair of barbels is approximately three-quarters as long as the outer two, and reaches the edge of the upper lip (Bramblett 1996, Smith 1979). The two species have been reported to hybridize, creating intermediate forms (Carlson et al. 1985, Simons et al. 2001, Tranah et al. 2001).

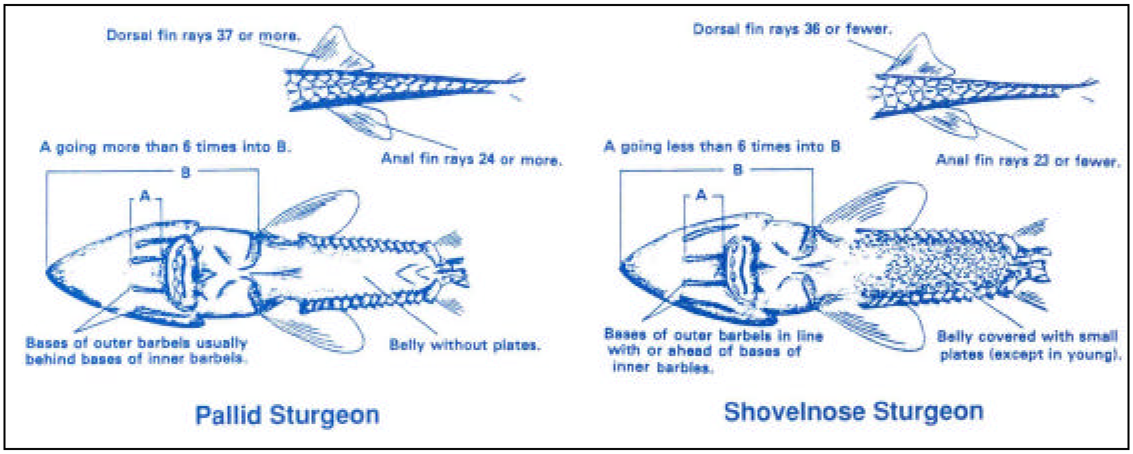

Figure 3: Comparative diagrams of the ventral sides of shovelnose sturgeon and pallid sturgeon, showing several measurements of ratios for identification. Source: SDGFP Undated.

Telemetry studies suggest that pallid sturgeon favor a sandy substrate and relatively swift current (Snook, Peters and Young 2002, Swigle 2003). Pallid sturgeon have also been documented in areas with current breaks (below sandbars, hard points, large snags etc.) in the main channel (Bramblett and White 2001, Jordan et al. in review, Swigle 2003).

The range of the pallid sturgeon extends from the Missouri and Yellowstone Rivers in Montana south to the Mississippi River in Louisiana, including the lower stretches of the major tributaries; Yazoo/Big Sunflower River, St. Francis River, Kansas River, and Platte River. The states within its range include Arkansas, Kansas, Kentucky, Illinois, Iowa, Louisiana, Mississippi, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Tennessee. The USFWS Recovery Plan (Dryer and Sandvol 1993) divides the range into six recovery-priority management areas (Figure 4). These management areas were identified as having recent pallid sturgeon records of occurrence, with the least degradation and highest habitat diversity and potential for successfully returning the areas to close to their pre-settlement conditions.   South Dakota is included in two of the recovery priority management areas; Recovery Priority Management Area 3, the Missouri River from Fort Randall Dam to Lewis and Clark Lake; and Recovery Priority Management Area 4, the Missouri River from below Gavins Point Dam to its confluence with the Mississippi River.

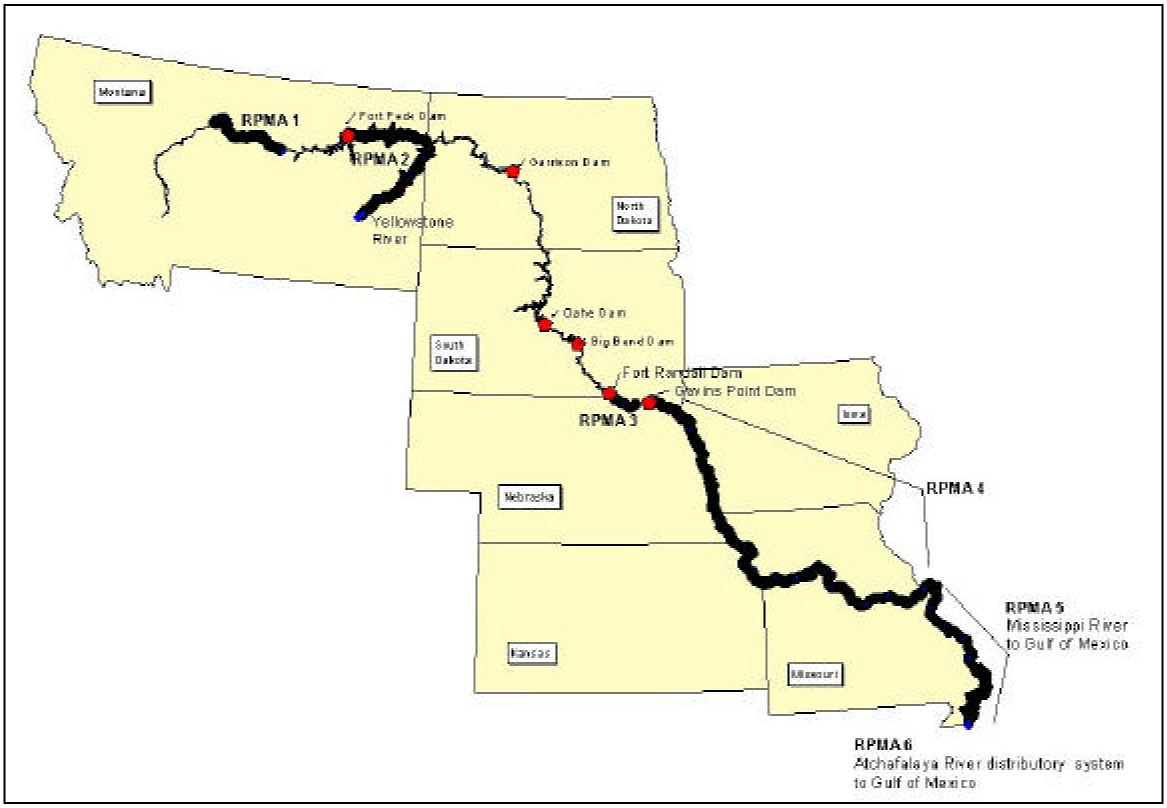

Figure 4: Recovery-priority management areas

1.2.1 Reproduction

The requirements for reproduction have not been well described for pallid sturgeon (USFWS 2003) and they have rarely been documented to spawn in the wild since dams were built (Dryer and Sandvol 1993, Tews 1994), so the species' spawning requirements are not well understood. Pallid sturgeon are thought to spawn in swift water over gravel or other hard surfaces (Erickson 1992, Keenlyne 1989). Spawning probably occurs between March and June (Forbes and Richardson 1905), with reproduction occurring earlier in the southern end of the range and later farther north, corresponding with spring flows from rainfall and icemelt. In fact, flow may be a key component initiating sturgeon reproductive behavior. A study of the closely related shovelnose sturgeon found that they seemed to respond to increased flow by moving upstream (Hofpar 1997). Auer (1996) found that lake sturgeon on the Sturgeon River in Michigan were more likely to spawn when flows approximated natural conditions and water temperatures were warmer. Turbidity, pH, and photoperiod cues are also likely important factors initiating spawning.

Pallid sturgeon are slow to reach sexual maturity, with males not reproducing until they are approximately five to seven years old, and females spawning for the first time at fifteen to twenty years (Erickson 1992, Keenlyne and Jenkins 1993). There are likely several years between spawning events for both males and females (Keenlyne 1989).

Pallid sturgeon reproduction was not documented to occur in the Missouri River since dam completion (Gilbraith et al. 1988, June 1976) until 1990, when some young-of-the-year fish were found near Columbia, Missouri (Reeves and Galat 2004, USFWS Website A Accessed January 28, 2005). After hatching, pallid sturgeon larvae drift for up to 13 days (Kynard et al. 2002). Drift distance probably varies with ambient water velocity, but may be more than 124 miles (200 km) in the first 11 days (Braaten and Fuller 2005). On the Missouri River system, larval drift time may be a serious impediment to reproduction.

The Fort Randall stretch (from the Fort Randall Dam to Gavins Point Dam) is approximately 69 miles long. It is not known whether this distance is long enough for pallid sturgeon larvae to begin actively swimming and remain in the stretch or whether some other factor (i.e. lack of spawning habitat) is responsible for the apparent lack of successful spawning. Paddlefish are known to spawn in the Fort Randall stretch and survive, but they are reported to be strong swimmers soon after hatch (Purkett 1961, Yeager and Wallus 1982). Since pallid sturgeon have rarely been documented to spawn anywhere within their range since dam construction, the lack of reproduction in the Fort Randall reach may be primarily due to the absence of appropriate spawning habitat. Larvae may not be able to survive in the reservoir habitat that they drift into.

Pallid sturgeon have been documented to hybridize with the more common shovelnose sturgeon, resulting in intermediate forms (Carlson et al. 1985, Heist and Schrey 2004). Some researchers have suggested that this may indicate that the reproductive requirements for the two species may be similar (Carlson et al. 1985), but others have pointed out that hybridization seems to be a fairly recent phenomenon and the two species likely avoided hybridization in the past by spawning in different microhabitats (Bramblett and White 2001, Swigle 2003). If this is the case, then shovelnose sturgeon may not be a good proxy species to determine pallid sturgeon reproductive needs.

1.2.2 Hatcheries

Pallid sturgeon were first spawned in a hatchery in 1992 at the Blind Pony State Fish Hatchery in Missouri. They were next successfully spawned at Gavins Point National Fish Hatchery in South Dakota during 1997. Some fry from the 1992 spawning event, as well as from all subsequent spawning events to date (2005), are retained at the Gavins Point National Fish Hatchery as a potential future brood stock (Pers. Comm. Herb Bollig, USFWS, Pallid Sturgeon Propagation Committee March 2004 - Draft).   The Gavins Point National Fish Hatchery plans to continue to keep representatives from future year classes on site.

In order to reduce the risk of a catastrophic event in a single hatchery impacting the entire program and to reduce stress on adults or young moving long distances to or from the hatchery, the Recovery Plan initially identified two hatcheries - the Gavins Point National Fish Hatchery in South Dakota and the Blind Pony State Fish Hatchery in

Missouri - as the primary hatcheries responsible for spawning and rearing pallid sturgeon. Since that time, five additional federal hatcheries (Garrison Dam National Fish Hatchery and Valley City National Fish Hatchery in North Dakota, Bozeman Fish Technology Center in Montana, Neosho National Fish Hatchery in Missouri, and Natchitoches National Fish Hatchery in Louisiana) and two state hatcheries (Miles City State Fish Hatchery in Montana, and Booker-Fowler Fish Hatchery in Louisiana) were also selected to spawn and rear pallid sturgeon (Pers. Comm. Herb Bollig, USFWS).

Pallid sturgeon have been successfully spawned streamside and also by bringing the adult females into hatcheries, although there have been some problems with survival of adult females post spawn (Holm 1999, Pers. Comm. Crystal Hudson, USFWS). Pallid sturgeon broodstock are brought into the Gavins Point Fish Hatchery in the fall, spawned the following spring, and released that fall. Biologists have found that they do not have mortalities when they separate the stressors of capture and spawning, releasing the fish when the water is cool (Pers. Comm. Herb Bollig, USFWS).

In order to reduce stress on adult pallid sturgeon, biologists are developing management practices to minimize fish handling when collecting the fish and obtaining sperm and eggs for propagation (Pallid Sturgeon Propagation Committee 2004).

1.2.2.1 Zebra Mussels

Since the discovery of invasive zebra mussel (*Dreissena polymorpha*) veligers (the juvenile form) below Gavins Point Dam and Fort Randall Dam in the summer of 2003 (Hesse 2003), the Gavins Point Fish Hatchery has been especially concerned with ensuring that they do not spread zebra mussels. To date (2005), no adult zebra mussels have been found in the Missouri River in South Dakota (Perkins and Backlund 2000, Pers. Comm. Stephen Wilson, NPS). The hatchery has established a standard operating procedure to ensure that the fish and water that they release from the hatchery do not harbor zebra mussels or their veligers (larvae) (USFWS Undated). This document can be seen in Appendix B.

1.2.3 Protection History

The pallid sturgeon was proposed to be listed as federally endangered in 1989 (54 FR 35901-35905, Available on USFWS Website A Accessed February 24, 2005) because of habitat modification, lack of reproduction, commercial harvest, pollution, and hybridization.   In September 1990, the species was listed as endangered (55 FR 36641-36647, Available on USFWS Website A Accessed February 24, 2005). Critical habitat has not been designated.

SDGFP changed the status of the pallid sturgeon to a state endangered species from a state threatened species at the January 10-11, 1991 SDGFP Commission meeting (SDGFP Website Accessed February 28, 2005).

1.2.4 Status of the Species Rangewide

Sturgeon worldwide are threatened due to changes to riverine habitat and overfishing (Rochard et al. 1990), and pallid sturgeon are no exception. When the species was first described in 1905 (Forbes and Richardson), it represented approximately one in five sturgeon in the Lower Missouri River. A 1985 (Carlson et al.) study on the Missouri and Mississippi Rivers found only one pallid sturgeon in 647 sturgeon caught. In 1994, the ratio in the Lower Missouri River was one pallid sturgeon to 341 shovelnose sturgeon (Doyle et al. 2005). Also, there has apparently been an increase in hybridization between pallid and shovelnose sturgeon in recent years (Grady et al. 2001). Many researchers are concerned about the threat that hybridization poses to the species (Keenlyne 1989, Simons et al. 2001).

Dam construction has adversely impacted pallid sturgeon both by impeding their movement to spawning areas and by changing the flow and temperature regime, so there is no longer suitable habitat along large parts of their historic range (Bailey and Cross 1954, Keenlyne 1989). There has been little evidence of spawning in recent years (Tews 1994, Webb et al. 2004), and it is not known whether any larval fish have survived to recruit into the population. Larval fish released from Garrison Dam National Fish Hatchery in Montana during 2004 were recaptured in 2005, so apparently at least short term fry survival is occurring (Pers. Comm. Pat DeHaan, USFWS).

1.2.5 Status of the Species in South Dakota

By 1967, the first year when all six dams on the mainstem Missouri River were operating as a system (Figure 1, Table 1), large portions of the Missouri River had changed from a riverine to a lacustrine (lake) environment (National Research Council 2002). There are remnant pallid sturgeon in the reservoirs, but there has been no evidence of any reproduction in the reservoirs since dam completion, and these pallids are dying out as they reach the end of their lifespan (Gilbraith et al. 1988). The longevity of pallid sturgeon is not known, but they are known to live for more than forty years (Dryer and Sandvol 1993, Ruelle and Keenlyne 1993).

There is no evidence of successful pallid reproduction in the riverine stretches below Fort Randall and Gavins Point dams. Hatchery-reared fish have been stocked in both stretches starting in 2000 (Pers. Comm. Herb Bollig, USFWS). The adults used for spawning were taken from the Yellowstone River/Missouri River confluence.

Table 1: Missouri River mainstem dams and year of completion

Dam	Year of Dam Closure
Fort Peck	1937
Garrison	1953
Oahe	1958
Big Bend	1963
Fort Randall	1952
Gavins Point	1955

Source: National Research Council 2002

2 THREATS TO PALLID STURGEON

At the time of listing, habitat modification, lack of natural reproduction, commercial harvest and hybridization were identified as the main reasons for the species' decline (Sept. 1990, 55 FR 36641-36647, Available on USFWS Website A Accessed February 24, 2005). These issues continue to threaten the species' survival today. Threats to the species rangewide are described in more detail below.

2.1 Habitat Modification

Human induced changes to riverine systems have been the main factor in the species' decline. Since construction of the mainstem dams, approximately one-third of the Missouri River has been impounded, one-third channelized, and the remainder has been drastically impacted with changes to the hydraulic cycle and sediment transport (Hesse et al. 1989). These changes have impacted the reproduction, growth, and survival of the pallid sturgeon (Dryer and Sandvol 1993). Sturgeon evolved in a big river system, with high turbidity, many snags and organic matter. With dam construction and channelization, the surface area of the Missouri River has been reduced by approximately one-half, while the velocity has nearly doubled (Gilbraith et al. 1988). Erickson (1992) suggests that pallid sturgeon select habitat at least partially based on flow velocity, so changes in flow may impact spawning behavior.

Pallid sturgeon caught in Lake Sharpe in recent years were in poor condition, indicating that they may not be finding adequate forage in the reservoir. After these adult pallid sturgeon were transferred to the Gavins Point National Fish Hatchery, they doubled in weight. In addition, the newly captured fish had little gonad (sexual organ) development, but after some time in the hatchery, their gonadal development resumed (Pers. Comm. Herb Bollig, USFWS).

2.1.1 Tributaries

The use of major tributaries and their confluences within the Missouri River basin has been documented in many areas of the pallid sturgeon’s historical range (Pers. Comm. Steve Krentz, USFWS). Pallid sturgeon have been documented in the Marias and Yellowstone Rivers and at the confluences of the Milk, Bighorn, and Tongue rivers in Montana as well as at the confluence of the Cannonball River in North Dakota (Pers.

Comm. Steve Krentz, USFWS). Farther south in Nebraska, pallid sturgeon have been documented in the Platte River and its major tributary, the Elkhorn River. Pallid sturgeon have also been reported in the Kansas River in Kansas (Pers. Comm. Steve Krentz, USFWS). Latka (1994) documented greater use of confluences by shovelnose sturgeon than the main river channel during the navigation season in channelized river stretches, but this preference may be caused by the lack of appropriate habitat in the main channel during high river flows. Pallid sturgeon have been captured at the confluence of the Niobrara and Missouri Rivers (Krentz 1999).

While pallid sturgeon spawning sites are not known, other related species such as the shovelnose sturgeon and paddlefish (*Polyodon spathula*) use the tributaries to spawn (Coker 1930, Forbes and Richardson 1909, Harrow and Schlesinger 1980, Swigle 2003). Swigle (2003) radiotracked two pallid sturgeon, including a gravid female which was captured in the lower Platte River. While care must be taken not to over-extrapolate from a single individual, this finding, in combination with evidence of hybridization, suggests that pallid sturgeon, like shovelnose sturgeon, may use the lower Platte River to spawn. Several researchers have suggested that pallid sturgeon use swifter water for spawning than shovelnose sturgeon (Erickson 1992, Forbes and Richardson 1909), so water velocity may have been a factor historically in keeping the two species isolated during spawning.

The connectivity of the Missouri River to its major tributaries within South Dakota has been limited by the construction of the four major dams along the Missouri River. Oahe Reservoir and the lower portions of its tributary confluences no longer have riverine characteristics, and there is no evidence that the pallid sturgeon which were trapped behind Oahe Dam at completion have reproduced since dam closure (June 1976, Gilbraith et al. 1988). Since pallid sturgeon are thought to be swift water spawners (Erickson 1992, Keenlyne 1989) appropriate conditions likely no longer exist in the impounded sections or the lower reaches of their tributaries. Major tributaries impacted by the construction of the dams in South Dakota include the Grand, Moreau, Cheyenne, Bad, and White Rivers. These tributaries are no longer connected with a riverine Missouri River, and thus the inputs of these systems no longer provide benefits to pallid sturgeon.

The recovery plan has identified the remaining riverine portions of the Missouri River in South Dakota as Recovery Priority Management Area 3 and Recovery Priority Management Area 4 (Figure 4). The major tributaries in these river stretches are the James, Vermillion, Big Sioux, and Niobrara rivers.

The USFWS conducted a telemetry study with adult and juvenile pallid sturgeon in the Fort Randall stretch and found the fish principally in the main channel of the Missouri River (Jordan et al. in review), although a 2002 study did find juvenile pallid sturgeon in

Lewis and Clark Lake (Pers. Comm. Gerry Wickstrom, SDGFP). However, none of the individuals were thought to be in breeding condition during the course of the study, so it is not known whether the tributaries would be used during spawning (Jordan et al. in review).

Although pallid sturgeon have not been documented within the tributaries in South Dakota, the role of tributaries in providing heterogeneity (variation in habitat types, turbidity, substrate etc.) to the Missouri River system is invaluable. These tributaries influence various physical and chemical characteristics of the Missouri River required by native fishes that flourished in the pre-dam Missouri River system including dissolved oxygen, temperature, turbidity, depth, velocity, and substrate (Keenlyne 1989, Snook 2001). Additionally, tributaries provide significant inputs of organic matter to the Missouri River which may enhance production of macro-invertebrates and forage fishes. There are reports of pallid sturgeon captures in the lower Platte River in Nebraska. The Platte River is not channelized, and the river still has braided channels and shallow sandbar habitat, with forested banks (Snook 2001).

The construction of the dams has created a discontinuity in the river continuum whose influence is felt for an extended distance down river (Ward and Stanford 1983). This discontinuity within the system decreases the annual variation in water temperatures, turbidity, hydrograph, nutrient levels, and nutrient recycling. Below the dams, there has been an average increase in substrate size and increased light transmission since the fines are trapped above the dams and scouring flows remove all but the larger sediments below (Ward and Stanford 1983). While there are more sport fish in the reservoirs than there were in the original riverine system (USFWS 2000), the ecosystem at large is less diverse than the pre-dam system. Major tributaries along the Missouri River may help to dampen the effects of impoundments since the tributaries have characteristics more similar to pre-dam conditions. These tributaries may now act as refugia for native species requiring habitats found in relatively unaltered rivers.

2.1.2 Flow

Altered flows on the Missouri River have had profound impacts on many aspects of the physical environment. In turn, these changes have likely affected all aspects of the pallid sturgeon's life cycle, particularly reproductive behavior. Figure 5 shows the average flow at Yankton from 1931 through 2005. The hydrograph's change from pre to post-dam can be clearly seen (USGS Website Accessed December 30, 2005, Pers. Comm. Mike Swenson, USACE, Pers. Comm. Craig Solberg USGS).

2.1.2.1 Sediment Transport and Channel Modification

Sediment load in a river is composed of two primary components, the suspended load and the bed load, the component which moves along with the water by rolling or bouncing (saltating) along the bed (Kellerhals and Church 1989). Because the suspended load tends to be deposited near the bank during normal flows, or on the bank during floods, it is important in stream shape and streambank composition. The bed load is the primary component that forms in-channel bed and bars, and thus is primarily important in channel morphology. Dams trap most of the sediment moving through the system, so both types of sediment load are reduced under the current system. Prior to construction of Gavins Point Dam, the sediment load was an estimated 133 million tons (121 million megagrams) at Yankton, approximately 4.5 miles (7 km) below Gavins Point Dam. Six years after dam completion, the sediment load at Yankton was measured at 16.5 million tons (1.5 million megagrams), almost a 90 percent decrease. In fact, even 1,300 miles (2,092 km) downstream from Gavins Point Dam, the annual suspended load is still only 30 percent of pre-dam levels (Williams and Wolman 1984).

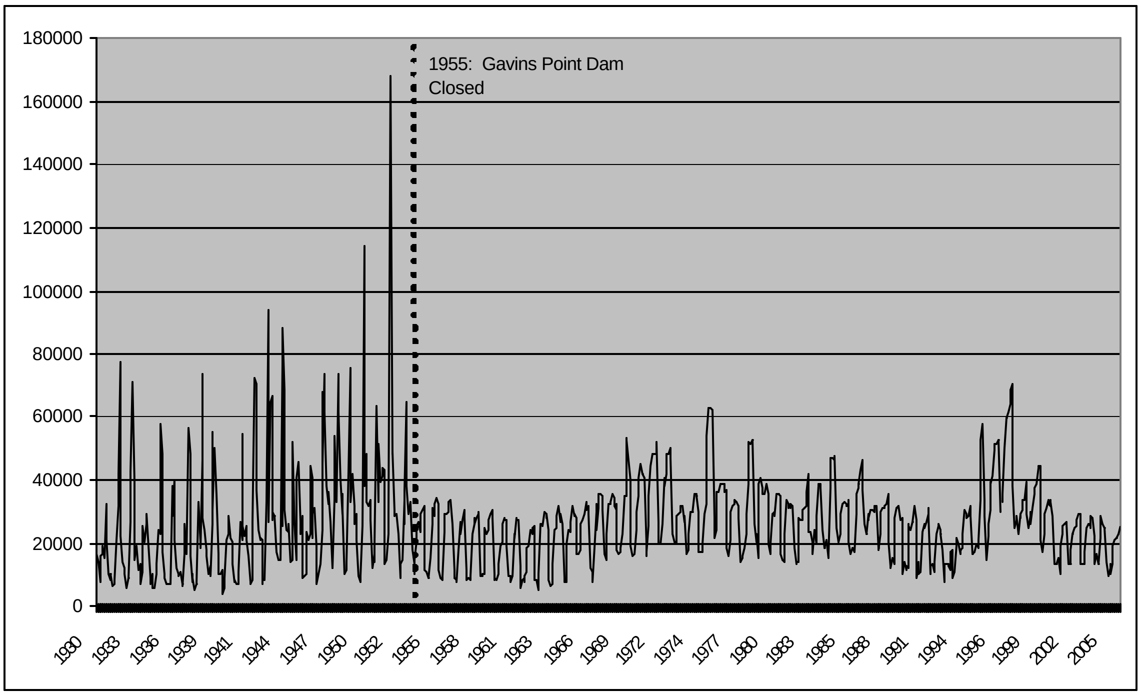

Figure 5: Average monthly flows from October 1930 through September 1995 at a USGS gauge station near Yankton, South Dakota. Dotted line indicates the year Gavins Point Dam was closed. Note the decrease in peak flow after dam completion. Source: 1930-1995 - USGS Website Accessed December 30, 2005, 1996-2000 - Pers. Comm. Mike Swenson, USACE, 2001-2005 - Pers. Comm. Craig Solberg USGS.

There are several impacts of this reduced sediment load on channel morphology and function. The most obvious impact is a deepening and narrowing of the channel directly below the dams. Water coming through the dams is sediment deprived, and the banks along the outflow are armored with rip-rap, so the water scours the channel bottom, deepening the bed and making the river more incised (Petts 1979). The USACE estimates that channel deepening below Gavins Point Dam extends approximately 20 miles downstream from the dam (USACE 1996).

Over time, a dam may lead to a wider channel due to a concurrence of factors. Sediment deprived water entrains sediment from the bed and banks without associated bank accretion. Dams often have wide daily flow variations in response to power needs. This constant wetting and drying erodes the lower sections of bank, leading to undermining and collapse of the higher bank sections. Rapid flow changes then cause the river to wander back and forth along one side of the bank and then the other, leading to erosion of one bank and then the other without deposition. Thus, while the channel may become narrower shortly after dam construction, over time the channel may actually become wider downstream of the dam (Williams and Wolman 1984). Widening may not be seen in the Fort Randall or Gavins Point stretches because of the extensive bank stabilization, which would prevent the channel from eroding the banks. The USACE reports that 22% of the stretch from Fort Randall to Lewis and Clark Lake and 32% of the stretch from Gavins Point to Ponca is currently stabilized in a mix of private and USACE stabilization projects (USACE 2003).

2.1.2.2 Substrate changes

Because both high and low flows tend to be reduced after dam construction, and because only the finest particles can move through the dams, rivers have less ability to move the bed load after dam construction (Rasid 1979, Stalnaker et al. 1989). This leads to a greater median bed material size. Since the water no longer has enough energy to move the substrate, the bed can be in effect armored with even a single layer of coarse material. A very large flow is then required to move the substrate (Petts 1979, Rasid 1979, Sherrard and Erskine 1991). Fine material collects within the gravel of the stabilized bed. This effect has been documented below Gavins Point Dam, where the bed material has been coarsening over time (USACE 1996).

This change in the substrate type may have important implications for potential pallid sturgeon spawning habitat. Pallid sturgeon are thought to spawn over hard surfaces, rocks, and gravel (Keenlyne 1989), so the infilling of these areas with fines may make them inappropriate as spawning grounds. If spawning were to occur, eggs may be more likely to be smothered by fine material caught in the crevices.

2.1.2.3 Effects of Tributaries

Since there is very little sediment moving with the main channel flow, a primary source of sediment in the post-dam system is from unregulated tributaries (Petts 1979). As discussed above, since the river can no longer move any but the finest sediment (Kellerhals and Church 1989, Petts 1979), this material is deposited in the main channel slightly below the confluence, forming a localized delta. The input from these tributaries is very important in providing sediment to develop or augment sandbars and in-channel islands (Perkins and Backlund 2000). The 2003 BO noted that pallid sturgeon are often located near sandbar islands (USFWS 2003), highlighting the importance of increasing the sediment load into the system to create appropriate habitat.

In the river stretch below Fort Randall dam, sediment input from the Niobrara River is creating a braided delta habitat in the Missouri River below the confluence. This delta is progressing into Lewis and Clark Reservoir. The USFWS sampling crew regularly catches juvenile (hatchery raised) pallid sturgeon in this braided delta habitat (Pers. Comm. Robert Klumb, USFWS).

2.1.2.4 Reproduction and Flows

As discussed previously (Section 2.2.1), pallid sturgeon reproductive needs in the wild are not well understood. However, there is evidence to suggest that flow is an important component in inducing spawning. Following a change from daily fluctuations to near run-of-the-river flows on the Sturgeon River in Michigan, more lake sturgeon were found directly below the dam, and a higher percentage of them were "ripe" - with fully mature eggs or sperm (Auer 1996). In a study of wild-caught pallid sturgeon, Keenlyne and Jenkins (1993) found evidence to suggest that spawning corresponds with high spring flows. The 2003 BO notes the likely importance of an appropriately timed spring rise, with suitable temperatures during and after the rise, to promote spawning and larval survival (USFWS 2003).

2.1.3 Bank stabilization/floodplain habitat

2.2 Lack of Natural Reproduction

As discussed above (Section 2.2.1), pallid sturgeon have rarely spawned in the wild for at least the last thirty years (McKean 2003), and there has been only limited, localized evidence of recruitment of wild-spawned fish into the breeding population (Reed and Dean 2005). The fish that are reproductively mature today were all spawned prior to dam construction (Gilbraith et al. 1988, June 1976) and are thought to be nearing the end of their lifespans (USFWS 2003, Pallid Sturgeon Propagation Committee 2004). Hatcheries have been successfully spawning pallid sturgeon since 1997 and releasing juveniles in RPMA 3 since 1997 (Krentz et al. 2005) (Table 2). Recaptures of released fish indicate that these young are surviving (Shuman et al. 2005), but it will be several years before they are old enough to reproduce. Since there is very limited wild sturgeon reproduction under current river conditions, released fish will likely not reproduce naturally either unless there are appropriate riverine and habitat modifications.

Table 2: Pallid sturgeon juveniles stocked in RPMA 3 (between Fort Randall Dam and Gavins Point Dam) and RPMA 4 (below Gavins Point Dam)

Year	Juvenile Pallids Stocked: RPMA 3	Juvenile Pallids Stocked: RPMA 4	Total RPMA 3 and RPMA 4
1992	-	2,412	2,412
1997	416	2,047	2,463
1998	98	-	98
1999	181	532	713
2001	558	6,897	7,455
2002	601	9,241	9,842
2003	515	10,058	10,573
2004	-	30,628	30,628
2005	868	8,510	9,378
Total	**3,237**	**70,325**	**73,562**

Source: Krentz et al. 2005, Pers. Comm. Steve Krentz, USFWS

2.3 Commercial Harvest

Until described by Forbes and Richardson (1905), pallid sturgeon were not identified as a separate species from shovelnose sturgeon, so early pallid sturgeon catch records are not known (Dryer and Sandvol 1993). Even after pallid sturgeon were recognized, commercial anglers often did not differentiate between shovelnose and pallid sturgeon so there are no good historical population estimates. However, there are limited reports of pallid sturgeon bycatch in the shovelnose sturgeon records (Carufel 1953, Walker 1952, Warren et al. 1986).

Today, any pallid sturgeon caught must be released unharmed, but fishing for the more common shovelnose sturgeon is still legal in several states where the two species' ranges overlap (Table 3). In fact, with the collapse of the sturgeon population in the Caspian Sea, there is increased pressure on the American sturgeon market to produce caviar (Williamson 2003). While the amount of pallid sturgeon bycatch is not known, there have been several cases of pallid sturgeon found for sale among the shovelnose sturgeon in fish markets, and live pallid sturgeon with "check marks" - a cut in the belly made by anglers to check for eggs - have been found by researchers monitoring pallid sturgeon (Pers. Comm. Dave Herzog, Missouri Department of Conservation).

In South Dakota, pallid sturgeon fishing was closed in 1978 (SDGFP 1978) and the fishery was closed on all sturgeon species in 1991 (SDGFP 1991). SDGFP is not aware of any illegal sturgeon fishing in the state.

Table 3: State regulations on shovelnose sturgeon harvest within the range of the pallid sturgeon.

State[1]	Recreational harvest legal?	Commercial harvest legal?	Limits/guidelines
Arkansas	No	Yes	Mississippi River closed
Kansas	Yes	Yes	
Kentucky	Yes	Yes	Currently developing size limits.
Illinois	Yes	Yes	
Iowa	Yes	Yes	Allowed on Mississippi River, not on Missouri River
Louisiana	No	No	
Mississippi	No	No	
Missouri	Yes	Yes	Proposed 10 bag limit (recreation) Parts of Missouri River closed
Montana	Yes	No[2]	40 in. limit
Nebraska	Yes	No	10 bag limit, 20 possession limit, no harvest upstream of Big Sioux River
North Dakota	No	No	
South Dakota	No	No	
Tennessee	Yes	Yes	30 in. limit

[1] Information was collected from state resource agencies in February, 2005. Links to state fishing guidelines are available at http://www.fishingworks.com/regulations/index.cfm.

[2] Shovelnose sturgeon is not technically closed to commercial fishing, but Montana Fish, Wildlife and Parks reports that applications would be reviewed by biologists and most likely denied.

2.4 Hybridization

Hybrids between pallid sturgeon and the more common shovelnose sturgeon have been found (Carlson et al. 1985) and are thought to be implicated in the species' decline (Gilbraith et al. 1988, Keenlyne et al. 1994, Dryer and Sandvol 1993). Hybridization between the two species probably did not occur until fairly recently, when extensive changes in the Missouri and Mississippi river systems degraded or eliminated riverine habitat (Grady et al. 2001). Genetic and morphological studies strongly suggest that shovelnose and pallid sturgeon are separate species (Heist and Schrey 2004, Simons et al. 2001, Tranah et al. 2001), but with a dwindling pallid sturgeon population, and little or no natural reproduction (Gilbraith et al. 1988, USFWS 2003), there is concern that the pallid sturgeon as a distinct species may disappear.

2.5 Disease/Iridovirus

A major problem in hatcheries in recent years has been the emergence of an infectious iridovirus, a disease with strains that infect numerous sturgeon species, including the pallid, shovelnose, white, Russian, and Italian sturgeon (Bozeman Fish Health Center 2003). Pallid sturgeon first showed signs of the iridovirus infection at the Gavins Point National Fish Hatchery in 1999 (Pers. Comm. Rick Cordes, SDGFP). As of spring 2005, pallid sturgeon in the Garrison Dam National Fish Hatchery, Miles City State Fish Hatchery, Gavins Point National Fish Hatchery, Neosho National Fish Hatchery, and

Valley City National Fish Hatchery hatcheries have had iridovirus outbreaks (Pers. Comm. Crystal Hudson, USFWS).

Infected fish go off of their feed, become lethargic, and die, with up to 100 percent mortality (MacConnell et al. 2001). A study of Russian sturgeon found that survivors were apparently immune to future outbreaks, feeding and growing normally during subsequent infections (Adkison et al. 1998).

The source of iridovirus infection is not known. An adult female pallid sturgeon tested positive at Garrison National Fish Hatchery (Pers. Comm. Crystal Hudson, USFWS), but it is not known whether the fish had the infection in the wild or contracted it at the hatchery. Some evidence suggests that the disease may be transmitted vertically (through the eggs), which indicates that it may exist in wild stock, but may only be expressed in the hatchery environment (Adkison et al. 1998, Georgiadis et al. 2001). A study of iridovirus in white sturgeon found that it can be transmitted through the water to uninfected fish (Hedrick et al. 1990). Because iridovirus has primarily been found in hatcheries, it is thought to be related to the stress of living in crowded hatchery conditions. However, at least for shovelnose sturgeon, fish density alone is not enough to induce a virus outbreak (Barrows and Toner 2005).

SDGFP is concerned both about the survival of pallid sturgeon in the wild and the potential of introducing disease into the Missouri River. A SDGFP policy is being developed to help state managers decide when to allow release from the hatcheries (SDGFP 2005, can be viewed in Appendix C). The policy states that no eggs or fish will be accepted from a source showing clinical signs of iridovirus for at least the previous six months. Because of the limited number of adults and progeny available, fish will be tested using both lethal and non-lethal sampling techniques. SDGFP's fish health specialist will determine the appropriate number of fish to be tested. The USFWS has developed a policy and handbook to perform health inspections on aquatic species prior to moving them (USFWS Website B Accessed January 5, 2006).

2.6 Other Fish Species/Predation

The congressionally authorized purposes of dam construction included fish, wildlife and recreation. As the riverine system changed to a deeper, clearer, more lacustrine environment, the fish community composition also changed. In order to boost recreational benefits, SDGFP stocked a number of species, as seen in Appendix D (Nelson-Stastny 2004).

There has been some concern that sport fish may prey on pallid sturgeon and thus be implicated in the species' decline. With the small number of pallid sturgeon in the system, especially pallid sturgeon small enough to be preyed upon, the potential impact of predation on pallid sturgeon is difficult to assess. Parken and Scarnecchia (2002) reported that walleye (*Sander vitreus*) and sauger (*S. canadense*) in Lake Sakakawea were capable of eating wild paddlefish up to 6.57 inches (167 mm) body length (12 inches, 305 mm, total length). Thus, small pallid sturgeon may also be preyed upon. However, Braaten and Fuller (2002, 2004) examined 759 stomachs and found no evidence of predation on sturgeon by seven piscivorous species. The only documented case of a walleye eating a pallid sturgeon was in a clear tank with no other prey available (Nelson-Stastny 2004). If more larval pallid sturgeon were in the system, there may be more instances of predation, as predators would be more likely to encounter them. When stocking pallid sturgeon, the benefits of stocking a greater number of smaller fish need to be balanced with stocking fewer larger fish to determine which is best for the species overall (Stancill et al. 2004).

Since pallid sturgeon evolved in a predator-rich environment, they can be expected to have strong predator-avoidance behavior (Nelson-Stastny 2004). In addition, the pallid sturgeon's preference for turbid environments likely reduces the ability of sight-feeding predators to locate them.

SDGFP has developed a document examining potential predation on pallid sturgeon by native or introduced Missouri River species (Nelson-Stastny 2004). This report found no evidence of predation on pallid sturgeon by sport fish (species favored by anglers).

3 STATE GOALS

Ultimately, SDGFP's goal is for the Missouri River in South Dakota to support a self-propagating population of pallid sturgeon. We view hatchery spawning as a stop-gap measure to be used only until Missouri River conditions improve sufficiently for the population to become self-sustaining in the wild.

However, it is not clear whether the Fort Randall Stretch is long enough for the pallid sturgeon reproductive process. As discussed in section 1.2.1, the extensive length of the pallid sturgeon drift (up to 13 days) (Braaten and Fuller 2005, Kynard et al. 2002) may cause any pallid sturgeon larvae which hatch in the stretch to sink in the reservoir or travel through the dam. Even if the pallid population in the Fort Randall Stretch is not self sustaining, the population may play an important role as an experimental unit or as a genetic resource for future stockings.

The Recovery Plan (Dryer and Sandvol 1993) states that downlisting to threatened will be considered when the population has at least ten percent sexually mature females within each recovery-priority area, and population numbers are sufficient to maintain stability in the wild. Delisting will be considered when pallid sturgeon are reproducing naturally in all six recovery-priority management areas. Given the current state of the pallid sturgeon population, with little or no natural reproduction since dam construction, and very limited local recruitment to reproductive age, the necessary population numbers for stability are not quantifiable at this time (Dryer and Sandvol 1993). SDGFP supports the goals as stated in the Recovery Plan. The USFWS has initiated a five-year review of the pallid sturgeon Recovery Plan, scheduled to be completed in 2006. SDGFP will assist and support this effort as needed.

SDGFP will explore and participate in opportunities to promote natural pallid spawning and fry survival, within the context of the overarching goal of supporting a self-sustaining population within suitable habitats.

4 MANAGEMENT ACTIONS

4.1 Pallid Sturgeon Assessment Project

SDGFP signed a contract with the USACE through September, 2009 to monitor pallid sturgeon and other sensitive Missouri River species from Gavins Point Dam to Ponca, Nebraska using a variety of gears designed to capture fish in all life stages. Monitoring began in the spring of 2005.

Because pallid sturgeon are so rare, the project assesses overall river health through monitoring a number of native river species. By monitoring more common surrogate species, changes in the fish community can be determined, allowing biologists to evaluate the success of management actions. All fish captured during monitoring are recorded, but eight species have been identified as focus species; sand shiner (*Notropis stramineus*), sicklefin chub (*Macrhybopsis meeki*), sauger (*Stizostedion canadense*), shovelnose sturgeon (*Scaphirhynchus platorynchus*), plains minnow (*Hybognathus placitus*), western silvery minnow (*Hybognathus argyritis*), speckled chub (*Macrhybopsis aestivalis*), sturgeon chub (*Macrhybopsis gelida*), and blue sucker (*Cycleptus elongatus*) (Drobish 2006). While the likelihood of capturing pallid sturgeon is low, it is hoped that habitat quality can be determined by monitoring these other fish species.

4.2 Juvenile Pallid Sturgeon Energetics Research

Natural reproduction is believed to be negligible in many reaches of the Missouri River. The lack of reproduction is attributed primarily to the loss (or alteration) of adequate spawning habitat and migration corridors (Quist et al. 2004). Hence, long-term recovery and maintenance of naturally reproducing pallid sturgeon will likely require significant habitat restoration efforts, with a particular emphasis on spawning and nursery habitat. Survival and natural recruitment in sturgeon populations, like most fish species, may be regulated by habitat conditions, predation, and prey availability during the first few years of life (Houde 1997). In young fishes, growth rate is often positively linked to survival. Because growth rate reflects physiological responses to habitat conditions, it can serve as a surrogate for fitness and an index of habitat quality. Bioenergetics modeling provides a simplified approach for quantifying growth rate of fishes and evaluating effects of environmental conditions on growth potential (Brandt and Kirsh 1993).

SDGFP, using state and federal dollars, is funding a research project in collaboration with USFWS and the USGS (the SD Cooperative Fish and Wildlife Research Unit in the Department of Wildlife and Fisheries at SDSU) to develop a bioenergetics model for juvenile pallid sturgeon. The project will quantify how water temperature, turbidity, and water velocity impact juvenile feeding rate, to model habitat suitability for juvenile pallid sturgeon, and to quantify prey selectivity of juvenile pallid sturgeon.

It is hoped that this research will help managers assess habitat suitability for juvenile pallid sturgeon in the Missouri River. By combining physiological energetics with physical habitat characteristics, the approach developed here will help biologists identify potentially important rearing areas in the Missouri River. This information, in turn, will help in developing stocking plans and monitoring improvements in habitat conditions for juvenile pallid sturgeon. This project is scheduled to be completed April 2008.

4.3 Reservoir Pallid Relocation

Recent genetics work has suggested that the pallid sturgeon from the northern part of the range are genetically distinct from fish in the southern end, while mid-range fish represent intermediate genetic forms (Heist and Schrey 2006). To retain the genetic integrity of these strains to the greatest extent possible, Heist and Schrey suggest that broodstock should be obtained from as near to the proposed release site as possible. Therefore, the remnant population in Lake Sharpe represents genetic stock that would be well suited for release below Fort Randall Dam.

SDGFP and USFWS fisheries staff will each provide a crew for a minimum of one week in 2006 or 2007 to attempt to capture pallid sturgeon in Lake Sharpe Reservoir. Capture and transport protocols will be followed (Appendix F, USFWS 2005).

4.4 Interagency Cooperation

Because of the large range of pallid sturgeon, with a number of different agencies sharing responsibility for different aspects required for recovery, SDGFP routinely works with a number of agencies on pallid sturgeon issues.

Since a South Dakota permit is required for the USFWS to stock hatchery-reared pallid sturgeon into South Dakota waters, SDGFP works with USFWS biologists on stocking plans. This cooperation has become especially important since the emergence of iridovirus. SDGFP fish health experts must balance the risk of spreading the disease through potentially infected fish with the risk of species extinction.

SDGFP is an active participant in several organizations involved in pallid sturgeon, fisheries, and Missouri River issues including the Missouri River Natural Resources Committee (MRNRC); Mississippi Interstate Cooperative Resources Association

(MICRA), in which South Dakota participates in an informal pallid/paddlefish workgroup; the American Fisheries Society; the Great Plains Fisheries Workers Association; the Missouri River Restoration Program/Task Force, a part of the Missouri River Trust; Missouri River Basin Association (MRBA), and in developing the Missouri River Recovery Implementation Committee. In addition, SDGFP participates in the Upper and Middle Basin Workgroups, which consist of state, federal and academic representatives with the goal of coordinating recovery activities.

Development of this management plan involved experts from multiple entities including DENR, SDSU, USFWS, USACE, NPS, Nebraska Game and Parks Commission, Santee Sioux Tribe, and Yankton Sioux Tribe.

4.5 Public Outreach

An important component of pallid sturgeon recovery is public understanding and support of the project. Many people in South Dakota enjoy recreating and fishing on the Missouri River, and it is important that they know to release any sturgeon unharmed. In addition, positive developments regarding the pallid sturgeon should be presented to the public.

SDGFP will put up and maintain signs at SDGFP boat ramps and include information in the fishing handbook (Figure 6) informing anglers about the requirement to release all captured sturgeon unharmed.

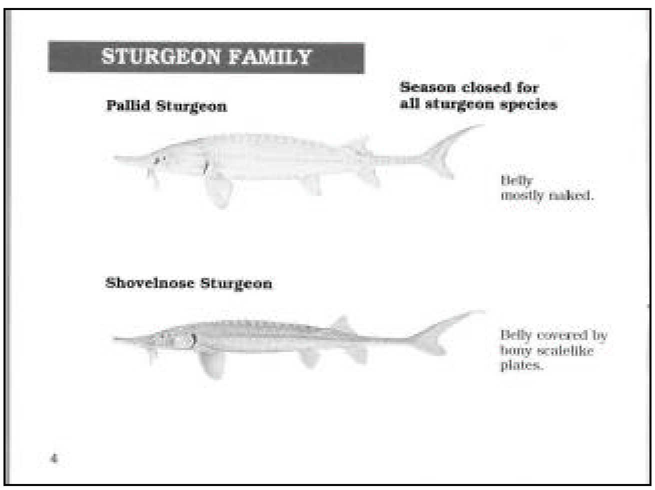

Figure 6. Information in Fishing Handbook to advise anglers that the sturgeon season is closed.

In 2000, the first year that pallid sturgeon were stocked in the Missouri River (Table 3), each of the fish stocked in the stretches below Fort Randall and Gavins Point in South Dakota was marked with a dangler tag (Figure 7), an external tag attached to the base of the dorsal fin (Pers. Comm. Steve Krentz, USFWS). The tag identified the fish as an endangered pallid sturgeon and informed anglers of the need to release the fish unharmed. This effort seems to have been successful, with a number of anglers reporting tagged fish catches (Pers. Comm. Tony Korth, Nebraska Game and Parks Commission). However, some fish appeared to drop their dangler tags over time, and the attachment site has become irritated in some fish, with the area re-opening and failing to heal. Because of these potential problems, dangler tags have not been used since 2000 (Pers. Comm. Herb Bollig, USFWS).

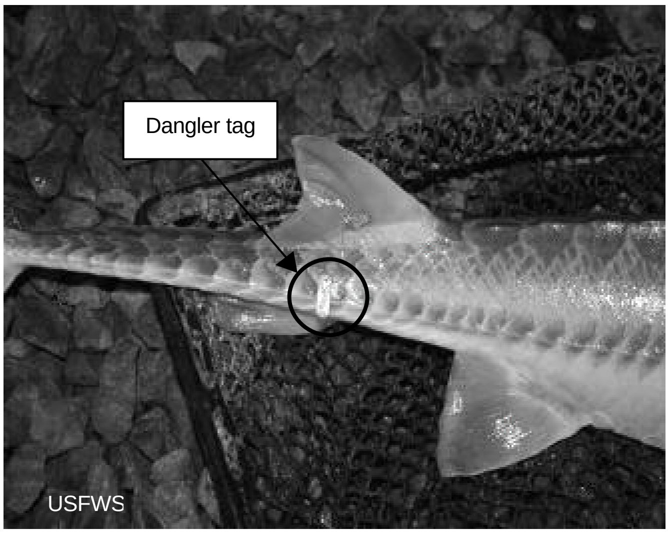

Figure 7: Dangler tag on a pallid sturgeon

News releases are a relatively easy way to include the public in pallid sturgeon happenings. To facilitate media inquiries, SDGFP personnel Jim Riis and Sam Stukel have been identified as state pallid sturgeon contacts. Items which should be included in a news report include stockings, capture of adults for broodstock, release of adults which have been spawned, interesting findings about pallid sturgeon movements, and any other information of interest. If possible, photographs should be available. A December 2005 newspaper article about SDGFP work on pallid sturgeon below Gavins Point Dam is shown in Appendix E.

Some activities may be conducive to more active public involvement. Inviting the public to participate in activities such as the release of hatchery reared sturgeon may promote public interest and support of pallid sturgeon recovery, both now and in the future.

Pallid sturgeon have also been provided for public display at Cabela's store in Mitchell, Dakota Zoo (Bismarck, ND), Bramble Park Zoo (Watertown, SD), and Gavins Point National Fish Hatchery has hosted several open house events to give the public a chance to observe the facilities. If fish are available, more displays of pallid sturgeon may be set up in public aquaria around the state.

4.6 Private Lands Options

While the Missouri River itself is obviously important for pallid sturgeon recovery, long-term sustainability depends on the health of the floodplain as well. Since most of the land along the riverine stretches of the Missouri River in South Dakota is in private ownership, a consortium of state and federal agencies recognized the need to include landowners in retaining and rehabilitating the natural river banks. A number of these organizations with an interest in the Missouri River system have joined together to support a full time employee with the Missouri River Futures organization to help landowners who are interested in conservation options.

There are a number of different options available for landowners who are interested in conserving existing natural habitat or returning the floodplain to natural conditions. These opportunities range from two-year easements, where the landowner retains the right to use the property for many uses, to ten years up to perpetual easements or land acquisition. Landowners interested in conserving natural conditions on their property should contact Steve Grube (402-755-4113) for information. Other types of easements, such as sloughing easements, in which the owner retains title of the land with the understanding that the shoreline will erode, may also be considered.

5 NEED FOR FURTHER INFORMATION/STUDIES REQUIRED

5.1 Reconnecting the Remnant Floodplain

Since dam construction, most of the Missouri River floodplain is either permanently inundated (along the reservoirs), or disconnected from the river (along the free-flowing stretches due to bank stabilization). Under current management, releases are rarely sufficient to produce overland flow, a situation which is compounded because the sediment-starved water has downcut the channel. Much of the original floodplain is no longer accessible to the river, even under high flow conditions.

Once the dams were built, the river no longer moved laterally, and it was possible to construct buildings and farm to the river's edge. This infrastructure has made it infeasible to reconnect the entire original floodplain. However, a second, lower floodplain is still connected to the river in many places along the Recreational River. Preserving and enhancing this lower tiered floodplain may be critical to providing many floodplain functions (Fischenich and Morrow 2000), and is possible without compromising existing riverfront development. Reconnecting backwaters, which are also important spawning grounds, should also help restore many species which have decreased since dam construction (Barnickol and Starrett 1951, Berland 1953, Funk and Robinson 1974, Guillory 1979, Lambou 1963, Sandheinrich and Atchison 1986).

A connected floodplain serves as an important spawning ground for many fish species, likely including pallid sturgeon and their prey species (Barnickol and Starrett 1951, Berland 1953, Burgess et al. 1973, Guillory 1979, Hesse et al. 1989). Extremely high flows are probably not required to improve riverine habitat conditions or to induce spawning.   In fact, there is some evidence that appropriately timed lower magnitude flows, rather than the extreme events, induce spawning in many fish species (Jenkins 2002). More regularly occurring spring flows of lower magnitude than the 1996-1997 high-water years should be sufficient to revitalize habitat and may induce spawning, if other cues (temperature, substrate etc.) are in place.

In order to reclaim the floodplain, areas with the potential to be reconnected to the river along the recreational river stretches need to be identified. These are areas on a low enough bench that higher flows will flood them during high flow events. Since erosion and deposition should occur, the areas should not be rip-rapped. Ideally, there may be backwater areas that could be reconnected in association with the identified areas. Most likely, these areas will be privately owned. Therefore, willing participants with appropriate shoreline property would need to be identified and contacted to participate.

A SDGFP property adjacent to the Frost Wilderness Area, the "Gunderson Property" in Clay County has been identified as a potential site for a backwater project as seen in Figure 8. As can be seen by the historical images below, a chute formerly ran through the property, and a low area remains.

Figure 8-a: Gunderson Property overlaid on 1941 photography.

Figure 8-b: Gunderson Property overlaid on topographic maps derived from 1946 photography.

Figure 8-c Gunderson Property overlaid on 2004 aerial photography.

Figure 8 a-c: Potential chute on Gunderson property (in yellow) overlaid on three images from 1941, 1946 and 2004. Note the chute visible in the 1941 and 1946 imagery (Source: Tim Cowman, SDGS).

The Gunderson property represents an opportunity to reclaim a small portion of the floodplain. SDGFP hopes that more such projects, hopefully accompanied by the return of a more natural hydrograph, will restore the Missouri River system for pallid sturgeon and other native species.

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Appendix A
Memorandum of Agreement

Appendix B
Standard Operating Procedure
Gavins Point National Fish Hatchery

Appendix C
Draft South Dakota Department of Game, Fish and Parks
Fish Health Management Policy

Appendix D
Selected Introduced and Native Fish Species of the Missouri River in South Dakota and their Potential as Predators of Pallid Sturgeon

Appendix E
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Appendix F
Biological Procedures and Protocol for Collecting, Tagging, Sampling, Holding, Culture, Transporting, and Data Recording for Researchers and Managers Handling Pallid Sturgeon