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

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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.

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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, fry survival and recruitment into the population.

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:
SDGFP will:
- 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, SDGFP 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:
SDGFP will:
- 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:
SDGFP will:
- 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 downstream 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:
SDGFP will:

- 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
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
SDDENR	South Dakota Department of Environment and Natural Resources
SDGFP	South Dakota Game, Fish and Parks
SDGS	South Dakota Geological Survey
SDSU	South Dakota State University
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS-BRD	U.S. Geological Survey - Biological Resources Division

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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 U.S. 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 (2006), only the recreation areas have been transferred to the state. This includes 12,375 acres that have been transferred and 1,659 acres leased to the state.

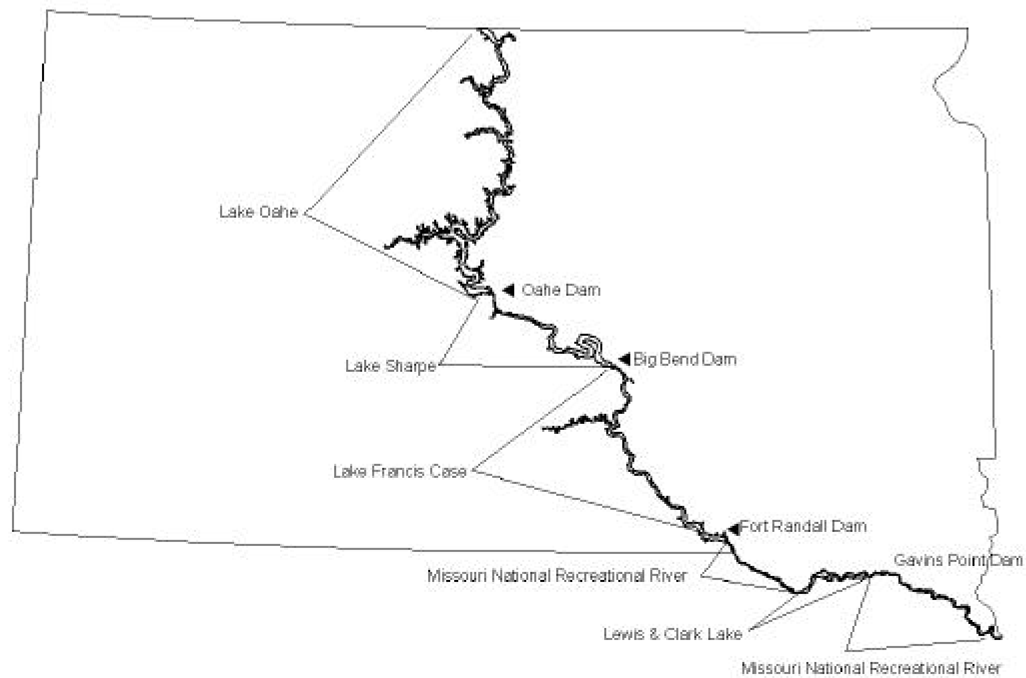

FIGURE 1. Map of Missouri River in South Dakota

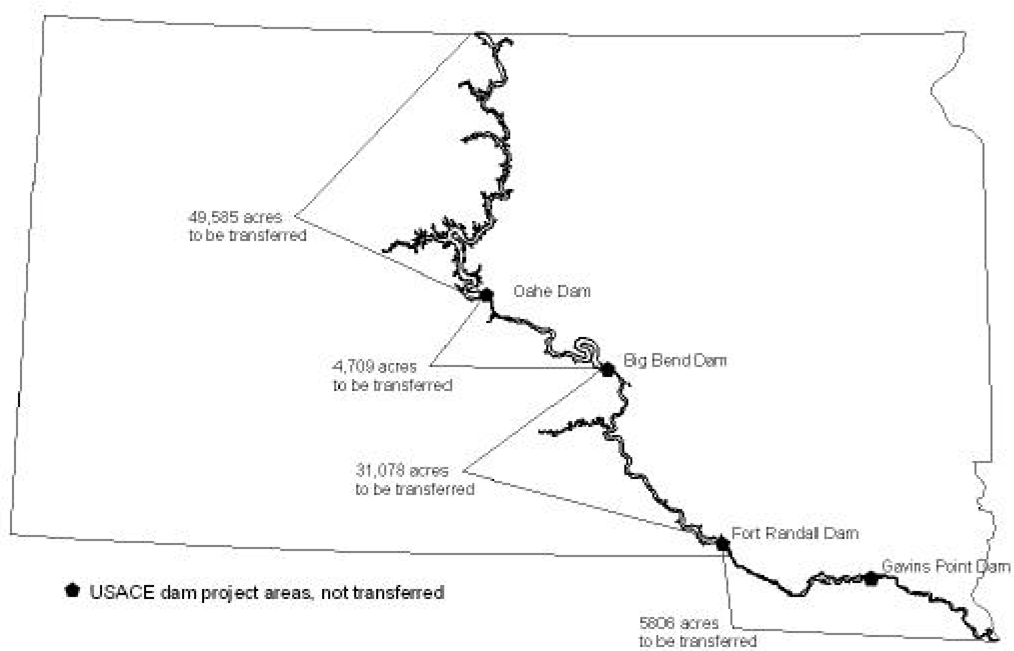

FIGURE 2. Lands to be transferred to South Dakota

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).

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).

Telemetry studies suggest that pallid sturgeon favor a sandy substrate and relatively swift current (Snook et al. 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 press, Swigle 2003).

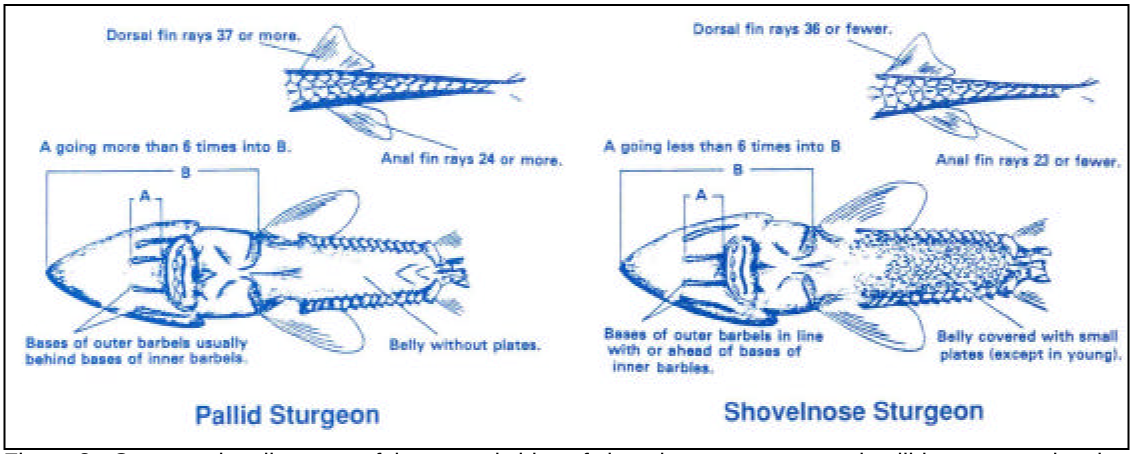

Figure 3: Comparative diagrams of the ventral sides of shovelnose sturgeon and pallid sturgeon, showing several measurements of ratios for identification. Source: SDGFP Undated.

The historical 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. Today, pallid sturgeon are still found in these rivers, but are restricted to areas where there is appropriate habitat available. 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 the start of 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.

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

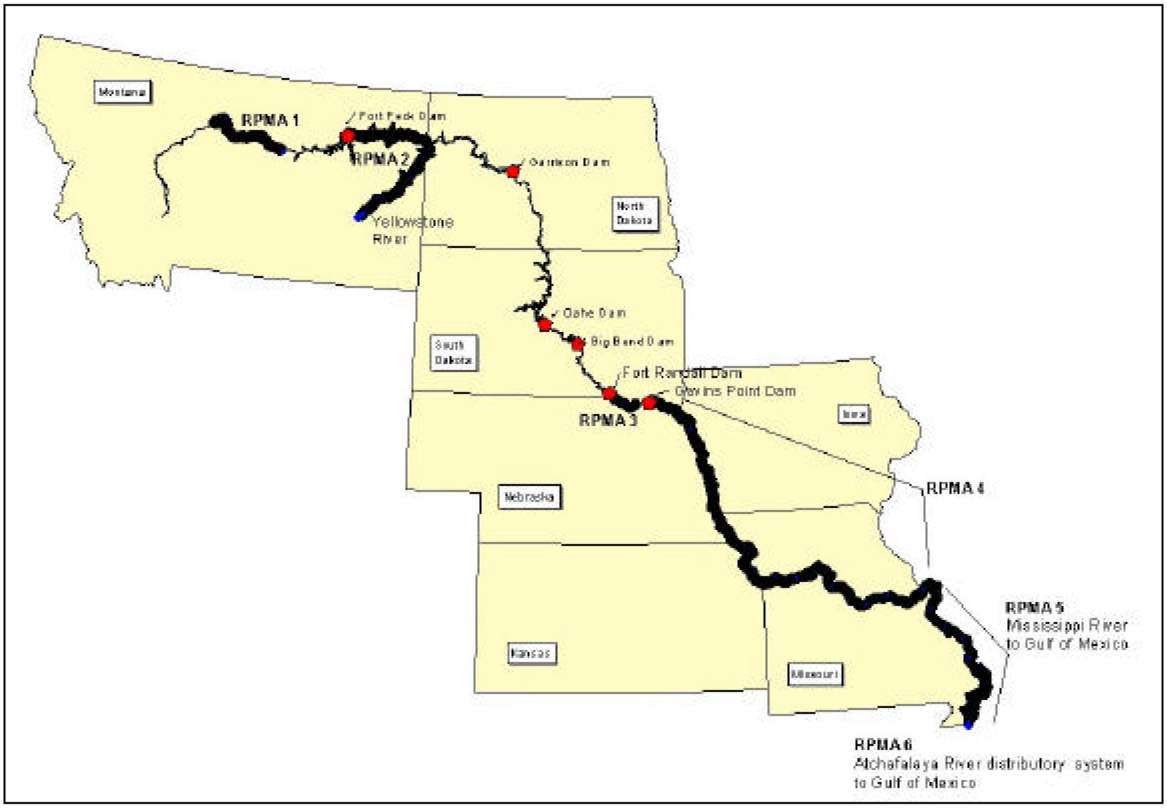

Figure 4: Recovery-priority management areas

(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 may also be important factors in 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-Draft).

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 In-stream 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).

2.2 Bank stabilization/ loss of floodplain habitat

Prior to dam construction, the river meandered constantly, eroding one side of the bank and accreting the other as it moved across the floodplain, so that landowners who lost land one year may gain accretion ground in future years as the river moved (National Research Council 2002). With dam construction however, the river channel became much more stable and landowners who experienced erosion could not expect to gain land in future years since the channel no longer moved. Also, with a fixed channel, development could occur on the edge of the shoreline, leading to increased stabilization. The USACE estimates that approximately 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 projects (USACE 2003-Draft). This stabilization has led to a disconnection of the river from the floodplain, so that sediment and nutrients from the banks are no longer available to the river system. Also, the combination of a stable river channel and bank armoring has led to a loss of floodplain, instream, and backwater habitat, all of which served as important nursery grounds for macroinvertebrates and native fishes (Berland 1953, Sandheinrich and Atchison 1986).

The Pallid Sturgeon Recovery Plan (Dryer and Sandvol 1993) identified habitat loss as a major reason for the species' decline. Even the so-called free flowing sections are becoming more channelized, with an associated loss of sediment input and instream features which are likely important for spawning and juvenile development.

2.3 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 press), 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 press).

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 them (Ward and Stanford 1983). While there are more sport fish in the reservoirs than there were in the original riverine system (Wooster 1993), 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.

2.4 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 1930 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).

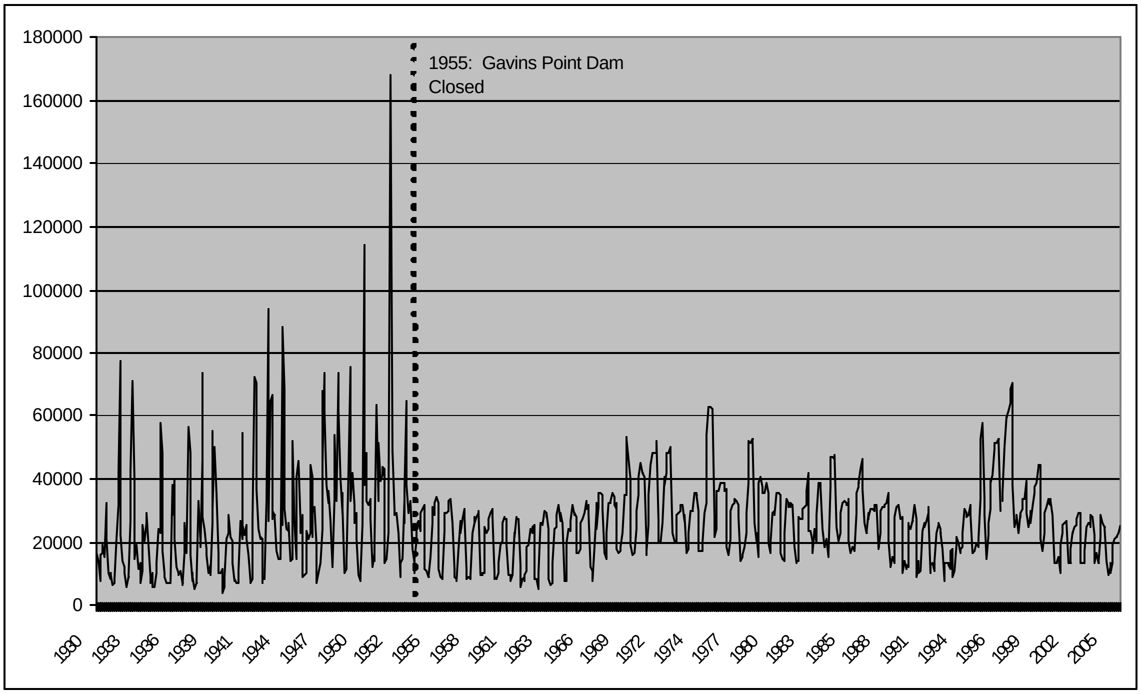

Figure 5: Average monthly flows from October 1930 through September 1995 at a USGS gauge station near Yankton, South Dakota. Dotted line indicates the year Gavins Point Dam was closed. Note the decrease in peak flow after dam completion. Source: 1930-1995 - USGS Website Accessed December 30, 2005, 1996-2000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

2.4.1 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).

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. As discussed above, the USACE reports that approximately 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-Draft).

2.4.2 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).

2.4.3 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 smothered by fine material caught in the crevices.

2.4.4 Effects of Tributaries on Flow

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).

2.4.5 Cold Water Releases

The water released from Fort Randall Dam comes from they hypolimnion, or cold bottom layer of the reservoir (National Research Council 2002). The effects of cold water releases on pallid sturgeon have not been examined, but studies on a number of other fish species have shown that larvae exposed to cold temperatures experienced delayed transformation to the juvenile stage (Clarkson and Childs 2000). Juvenile fish also exhibited decreased growth rates and decreased swimming ability in colder than warmer water (Robinson and Childs 2001, Ward et al. 2002). This effect is compounded because smaller fish are weaker swimmers than larger fish (Ward et al. 2002). Shovelnose sturgeon did not spawn until water temperatures reached 18-19°C (Moos 1978). Spawning requirements for pallid sturgeon are not known, but they likely have similar temperature requirements as shovelnose sturgeon. Water temperatures may impact every aspect of the pallid sturgeon reproductive cycle.

2.5 *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.

2.6 *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).

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

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 instances 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 harvest was prohibited beginning in 1978 (SDGFP 1978) and harvest of all sturgeon species was prohibited 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.

2.7 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.

2.8 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). There have been historic outbreaks 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 (Pers. Comm. Crystal Hudson, USFWS), but as of this writing (Spring 2006) there are no known infected fish at any hatcheries.

Infected fish stop eating, 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-Draft, 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).

2.9 *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-Draft).

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 examine 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.

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 erect 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.

In 2000, the first year that pallid sturgeon were stocked in the Missouri River (Table 2), 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).

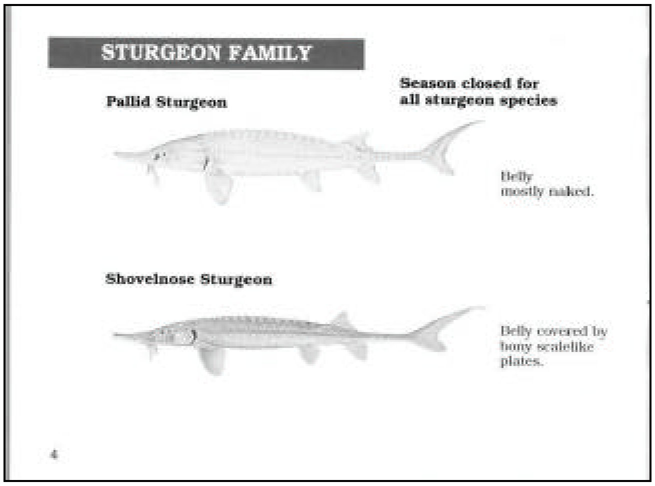

Figure 6. Information in Fishing Handbook to advise anglers that the sturgeon season is closed.

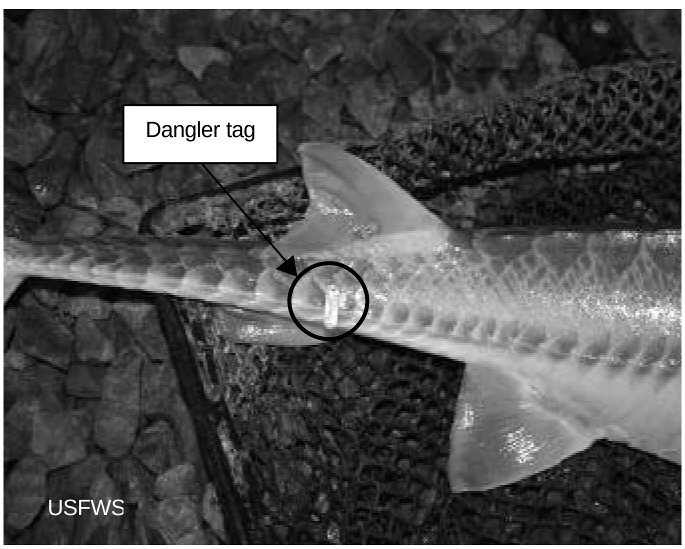

Figure 7: Dangler tag on a pallid sturgeon

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. The fish hatchery has also 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.

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.

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).

6 CONCLUSIONS

The pallid sturgeon is threatened with extinction in South Dakota and throughout much of its range due to changes in the riverine habitat. SDGFP is working with a number of other agencies to research the species' needs and to engage in actions to benefit the species. SDGFP believes that with appropriate changes to the Missouri River and floodplain, the pallid sturgeon population can rebound, with natural reproduction and recruitment occurring system-wide again. Management changes that benefit the pallid sturgeon should also benefit a wide variety of native species that use the Missouri River corridor. We hope that this management plan will help provide guidance for managers to improve conditions for the pallid sturgeon.

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Appendix A
Memorandum of Agreement

MEMORANDUM OF AGREEMENT

AMONG

**SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS,
U.S. FISH AND WILDLIFE SERVICE,
U.S. ARMY CORPS OF ENGINEERS, AND NATIONAL PARK SERVICE**

Least tern, piping plover, pallid sturgeon, and bald eagle management, protection, and recovery along the Missouri River in South Dakota

I. Purpose

The purpose of this Memorandum of Agreement (MOA) is to provide guidance and specific agency commitments for management, protection, and recovery of the least tern, piping plover, pallid sturgeon, and bald eagle along the Missouri River for the four signatory agencies, since each has a statutory responsibility for endangered species recovery. The signatory agencies agree that fulfillment of conditions contained in this MOA will help enhance annual productivity and in the long term contribute to recovery of these species.

II. Actions

It is the intent of the signatory agencies to cooperatively protect and manage nesting populations of the least tern and piping plover along the Missouri River in South Dakota through monitoring, site protection, law enforcement, and public outreach. It is also the intent of the signatory agencies to protect bald eagle nesting sites and important winter roost sites along the Missouri River in South Dakota. Additionally, signatory authorities will commit to protect pallid sturgeon and their habitat by minimizing threats from existing and proposed human activities, law enforcement and public outreach.

A. South Dakota Department of Game, Fish and Parks (SDGFP):

1. Will hire at least three seasonal employees each nesting season to be stationed where most needed to assist the U.S. Army Corps of Engineers (Corps) in monitoring and protecting least tern and piping plover nesting areas.
2. Will provide law enforcement assistance where and when most needed to patrol for human disturbance at least tern and piping plover nesting colonies up to 10 potential weekend periods from Memorial Day weekend to August 15 (including the high use events such as the July 4 holiday). This would be a cooperative effort by both SDGFP and the U.S. Fish and Wildlife Service (Service) providing staff on the river for the tern and plover nesting period. The details of such efforts will be worked out

on an annual basis and dependent on nesting locations and active recreation areas on the river.

3. Will make arrangements with the Service and the Corps to obtain the necessary tern and plover training for law enforcement and seasonal personnel.
4. Will work cooperatively with the Corps and the Service to develop a Missouri River Management Plan for least terns, piping plovers, pallid sturgeons, and the bald eagles that establishes biological/conservation goals for South Dakota and management actions to achieve those goals. Management actions would include at least the following actions.

    A.) On sites owned or managed by SDGFP, will close portions of the area where least terns or piping plovers are nesting, to include appropriate buffer zones.
    B.) On sites owned or managed by SDGFP, will buoy off least tern foraging areas if potentially impacted by watercraft traffic.
    C.) Will participate in public outreach efforts, including but not limited to placing informational posters at recreation sites, distributing informational brochures to recreation site users, random patrolling of nesting areas, and posting of nesting areas. Results of random patrolling of nesting areas will help set priorities for law enforcement follow-up.
    D.) Will participate with signatory agencies and other interested entities in seeking solutions to site-specific threats to nesting success, such as livestock grazing.
    E.) On sites owned or managed by SDGFP, will develop specific management strategies on sites consistently used each year by least terns and piping plovers, such as fencing or posting sites prior to arrival of nesting birds.
    F.) Will not remove bald eagle nest trees on areas owned or managed by SDGFP, except for limited removal of single trees within campgrounds that pose a human safety hazard. Any tree removed will be replaced at a 4:1 ratio.
    G.) Except for limited removal of single trees within campgrounds that pose a human safety hazard, will not remove trees from documented bald eagle winter roost sites if removal could adversely affect winter roost site use at areas owned or managed by SDGFP. Any tree removed will be replaced at a 4:1 ratio.
    H.) Will continue winter recreational limits currently placed by the Corps of Engineers to protect known bald eagle roost sites, such as at Chief White Crane below Gavins Point Dam and Campground No. 3 below the Oahe Dam, and will evaluate future restrictions on a case-by-case basis.

I.) Will not construct within ¼ mile of bald eagle roost areas during the time of roost occupation.
J.) Will not construct within ½ mile of bald eagle nests during the nesting season.
K.) Will continue law enforcement and public outreach activities at State park and recreation areas in regard to State regulations prohibiting the take of pallid sturgeon.

B. U.S. Fish and Wildlife Service (Service):

1. Will investigate all Complaints of Violation concerning take and nest disturbances at tern/plover sites and/or colonies.
2. Will provide law enforcement assistance commensurate with State law enforcement action where and when most needed to patrol for human disturbance at nesting least tern and piping plover colonies up to 10 potential weekend periods from Memorial Day weekend to August 15 (including the high use events such as the July 4 holiday). This would be a cooperative effort by both SDGFP and the Service providing staff on the river for the tern and plover nesting period. The details of such efforts will be worked out on an annual basis and dependent on nesting locations and active recreation areas on the river.
3. Will provide law enforcement guidance and training to Corps and SDGFP personnel for proper documentation on investigation of potential violations.
4. Will work with SDGFP and the Corps to provide technical assistance and review the development of a Missouri River Management Plan that establishes biological/conservation goals for South Dakota and management actions to achieve those goals.
5. Will work cooperatively with the Corps and SDGFP to detail an experienced Service person to craft a legal process such as a Habitat Conservation Plan, or some similar process, that will allow the State to have assurances for active management and potential "take" opportunities.

C. U.S. Army Corps of Engineers (Corps):

1. Will provide yearly survey and productivity monitoring techniques training for all seasonal and permanent employees working with least terns and piping plovers.
2. With assistance from SDGFP seasonal employees, will conduct distribution and census surveys, and productivity monitoring on all potential nesting habitat.
3. Will ensure near real time data availability to all signatories, including all nest locations and nest and chick status, through its web based Data Management System.
4. With assistance from SDGFP seasonal employees, will implement nest specific management actions at all nesting sites (cages, moving nests, etc.).

5. On sites owned or managed by Corps, will close portions of the area where least terns or piping plovers are nesting, to include appropriate buffer zones.
6. On sites owned or managed by Corps, will buoy off least tern foraging areas if potentially impacted by watercraft traffic.
7. Will work cooperatively with SDGFP and the Service to develop a Missouri River Management Plan for least terns, piping plovers, pallid sturgeons, and the bald eagles that establishes biological/conservation goals for South Dakota and management actions to achieve those goals.
8. Will work cooperatively with SDGFP and the Service on a Habitat Conservation plan or some similar process for State actions.
9. Will participate with the Service and SDGFP on training Corps personnel for proper documentation on investigating potential violations of State and Federal law.

D. National Park Service (NPS):

1. On sites owned or managed by NPS, will close portions of the area where least terns or piping plovers are nesting, to include appropriate buffer zones.
2. On sites owned or managed by NPS, will buoy off least tern foraging areas if potentially impacted by watercraft traffic.
3. Will work cooperatively with SDGFP, the Service, and the Corps to develop a Missouri River Management Plan for least terns, piping plovers, pallid sturgeons, and bald eagles that establishes biological/conservation goals for South Dakota and management actions to achieve those goals.
4. Will work cooperatively with SDGFP, the Service, and the Corps on a Habitat Conservation plan or some similar process for State actions.
5. Will continue public outreach activities related to least terns, piping plovers, bald eagles, and pallid sturgeon at Missouri National Recreational River.
6. Will coordinate with SDGFP, the Service, and the Corps to conduct annual bald eagle nesting surveys from Fort Randall Dam to Ponca, Nebraska.

E. All signatory agencies:

1. Will participate in at least two meetings or conference calls per year, timed before the nesting season begins (to plan for the upcoming nesting season) and after the nesting season ends (to evaluate and report on success of cooperative efforts.) Other meetings or specific coordination will be scheduled as needed during the tern and plover nesting season or if other species management needs warrant an additional meeting.
2. Will participate in the identification of pallid sturgeon backwater restoration areas along the Missouri River below Gavins Point and Fort Randall Dam.
3. May assign special designation to areas under their authority for endangered species emphasis, as appropriate. For example, ownership of Blue Blanket Recreation Area

will not transfer to SD Game, Fish and Parks on January 1, 2002. However, this area will be managed by the SDGFP Wildlife Division under a wildlife management lease agreement with the U.S. Army Corps of Engineers and will be designated as a least tern and piping plover recovery area to be managed specifically for the enhancement and recovery of nesting least terns and piping plovers.

4. Will participate in preparation of an annual accountability report, with SDGFP as lead agency for report preparation.

III. Principal Contacts

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IV. Agreement Term

This MOA will remain in force until November 8, 2006.

V. Approval

We, the undersigned designated officials, do hereby approve this Memorandum of Agreement.

Approved ______________________ Date 6/6/05
John L. Cooper
Secretary
SD Dept. of Game, Fish and Parks

for ______________________ Date 6/23/05
Ralph Morgenweck
Regional Director, Region 6
US Fish and Wildlife Service

______________________ Date 6/14/05
Jeffrey A. Bedey
Colonel, Corps of Engineers
District Engineer

______________________ Date 6·20·05
Paul Hedren,
MNRR Superintendent
National Parks Service

Appendix B
Standard Operating Procedure
Gavins Point National Fish Hatchery

Standard Operating Procedures For The Distribution Of Fish
Gavins Point National Fish Hatchery
Yankton, South Dakota

In February of 2004 it was discovered that the invasive **Zebra mussel**, *Dreissena Polymorpha* was found in the Missouri river system below Gavins Point Dam as well as below Ft. Randall dam both in South Dakota. In order to eliminate the spread of Zebra mussels within the Gavins Point National Fish Hatchery a Standard Operating Procedures plan has been established. This plan is to serve as a step by step protocol for fish cultural operations when dealing with fish that are reared on the hatchery's lake water supply. This will also serve as a document to our partners so that they will be assured that the personnel of the Gavins Point National Fish Hatchery are taking the appropriate measures in dealing with this invasive species.

1. **Pond Rearing** -Because there is no realistic way to eliminate zebra mussels in the water supply it is to be assumed that the hatchery does have the potential to harbor them. Pond culture operations will be the same as always. Ponds will be filled using pond socks as small as realistically possible without impeding the progress of filling the pond in a timely manner.

2. **Harvesting of ponds** - Ponds will be harvested using normal harvesting procedures. Kettles will be swept clean of debris before harvest. During harvest detritus, algae, and all assorted debris will be removed before fish are loaded on to the distribution truck. Distribution trucks transporting fish from the ponds to the hatchery building will be loaded with lake water that has been filtered through 2 twenty micron pond socks.

3. **Chemical Treatments –** Fish that are harvested from the Gavins Point NFH ponds will be brought to the hatchery building for distribution off site. Using the protocols established at the Fairport State Fish Hatchery, Muscatine, Iowa (personal communication with Ken Snyder, Manager) we will begin a two part treatment using potassium chloride and formalin. **Potassium Chloride** will be used in a static bath treatment at a rate of 750 mg/l for 1 hour prior to loading distribution trucks. Aeration will be provided to the fish in the tanks during this period and dissolved oxygen levels will be monitored. After 1 hour of treatment well water will be added to the tank to boost oxygen levels and the fish will be loaded into the distribution truck.

4. **Loading –** Distribution trucks will be filled from a tank that has been fitted with a 20 micron filter sock on the discharge pipe at the head end of the tank. Water will be pumped onto the truck using a water pump fitted with a 20 micron filter sock. This will serve as a two part filtration regime thereby eliminating the potential for zebra mussels at any life stage to enter the distribution truck. Once the truck has been loaded with fish for distribution a 25 mg/l treatment of formalin will be administered on the distribution truck for a two hour minimum treatment.

5. **Stocking –** Fish will be unloaded at the stocking site (post 2 hour treatment) by hand, using dip nets. No water will be discharged at the socking site. Once the fish are unloaded at the stocking site the distribution truck will leave the stocking

site and unload the hauling water on land away from the site en route back to the Gavins Point NFH.

6. **Post Stocking –** Once the distribution truck arrives back at the Gavins Point NFH it and all equipment associated with loading and distribution will be hosed down and scrubbed thoroughly using chlorinated domestic water. The truck and all equipment will be sprayed with a fish safe disinfectant (Sterilize) and inspected by hatchery staff.

*****It will be the responsibility of the receiving hatchery to properly clean and disinfect their own distribution trucks and equipment after receiving fish from the Gavins Point NFH.

<u>Amounts of formalin to use for distribution trucks for a 2 hour static treatment:</u>

GALLONS
50 = 13mls
60 = 15mls
70 = 18mls
80 = 20mls
90 = 23mls
100 = 25mls
110 = 28mls
115 = 30mls
120 = 32mls
130 = 34mls
140 = 36mls
150 = 39mls
160 = 42mls
170 = 44mls
180 = 46mls
190 = 49mls
200 = 51mls

Pond Truck w/ small tank 70 gal/tank = 36mls total (*note water transfers between the two tanks. Use 1 treatment of 36mls before filling the truck up with water

Pond Truck w/ large tank 115 gal/tank = 30mls/tank.

White Distribution Truck = 190 gal/tank = 49mls/tank

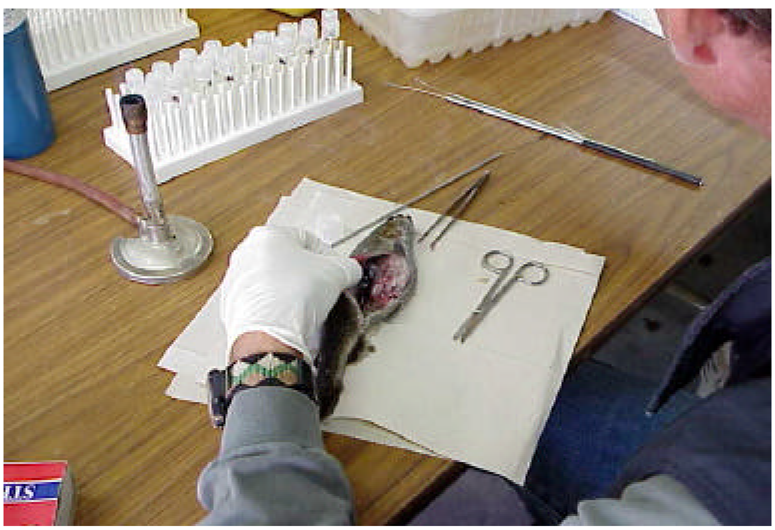
Appendix C
Draft South Dakota Department of Game, Fish and Parks
Fish Health Management Policy

Appendix C

South Dakota Department of Game, Fish and Parks

Fish Health Management Plan and Risk Assessment Protocols

January 2005



Rick Cordes
Hatchery Manager
Fish Health Specialist

Draft

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Table of Contents

Appendix C

South Dakota Department of Game, Fish and Parks Fish Health Management Plan and Risk Assessment Protocols

Section I. Purpose

The purpose of this fish health management plan and risk assessment protocols is to define fish health management and fish disease control in South Dakota. South Dakota statutes and South Dakota Department of Game, Fish and Parks Commission Rules provide the authority for developing and implementing fish protection, importation, and propagation guidelines, and give South Dakota Department of Game, Fish and Parks (SDGF&P) the responsibility to develop policies and plans for fish health protection and disease control to protect South Dakota's fisheries from the introduction and spread of pathogens. This plan defines suggested guidelines that can be used in specific situations.

Section II. Scope

This plan deals with fish health and disease-related issues associated with fish importation and hatchery and wild fish transfers. It identifies health and pathogen control requirements that are suggested to be used by fish hatchery managers, fisheries managers and fisheries program administrator in the performance of hatchery and fisheries management practices.

Section III. Authority

Under South Dakota statute (**41-2-18.**) SDGF&P is given the authority to develop rules to provide for the protection of South Dakota's fishery resources. South Dakota statutes **41-2-18, 41-13-3.1 and 41-15-1** (Appendix C) and the SDGF&P Commission rules **Chapter 41:09:08** (Appendix D) provide fish disease control and importation requirements. This plan has been developed to provide suggested guidelines and procedures for implementing South Dakota's statutes and SDGF&P Commission rules.

South Dakota Department of Game, Fish and Parks Commission Authority: The SDGF&P Commission shall review and approve all rules regarding fish importation, fish disease control, and fish health management.

South Dakota Department of Game, Fish and Parks Secretary: The SDGF&P Secretary is responsible for approving import permit exemptions.

South Dakota Department of Game, Fish and Parks Fisheries Program Administrator: The fisheries program administrator is responsible for approval of all proposed Commission rule changes affecting fish importation and fish health management and the final approval of all wild fish transfers.

South Dakota Department of Game, Fish and Parks Fish Health Specialist: The fish health specialist is responsible for the following:

1. Reviewing and acting on all import permits. Has the authority in SDGF&P Commission rule (**41:09:08:03.04** and **41:09:08:03.05**) to approve or deny import permits request based on the review of the request, unless unusual

circumstances exist. Import permits which involve unusual circumstances may require SDGF&P fisheries program administrator and/or SDGF&P Secretary action.

2. Review with the assistance of the fisheries managers all wild fish transfer requests and prepare necessary background information.
3. Review with the assistance of fish hatchery managers, fish hatchery assistant managers, and fish hatchery biologists all culture facility fish health management plans.

Section IV. Jurisdiction

This plan applies to: 1) all hatchery produced fish gametes, fish eggs, and fish, including all fish reared in state, federal or private hatcheries; 2) all live fish gametes, fish eggs, and fish imported into South Dakota; and 3) the movement of any wild fish within the state of South Dakota by state or federal government agency or private individual.

Section V. Pathogens of Concern

It shall be the goal of South Dakota Department of Game, Fish and Parks (SDGF&P) to prevent the introduction or spread of aquatic animal pathogens of concern into waters within the State of South Dakota. The SDGF&P Commission Rule, **41:09:08:03.03. Diseases of regulatory concern.**, list diseases of regulatory concern which have been determined by SDGF&P to pose a threat to South Dakota fisheries. Pathogens on that list, in addition to others listed in this plan, are pathogens of concern in South Dakota. Pathogens maybe added or re-categorized as necessary to protect South Dakota fisheries from introduction or spread of disease and fish pathogens. This list may contain more pathogens than listed in SDGF&P Commission rules. As new pathogens of concern are identified, they will be added to the list. It is the policy of the SDGF&P to include pathogens of concern to this plan as they are identified. They will be added to SDGF&P Commission Rule, **41:09:08:03.03. Diseases of regulatory concern.**, periodically to ensure the rule list is complete.

A. Emergency Prohibitive – pathogens not known to be present in South Dakota, have the potential to cause severe mortality, and cannot be controlled.

1. Viral Hemorrhagic Septicemia - V.H.S. virus
   a. V.H.S. virus is an acute to chronic viscertropic disease of rabdoviral etilology that occurs in Europe amoung certain fish in husbandry. In the 1990's V.H.S. was isolated in salmonids and pacific cod from Pudget Sound of Washington State and the Gulf of Alaska near Cordova, Alaska. Inspection required for all live salmonids.
2. *Oncorhynchus masou* virus - O.M. virus
   a. O.M. virus is an extremely virulent disease of pacific salmon originating from Japan. No known controls. Inspection required only for importation of live pacific salmon originating in Japan.
3. Salmonid Rickettsial Septicemia - S.R.S. virus
   a. S.R.S. virus is an extremely virulent virus of coho salmon in Chile. No known controls. Inspection only required for importation of live salmonids originating from South America countries.
4. Spring Viremia of Carp - *Rhabdovirus carpio* - S.V.C. virus

   a. S.V.C. virus is an extremely virulent virus of the carp family. Inspection only required for importation of non-salmonids from outside North America.
5. Rhabdovirus Disease of Northern Pike Fry - P.F.R.D. virus
   a. P.F.R.D. virus is an extremely virulent virus of the pike family. Inspection only required for importation of live Esocids and or Percids originating from countries of Europe.
6. Infectious Salmon Anemia Virus – I.S.A. virus
   a. I.S.A. virus is highly infectious disease of Atlantic salmon first reported in Norwegian aquaculture facilities. The disease is now described in pre-market Atlantic salmon in New Brunswick, Canada, the Cobscook Bay region of the United States, and in coho salmon in Chile. Inspection only required for importation of live Atlantic salmon originating from Europe, Atlantic salmon originating from east coast of Canada and United States and Atlantic salmon and coho salmon from South America countries. (not listed at this time in **41:09:08:03.03. Disease of regulatory concern**).
7. Exotic or Emerging Pathogens - all other exotic or emerging pathogens that may adversely impact aquatic animals that have not been specifically identified. Exotic or emerging pathogens include those pathogens that have no historical presence in South Dakota using adequate detection methods. The detection of exotic or emerging pathogens may result from the culture of new species.

B. Prohibitive – pathogens not known to occur, pathogens known to occur, or have historically occurred in South Dakota, but may be limited in geographical or host distribution. These are pathogens that have the potential to cause high mortality and are difficult to control.

1. Infectious Hematopoietic Necrosis - I.H.N. virus
   a. I.H.N virus is an acute, systematic, and virulent rhabdovirus disease that occurs in the wild, but is seen in epizootic proportion among young trout and certain Pacific salmon cultured in North America from California to Alaska, and in Japan. Inspection required for all live salmonids.
2. Infectious Pancreatic Necrosis - I.P.N. virus
   a. I.P.N. virus is an acute systemic birnavirus disease of fry and fingerling trout. The disease has worldwide distribution and results in the highest mortality in the youngest fish and is rare in older fish. Inspection required for all live salmonids.
3. Ceratomyxosis - *Ceratomyxa shasta*
   a. *Ceratomyxa shasta* is a histozoic myxosporean parasite which causes ceratomyxosis in salmonids. Inspection shall be required for *Ceratomyxa shasta* for imports into South Dakota from Washington. Oregon, Idaho, that portion of California north of a line drawn due east from the southern tip of San Francisco Bay, and that portion of the Canadian Province of British Columbia south of a line drawn due east from the northernmost tip of Vancouver Island or any areas where the occurrence of *Ceratomyxa shasta* becomes documented.
4. Proliferative Kidney Disease - PKD/PKX agent
   a. PKD is caused by a myxosporean that is poorly understood. Inspection shall be required for the PKD/PKX pathogen of all live fish imports into South Dakota from PKD/PKX areas in California, Oregon, Washington, Idaho, Montana, and British Columbia or any areas where occurrence of PKD/PKX becomes documented.
1. Epizootic Epitheliotropic Disease – EED virus

   a. An incompletely described virus that has caused documented catastrophic losses of lake trout in the Great Lakes Basin hatcheries. It appears that EED is specific for lake trout, therefore the importation of lake trout eggs and or live fish shall not be permitted into South Dakota from the Great Lakes Basin. No importation of other salmonid species from the Great Lakes Basin will be permitted if they have had contact with a documented EED epizootic in the pervious 24 months.

6. Channel catfish herpevirus - C.C.V.D.
   a. C.C.V.D. is an extremely virulent virus of catfish in the southern United States. No importation of eggs and or fish from a source with a reported epizootic in the past 24 months.
7. White sturgeon iridovirus - W.S.I. virus of white sturgeon
   a. W.S.I.V. is a recently described virus of the white sturgeon family. Until further characterization of the virus can be determined importation of eggs or live sturgeon from a known positive source in the last 12 months is prohibited.
8. Largemouth Bass Virus – L.M.B.V.
   a. L.M.B.V. is a new virus of the bass family. It as been associated with largemouth bass (LMB) mortality in southern reservoirs in the United States and as also been isolated in healthy stocks of LMB. Until further characterization of the virus can be determined importation of eggs or live LMB from a known positive source in the last 12 months is prohibited.

C. Notifiable – pathogens not known to occur, pathogens known to occur, or have historically occurred in South Dakota, but may be limited in geographical or host distribution. These pathogens can often be controlled by management practices and or therapeutic agents. These pathogens may be enzootic but not of sufficient concern to prevent fish transfer.

1. Bacterial Kidney Disease - *Renibacterium salmoninarum*
   a. *Renibacterium salmoninarum* is a gram positive, slow growing bacillus bacteria producing a serious to chronic systemic infection in salmonids. The disease is characterized by granulomatous lesions in the kidney and other organs. No importation of live fish positive for the bacteria or eggs from parents that are positive for the bacteria.
2. Furunculosis - *Aeromonas salmonicida*
   a. *Aeromonas salamonicida* is a gram negative short rod-shaped bacteria producing a serious, septicemic bacterial disease in salmonids, but also occurs in warmwater fish. No importation of live positive fish. Eggs from a positive source maybe imported with approval of the fish health specialist. Eggs must be disinfected using a povidone iodine compound (1% active iodine) at 100 ppm for a minimum of 10 minutes before they are allowed to come in contact with water used for fish culture purposes, rearing units, or equipment at the receiving station. All egg shipping containers and water will be disinfected with 200 ppm chlorine for 10 minutes.
3. Enteric Redmouth - *Yersinia ruckeri*
   a. *Yersinia ruckeri* is a gram-negative, nonspore forming curved rod-shaped bacteria producing a systemic bacterial infection of fish. No importation of live positive fish. Eggs from a positive source maybe imported with approval of the fish health specialist. Eggs must be disinfected using a povidone iodine compound (1% active iodine) at 100 ppm for a minimum of 10 minutes before they are allowed to come in contact with water used for fish culture purposes, rearing units, or

equipment at the receiving station. All egg shipping containers and water will be disinfected with 200 ppm chlorine for 10 minutes.

4. Whirling Disease - *Myxobolus cerebralis*
   a. Myxobolus cerebralis is a myxosporean parasite causing whirling disease, a chronic parasitic infection of cultured and wild salmonids. The parasite has a specific tropism for cartilage. Infections result in axial skeleton and neural damage. No importation of live fish from positive sources or fish demonstrating clinical signs of the disease. Eggs from a positive source maybe imported with approval of the fish health specialist. Eggs must have been incubated from the time of collection to date of shipping in water free of *Myxobolus cerebralis.* Eggs must be disinfected using a povidone iodine compound (1% active iodine) at 100 ppm for a minimum of 10 minutes before they are allowed to come in contact with water used for fish culture purposes, rearing units, or equipment at the receiving station. Upon completion of the iodine disinfection eggs shall be disinfected in formalin at a minimum concentration of 1667 ppm for 15 minutes before being placed in incubation units to prevent the introduction of the *Myxobolus cerebralis* TAM stage. All egg shipping containers and water will be disinfected with 200 ppm chlorine for 30 minutes.
5. Pallid Sturgeon Iridovirus – P.S.I. virus of pallid sturgeon
   a. P.S.I.V. is a recently described virus of pallid and shovelnose sturgeon cultured in the Dakotas and Montana. No importation of eggs and or fish from a source demonstrating clinical signs of the disease in the past 6 months. Because of the limited number of adults and progeny for sampling, inspections will use lethal and non-lethal sampling techniques and acceptable sampling numbers will be approved by the fish health specialist.
6. Heterosporis - *Heterosporis sp*
   a. Heterosporis is a microsporidean parasite currently found in natural yellow perch populations in Minnesota, Wisconsin and Lake Ontario. Yellow perch or other members of the Percidae family may not be imported if they exhibit clinical signs of the parasite (muscle tissue is milky white in color and granular in texture appearing as if the freezer burned or cooked).

Section VI. Requirements and Procedures

The following requirements, guidelines and procedures have been developed to support the SDGF&P Commission Rule **41:09:08 Importation of Fish**, to provide guidelines for the movement of hatchery reared or wild salmonid and non-salmonid fish within the boundaries of South Dakota, and define the requirements of a fish health inspection.

A. Fish and Gamete Importation Requirements

1. A fish health certificate and/or fish health inspection report is required before importation of eggs and or fish originating from sources or being held in separate waters outside the boundaries of South Dakota with the exceptions noted in **41:09:08:01.01. Fish importation prohibited – Exceptions**.
2. The fish health inspection of a source of eggs and or fish will include all lots of fish present including broodstock.
3. The fish health inspection of a salmonid egg and/or fish source, hatchery or wild will be required annually.

4. If the importation is approved for gametes, fertilized eggs, or live fish from wild salmonid fish stocks that do not have a current fish health inspection measures must be taken to quarantine eggs or live fish until the results of the fish health inspection are reported.
5. The need for fish health inspections and the frequency of inspections for a non-salmonid source, hatchery or wild, will be at the discretion of the fish health specialist.
6. A fish pathologist, fish health inspector, or a recognized fish health specialist approved by the department will conduct all inspections. All inspections will be conducted in accordance with the accepted guidelines in the latest edition of the "Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens (Bluebook) published by the Fish Health Section of the American Fisheries Society. Generally accepted validated new or alternative procedures may be used for the detection and diagnosis if the Technical Procedures Committee of the Fish Health Section/American Fisheries Society approves such procedures. In addition the minimum inspection requirements for imported fish and gametes must comply with the requirements of Section VI. E. 1-11. of this plan.
7. Fish health inspections for salmonids will screen for pathogens listed as emergency prohibitive, prohibitive and notifiable unless otherwise stated.
8. No importation permit will be issued for live fish or gametes from a fish or gamete source that is positive for a emergency prohibitive or prohibitive pathogen.
9. No importation permit will be issued for live fish from a source that is positive for a notifiable pathogen unless noted in Section V. C. 1-6. of this plan and approved by the fish health specialist. Eggs from sources positive for a notifiable pathogen can be imported with the approval of the fish health specialist and the approved egg disinfection procedures are followed as noted in Section V. C. 1-6 of this plan.
10. Egg and or fish sources outside the boundaries of South Dakota with a confirmed occurrence of an emergency prohibitive or prohibitive pathogen may not export eggs and or fish to South Dakota until the appropriate disinfection and or depopulation procedures have been conducted. Two consecutive fish health inspections at six-month intervals of the remaining fish lots shall be conducted with no occurrence of the pathogen prior to importation. If the facility has undergone a complete facility depopulation and decontamination, eggs and or fish may not be imported until completion of a minimum of one negative inspection 12 months after repopulation.
11. The owner of the destination facility must submit an importation application form, supplied by the department for an importation permit. The application must be received at least ten working days prior to the date of importation by the department's fish health specialist for review.
12. It shall be the responsibility of the applicant to obtain the fish health inspection report from the source of the eggs and or fish and provide said report for the state's fish health specialist's review.
13. A Fish Importation Permit will be issued to the applicant and shall be included with the shipment of eggs and or fish if the above conditions are met.
14. The applicant and egg and live fish supplier are legally accountable for the completeness and accuracy of the information supplied in the application and fish

health inspection report (**41:09:08:03.01. Application requirements for fish importation permit, 41:09:08:06. Shipments in violation of rules – Disposal**).

B. Transfer of Fish Stocks between In-State Facilities and Wild Fish Transfer to In-State Facilities

1. Gametes or fertilized eggs may be transferred to Department fish culture facilities if their pathogen status will not change the pathogen status of the receiving facility.
2. Salmonid eggs will be disinfected from outside sources using a povidone iodine compound (1% active iodine) at 100 ppm for a minimum of 10 minutes before they are allowed to come in contact with water used for fish culture purposes, rearing units, or equipment at the receiving station.
3. It is suggested that all salmonid eggs be disinfected during the water-hardening process using the species-specific guidelines established by the receiving facility and the fish health specialist.
4. It is suggested that all non-salmonid egg be disinfected during water hardening or when received at the receiving facility.
5. Gametes, fertilized eggs (if they do not meet the requirement of Section II. B.1.) or live fish will not be transferred between Department fish culture facilities or to Department fish culture facilities from wild fish stocks unless approved by the fish hatchery manager, fish health specialist, and the fisheries program administrator based on the fish health score and risk classification generated from the Fish Health Risk Assessment for Movement of Fish into a Facility worksheet (Appendix A, Tables 1 and 2).
6. All transfer equipment used in the transfer eggs and/or fish between fish culture facilities will be disinfected in 200 ppm chlorine for 10 minutes.
7. The previous criteria are recommended for all non-department fish propagation facilities.

C. Trap and Transfer of Wild Fish Stocks Between Waters of the State of South Dakota and Private Waters

1. The trap and transfer of wild fish stocks is defined as the legal trap and transfer of public or private wild fish stocks by the Department of Game, Fish and Parks for the management of wild fish stocks.
2. Private Pond Management Facility licensees may trap and transfer wild fish stocks on their own private waters.
3. Baitfish may be trapped and transferred to non-public waters by licensed resident anglers and licensed bait dealers as defined in the Baitfish Regulations (**41:09:04. Bait and Biological Specimens**).
4. The trap and transfer of wild salmonids stocks will require the Fisheries Manager and the Fish Health Specialist to complete a Fish Health Risk Assessment for the Transfer of Wild Fish between Waters worksheet (Appendix A, Tables 3 and 4). If the generated fish health risk score indicates that inadequate fish health information is available a fish health inspection conducted in accordance with the policy guidelines in Section II. E. Fish Health Inspections will be required if moving from one watershed to another and recommended if the transfer is in the same watershed.

5. Upon completion of the fish health inspection of the wild salmonid stock destined for trap and transfer the fisheries manager and the fish health specialist will complete a second Fish Health Risk Assessment for the Transfer of Wild Fish between Waters worksheet (Appendix A, Table 2). The new generated fish health risk score and risk classification will determine if the fisheries program administrator approves the trap and transfer.
6. The trap and transfer of non-salmonids stocks will require the Fisheries Manager and the Fish Health Specialist to complete a Fish Health Risk Assessment for the Transfer of Wild Fish between Waters worksheet (Appendix A, Tables 3 and 4). If the generated fish health risk score indicates that inadequate fish health information is available it is recommended that a fish health inspection be conducted in accordance with the policy guidelines in Section II. E. Fish Health Inspections.
7. Upon completion of the fish health inspection of the non-salmonid stock destined for trap and transfer the fisheries manager and the fish health specialist will complete a second Fish Health Risk Assessment for the Transfer of Wild Fish between Waters worksheet (Appendix A, Table 2). The new generated fish health risk score and risk classification will determine if the fisheries program administrator approves the trap and transfer.
8. All transfer equipment that has the potential to be used in new waters with an unknown fish health history or on a fish culture facility should be disinfected with 200 ppm active chlorine for 10 minutes. Chlorine neutralization can be achieved with sodium thiosulfate at 5.6 grams per gallon of water with 200 ppm chlorine.

D. Movement of Fish from a Facility to a Receiving Water

1. Emergency Prohibitive Pathogen
   a. Eggs and/or fish sources inside the boundaries of South Dakota with a confirmed occurrence of an emergency prohibitive pathogen shall not operate or stock fish in South Dakota and will be required to immediately incinerate, deep bury utilizing lime on site, or dispose of in an South Dakota Department of Environment and Natural Resources approved landfill all eggs and/or fish at the facility.
   b. Complete chemical disinfection of such facility will be immediately planned and executed with the supervision of the fish health specialist to prevent the reestablishment of the pathogen.
   c. Two consecutive inspections at six-month intervals after repopulating will be conducted. Results of the two inspections must be negative for pathogens of concern before distribution of eggs and/or fish may resume.
2. Prohibitive Pathogen
   a. Eggs and/or fish sources inside the boundaries of South Dakota with a confirmed occurrence of prohibitive pathogen shall not operate or stock fish in South Dakota until the fish health specialist, the fisheries manger, and the fisheries program administrator determines the disposition of the eggs and/or fish based on recommendations develop using the Fish Health Risk Assessment for the Movement of Fish from a Facility worksheet (Appendix A, Tables 5 and 6).
   b. The facility will be depopulated and disinfected with the supervision of the fish health specialist to prevent the reestablishment of the pathogen.

c. Two consecutive inspections at six-month intervals after repopulating will be conducted. Results of the two inspections must be negative for pathogens of concern before distribution of eggs and/or fish may resume.

3. Notifiable Pathogen - Clinical Level
   a. Eggs and/or fish sources inside the boundaries of South Dakota with a confirmed occurrence of notifiable pathogen at a clinical level exhibiting significant losses shall not stock fish in South Dakota until the fish health specialist, the fisheries manger, and the fisheries program administrator determines the disposition of the eggs and/or fish based on recommendations develop using the Fish Health Risk Assessment for the Movement of Fish from a Facility worksheet (Appendix A, Tables 5 and 6).
   b. It will be recommended that the facility be depopulated and disinfected under the supervision of the fish health specialist.
   c. Two consecutive inspections at six-month intervals after repopulating will be conducted. Results of the two inspections must be negative for pathogens of concern before distribution of eggs and/or fish may resume.
4. Notifiable Pathogen - Carrier or Subclinical
   a. Eggs and/or fish sources inside the boundaries of South Dakota with a confirmed occurrence of notifiable pathogen at a carrier or subclinical level may continue to stock fish in South Dakota in watersheds where the pathogen occurs in the existing fish population if agreed to by all parties and/or agencies directly affected.
   b. It recommended that fish from these facilities not be stocked into the immediate watershed of other fish culture facilities, unless all parties and agencies affected agree to the stockings.
5. Reportable Pathogens
   a. If a reportable pathogen occurs at a facility inside the boundaries of South Dakota, the fish health specialist must be notified.
6. Exotic or New Emerging Pathogens
   a. Contact the fish health specialist immediately upon detection or suspicion of exotic or new emerging fish pathogen.
7. It shall be the responsibility of each operator to notify the fish health specialist of a fish health problem involving significant mortality. Upon the confirmation of the pathogen/disease, the fish health specialist will proceed with the appropriate action as stated previously in the plan.

E. Fish Health Inspections

1. Annual fish health inspections performed by an inspecting agent of the Department of Game, Fish and Parks shall be mandatory of any in-state aquaculture facility that cultures, holds, sells, or stocks gametes, fertilized eggs or live fish of the family Salmonidae.
2. Any in-state aquaculture facility that cultures, holds, sells or stocks gametes, fertilized eggs or live fish not in the salmonidae family may be required to have fish health inspections if evidence indicates that there may be a pathogen of regulatory concern present.
3. Approved inspecting agents of the Department of Game, Fish and Parks shall be responsible for inspecting state fish culture facilities; wild, free-ranging populations and broodstock populations, and in-state private hatcheries.

4. All inspections will be conducted in accordance with the accepted guidelines in the latest edition (5th Edition, 2003) of the "Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens" (Bluebook) published by the Fish Health Section of the American Fisheries Society except where noted in this section. Generally accepted validated new or alternative procedures may be used for the detection and diagnosis if the Technical Procedures Committee of the Fish Health Section/American Fisheries Society approves such procedures.
5. The inspecting agent shall conduct sampling on a lot-by-lot basis for the entire hatchery population with samples from each lot distinctively marked, maintained, and processed separately.
6. A lot will be defined as a group of cultured fish of the same species, of the same year class, originating from the same spawning population, and sharing the same water supply.
7. Broodstock of the same species or lot, consisting of more than one year-class held in a common water supply may be considered as one lot for sampling purposes.
8. The sampling will include moribund fish and an unbiased grab sample from the rearing units for each lot. The fish must be alive when collected or, if killed, held on ice for no more than 1 hour. All tissue samples must be collected in a manner that avoids contamination between lots or from external sources.
9. The minimum sample size for each lot of fish shall provide a 95% confidence of detecting a pathogen. Attribute sampling will be based on the assumption of a pathogen's prevalence in facilities or free-ranging wild populations from Table 1.

Table 1. Attribute Population Sampling for Fish Pathogens

Population of Lot Size	2% Assumed Prevalence Number to Sample	5% Assumed Prevalence Number to Sample
50	50	35
100	75	45
250	110	50
500	130	55
1,000	140	55
2,000	145	60
10,000	145	60
100,000 or greater	150	60

10. Procedures for sampling production fish.
    a. Viral-sample all lots, including broodstock lots, at the 5% (or lower) level of assumed prevalence of listed pathogens. This pertains to lethal sampling of both hatchery and wild populations.
    b. The minimum sampling for the listed bacterial pathogens shall be 60 fish from each water supply at each facility with the exception for *Renibacterium salmoninarum* which requires a 60 fish sample from each lot.
    c. The minimum sample size for the detection of *Myxobolus cerebralis* shall be 60 fish heads (heads, including gill arches), six (6) months or older in age where the water supply temperature exceeds 54^{o}F and eight (8) months or older in age where the water supply temperature is 54^{o}F or less, from each water supply. Fish must be on the same water supply for a minimum of four (4) months prior to sampling. The sampling shall be biased toward those fish

species most susceptible to *Myxobolus cerebralis* (susceptibility in approximate decreasing order: rainbow trout, brook trout, cutthroat trout, lake trout, brown trout, and chinook salmon).

   d. If more restrictive sampling requirements are required by receiving federal, state or other agent, those sampling requirements will be met.

11. Procedures for sampling salmonid production broodstocks.
    a. Sample all salmonid broodstock lots at the 5% (or lower) level of assumed prevalence of listed pathogens, for the non-lethal method of collecting reproductive fluids, if adequate numbers of broodstock are available. Ovarian fluid samples must account for the majority (31 samples or greater) of the collective reproductive fluids.
    b. If dealing with small populations of domestic salmonid broodstock with a current disease free inspection and no infusion of new fish or fish eggs, progeny from the broodstock shall be used for lethal samples at the prescribed number to meet inspection requirements provided the progeny are held in the same water supply and downstream from the same rearing space for a minimum of four months prior to inspection.
    c. The establishment of a new disease free salmonid broodstock will require three consecutive annual fish health inspections prior to clearance and use of gametes for the development of a confined fish populations. The fish health inspections will include all age classes of the broodstock population held at a facility.
12. The sampling of wild salmonid broodstocks must meet the previous criteria for domestic production salmonid broodstocks with the following exception.
    a. If the population numbers of wild salmonid broodstocks are limited and/or it is not feasible to capture adequate numbers then collect ovarian and seminal fluids from adult spawning fish for screening, disinfect eggs using the standard iodine bath, incubate and hatch eggs in an isolation facility, raise the progeny in the isolation facility to a size of 2 inches, conduct lethal sampling at the 5% assumed prevalence level for a complete fish health inspection.
13. Non-salmonid broodstock may be sampled for listed pathogens at the discretion of the fish health specialist if there is evidence that a pathogen may be present in the broodstock population.

Section VII. Aquaculture Facility Fish Health Plans

The following guidelines and procedures for aquaculture facility fish health plans have been developed to reduce the risk of introducing fish pathogens, fish disease impacts on cultured fish, and maintaining acceptable fish health standards.

A. Fish Health Management Plans

1. Fish Health Management Plans will be developed and maintained for all state owned fish culture facilities.
2. The plans will be reviewed and updated as needed by a team comprised of the hatchery manager, the hatchery biologist, the assistant hatchery manager from the facility, a hatchery biologist from another facility, and the fish health specialist.
3. It will be the responsibility of the hatchery manger, hatchery assistant manager and hatchery biologist to develop in cooperation with the fish health specialist facility specific fish health management plans.

4. Each plan will be developed address:
    a. Facility specific water sources.
    b. Egg incubation units.
    c. Early life-stage rearing units.
    d. Advanced life-stage rearing units.
    e. Broodstock rearing units.
    f. Isolation or quarantine rearing units.
    g. Separation and sanitation of fish culture equipment.
    h. Disinfection of rearing units and fish distribution units.
    i. Reduce or prevent the exposure of cultured fish to non-fish pathogen vectors.
5. At minimum, the plan should include objectives that address::
    a. Prevention and introduction of fish pathogens.
    b. Minimizing the impact of fish pathogens by identifying and eliminating potential stressors within the hatchery environment.
    c. Develop an understanding of the relationship between the fish hatchery environment, the pathogen and the fish as a pathogen host.
6. At minimum, strategies should be developed to:
    a. Provide the highest water quality possible for fish culture.
    b. Provide sanitary rearing conditions at all times.
    c. Utilize effective hatchery programming and production techniques to minimize unfavorable rearing conditions.
    d. Train hatchery staff in proper fish culture techniques.
    e. Train hatchery staff in proper fish health management practices.
    f. Maintain high quality fish foods.
    g. Administer approved, safe and effective therapeutants and or disinfectants to control fish pathogens.
    h. Utilize diagnostic screening, monitoring and annual fish health inspections.
    i. Utilize the "South Dakota Department of Game, Fish and Parks Fish Health Management Plan and Risk Assessment Protocols" as a tool to guide fish health management in South Dakota.

Section VIII. Fish Health Risk Assessment for the Movement of Propagated and Wild Fish Species

This section provides guidelines for the generation of fish health recommendations to culture facilities and personnel involved in the movement of propagated and wild fish. The Fish Health Risk Assessments attempt to balance the resource need for the movement of propagated and wild fish and fish health needs.

A. Fish Health Risk Assessment for the Movement of Propagated and Wild Fish Species

1. For each assessment the fish health specialist, with input from hatchery managers or fisheries managers, and the fisheries program administrator, will assign a risk classification (high, moderate, or low) to:
    a. The movement of propagated fish species between in-state facilities.
    b. The movement of propagated fish species to waters of the State of South Dakota.
    c. The movement of wild fish species to in-state facilities.

   d. The movement of wild fish species between waters of the State of South Dakota.
2. The risk classification(s) developed by the fish health specialist will be based on several general categories of information.
   a. Data confidence - includes the knowledge about the subject fish and diagnostic tests used for diseases and pathogens.
   b. Risk mitigation Measures - Includes information about the facility characteristics, the ability to treat for a given pathogen, the level of pathogen testing, and the ability to obtain lethal samples.
   c. Pathogen Prevalence Data - Includes pathogen prevalence information from the facility, from the geographical region/watershed where the fish species will be originated, and from geographical region/watershed where the fish species will be stocked, introduced or reintroduced.
3. The worksheets (Appendix A. Tables 1-6) referred to herein are designed to document the health risk associated with the movement of fish species and to help formulate recommendations associated with assigned health risk.
4. The range of scores for the Fish Health Assessment Worksheets (Apeendix A. Tables 1-6) is for comparative modeling and should be used as a factor in the final recommendation.
5. All generated Fish Health Risk Assessment worksheets (Appendix A. Tables 1-6) for the movement of propagated and wild fish shall be maintained by the fish health specialist.

Section IX. Implementation Guidelines and Plan Revisions

This section provides the guidelines to implement the Fish Health Management Plan and Risk Assessment Protocols and plan revisions.

A. The SDGF&P fish health specialist, fisheries managers, and the fisheries program administrator will oversee and implement this plan.
B. The guidelines, recommendations, and procedures outlined in this plan should be used by all SDGF&P employees involved in fisheries management, fish culture or fish health in South Dakota.
C. It is recommended that this plan be applied equally to all fish culture facilities, including state, federal and private facilities.
D. The importation and transfer of propagated and wild fish request will receive equal evaluation under the provisions of this plan, whether the request is made by state or federal agencies or private individuals.
E. This plan has been developed to support and implement the statutes and SDGF&P Commission rules of South Dakota.
F. Specific items addressed either by state statutes or SDGF&P Commission rules, which are not addressed in this plan are considered self-explanatory.
G. This plan may be revised periodically as the need arises. The plan may only be revised with the approval of the fisheries program administrator.

Section X. Fish Health Management Plan and Risk Assessment Protocols Development

The Fish Health Management Plan and Risk Assessment Protocols were developed using the policies, plans and guidelines from the following sources.

Appendix C

1. South Dakota Salmonid Fish Disease Control Policy. Adopted by the South Dakota Department of Game, Fish and Parks Commission, January 1988. Amended by the South Dakota Department of Game, Fish and Parks Commission, January 1989.

2. Montana Fish, Wildlife and Parks, Fish Health Policy, December 2, 2003. Revised June 23, 2004.

3. Wyoming Game and Fish Department, Appendix I. Cold Blooded Wildlife Inspection Procedures.

4. U.S. Fish and Wildlife Service Manual, National Aquatic Animal Health Policy, Chapters: 713 FW 1 – 5. March 3, 2004.

5. Great Lakes Fisheries Commission, A Guide to Integrated Fish Health Management in the Great Lakes Basin. April 1983.

6. U.S. Fish and Wildlife Service, Introduction to Fish Health Management. 2nd Edition, 1995.

7. Fish Health Section of the American Fisheries Society, Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens. 5th Edition, 2003.

8. U.S. Fish and Wildlife Service and Fish Health Section of the American Fisheries Society, Standard Procedures for Aquatic Animal Health Inspections. 2003.

Appendix C

Appendix A. Fish Health Risk Assessment Worksheets

Table 1: Fish Health Risk Assessment for Movement of Fish into a Facility.

Fish Source (5)		
Traditional propagated aquaculture species at aquaculture facility(1)		
Non-traditional propagated aquaculture species at aquaculture facility (3)		
Wild species (5)		
Lifestage (10)		
Gametes/fertilized eggs with parental history of no significant pathogens (1)		
Gametes/fertilized eggs with parental history of significant pathogens (5)		
Gametes/fertilized eggs with no parental history (5)		
Fish (5)		
Receiving Facility Location (5)		
Within propagated population's watershed (2)		
Outside of propagated populations watershed (5)		
Pathogens Surveillance of Proposed Propagated or Wild Population, related populations in same watershed, or source facility (10)		
High level of wild population or source facility pathogen history (multiple, statistically valid, & lethal samples)		
Significant pathogen(s) of concern detected (5)		
No significant pathogens detected (1)		
Low level of wild population or source facility pathogen history (single and/or non-standard samples)		
Significant pathogen(s) of concern detected (5)		
No significant pathogens detected (3)		
No population pathogen history (5)		
Facility Disease History (10)		
High level of facility pathogen history (multiple, statistically valid, & lethal samples)		
Significant pathogen(s) of concern detected (5)		
No significant pathogens detected (1)		
Low level of facility pathogen history (single and/or non-standard samples)		
Significant pathogen(s) of concern detected (5)		
No significant pathogens detected (3)		
No facility pathogen history (5)		
Facility Health Capabilities (diagnostics and sampling) (1)		
High (diagnostic and sampling capabilities) (1)		
Medium (sampling capabilities) (3)		
Low (require on site fish health specialist assistance) (5)		
Facility Type (10)		
Isolation A/Quarantine (see definition section) (1)		
Isolation B (see definition section) (2)		
Isolation C (see definition section) (3)		
Intensive (high environmental control) (5)		
Extensive (low environmental control) (7)		
Water Source (5)		
Closed (protected or enclosed well or spring) (1)		
Open; animal free or treated/disinfected (2)		
Open: with any animals (non-treated or non-disinfected) (5)		
Cultural Impacts on Animal Health (knowledge of requirements for species) (5)		
Optimal (understand cultural requirements) (1)		
Adequate (incomplete cultural requirements understood) (3)		
Unknown (automatically pick "unknown" facilities) (5)		
Cultural Impacts on Animal Health (facilities) (10)		
Optimal (minimal stress for grow, reproduction, or etc.) (1)		
Adequate (for maintenance, potential health problems) (3)		
Inadequate (high potential or significant mortalities) (5)		
Unknown (due to "unknown" cultural requirements) (5)		

TOTAL RISK SCORE	

Appendix A. (cont.)

Table 2. Health Risk Score and Risk Classification for Movement of Fish into a Facility.

Health Risk Score	Risk Classification	Suggested or Recommended Actions
>250	High	Do not accept or Level A receiving facility that can quarantine for entire rearing cycle
150-249	Moderate	Do not accept or Level B receiving facility with restricted rearing conditions for a defined period to allow for testing
<150	Low	Level C - Standard intensive or extensive culture

Isolation Level Descriptions and Definitions.

1. Level A: a quarantine facility with the following characteristics:
   a. Completely enclosed, locked structure with a given room or space allotted to only one fish population. Water is either supplied by a well or is disinfected.
   b. Operated by a written Standard Operating Plan, with the highest level of sanitation, including, but not limited to: restricted personnel access; dedicated equipment, such as brooms, nets, etc.; dedicated external garments, such as boots and raingear; disinfected foot baths; and landfill disposal of fish carcasses.
   c. Effluent is disinfected by ultraviolet light sterilization or strong oxidation, or is sent into a documented "dead-end" location and cannot enter facility water supplies or receiving waters.
2. Level B: same as Level A except effluent is not disinfected prior to contact with receiving water. Effluent from this facility should not contact a water supplies at the facility.
3. Level C: same as Level B except multiple populations or groups may be housed in the same containment building, and there is no restriction on the facility water supply. It is recommended that some form of airbourne pathogen separation between populations (such as curtains), as well as unit-specific equipment, be used in the type facility.
4. Intensive: open facility with adjacent rearing units that allow for direct observation and husbandry of fish species (e.g. standard hatchery with raceways and tanks). Typically fish densities are high, and rearing units are proximity to each other.
5. Extensive: open facility with limited ability for observation and husbandry of fish species (e.g. earthen pond systems). Typically fish densities are low to moderate, and rearing units are not in close proximity to each other.

Appendix A. (cont.)

Table 3: Fish Health Risk Assessment for the Transfer of Wild Fish between Waters.

Lifestage (10)		
Gametes/fertilized eggs with parental history of no significant pathogens (1)		
Gametes/fertilized eggs with parental history of significant pathogens (5)		
Gametes/fertilized eggs with no parental history (5)		
Fish (5)		
Pathogens Surveillance of Watershed and/or Proposed Wild Fish Population to Transfer to another Water (10)		
High level of population pathogen and/or watershed history (multiple, statistically valid, & lethal samples)		
Significant pathogen(s) of concern detected (5)		
No significant pathogens detected (1)		
Low level of population pathogen and/or watershed history (single and/or non-standard samples)		
Significant pathogen(s) of concern detected (5)		
No significant pathogens detected (3)		
No population pathogen history (5)		
Receiving Water or Watershed Wild Fish Disease History (5)		
High level of wild fish pathogen history in receiving water or watershed (multiple, statistically valid, & lethal samples)		
Significant pathogen(s) of concern detected (5)		
No significant pathogens detected, but pathogens in source watershed and/or wild fish (5)		
Same pathogen(s) as source watershed and/or wild fish (3)		
No significant pathogen(s) in receiving or source watershed and/or wild fish (1)		
Low level of wild fish pathogen history in receiving water or watershed (single and/or non-standard samples)		
Significant pathogen(s) of concern detected (5)		
No significant pathogens detected, but pathogens in source watershed and/or wild fish (5)		
Same pathogen(s) as source watershed and/or wild fish (3)		
No significant pathogens detected (3)		
No pathogen history (5)		
Receiving Watershed (20)		
Same as feral population's original watershed (1)		
Different from feral population's original watershed (5)		
TOTAL RISK SCORE		

Table 4. Health Risk Score and Risk Classification for the Transfer of Wild Fish between Waters.

Health Risk Score	Risk Classification	Suggested or Recommended Actions
>250	High	No movement recommended
200-250	Moderate High	No movement or only into same watershed
150-200	Moderate	Movement into same watershed or watershed with same pathogen history
<150	Low	Movement recommended

Appendix A. (cont.)

Table 5. Fish Health Risk Assessment for the Movement of Fish from a Facility.

Confidence of pathogen surveillance – Methods (5)		
Standard methods (includes lethal) as noted in F.4. (1)		
Non-traditional methods (e.g. bioassays, pathogen free animals held in effluent, non-lethal (3)		
No surveillance conducted (7)		
Confidence of pathogen surveillance – Efforts (5)		
Standard inspection (includes lethal) to include examination of representative samples of moribund fish (1)		
Examination of non-representative samples of fish (4)		
No surveillance conducted (5)		
Life stage released (5)		
Gametes/fertilized eggs with parental history of no significant pathogens (1)		
Gametes/fertilized eggs with parental history of significant pathogens (5)		
Gametes/fertilized eggs with no parental history (5)		
Fish (5)		
Pathogen Surveillance of Propagated Fish Population (10)		
High level of population history (multiple, statistically valid, and lethal samples)		
Significant pathogen(s) detected in population and not known in receiving watershed (5)		
Significant pathogen(s) detected in population and present in receiving watershed (3)		
No significant pathogens detected (1)		
Low level of population pathogen history (single and/or non-standard sampling)		
Significant pathogen(s) detected in population and not known in receiving watershed (5)		
Significant pathogen(s) detected in population and present in receiving watershed (3)		
No significant pathogens detected (3)		
No population history (5)		
Receiving Watershed (20)		
Same as propagated population's original watershed and facility's watershed (1)		
Same as population's original watershed, not facility's watershed and closed water supply (1)		
Same as population's original watershed, not facility's watershed and open water supply (3)		
Different from population's original watershed and same as facility's (5)		
Different from population's original watershed and different from facility's watershed (3)		
TOTAL RISK SCORE		

Table 6. Health Risk Score and Risk Classification for the Movement of Fish from a Facility.

Health Risk Score	Risk Classification	Suggested or Recommended Actions
>185	High	No movement and appropriate disposal recommended
	Moderate	No movement or only into watersheds with history of same pathogen
<85	Low	Movement recommended

Appendix B: Fish Health Risk Assessment Scenarios

Management scenarios to test Fish Health Assessment Worksheets Tables 1 – 6.

Scenario 1: Move adult brook trout from one watershed that was tested in the 2003 Wild Fish Health Survey and no significant pathogens (NSP) were detected to another watershed never surveyed for fish pathogens.

TABLE 3. Fish Health Assessment for the Transfer of Wild Fish between Waters			
Question	**Response**	**Weight x Response**	**Risk Score**
Lifestage	Fish	10 x 5	50
Pathogen surveillance of watershed and/or proposed wild fish to transfer	Low Level Surveillance No pathogens detected	10 x 3	30
Receiving water or watershed wild fish disease history	Low Level History No pathogen history	10 x 5	50
Receiving watershed	Different	20 x 5	100
Health Risk Score			230
Risk Classification			Moderate High

Moderate High: Movement only recommended into same watershed, until new watershed surveyed for pathogens.

Scenario 2: Move adult brook trout from one watershed that was tested in the 2003 Wild Fish Health Survey and the *Y. ruckeri* pathogen was detected to another watershed surveyed also in 2003 and *Y. ruckeri* detected also.

TABLE 3. Fish Health Assessment for the Transfer of Wild Fish between Waters			
Question	**Response**	**Weight x Response**	**Risk Score**
Lifestage	Fish	10 x 5	50
Pathogen surveillance of watershed and/or proposed wild fish to transfer	Low Level Surveillance Significant pathogen	10 x 5	50
Receiving water or watershed wild fish disease history	Low Level History Same pathogen(s) detected	10 x 3	30
Receiving watershed	Diffferent	20 x 1	20
Health Risk Score			150
Risk Classification			Moderate

Moderate: Movement recommended into to same watershed or watershed with same pathogen history.

Appendix B. (cont.)

Scenario 3: Move lake chub from Deerfield into the headwaters of Bear Butte Creek. No fish health work done on fish populations in Deerfield. Receives pathogen free RBT from hatchery. Castle Creek upstream sampled in 2003 (NSP) and Bear Butte sampled in 1998 and 2002 (NSP).

TABLE 3. Fish Health Assessment for the Transfer of Wild Fish between Waters			
Question	**Response**	**Weight x Response**	**Risk Score**
Lifestage	Fish	10 x 5	50
Pathogen surveillance of watershed and/or proposed wild fish to transfer	Low Level Surveillance *No significant pathogens detected	10 x 3	30
Receiving water or watershed wild fish disease history	Low Level History No pathogen(s) detected	10 x 3	30
Receiving watershed	Diffferent	20 x 1	20
Health Risk Score			130
Risk Classification			Low

* The fish health information available would suggest that though no fish have ever been sampled from Deerfield that the presence of a pathogen of concern would be low.

Low: Movement recommended.

Senario 4: Spawn brown trout in headwaters of Rapid Creek, no pathogen testing of wild fish or watershed. Want to takes eggs to McNenny State Fish Hatchery.

TABLE 1. Fish Health Assessment for the Movement of Fish into a Facility			
Question	**Response**	**Weight x Response**	**Risk Score**
Fish Source	Wild	5 x 5	25
Lifestage	Eggs with no parental pathogen history	10 x 5	50
Receiving Facility Location	Not same watershed	5 x 5	25
Pathogen surveillance of proposed propagated or wild fish	Low Level Surveillance No population pathogen history	10 x 5	50
Facility Disease History	High pathogen history No pathogens	10 x 1	10
Facility Health Capabilities	High diagnostic	1 x 1	1
Facility Type	Intensive (no quarantine capabilities)	10 x 5	50
Water Sourse	Closed	5 x 1	5
Cultural Impacts (Species requirements)	**Optimal**	**5 x 1**	5
Culture Impacts (Facility requirements)	**Optimal**	**5 x 1**	**5**
Health Risk Score			231
Risk Classification			Moderate

Moderate: Do not accept or Level B receiving facility with restricted rearing conditions for a defined period to allow for testing.

Appendix C: Glossary

Acute – severe or crucial, often progressing rapidly; i.e., acute inflammation.

Aquatic animal – those species, excluding mammals and birds, their gametes and fertilized eggs. Aquatic animals spend some portion of their live within water.

Broodstock – aquatic animals maintained and/or reared in captivity for the production of gametes.

Carrier – an individual harboring the specific organism(s) which can cause disease.

Certificate – a document indicating that a statistically-based on-site inspection (sampling) was conducted of all lots of aquatic animals on the facility with subsequent examination of the collected tissues and fluids for the detection of listed pathogens of concern.

Clinical – when applied to a disease or signs of disease, a term that indicates a condition ready apparent, overt, or obvious by gross inspection and pathology, either internally or externally.

Chronic – describes the course of a disease which is long and drawn out – not acute.

Decontamination – to remove the contamination; i.e., a pathogen, diseased fish.

Depopulation – to remove all aquatic animals.

Disease – a pathological condition of the body that presents a group of signs indicating the existence of an abnormal histological or physiological entity.

Disinfectant – an agent which will destroy infective organisms.

Domestic – aquatic animals domesticated to live and breed in cultured conditions.

Emerging Pathogen – an aquatic animal pathogen not previously known to occur in a given population, but found as a result of newly developed diagnostic techniques or from a species not previously cultured.

Enzootic – a disease which is present in an animal population at all times.

Epizootic – outbreak of disease attacking many animals in a population at the same time and rapidly spreading.

Etiology – all of the causes of a disease or abnormal condition.

Exotic Pathogen – an aquatic animal pathogen not previously know to occur in a given in a given United States watershed or other jurisdictional boundaries.

Facility – means a hatchery whose primary role is to maintain, on site, a resident population of aquatic animals.

Fish Health Specialist – South Dakota Department of Game, Fish and Parks, Wildlife Division employee assigned the responsibilities of the state-wide fish health management program by the SDGF&P's fisheries program administrator.

Fisheries Manager – South Dakota Department of Game, Fish and Parks, Wildlife Division employees, including: Regional Fisheries Mangers in the division's operations section, technical service's wildlife biologist assigned to specific fisheries programs, i.e., coldwater.

Fisheries Program Administrator – South Dakota Department of Game, Fish and Parks, Wildlife Division, fisheries employee that administers state-wide fisheries programs and supervises state-wide technical services fisheries biologist and hatchery employees.

Histozoic – originating in tissue.

Importation – to bring from a source outside the boundaries of South Dakota.

Inspection report – see certificate.

Lot – a group of culture aquatic animals of the same species, of the same year class, originating from the same spawning population, and sharing the same water supply.

Microsporean – in the phylum Microspora. Spores unicellular, comparatively small (3-8 µm), without polar capsules, with sporoplasm and extrusible polar tube; obligate intracellular parasites.

Moribund – approaching death.

Myxosporean – in the phylum Myxzoa. Spores multicellular, comparative large (6-65 µm), with a polar capsules, polar filaments, sporoplasm(s), and vavles; usually histozoic, intercellualr parasites of various tissues.

Quarantine – the cessation of all movement of aquatic animal and potential infectious material from a facility suspected of containing an exotic, emergency prohibitive, or prohibitive pathogen.

Prevalence – the number of detectable cases of a disease or disease agent (i.e. pathogen) present in a population at a given time.

Pathogen – an organism capable of causing disease.

Sanitation – the prevention of disease by maintenance of sanitary conditions.

Septicemic – severe infection of the bloodstream and associated organs.

Subclinical – a course of disease which exhibits some clinical and some chronic symptoms.

Systemic – affecting the body or all organs in general.

Virulent – the ability of a pathogen to cause a rapid and severe disease.

Watershed – a region or area draining to a particular water course or body of water.

Wild – not domesticated or cultured.

Appendix D: South Dakota Codified Laws

Volume 12B
2002 Revision
41. Game, Fish, Parks and Forestry

41-2-18. **Rules for implementation of game, fish and conservation laws.** The Game, Fish and Parks Commission may adopt such rules as may be necessary to implement the provisions of chapter 41-1 to 41-15, inclusive. The rules may be adopted to regulate:

(1) The conservation, protection, importation and propagation of wild animals and fish except for any nondomestic animal which is regulated pursuant to § 40-3-26;

(9) The gathering, purchasing, distributing and transferring of all wild animals and fish for population management, stocking purposes, scientific study and intergovernmental trades;

41-3-1. **Department in charge of propagation and preservation of game and fish.** The Department of Game, Fish and Parks shall have charge of the propagation and preservation of such varieties of game and fish as it shall deem to be of public value.

41-3-8. **Enforcement of laws for protection and propagation of animals, birds and fish.** The Department of Game, Fish and Parks shall enforce the laws of this state involving the protection and propagation of all game animals, game birds, fish, and harmless birds and animals.

41-3-13. **Seeding and stocking of fishing waters – Stocking of game animals and birds.** The Department of Game, Fish and Parks shall have charge of the taking of fish from public waters of the state for the propagation and stocking of other waters therein and the transferring of game animals or game birds from one section of the state to another for stocking purposes.

41-13-3. **Commission authority required to introduce fish or eggs into public waters – Violation as misdemeanor.** It is a Class 2 misdemeanor for any person to transplant or introduce any fish or fish eggs into any of the public waters of this state without express authority of the Department of Game, Fish and Parks.

41-13-3.1. **Unauthorized importation of salmonidae as misdemeanor.** It is a Class 2 misdemeanor for any person to import live fishes or viable eggs of the family salmonidae into the State of South Dakota unless such importation complies with rules and regulations established by the Department of Game, Fish and Parks.

Appendix C

41-15-1. **Department to enforce game and fish laws.** The Department of Game, Fish and Parks shall enforce the laws of this state involving the protection and propagation of all game animals, game birds, fish and harmless birds and animals.

Appendix E: CHAPTER 41:09:08.

IMPORTATION OF FISH

Section

41:09:08:01. Salmonidae importation prohibited without permit. Repealed.
Source: SL 1975, ch 16, § 1; 10 SDR 76, 10 SDR 102, effective July 1, 1984; 15 SDR 103, effective January 19, 1989; repealed, 29 SDR 80, effective December 10, 2002

41:09:08:01.01. Fish importation prohibited -- Exceptions. A person may not import live fish or any fish reproductive product into the state except for the following:
(1) A person possessing a valid fish importation permit issued by the department;
(2) A lawful angler, a wholesale bait dealer, or a person licensed as a nonresident wholesale bait dealer may import fathead minnows (*Pimephales promelas*), golden shiners (*Notemigonus crysoleucas*), creek chubs (*Semotilus atromaculatus*), or white suckers (*Catostomus commersoni*);
(3) An angler fishing on any boundary water as defined in § 41:07:01:01; or
(4) A person importing fish designated for aquaria use.
Source: 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

41:09:08:02. Certificate of source required. Repealed.
Source: SL 1975, ch 16, § 1; 10 SDR 76, 10 SDR 102, effective July 1, 1984; repealed, 15 SDR 103, effective January 19, 1989.

41:09:08:03. Disease-free certificate required. Repealed.
Source: SL 1975, ch 16, § 1; 10 SDR 76, 10 SDR 102, effective July 1, 1984; 15 SDR 103, effective January 19, 1989; repealed, 29 SDR 80, effective December 10, 2002.

41:09:08:03.01. Application requirements for fish importation permit -- Validity. A person shall make application for a fish importation permit on forms provided by the department. The application must be received at least ten working days prior to the date of importation if the application is from a new facility or supplier. The application period shall be waived for a fish importation permit if the facility or supplier has a valid fish health inspection certification or fish health report on file with the department. Applications are subject to review by the department's fish health specialist.
Source: 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

41:09:08:03.02. Fish health inspection and accepted guidelines. A fish health inspection may only be conducted by a fish pathologist, fish health inspector, or a recognized fish health specialist approved by the department. A fish health inspection shall be conducted according to procedures in "Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens," 4th edition, 1994. Rule proposed to be amended in the near future to "5th edition, 2003".
Source: 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.
Reference: "Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens," 4th edition, 1994. American Fisheries Society, Fish Health Section, 5410 Grosvenor Lane, Suite 110, Bethesda, Maryland, 20814.

41:09:08:03.03. Diseases of regulatory concern. Fish diseases of regulatory concern are as follows:
(1) Emergency prohibitive diseases:
(a) Viral hemmorrhagic septicemia – V.H.S. virus;
(b) Oncorhynchus masou virus – O.M. virus;
(c) Salmonid rickettsial septicemia – S.R.S. virus;
(d) Spring viiremia of carp – *Rhabdovirus carpio* – S.V.C. virus; and
(e) Rhabdovirus disease of northern pike fry – P.F.R.D. virus;
(2) Prohibitive diseases:
(a) Infectious hematopoietic necrosis – I.H.N. virus;
(b) Infectious pancreatic necrosis – I.P.N. virus;
(c) Ceratomyxosis – *Ceratomyxa shasta*;
(d) Proliferative kidney disease – PKD/PKX agent;
(e) Epizootic epitheliotropic disease – EED virus;
(f) Channel catfishy herpevirus – C.C.V.D.;
(g) White sturgeon iridovirus – W.S.I. virus of white sturgeon; and
(h) Largemouth bass virus – L.M.B.V.; and
(3) Notifiable diseases:
(a) Bacterial kidney disease – *Renibacterium salmoninarum*;
(b) Furunculosis – *Aeromonas salmonicida*;
(c) Enteric redmouth – *Yersinia ruckeri*;
(d) Whirling disease – *Myxosoma cerebralis*;
(e) Shovelnose sturgeon iridovirus – S.S.I. virus of shovelnose and pallid sturgeon; and
(f) Heterosporis – *Heterosposris sp*.
Source: 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

41:09:08:03.04. Importation requirements for fish or fish reproductive products obtained from facility containing salmonids. Before the department may issue to a person a fish importation permit for importation of fish or any fish reproductive product, the person shall submit to the department a current fish health certification or a fish health inspection report from a facility containing salmonids indicating that the facility has been inspected within the past twelve months and that there is no evidence of diseases of regulatory concern or their causative pathogens. If a notifiable disease or causative pathogen is detected at a facility, the department's fish health official may allow the fish or fish reproductive products to be imported if the official determines the requested importation will not cause introduction or spread of any notifiable aquatic animal pathogens to areas they currently do not occur. Non salmonids from the same facility may be subject to sampling.
Source: 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

41:09:08:03.05. Importation requirements for fish or fish reproductive products obtained from non salmonid facility. Before the department may issue to a person a fish importation permit for fish or any fish reproductive product obtained from a non salmonid facility, the person shall submit to the department a current fish health certification or a fish health inspection report signed by an inspecting agent approved by the department indicating the absence of any fish disease of regulatory concern, any new fish disease, and exhibition of any clinical sign of disease. Evaluation of the disease history of the originating facility may require a fish health inspection.

Source: 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

41:09:08:04. Packaging and shipping procedure. Any live fish or fish reproductive product that requires an importation permit shall be packaged and shipped in the original containers from a facility that has been inspected as provided in this chapter. The original copy of the importation permit must accompany each shipment and shall include a statement of prophylactic treatments used prior to departure from the original facility. The importation permit must be readily accessible to South Dakota authorities. Shipments arranged by a broker may be imported if they are delivered directly from the certified facility, in original containers, to the receiver in South Dakota.
Source: SL 1975, ch 16, § 1; 10 SDR 76, 10 SDR 102, effective July 1, 1984; 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

41:09:08:05. Inspection of shipments. Any live fish or fish reproductive product imported under this chapter is subject to inspection either at the place of entry into the state or at other locations suitable to the department. The inspection may include the removal of reasonable samples of fish or any fish reproductive product for biological examination.
Source: SL 1975, ch 16, § 1; 10 SDR 76, 10 SDR 102, effective July 1, 1984; 15 SDR 103, effective January 19, 1989; 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

41:09:08:06. Shipments in violation of rules -- Disposal. Any shipment failing to display an importation permit, found to be diseased upon inspection, containing any species not authorized by the import permit, or otherwise in violation of this chapter shall be refused entry, immediately destroyed, or transported out of the state at the direction of the fish health specialist as designated by the secretary.
Source: SL 1975, ch 16, § 1; 10 SDR 76, 10 SDR 102, effective July 1, 1984; 15 SDR 103, effective January 19, 1989; 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

41:09:08:07. In-transit shipments exempt -- Exceptions. Any in-transit shipment through South Dakota substantiated by an invoice or shipping document is not subject to the provisions of this chapter. However, such a shipment shall be considered an importation if any repackaging or exchange of containers or water in containers is attempted within the borders of the state.
Source: SL 1975, ch 16, § 1; 10 SDR 76, 10 SDR 102, effective July 1, 1984; 29 SDR 80, effective December 10, 2002.
General Authority: SDCL 41-2-18(1).
Law Implemented: SDCL 41-2-18(1), 41-13-3.1.

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

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

Prepared for

In Re: Missouri River System Litigation

(03-MD- 01555)(and associated litigation)

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Introduction

This report discusses several native and introduced species to the Missouri River that have increased in abundance or have become important components of the fish community in the mainstem of the Missouri River in South Dakota. Because of the changes in the fish community, whether through increased abundance of a native species or stocking of a nonnative species, concern has been expressed regarding the potential impacts to native species, in particular predation on pallid sturgeon. Therefore, this report examines the reasons behind the changes to the fish community, the changes to the fish community itself, and individual species ecological characteristics. Lastly, the potential for predation of selected species is reviewed.

General Change in Missouri River

Four mainstem dams, Oahe, Big Bend, Fort Randall and Gavins Point, have dramatically changed the Missouri River that either passes through or borders South Dakota. The Missouri River was often referred to as the “Big Muddy” because of the turbid waters and sediment load. This characteristic was due in part to the two spring floods characteristic of the Missouri River that annually reorganized the river complex of chutes, side channels, back waters and sinuous main channel. A floodplain consisting of highly erodable soils and a relatively low gradient also added to the diversity of habitats and turbidity of the Missouri River (National Research Council 2002). The Missouri River supported a diverse fish community that was dominated by species adapted to high turbidities, shifting substrates, high water velocities and annual flooding events (Galat et al. in press).

The Pick Sloan Plan as part of the Flood Control Act of 1944 authorized the construction of six mainstem dams (four in South Dakota) on the Missouri River. In South Dakota, Fort Randall Dam was the first to be closed in 1952 and Big Bend Dam the last in 1963 (Benson 1988). At full pool, the reservoirs behind the four mainstem dams effectively convert 377 miles of the 498 miles of the Missouri River bordering or passing through South Dakota from a riverine/lotic environment to that of a lake/lacustrine environment. Of the Missouri River bordering or passing through South

Dakota, 75.6% has been changed from the turbid, riverine habitat, to a clearer, calmer lacustrine environment. The majority of the Missouri River floodplain in South Dakota has been effectively flooded since 1967 by the reservoirs behind the mainstem dams. The reservoirs range in average depth from 16 feet (Lewis and Clark Lake) to 62 feet (Lake Oahe) (Martin et al. 1980). The maximum depth in Lake Oahe extends to 205 ft (Benson 1988). Lake Oahe is the only one of the four mainstem reservoirs that normally thermally stratifies (Martin et al. 1980; Benson 1968). Cold water habitat (≤ 15° C) normally covers 118,000 acres of the deeper portions of Lake Oahe (Lott et al. 2002). The large lake environments and coldwater habitat created by the construction and filling of the reservoirs were foreign to many of the fish species adapted to the turbid flowing waters of the preimpoundment Missouri River. With the changes in habitat, the composition of fish communities changed. Native species that were in relatively low abundance in the unaltered Missouri River and were more suited for a lacustrine environment increased in relative abundance, while many of the native species which were suited to the turbid waters of the preimpoundment Missouri River declined in abundance. The relationship of fish community changes to habitat alterations will be discussed in more detail throughout this report. The initial policy of the South Dakota Department of Game Fish and Parks (SDGF&P) was to not stock fish into the mainstem reservoirs. Partly because the congressionally authorized use of these projects included fish, wildlife and recreation (USACE 1979), SDGF&P staff eventually sought out and stocked species preadapted to the new lacustrine environment in the postimpoundment Missouri River to enhance sport fisheries and fill habitat niches such as the coldwater portion of Lake Oahe. In a discussion of the mainstem reservoirs project purposes, Sveum (1988), Chief of the Reservoir Control Center for the U. S. Army Corps of Engineers (USACE), stated the following with regard to recreation, one of the authorized project purposes:

> The State of South Dakota boasts of the excellent walleye fishing and has attracted many out-of-state fishermen. Angling pressure in North Dakota has been increasing as the word spreads, and it will probably continue as long as quality fishing continues. An important management goal is to maintain the excellent walleye fishing, but other species including cool-water species such as northern pike and muskellunge and cold-water species such as chinook salmon, lake trout, and rainbow and

brown trout are also an important part of the long-term reservoir fisheries management plan.

Several species, primarily introduced, have been brought into question with regard to the potential that they would prey on pallid sturgeon. Following is a discussion of introduced and native species which have been stocked, are currently stocked and/or whose native status in the Missouri River has been brought into question in the pending litigation. The species listed in Table 1 have either been introduced into the Missouri River system to utilize the altered habitat or have been stocked to enhance abundance of preexisting native species popular with anglers. Several stocking attempts were made with other fish species to try and utilize the newly created habitat in the South Dakota portion of the Missouri River. The fish species stocked which were eventually discontinued are: *Coregonus clupeaformis* – lake whitefish, *Oncorhyncus nerka* – sockeye salmon/kokanee, *Oncorhyncus clarki* – cutthroat trout, *Salvelinus namaycush* – lake trout, *Prosopium gemmiferu* – Bonneville cisco, *Esox masquinongy* – muskellunge, *Esox lucius x masquinongy* – tiger muskellunge (Hanten and Talsma 1984, Marrone and Stout 1997, SDGF&P fish stocking database). Of this list, only lake whitefish and tiger muskellunge are occasionally sampled either by anglers or in fish population surveys (Missouri River Fisheries Center staff, SDGF&P). In both cases the fish are believed to be from original stocking events, i.e. large adults (Missouri River Fisheries Center staff, SDGF&P). The salmonid species listed in Table 1 are the only species that require regular maintenance stockings because they do not reproduce naturally in the South Dakota portion of the Missouri River (Marrone and Stout 1997). The trout, brown and rainbow, as well as the Chinook salmon fisheries have become established components of the recreational opportunity/sport fisheries on the mainstem of the Missouri River in South Dakota (Johnson et al. 2002; Lott et al. 2002; Stone and Sorensen 2002). Although there are numerous other native and nonnative species in the Missouri River, the majority of the species in Table 1, both native and nonnative, have been suggested in the pending litigation as being potential predators of the federally endangered pallid sturgeon.

Several nonnative species, (spottail shiner, smallmouth bass, white bass, lake herring, and rainbow smelt) have established naturally reproducing populations and are important to the fishery in the Missouri River as either prey fish or sport fish. Following the establishment of rainbow smelt, several coldwater species were stocked and failed to fill the void as a coldwater predator. However, stocked Chinook salmon were a success and have become the main coldwater predator stocked to utilize rainbow smelt. In addition to their importance as prey to Chinook salmon (Hill 1997), when abundant, rainbow smelt are the primary prey fish in Lake Oahe for several other sport fish populations (Jackson 1992; Bryan 1995; R. P. Hanten, SDGF&P fishery biologist, personal communication).

Table 1. Native and introduced fish species stocked into the Missouri River system discussed in this report (Hanten and Talsma 1984, SDGF&P fish stocking database). Origin as a native (N), introduced (I) or probable native (PN) is denoted along with a superscript for the corresponding reference, ([1]Bailey and Allum 1962, [2]Cross et al. 1986, [3]Galat et al. in press). Stocking status refers to one of the following:
Established sport fishery - stocking required to maintain (EFS)
Established population - stocking discontinued (EPD)
Native – if stocked, additive to natural reproduction (NSA)
Species in this table are actively managed via stocking or other means at the present time and/or have had their status, whether native or nonnative, brought into question by others in the pending litigation.

Species name	Common name	Origin	Stocking status	Years Stocked in Missouri River in SD
Oncorhynchus mykiss	rainbow trout	I	EFS	1951, 56, 57, 64, 68, 69, 1972-2003
Oncorhynchus tshawytscha	Chinook salmon	I	EFS	1982-2000. 2003
Salmo trutta	brown trout	I	EFS	1964, 68, 79, 1981-2003
Morone chrysops	white bass	I	EPD	1960-62
Coregonus artedi	lake herring	I	EPD	1984, 88, 90-92
Polyodon spathula	paddlefish	N[1. 2. 3]	NSA*	1974, 76-78, 1985-2003
Osmerus mordax	rainbow smelt	I	EPD**	-
Notropis hudsonius	spottail shiner	I	EPD	1973-75, 78, 79
Micropterus dolomieu	smallmouth bass	I	EPD	1972, 74, 80, 83-92, 94-98
Esox lucius	northern pike	PN[1], N[2, 3]	NSA	1957, 58, 71, 82, 83, 85, 86, 88-97
Perca flavescens	yellow perch	PN[1], N[2, 3]	NSA	-
Sander vitreum	walleye	N[1. 2. 3]	NSA	1952, 53, 57, 58, 83-98, 2002

*Paddlefish stocking in the last decade has only been in Lake Francis Case. An adult population exists in Lake Francis Case, however natural reproduction has not been documented.
** Rainbow smelt in the South Dakota portion of the Missouri River originated from fish stocked in Lake Sakakawea in North Dakota.

Several nonnative species, (spottail shiner, smallmouth bass, white bass, lake herring, and rainbow smelt) have established naturally reproducing populations and are important to the fishery in the Missouri River as either prey fish or sport fish. Following the establishment of rainbow smelt, several coldwater species were stocked and failed to fill the void as a coldwater predator. However, stocked Chinook salmon were a success and have become the main coldwater predator stocked to utilize rainbow smelt. In addition to their importance as prey to Chinook salmon (Hill 1997), when abundant, rainbow smelt are the primary prey fish in Lake Oahe for several other sport fish populations (Jackson 1992; Bryan 1995; R. P. Hanten, SDGF&P fishery biologist, personal communication).

South Dakota anglers ranked walleye and northern pike first and second respectively as their most preferred fish species in the Missouri River (Stone 1996). Because of anglers' preference for walleye and northern pike, they have been stocked in the past to enhance naturally reproducing sport fish populations in the Missouri River in South Dakota.

Accounts of Stocked Fish Species

A discussion of each of the species listed in Table 1 follows. Some of the discussions will be broad when applicable others will be fairly short. Primary issues discussed include the following: origin (nonnative/native), stocking status. stocking plans, habitat preferences, food habitats, and importance to the sport fishery

Rainbow trout

Rainbow trout are an introduced species to the Missouri River in South Dakota (Bailey and Allum 1962; Hanten and Talsma 1984; Cross et al. 1986; Galat et al. in press). The first introduction of rainbow trout into the Missouri River in South Dakota occurred in Lake Francis Case in 1951, a stocking of 600 fingerlings (Hanten and Talsma 1984). Various sizes and quantities of rainbow trout were stocked throughout most of the mainstem Missouri River in South Dakota in past years (SDGF&P fish stocking database). A total of 35,000 catchable rainbow trout (3/lb) are scheduled to be stocked below Oahe Dam in 2004 (SDGF&P). Catchable rainbow trout stockings provide a unique angling opportunity for anglers in the area (Johnson et al. 1998), especially for youth and handicapped anglers, in locations with easy shoreline access, close to Pierre and within Pierre. A portion of the stocked rainbow trout that are not captured in the several weeks post-stocking eventually add to the tailrace fishery in later months and subsequent years as larger trout often reaching trophy size. One of the primary reasons rainbow trout tend to stay within the Oahe tailrace area is because of the relatively clear, cool-cold water releases from the Oahe powerhouse, even during the hot summer months. South Dakota anglers ranked trout as their eighth most preferred fish in the Missouri River (Stone 1996). Rainbow trout have been stocked below Oahe Dam annually since 1980 (Hanten and Talsma 1984; SDGF&P fish stocking database) enabling the fishery to become well-known and well-established amongst anglers. Because natural reproduction by rainbow trout has not been documented and likely does not occur in the mainstem of the Missouri River in South Dakota (Marrone and Stout 1997), stocking is required to maintain this fishery.

Rainbow trout have an upper lethal temperature limit between 75.2° F (Black 1953) and 77° F (Morrow and Fischenic 2000). Garside and Tait (1958) reported the preferred or optimum temperature as 55.4° F, while a range of 53.6° to 64.4° F was reported by (Morrow and Fischenic 2000). Rainbow trout require a gravelly river in which adults can migrate to spawn in order to be self-sustaining (Scott and Crossman 1973).

In general rainbow trout feed on invertebrates, plankton and occasionally other fish shifting from plankton to insects and crustaceans and then to fish as trout size increases (Scott and Crossman 1973). Lynott (1995) reported a similar pattern in Lake Oahe with rainbow trout's diets shifting from zooplankton, to terrestrial insects to rainbow smelt as rainbow trout size increased. Rainbow smelt dominated the diet of rainbow trout > 460 mm in length in Lake Oahe (Lynott 1995). Because rainbow trout are primarily visual feeders increased turbidity could impact foraging efficiency. Others have reported decreased (19-42%) capture success and prey consumption rates at turbidities of 30-60 NTU's (nephelometric turbidity units) (Noggle 1978; Gardner 1981; Berg and Northcote 1985). Barrett et al. (1992) reported that rainbow trout reactive distances to prey items in the 15 and 30 NTU treatments were only 80% and 45% of those observed at turbidities of 4-6 NTUs. It is apparent from these results that rainbow trout would show an affinity for the cooler and clearer waters available in the Oahe tailrace. Moreover, rainbow trout exhibited decreased reactive distance to prey items at turbidities as low as 15 NTU's would likely find foraging for prey in the unaltered

Missouri River difficult. The mean annual turbidity in the unaltered Missouri River at a Saint Louis water treatment facility ranged from in excess of 1,000 NTU's to more than 2,500 NTU's (Pflieger and Grace 1987).

Chinook salmon

Chinook salmon are an introduced species in the Missouri River in South Dakota (Hanten and Talsma 1984; Cross et al. 1986; Galat et al. in press). Chinook salmon which had been stocked in North Dakota reached Lake Oahe as early as 1979 (Lott et al. 1997), likely after being entrained through the Garrison powerhouse. Eggs taken from Chinook salmon that had passed from Lake Sakakawea into Lake Oahe and from Lake Michigan salmon were utilized for the first stocking of nearly 300,000 Chinook salmon smolts directly into the mainstem Missouri River in South Dakota (Hanten and Talsma 1984; Lott et al. 1997). The majority of the Chinook salmon stocked (90%) into the Missouri River in South Dakota have been stocked into Lake Oahe (SDF&P fish stocking database). A popular fishery for Chinook salmon has been established in Lake Oahe. In 1996, an estimated 33,077 fish were harvested from Lake Oahe, second only to walleye harvest (Johnson et al. 1998). Because natural reproduction by Chinook salmon has not been documented and likely does not occur in the mainstem of the Missouri River in South Dakota (Marrone and Stout 1997) stocking is required to maintain this fishery. A total of 155,000 Chinook salmon (35-100/lb) are scheduled to be stocked in Lake Oahe in 2004 (SDGF&P).

Chinook salmon have an upper lethal temperature limit of 77.2° F (Brett 1952; Morrow and Fischenic 2000). Brett (1952) reported their preferred temperature range as 53.6° - 57.2° F, while a range of 53.1° - 59.9° F was reported by Morrow and Fischenic (2000). Chinook salmon require a gravelly river or stream in which adults can migrate to spawn in order to be self-sustaining (Scott and Crossman 1973).

In Lake Oahe, the diet of age-0 Chinook salmon in May consisted entirely of invertebrates, nearly equal parts by weight of zooplankton, aquatic insects and invertebrates (Hill 1997). By June age-0 rainbow smelt made up the largest part of the diet (73.5%) and dominated the diet through September (Hill 1997). Age-1 and older Chinook salmon relied almost exclusively on adult rainbow smelt, with the only exception for age-1 and age-2 Chinook salmon which occasionally preyed on age-0 rainbow smelt (Hill 1997). Chinook salmon are generally considered sight feeders, which like rainbow trout, would have difficulty locating prey in increasing turbidity.

Brown trout

Brown trout are an introduced species in the Missouri River in South Dakota (Hanten and Talsma 1984; Cross et al. 1986; Galat et al. in press). The first introduction of brown trout into the Missouri River in South Dakota occurred in Lake Sharpe in 1964 with a stocking of 314,806 fingerlings (Hanten and Talsma 1984). Various sizes and quantities of brown trout were stocked throughout most of the mainstem Missouri River in South Dakota in past years (SDGF&P fish stocking database). A total of 15,000 catchable brown trout (3/lb) are scheduled to be stocked below Fort Randall Dam in the tailrace area in 2004 (SDGF&P). The brown trout stocking in the marina below Fort Randall Dam provides a unique fishery, which is geared primarily towards youth, elderly and handicapped anglers. The relatively easy accessibility from shore makes this a popular local fishery. Fishing use for brown trout more than doubled between 2000 and 2003 (J. Sorensen, SDGF&P resource biologist, personal communication). Brown trout have been stocked in the tailwaters below Fort Randall Dam annually since 1987 (SDGF&P fish stocking database) making this a well-established put-and-take fishery. Because natural reproduction by brown trout has not been documented and likely does not occur in the mainstem of the Missouri River in South Dakota stocking is required to maintain this fishery.

Rainbow trout have an upper lethal temperature limit between 73.4° and 79.5° F (Morrow and Fischenic 2000). Brynildson et al. (1963) reported the preferred or optimum temperature between 65° - 75° F, while a range of 53.6° to 66.2° F was reported by Morrow and Fischenic (2000).

Brown trout feed on a wide variety of prey including terrestrial and aquatic insects, while fish and crayfish become more important in the diet as the size of brown trout increases (Scott and Crossman 1973). Brown trout are generally considered sight feeders, which like rainbow trout, would have difficulty locating prey in increased turbidity.

White bass

White Bass are generally considered as an introduced species to the Missouri River in South Dakota (Cross et al. 1986; Galat et al. in press), although Baily and Allum (1962) discusses the potential for their natural introduction to the middle Missouri River via stream crossovers. Based on early reports by staff from North Central Reservoir Investigations (NCRI) staff, it is believed that white bass were derived from introductions to Heart Butte Reservoir, North Dakota, which is located on the Heart River, a tributary to the Missouri River (Gasaway 1970; Gabel 1974). White Bass were first sampled in Lake Francis Case in 1961 (Gasaway 1970). The only stocking of white bass directly into the Missouri River in South Dakota occurred in Lewis and Clark Lake, where less than 5,000 adults were stocked from 1960 to 1962 (Hanten and Talsma 1984). White bass have become well established in the Missouri River in South Dakota. White bass had the third highest catch per unit effort in Lake Oahe coolwater fish population surveys from 1998 –2001 (Lott et al. 2002). White bass were ranked twelfth in preference on the Missouri River by South Dakota residents (Stone 1996). Nevertheless, they often are often one of the most abundant fish in angler harvest from Missouri River reservoirs in South Dakota (Johnson et al. 2002; Lott et al. 2002; Stone and Sorensen 2002; Wickstrom 2002). White bass have not been stocked in the Missouri River in South Dakota since 1962 (Hanten and Talsma 1984; SDGF&P fish stocking database). Because this species is well established, there are no plans to stock white bass in the Missouri River in South Dakota.

White bass prefer clear water rather than turbid water and tend to occupy the upper water layers or epilimnion (Scott and Crossman 1973). Scott and Crossman (1973) speculated that low turbidity levels may be important to the survival of white bass because they are visual feeders (Greene 1962) and are not attracted to prey by scent. White bass prefer water temperatures between 66.2° - 82.4° F (Morrow and Fischenic 2000). White bass are carnivorous with young fish feeding on microscopic crustaceans and insect larvae and fish (Scott and Crossman 1973). Fish become increasingly important in the diet of white bass as they increase in size (Scott and Crossman 1973).

Lake Herring

Lake herring are an introduced species to the Missouri River in South Dakota (Hanten and Talsma 1984; Cross et al. 1986; Galat et al. 2004). Lake Herring were introduced into Lake Oahe to supplement rainbow smelt as a coldwater prey species because of the cyclic nature of rainbow smelt populations. Selgeby et al. (1974) noted an inverse relationship between rainbow smelt and lake herring populations. The first introduction of lake herring into the Missouri River in South Dakota occurred in Lake Oahe in 1984 (SDGF&P fish stocking database). A substantial effort to establish lake herring in Lake Oahe was undertaken from 1990 to 1992, (more than 30 million fry stocked), (SDGF&P fish stocking database). Lake herring have become established as a part of the coldwater fish community in Lake Oahe. Larval lake herring have been sampled annually since 1995 indicating natural reproduction is occurring regularly (Lott et al.2002). Lake herring are recruiting to the adult population as evidenced by the presence of young, age-1 and age-2, lake herring in recent lake surveys. Although there is a daily creel limit on lake herring, because of their feeding habits they are rarely caught by anglers and are, in general, considered a prey fish, especially during the early portion of their life. Because this species is well established, there are no plans to stock lake herring in the Missouri River in South Dakota.

Lake herring are essentially a lake species (Scott and Crossman 1973). Lake herring are pelagic, forming large schools at midwater depths primarily to remain in cooler waters below the thermocline during summer months (Scott and Crossman 1973). Edsall and Colby (1970) determined young lake herring had an upper lethal temperature of 78.8° F. Zooplankton and immature stages of aquatic insects, such as mayflies and caddisflies are important prey items for lake herring (Scott and Crosssman 1973). Lake herring eggs, whitefish eggs and small minnows have also been reported in the diet of lake herrring (Scott and Crossman 1973).

Paddlefish

Paddlefish are native to the Missouri River in South Dakota (Bailey and Allum 1962; Cross et al. 1986; Galat et al. in press). The construction of mainstem Missouri River dams has severely impacted paddlefish populations through the loss of spawning habitat, blocked migration routes, altered flow regimes and altered hydrology (Sparrowe 1986; Unkenholz 1986). The concentration of paddlefish below dams during annual spawning migrations following dam construction initially increased paddlefish fisheries, however with riverine spawning grounds blocked or inundated by reservoirs, natural recruitment declined as did paddlefish abundance (Unkenholz 1986). If paddlefish spawning and recruitment can occur above a reservoir, since paddlefish are filter feeders on zooplankton, conditions in reservoirs are more favorable for feeding and growth of paddlefish (Rehwinkel 1978, Russell et al. 1980). Remnant populations with little or no recruitment do exist in between mainstem dams on the Missouri River in South Dakota. The tailrace paddlefish fishery below Big Bend Dam and above Lake Francis Case was one of those that was substantial and then declined because of a lack of recruitment due to the loss of spawning grounds and/or migration routes. In an effort to restore this fishery and maintain a population of paddlefish within Lake Francis Case, with the exception of 1987, paddlefish have annually been stocked into Lake Francis Case since 1985. In Lake Francis Case, the primary sampling of paddlefish occurs at a spawning congregation below the mouth of the White River during broodfish collection. Because sexual maturity isn't reached until about 8 years for males and 11 years for females (Hesse et al. 1989, 1991) it wasn't until recent years that stocked fish began to be sampled in this area (Jason Sorensen, SDGF&P resource biologist, personal communication). A total of 25,000 paddlefish (1.9/lb.) are scheduled to be stocked in Lake Francis Case in 2004. Because of the archetypical status of paddlefish in the Missouri River and their coexistence in the Missouri River with pallid sturgeon, other life history characteristics will not be discussed.

Rainbow smelt

Rainbow smelt are an introduced species to the Missouri River in South Dakota (Cross et al. 1986; Galat et al. in press). However, rainbow smelt have never been directly stocked into the Missouri River in South Dakota (Hanten and Talsma 1984; SDGF&P fish stocking database), having been introduced via transfer from Lake Sakakawea. In 1971, a total of 7,200 Lake Superior strain adult rainbow smelt were stocked into Lake Sakakawea, North Dakota (Berard 1978 my report). Entrainment of rainbow smelt, flushing fish from Lake Sakakawea, through the Garrison powerhouse led to an introduction of rainbow smelt into Lake Oahe. Rainbow smelt have never been directly stocked in the mainstem Missouri River in South Dakota. With large volumes of suitable coldwater habitat essentially void of coldwater prey fish, rainbow smelt flourished in Lake Sakakawea and Lake Oahe. Larval smelt were first collected in Lake Oahe in 1977 (Nelson 1980). By 1977, rainbow smelt were abundant in Lake Oahe (Burczynski et al. 1987; Warnick 1987) and fisheries managers began efforts at developing a coldwater sport fishery. Because this species is well established, there are no plans to stock rainbow smelt in the Missouri River in South Dakota.

The geographical and vertical distribution of rainbow smelt is strongly temperature dependent (Burcynski et al. 1986; Stone and Nealson 1990; Nelson-Stastny 2001). Age-0 rainbow smelt tend to segregate to higher temperatures away from older rainbow smelt, while age-1 and older rainbow smelt were within and below the metalimnion (Dryer 1966; Emery 1973; Brandt et al. 1980; Argyle 1982; Heist and Swanson 1983; Brandt and Madon 1986; Nelson-Stastny 2001). Observations of rainbow smelt in Lake Erie suggest that after the lake is stratified, adult rainbow smelt remain below the thermocline in water temperatures between 42.8 to 50 °F (Ferguson 1965; MacCallum and Regier 1970). In Lake Oahe, age-0 rainbow smelt were above the thermocline in water greater than 59.9° F, while age-1 rainbow smelt were within and just above the thermocline in water temperatures ranging from 44.6° to 59.9° F (Nelson-Stastny 2001). A high abundance of age-1 and older rainbow smelt might cause age-0 rainbow smelt to occupy water temperatures warmer than preferred.(Nelson-Stastny 2001). In 1996 with a high abundance of age-0 and age-1 and older rainbow smelt, age-0 rainbow smelt were observed in water temperatures as high as 71.6° F in Lake Oahe (Nelson-Stastny 2001). The upper lethal water temperature for rainbow smelt is approximately 77° F (Morrow and Fischenic 2000).

Entrainment of rainbow smelt can and does occur from Lake Oahe through the Oahe powerhouse (Unkenholz 1998; Smith 2000). In 1997, in excess of 400 million rainbow smelt were flushed from Lake Oahe the majority of which were larval and juvenile rainbow smelt (Smith 2000). The transfer of rainbow smelt has been documented downstream from Gavins Point Dam into the Mississippi River below the mouth of the Missouri River (Pflieger 1997). Rainbow smelt were first reported from the

Missouri River in 1978 (Pflieger and Grace 1987) which corresponds well to the time frame in which they became established in Lake Oahe. Pflieger (1997) pointed out that there are drastic seasonal fluctuations in the abundance of rainbow smelt from the Missouri River in Missouri. The largest numbers of rainbow smelt were collected in November and December, however no rainbow smelt reported from April to June from the Missouri River in Missouri (Pflieger 1997). No adult rainbow smelt have been sampled from the Missouri River in Missouri (specimens ranged from 1.4 to 3.2 inches) (Pflieger 1997). This is not surprising because of rainbow smelt avoid warmer water temperatures, especially by adult smelt. Additionally, summer water temperatures in riverine stretches, especially in the lower river, often exceed the upper lethal temperature for rainbow smelt. Pfleiger (1997) states that few if any smelt survive their first year in the Missouri River in Missouri based on wide fluctuations in abundance and the lack of adults in samples. Escapement of larval and juvenile smelt is the likely source for smelt in the Missouri River in Missouri (Pflieger 1997). Based on larval surveys, entrainment information, temperature preferences and the months smelt were sampled in the Missouri River it is evident that Pflieger's observations are sound. Adult rainbow smelt are entrained through the Oahe powerhouse (Unkenholz 1998; Smith 2000). Thermal tolerance and/or increased vulnerability to predation in more turbid waters likely explain the absence of adult rainbow smelt in the lower river.

Rainbow smelt are a carnivorous fish, feeding on a wide variety of smaller prey items. In the Great Lakes Mysis relicta, a shrimp-like crustacean, is the primary prey while other invertebrates eaten included amphipods, ostracods, aquatic insect larvae and aquatic worms (Smith and Crossman 1973). Fish seldom occur in rainbow smelt stomachs but made up about 6-10% of the volume in the Great Lakes (Scott and Crossman 1973). Small rainbow smelt and sculpins were the primary prey of larger rainbow smelt, while burbot, white bass, whitefish, and emerald shiner have also been reported (Scott and Crossman 1973). Rainbow smelt in Lake Oahe are primarily selective planktivores, selecting for the largest prey item available (Schmulbach et al. 1983; Karnitz 1992) indicative of a visual feeder. Schmulbach et al. (1983) reported that in rainbow smelt examined from Lake Oahe that 99.5% of the prey items were zooplankton, while benthos accounted for 0.4% and fish accounted for <0.1%. Karnits

(1992) reported similar results for rainbow smelt in Lake Oahe, preying primarily on zooplankton and to a lesser extent insect larvae and pupae and fish (fish found in 2 of 320 stomachs examined). Schmulbach et al. (1983) examined 319 rainbow smelt stomachs with 27 (8.5%) containing fish. All of the fish eaten by rainbow smelt were age-0 smelt (Schmulbach et al. 1983). Food habit studies in Lake Michigan, Lake Huron and Lake Erie have shown rainbow smelt prey primarily on fish after reaching 180 mm (Gordon 1961; Price 1963; Foltz and Norden 1977 in Karnitz thesis chapter 2). However rainbow smelt in Lake Oahe rarely exceed 180 mm (Karnitz 1992; Johnson et al. 1998; Nelson-Stastny 2001).

Rainbow smelt are the most important prey species in Lake Oahe (Jackson 1992; Bryan 1995; Lynott 1997; Hill 2000 R. P. Hanten, SDGF&P fishery biologist, personal communication) enabling many sport fish species to grow fast, often achieving trophy size. Without abundant smelt in Lake Oahe, condition and growth decline making the sport fishery less attractive to anglers resulting in less angling pressure and lost revenue for surrounding communities. When abundant rainbow smelt have been popular as a food fish for shoreline seiners during the rainbow smelt's spring spawning run (Missouri River Fisheries Center staff, SDGF&P).

Spottail shiner

The spottail shiner is an introduced species to the Missouri River in South Dakota (Hanten and Talsma 1984; Cross et al. 1986; Galat et al. in press). Spottail Shiners were introduced as an alternative prey species to take advantage of the increased volume of clearer water in the littoral area of the mainstem Missouri River reservoirs in South Dakota. Spottail shiners were introduced in mainstem reservoirs in South Dakota as follows: Lake Oahe 1973-75, Lake Sharpe 1978, Lake Francis Case 1979, Lewis and Clark Lake 1973 (Hanten and Talsma 1984). Spottail shiners have become well established in the mainstem Missouri River reservoirs in South Dakota. Spottail shiner and emerald shiner *Notropis atherinoides* are two of the most abundant littoral prey species in the mainstem reservoirs in South Dakota (Johnson et al. 2002; Lott et al. 2002; Stone and Sorensen 2002; Wickstrom 2002). Spottail shiners are important as prey for many sport fish in the Missouri River in South Dakota (Jackson 1992). In Lake Oahe, spottail shiner presence in habitats, i.e. the warmer littoral zone, helps to provide a prey source where rainbow smelt are scarce (Sewell 1993). Because this species is well established, there are no plans to stock spottail shiners in the Missouri River in South Dakota.

The most commonly eaten prey items of spottail shiners in Lake Oahe were larger zooplankton (Daphnia), aquatic insect larvae (chironomids) and adult insects (Diptera) (Sewell 1993). No fish were present in the diets of spottail shiners sampled from Lake Oahe (Sewell 1993). The propensity for spottail shiners to select larger prey items indicates that they are visual feeders.

Smallmouth Bass

The smallmouth bass is an introduced species to the Missouri River in South Dakota (Bailey and Allum 1962; Hanten and Talsma 1984; Cross et al. 1986; Galat et al. in press). The first introduction of smallmouth bass into the Missouri River in South Dakota occurred in Lewis and Clark Lake in 1972 with a stocking of 46,400 fingerlings (Hanten and Talsma 1984). A substantial effort to introduce and establish smallmouth bass in throughout the mainstem Missouri River in South Dakota began in the early 1980’s and continued for more than a decade (Hanten and Talsma 1984; SDGF&P fish stocking database). Smallmouth bass are naturally reproducing and have become well established in the Missouri River in South Dakota (Lott 2000). Smallmouth bass ranked fifth in preference on the Missouri River by South Dakota residents (Stone 1996). They are generally in the top five of most abundant fish in angler harvest from Missouri River reservoirs in South Dakota (Johnson et al. 2002; Lott et al. 2002; Stone and Sorensen 2002; Wickstrom 2002). Smallmouth bass have not been stocked in the Missouri River in South Dakota since 1998 (SDGF&P fish stocking database). Because this species is well established, there are no plans to stock smallmouth bass in the Missouri River in South Dakota.

Large, clear lakes and reservoirs with an average depth greater than 9 m characterize optimum habitat in lakes (Turner and MacCrimmon 1970; Coble 1975; Miller 1975; Pflieger 1975). Cool, clear, midorder streams were characteristic of optimum riverine habitat (Carlander 1977). Preferred temperature in the field was reported between 68.5° – 70.3° F (Ferguson 1958). Habitat use by smallmouth bass varies with size and time of the year (Scott and Crossman 1973; Lott 2000). Larger adult smallmouth bass move shallower and closer to shore prior to spawning earlier than smaller bass prior to spawning in Lake Oahe (Lott 2000). Later in the season larger smallmouth bass are generally located deeper and further from shore than medium sized bass (Lott 2000). Smallmouth bass tend to found around the protection of cover such as rip-rap, rock, submerged trees, and aquatic vegetation (Scott and Crossman 1973). Higher frequencies of cover use have been documented for smaller smallmouth bass versus larger smallmouth bass (Reynolds and Casterlin 1976). This pattern of cover use by different size groups of smallmouth bass was also observed in Lake Oahe (Lott 2000). Smallmouth bass can tolerate periodic turbidity (Webster 1954; Cleary 1956). However, excessive turbidity and siltation will reduce a population of smallmouth bass (Coutant 1975). Typical smallmouth bass habitat has very low turbidity, usually $\leq$ 25 JTU (Jackson turbidity units – roughly equivalent to NTU), and almost never > 75 JTU with the exception of flood conditions when turbidity has approached 250 JTU (Hubert and Lackey 1980). Jenkins (1975) found that smallmouth bass populations were more productive in clearer, less fertile reservoirs. In a Kentucky lake with a well-defined nutrient gradient from eutrophic upreservoir to oligotrophic near the dam, stocked smallmouth bass became significantly more abundant in the lower, infertile are compared with the more fertile middle and upper areas (Buynak et al. 1991).

In general, prey size of smallmouth bass increases from zooplankton, to immature aquatic insects and finally crayfish and fish as the size of smallmouth bass increases (Scott and Crossman 1973). While fish and crayfish were well represented in smallmouth bass diets, aquatic and terrestrial invertebrates were also major components of diet in Lake Oahe (Lott 1996). Fish species consumed by smallmouth bass in Lake Oahe include the following: johnny darter *Etheostoma nigrum*, fathead minnow *Pimephales promelas*, spottail shiner, rainbow smelt and unidentified percids (Lott 1996).

Northern Pike

There is general agreement that northern pike are native to the James-Sioux and Niobrara-Platte drainages (Cross et al. 1986; Galat et al. in press). Bailey and Allum (1962) listed northern pike as a probable native for the same drainages based on the potential distribution via headwater stream connections between the Lac Qui Parle River of the Minnesota River draining to the east, and the western connection with Deer Creek of the Big Sioux drainage and upper Missouri drainages (additional connections were also mentioned. Galat et al. (in press) stated the following regarding the status of northern pike in the upper Missouri River:

> However, North Dakota Game and Fish consider it a native species as records indicate its presence at the time Bismarck was settled (1882-1883, Barrett 1895). Rail service arrived in central North Dakota in the 1860s and U.S. Bureau of Fisheries beginning in 1880 do not indicate northern pike stockings until 1899. We therefore list its status to the Little Missouri-White drainage unit drainage as native.

Based on the discussion above it is reasonable to conclude that northern pike are native to the entire South Dakota portion of the Missouri River. Initial sampling in the mainstem Missouri River reservoirs in South Dakota revealed a relatively low abundance of northern pike (Nelson and Walburg 1977). The initial abundance in the mainstem reservoirs in South Dakota was likely indicative of a relatively low abundance in the previously unaltered Missouri River. However, as the reservoirs filled and the prairies were flooded, spawning conditions with abundant flooded vegetation were ideal for northern pike and their abundance increased substantially (Nelson and Walburg 1977). Northern pike’s potentially large size, table quality and increased abundance made them popular with anglers. Northern pike were ranked second in preference on the Missouri River by South Dakota residents and were also the second most fished for species on the Missouri River (Stone 1996). Once the mainstem Missouri River reservoirs in South Dakota reached normal operating levels, the frequency of flooded vegetation providing favorable spawning conditions for northern pike became sporadic. Consequently, production of northern pike became sporadic and northern pike populations declined in abundance (Nelson and Walburg 1977). In an attempt to supplement natural reproduction, northern pike were stocked with increasing frequency as their abundance declined (Hanten and Talsma 1984; SDGF&P fish stocking database). Northern pike stocking attempts in the mainstem of the Missouri River in South Dakota met with limited success, i.e. when conditions were good for natural reproduction stocking success was good and vice versa (John Lott, SDGF&P, personnal communication). Northern Pike have not been stocked into the mainstem of the Missouri River since 1997

(SDGF&P fish stocking database). There are currently no plans to stock northern pike in the mainstem of the Missouri River in South Dakota to augment natural reproduction.

Northern Pike occur in a wide range of habitats. Northern pike are a coolwater fish that are most productive in temperate mesotrophic-eutrophic environments in which transparency is high, vegetative cover abundant, and the development of the vegetation-open water interface is high (Casselman 1978). Northern pike inhabit clear, warm, slow, meandering heavily vegetated rivers or warm, weedy bays of lakes (Scott and Crossman 1973). In general, throughout their range, northern pike occur more frequently in lakes than in rivers (Crossman 1978), as they are not adapted for life in strong current velocities. Northern pike move into shallow water in the spring and fall then move to deeper cooler water in the summer (Scott and Crossman 1973). While submerged vegetation is important for spawning northern pike (Scott and Crossman 1973), sufficient macrophyte cover for nursery habitat providing protection predation and cover for prey species where young pike lie in wait, may be more important (Casselman and Lewis 1996). The optimal temperature range for growth of northern pike is 66.2° to 69.8° F, while the incipient lethal temperature of subadult northern pike was 84.9° F (Casselman 1978).

Over a whole season the food of adult northern pike is 90% fish, however at times they will prey heavily on frogs, crayfish, mice, muskrats and ducklings (Scott and Crossman 1973). Northern pike select for, and are especially adept at capturing fish that swim high in the water column and are silhouetted against a lighter background (Casselman 1978). In the St. Lawrence River northern pike preferred soft-rayed species such as alewives that swim in midwater (Casselman 1978). As has been discussed with other species in this report, for a fish that is a visual feeder, increased turbidity can affect the ability to forage. Craig and Babaluk (1989) showed that decreased water transparency, i.e. increased turbidity, decreased the body condition of northern pike. Craig and Babaluk (1989) concluded that increased turbidity reduced the ability of northern pike to feed.

Yellow Perch

There is agreement that yellow perch are native to the James-Sioux drainage (Evermann and Cox 1896; Bailey and Allum 1962; Cross et al.1986; Galat et al. in press).

It was speculated that the James River may have been the western boundary for yellow perch (Evermann and Cox 1896; Bailey and Allum 1962). However, Galat et al. in press also list the yellow perch as native to the Little Missouri-White drainage. In August of 1952, Bailey and Allum (1962) sampled yellow perch from a connected Missouri River backwater 3 miles southeast of Pierre South Dakota prior to impoundment of Lake Sharpe (a month after the closure of Fort Randall Dam). Yellow perch were sampled during early fish populations surveys in the impoundments of the mainstem Missouri River in South Dakota (Shields 1955; Nelson and Walburg 1977). Finally, yellow perch have not been stocked directly into the mainstem of the Missouri River in South Dakota (Hanten and Talsma 1984; SDGF&P fish stocking database). It is reasonable to conclude that yellow perch are indeed native to nearly all of the Missouri River in South Dakota.

Abundance of yellow perch was low in the original Missouri River. Yellow perch followed the same patterns in abundance as northern pike because of their reliance on flooded vegetation for successful spawning and production. As the mainstem reservoirs filled flooded vegetation was abundant, optimal spawning conditions were created and strong year classes of yellow perch were produced (Beckman and Elrod 1971; Gasaway 1970). After reservoirs filled, the spawning habitat deteriorated and there were strong year classes of yellow perch in years of high water (Nelson and Walburg 1977), likely when high waters flooded vegetation. In recent years, yellow perch production has fluctuated considerably from year to year in the mainstem reservoirs in South Dakota (Lott et al. 2002; Johnson et al. 2002; Stone and Sorensen 2002; Wickstrom 2002). Benson (1968) speculated that the higher turbidity characteristic of Lewis and Clark Lake, and to a lesser degree, Lake Francis Case, may limit survival of yellow perch. Yellow perch numbers will decline in a body of water in which turbidity increases or vegetation declines (Scott and Crossman 1973). Conditions for yellow perch may be more suitable in the larger mainstem Missouri River reservoirs, which more closely approach lake conditions (Benson 1968). Scott and Crossman (1973) stated that yellow perch are more abundant in the open water of lakes with moderate vegetation, clear water and bottoms of muck to sand and gravel. Nelson and Walburg (1977) reported that yellow perch were most abundant in sections of main stem Missouri River reservoirs in South Dakota that tended to be shallow and productive and least abundant in those that tended to be deep and less productive or river like. The optimal temperature range for yellow perch is 69.8° to 77.0° F (Scott and Crossman 1973), while the upper lethal temperature is 90.1° F (Ferguson 1958). The diet of yellow perch is largely immature insects, larger invertebrates, and fishes, taken in open-water or off the bottom (Scott and Crossman 1973). Yellow perch will prey on fish eggs and young fish of a wide variety of species (Scott and Crossman 1973).

Yellow perch were ranked third in preference on the Missouri River by South Dakota residents and were also the third most fished for species on the Missouri River (Stone 1996). Although, yellow perch are often considered a sport fish, relatively slow growth in the mainstem of the Missouri River reservoirs has relegated them to prey fish status. Yellow perch are an important food item for many of the important sport fish species; this is especially true in Lake Oahe during downward trends in rainbow smelt populations (Jackson 1992).

Walleye

The walleye is listed as native to eastern South Dakota and the Missouri River by Bailey and Allum (1962). Cross et al. (1986) and Galat et al. (in press) list walleye as native to the White-Little Missouri drainage, thereby encompassing much of the mainstem Missouri River in South Dakota. Cross et al. (1986) also listed it as native to the Sioux-James drainage and uncertain in the Platte-Niobrara drainage. Because Galat et al. (2004) combined the Sioux-James and Platte-Niobrara drainage units, walleye were listed as uncertain for the whole unit. Bailey and Allum (1962) added that it persisted in the Missouri River, but in smaller numbers than the sauger, *Sander canadense*. The lower density of walleye, relative to other species better adapted to the turbid riverine environment of the unaltered Missouri River, such as sauger, in addition to the difficulty in sampling the Missouri River were likely the reason their presence wasn’t noted until Everman and Cox (1896) reported them. Moreover, the similarity of walleye to sauger could have led to misidentification of walleye as sauger in the earliest faunal surveys of Missouri River fishes, i.e. less abundant walleye may have been lumped together with more abundant walleye. In fact, Everman and Cox (1896) reported difficulty in identification of younger percid specimens based on external characteristics alone. This is why they counted and measured pyloric caeca which provide reliable differences between the species (Eddy and Underhill 1978). It is important to note the location of sampled walleye reported by Everman and Cox (1896) because of the proximity to the Missouri River and the state of the Missouri River when walleye were sampled. From Chamberlain, South Dakota, Everman and Cox (1896) gave the following account of the Missouri River and the difficulty of sampling it:

> The Missouri river itself was examined at Chamberlain, S. Dak., where the stream is divided into two channels by and island, the west channel being 1,200 feet wide and the east 1,436 feet. At the time of the visit the water was higher than usual, "the June rise," as the people call it, and the current was swift, in some places averaging 3 feet per second. Owing to the high water it was impossible to do successful seining, although we attempted it at the north end of the island. As is usually the case with this river, the water was exceedingly muddy. At places the recently deposited silt was so deep that it was dangerous to attempt to wade in the water over it. Where the water had receded enough to allow a light crust to form on top of the mud it was possible to stand and shake the whole mass for a distance of 10 feet or more in all directions. The Missouri was also examined at Running Water, opposite Niobrara, but no specimens were obtained.
>
> The larger more important river fishes, such as sturgeon, cat, and buffalo are said to be abundant in this portion of the river and to furnish a considerable food supply.

Based on their itinerary, Crow Creek, which empties into the Missouri River a couple miles north of Chamberlain, South Dakota, was examined on June 23, 1893, likely the same day or day after the above observation was made.(Everman and Cox 1896). On June 27, 1893, Choteau Creek was sampled by Everman and Cox (1896). Walleye were sampled from both of these sights and identification confirmed by pyloric caeca counts (Everman and Cox 1896). The timing and size of creeks is significant because the creeks normally would have been had enough flow to support movement of fish, including walleye, moving into them from the Missouri River. Walleye may have moved into these smaller tributaries to spawn and may remained in these smaller tributaries as long as flow was sufficient to support them, i.e. spring runoff was sufficient. However, in many years flows in these streams would have likely dropped sufficiently to force the walleye to vacate these small tributaries and move back into the main stem of the Missouri River. The United States Geological Survey has recorded flows in Choteau creek < 0.01 cfs.

Walleye were not stocked into the main stem Missouri River in South Dakota until 1952 (Hanten and Talsma 1984).

Walleye should be classified as native to the Missouri River in South Dakota based on the following: (1) Lack of a stocking record into the main stem Missouri River prior to the first recorded sampling in 1893;   (2) Detailed information provided in Everman and Cox (1896) regarding identification, locations of samples with regard to behavior of walleye, difficulty in sampling the main stem Missouri River, especially for a fish in relatively low abundance the walleye; (3) The potential for misidentification of walleye as sauger in initial surveys; (4) The native classification by Bailey and Allum (1962), Cross et al. (1986) and Galat et al. (in press).

Walleye are tolerant of a wide range of environmental conditions, but are most abundant in medium to large lakes with extensive littoral areas, moderate turbidities, and moderate turbidities (Scott and Crossman 1973). Ryder (1977) showed that peak feeding occurs at water transparency levels of 1 to 2 m Secchi disk depth, with a great decrease in activity at < 1 or > 5 m Secchi disk depths. The preferred spawning habitats in lakes are shallow rocky or coarse gravel shoreline areas (Scott and Crossman 1973). The spawning habitat requirements are a likely explanation for the delay in development of abundant walleye populations in the mainstem reservoirs. Optimal temperature for walleye ranges from 71.8° - 73.4° F with an upper limit at 88.9° F (Morrow and Fischenic 2000).

While walleye are native to the Missouri River in South Dakota, stocking of walleye has been utilized to try and enhance the abundance of this important and popular sport fish. A total of 220,000 walleye fry were stocked into Lake Francis Case in from 1952 –1953 (Hanten and Talsma 1984). From 1957 to 1958, a total of 411,900 walleye fry were stocked into Lewis and Clark Lake (Hanten and Talsma 1984). While the number of stocked fish appears large, they should be put into perspective with the standard stocking protocol of 1,000 walleye fry/acre/year exercised by the South Dakota Department of Game Fish and Parks (SDGF&P). The number of walleye was probably insufficient to change the structure of the fish community. Based on the surface area and walleye stocked per year the stocking density in Lake Francis Case from 1952-1953 was only 1.4 walleye fry/acre and in Lewis and Clark Lake from 1957-1958 only 8.2 walleye fry/acre. These stocking rates were only 0.14% and 0.82% of the SDGF&P stocking protocol for walleye fry and were likely inadequate to change the structure of the fish community. Fish population surveys in Lake Francis during 1954 failed to sample walleyes, however the likelihood of their presence in the reservoir was suggested by the presence of walleye in low numbers in the Fort Randall tailrace (Shields 1955). Four walleye were sampled from Lake Francis Case in 1955, which were determined to be from the 1953 year class (age-2) and 1954 year class (age-1) (Shields 1956). The presence of walleye from the 1954 year class in Lake Francis Case is important because walleye were only stocked in Lake Francis Case in 1952 and 1953. These walleye would not have been sexually mature in 1954 as age-1 and age-2 walleye, since walleye don't reach sexual maturity until at least age-3 or age-4. Therefore, the presence of walleye from the 1954 year class indicates spawning occurred from walleye older than those initially stocked into the Missouri River in 1952. In each of Lakes Oahe, Francis Case, and Lewis and Clark, only a single age-0 walleye was seined in the first 6 years after impoundment (Nelson and Walburg 1977). Evidence is lacking that would show the initial walleye stockings from 1952 and 1953 in Lake Francis Case had any impact on abundance of walleye in the reservoir as populations remained low for several years after the stocking (Shields 1957). Nelson and Walburg (1977) showed that the walleye population in Lake Francis Case developed slowly and was dependent on the development of suitable spawning substrate of rubble and gravel by wave action removing finer soil particles from the lake shores. Adults were abundant in Lakes Oahe, Sharpe and Francis Case by the early 1970's having been the slowest to develop in Lake Francis Case and the fastest in Lake Sharpe (Nelson and Walburg 1977). In general, spawning habitat developed in the reservoirs over a period of years as mentioned earlier and walleye populations followed. In Lake Sharpe, spawning habitat was available immediately and abundant walleye populations developed soon after impoundment (Nelson and Walburg 1977). It is important to note that abundant walleye populations had developed in the three upper mainstem reservoirs and the only one that had been stocked with no evidence of success, was the lowermost, Lake Francis Case. As of 1955, the policy of the then Game, Fish and Parks Commission was to not stock fish in the main stem reservoirs. Added to that, Sheilds (1955) stated that despite low abundance of walleye and northern pike, when or if conditions are favorable, the stock is sufficient to perpetuate the species. More favorable habitat conditions, not stocking, in the three uppermost reservoirs had allowed walleye to not only perpetuate but become abundant. No walleyes were stocked in the main stem of the Missouri from 1959-1982 (Hanten and Talsma 1984). Walleyes were stocked in attempts to supplement natural reproduction from 1983-1998. The stocking density in a given year for a given lake was always well below the standard SDGF&P protocol and likely had minimal affect on abundance in a given lake as a whole. The only walleye stocking since 1998 was done in an attempt to lessen the impact of declining reservoir levels in Lake Francis Case during the spring of 2002. There are no plans to stock walleyes into the main stem of the Missouri River in South Dakota in 2004. The walleye populations in the Missouri River mainstem reservoirs of South Dakota are have not collapsed without stocking in recent years, and continue to be one of the most popular and valuable benefits resulting from the Pick Sloan Plan.

Juvenile and adult walleyes are generally piscivorous (Priegel 1963; Kelso 1973; Johnson and Hale 1977; Swenson 1977; Knight et al. 1984; Vigg et al. 1991, Jackson 1992: Mero 1992; Bryan 1995). Age-0 walleye feed on zooplankton, then generally shift to a primarily piscivorous diet at a length between 30 mm and 60 mm (Jackson 1992). Colby et al. (1979) suggested that invertebrates are gradually displaced by fish in the diet of walleye in the summer, probably because immature insects become adults and emerge concurrently with increased availability of age-0 prey fish. However, invertebrates can be important to all lengths of walleyes in late spring and early summer (Kelso 1973; Forney 1974; Colby et al. 1979; Johnson et al. 1988) and overwinter when prey fish are scarce (Priegel 1963). Both Jackson (1992) and Bryan (1995) noted macroinvertebrates were not a substantial part of the diet of walleye sampled in all of Lake Oahe, but they were more important in upper Lake Oahe than in lower portions of Lake Oahe.

Juvenile and adult walleyes generally eat a variety of fish species. For example, age-0 and yearling walleyes in Lake Erie first fed on yellow perch and then spottail shiners, emerald shiners and alewives in order of importance (Parsons 1971). Yellow perch and freshwater drum are often important in the diets of percids (Priegel 1969; Parsons 1971; Scott and Crossman 1973; Forney 1974, 1977; Wahl and Nielson 1985).

Reviews of walleye food habit studies, assuming equal prey availability of soft-rayed and spiny-rayed fishes, revealed a general selection toward soft-rayed prey fishes. In water bodies where rainbow smelt and yellow perch were available, walleyes select for soft-rayed rainbow smelt (Swenson 1977; Hiltner 1983; Lyons and Magnuson 1987; Jackson 1992; Mero 1992; Bryan 1995). Mero (1992) noted the absence of rainbow smelt from walleye food habits corresponded to an increase in availability of age-0 prey fishes of other species. When a variety of prey species are available, no one prey will dominate predator diets unless highly selected. Hiltner (1983) found that walleye in Lake Sakakawea, ND fed exclusively on rainbow smelt spring and summer. Catch data indicated that rainbow smelt were the most abundant and available prey species at that time. Hiltner (1983) rationalized Lake Sakakawea walleye selected for rainbow smelt due to the availability of, walleye preference for, and lack of evasiveness of rainbow smelt. Swenson (1977) showed that walleye consumed a higher percentage of pelagic prey, i.e. rainbow smelt, yellow perch, and spottail shiners, versus a relatively low percentage of demersal prey, i.e. trout perch.

In August 1991, Jackson (1992) noted rainbow smelt dominated the diet of walleye in lower Lake Oahe, while presence of rainbow smelt in walleye diets decreased substantially from lower to middle Lake Oahe and no rainbow smelt were consumed by walleye in upper Lake Oahe. In 1991, reservoir water elevation was low and warm water temperatures established a deep, well-developed thermocline which limited the amount of coldwater habitat in the reservoir (i.e., coldwater habitat was absent in upper Lake Oahe and relatively low in middle Lake Oahe). The diet of walleye was diverse in middle and upper Lake Oahe, where yellow perch, emerald shiners, spottail shiners, white bass, white crappie, and freshwater drum dominated walleye diets (Jackson 1992). Bryan (1995) documented a predominance of rainbow smelt in the diet of walleye throughout the reservoir in 1993 and related this to cooler water temperatures and coldwater habitat in middle and upper Lake Oahe than in 1991. This allowed rainbow smelt to occupy areas of the reservoir where water temperatures had exceeded their upper thermal limit in 1991. Mero (1992) found similar trends in Lake Sakakawea. Rainbow smelt were the most important prey of walleyes near the dam in August but were less important further up the reservoir. He attributed the decreased importance of rainbow smelt to an increased diversity of the prey base at the upper end of the reservoir, turbidity and water temperatures.

Rainbow smelt are the primary prey fish in Lake Oahe and their numbers declined since 1996 (Nelson-Stastny 2001). Robert Hanten, a fisheries biologist with the SDGF&P is completing a seasonal walleye food habits study in Lake Oahe and reported the following. During the spring of 2001, walleye were eating primarily macroinvertebrates (i.e., aquatic insects). Walleye shifted from a macroinvertebrate diet spring of 2001 to a diet composed almost entirely of fish summer of 2001 through spring of 2002. The fish diet included rainbow smelt, white bass, freshwater drum, emerald shiners, spottail shiner, gizzard shad, yellow perch, lake herring and white crappies. The type of prey fish found in walleye stomachs varied by season and location on the reservoir. Walleye throughout Lake Oahe ate primarily rainbow smelt during the spring. During the rest of the year, rainbow smelt were more common in walleye diets, the nearer walleyes were to Oahe Dam. This is expected as coldwater habitat, necessary for rainbow smelt survival, increases from upper Lake Oahe to lower Lake Oahe (Nelson-Stastny 2001). As reservoir levels have declined in recent years, by early September, cold water habitat has been restricted to the lower one-third of the lake (Nelson-Stastny personal observation). Consequently, rainbow smelt are restricted to the portion of Lake Oahe containing coldwater habitat. During the fall and winter of 2002, gizzard shad were collected for the first time from the stomachs of walleyes in lower Oahe. Gizzard shad provided a food source that helped support walleyes through the fall and winter. This was the first time shad were documented as a significant food source for walleyes in Lake Oahe. No pallid or shovelnose sturgeon whole fish or bony structures were found in walleye stomachs during the course of spring 2001 through 2002 walleye food habits study. The only evidence of a walleye predating on a sturgeon species, (white sturgeon, *Acipenser transmontanus*, native to the Columbia River), was from a laboratory tank test in clear water with larval white sturgeon as the only prey item available (Dena Gadomski, US Geological Survey, personal communication). However, Mike Parsley, (US Geological Survey, personal communication), was unaware of any documented predation of sturgeon species by walleye in a natural environment. Additionally, a clear water tank is far different from the turbid riverine environment in which pallid sturgeon larvae would be found (Keenlyne 2003)

Fish Community Changes

The native fish community of the Missouri River is diverse with 108 species native to the mainstem (Cross et al. 1986). Many of these fishes were well-adapted to a Missouri River characterized by high turbidity, swift current, shifting substrates of a sand-silt bottom, and a hydrologic cycle characterized by two spring rises and low summer flows (Pflieger 1971). Fishes adapted to these conditions were termed “big river” fishes (Pflieger 1971). The big river fishes are ecomorpholociccally adapted as turbid river, benthic specialists exhibiting several common adaptations including: an inferior mouth position, dorsoventral flattening of the head, streamlined or deep, humpbacked body shape, sickle-shaped or enlarged pectoral fins, reduced eyes and diverse and well developed chemosensory organs (i.e., sturgeons, chubs, buffaloes, carpsuckers, blue suckers, catfishes, burbot, and freshwater drum) (Galat et al. in press).

Over the course of the twentieth century the Missouri River was changed from its relatively natural state, experiencing large floods with a sinuous meandering channel moving across its floodplain and carrying voluminous amounts of sediment to a river that has been channelized, impounded behind massive dams creating large reservoirs, with a controlled hydrologic cycle that has dampened spring rises and increased summer flows, and transformed to a clearer river carrying only a fraction of the sediment it moved historically, as much of it is now trapped behind impoundments (National Research Council 2002). The river can be broken into thirds with the upper third characterized as relatively natural, the middle third impounded with short interreservoir riverine stretches, and the lower third as a constricted channelized river. Alterations of the Missouri River have had significant impacts to species composition. Several of the native big river species have declined in abundance; this is especially so in the South Dakota portion of the main stem Missouri River as the vast majority of the river is now a lentic environment. The small remaining riverine stretches are either isolated and/or have traditional migration routes blocked and experience decreased water temperatures because of deepwater releases from reservoirs, significantly reduced turbidity levels and altered hydrologic cycles. Native species that have increased in abundance are similar in their adaptations, i.e. largely planktivores and sight-feeding carnivores, similar to those Pflieger and Grace (1987) reported as increasing in Missouri. In addition to habitat changes realized in the state of Missouri, in South Dakota, mainstem fish communities experienced dramatic increases in the amount of lacustrine habitat as 75% of the riverine miles in South Dakota were impounded behind reservoirs. The habitat changes further favored increases in abundance of native species more suited to lacustrine habitat, which had traditionally been in low abundance in the unaltered Missouri River.

One of the most noted examples of increased abundance for a native sight-feeding carnivore was that of the walleye, while the more turbid riverine adapted sauger declined in abundance. Saugers were the predominant percid in the original Missouri River, however after the lake-like conditions fully developed in the reservoirs, and sauger spawning habitat was reduced, sauger declined in all of the mainstem reservoirs in South Dakota except in Lewis and Clark Lake (Nelson and Walburg 1977). Sauger abundance has remained relatively stable in Lewis and Clark because as the smallest of the four mainstem reservoirs in South Dakota, current velocities remain higher and turbidity is higher relative to the other reservoirs. Additionally, there is a 39-mile relatively unaltered interreservoir riverine stretch above Lewis and Clark Lake which is important for spawning sauger (Nelson 1968). Increases in walleye abundance were discussed earlier in this report. The change in abundance of sauger and walleye described by Nelson and Walburg (1977) has been maintained into the 21st century. Relative abundance (percent composition) of walleye and sauger from coolwater fish population surveys in the main stem reservoirs in South Dakota from 200: Lake Oahe - walleye (29%): sauger (0.2%); Lake Sharpe - walleye (41%):sauger (7%); Lake Francis Case - walleye (26%):sauger (11%); Lewis and Clark Lake – walleye (15%):sauger (17%) (Lott et al. 2002; Johnson et al. 2002; Stone and Sorensen 2002; Wickstrom 2002). Observations were similar to those in South Dakota for populations of sauger and walleye in the Missouri River. Sauger populations have declined substantially in the Nebraska portion of the channelized Missouri river (Hesse 1994). Walleye abundance has increased since 1956 in Lake Sakakawea following its impoundment on the mains stem Missouri River in North Dakota (Hendrickson and Power 1999).

Changes in the fish community as the habitat changed were also evidenced amongst cyprinid (minnow) species. Bailey and Allum (1962) recorded the flathead chub, *Platygobio gracilis,* as the dominant minnow in the turbid flowing waters of the Missouri River in South Dakota. The emerald shiner, *Notropis atherinoides*, was recorded as uncommon in the Missouri River prior to impoundment (Bailey and Allum 1962). Bailey and Allum (1962) pointed out, that following impoundment emerald shiners increased and could likely become a dominant species in the reservoirs. Beckman and Elrod (1971) examined the abundance and distribution of age-0 fishes during the last five years of the filling of Lake Oahe, 1965-1969. The catch of age-0 emerald shiners in seine hauls ranged from 18-50 per haul from 1965-1969 in Lake Oahe, second only to the catch of age-0 yellow perch (Beckman and Elrod 1971), which also had been rare to absent (see earlier discussion) in the preimpounded Missouri River. Flathead chubs which had once been the dominant cyprinid in the Missouri River experienced poor production. In three of the five years of sampling no age-0 flathead chubs were sampled and in the other two years the number per seine haul was 0.1 or less (Beckman and Elrod 1971). Their work was done prior to the stocking of fish in the South Dakota portion of Lake Oahe (Hanten and Talsma 1984). The only record of fish stocked into Lake Oahe prior to the work of Beckman and Elrod was of northern pike into the North Dakota portion of the lake (Hendrickson and Lee 2000). Today emerald shiners continue to be an important component of the prey fish community in the mainstem reservoirs in South Dakota, however from 1997-20001 flathead chubs were not represented in the same fish population surveys (Johnson et al. 2002; Lott et al. 2002; Stone and Sorensen 2002; Wickstrom 2002). Beckman and Elrod (1971) noted that although adults of long-lived big river species such as pallid sturgeon, shovelnose sturgeon, paddlefish, and flathead catfish were observed in Lake Oahe, during 5 years of seining and trawling no age-0's of these species were captured. Beckman and Elrod (1971) concluded that the loss of river habitat as Lake Oahe filled, and the alteration of the river above Lake Oahe, i.e. altered hydrograph, reduced summer water temperatures and decrease silt load greatly reduced production of those big river fishes.

The walleye/sauger and flathead chub/emerald shiner are but two examples of numerous changes to fish communities as the habitat of the Missouri River was altered.

The ability of both prey and predator species to exploit the altered habitat is a testament to the wide array of species present in the native fish fauna of the Missouri River. Based on the examples described above, a review of a wide body of literature and my own experience, habitat alterations were key to the changes in fish communities in the Missouri River. The declines of big river fish species occurred prior to the majority of fish stockings especially the stocking of the various nonnative species eventually stocked. As mentioned earlier, in the initial years of impoundment of the Missouri River in South Dakota, it was SDGF&P policy (Shields 1955) to not stock fish into the mainstem. Nelson and Walburg (1977) summed up the changes in the fish community in the main stem reservoirs in South Dakota as follows:

> Species composition and abundance in the four reservoirs are a reflection of the populations originally present in the Missouri River and the adaptability of individual species to a reservoir environment.

Introduced Species

In general, the unaltered Missouri River in South Dakota was a relatively warm water prairie river. The filling of the mainstem reservoirs created one habitat type that was not present year-round in the preimpounded Missouri River, that being coldwater habitat in the largest of the mainstem reservoirs. Despite the diversity of native species present in the Missouri River, the coldwater (hypolimnetic) portions of the largest reservoirs, in South Dakota, primarily Lake Oahe remained relatively unutilized. This led to several attempts and the eventual success at establishing a viable coldwater prey base, primarily rainbow smelt and secondarily lake herring, as well as an established fishery for Chinook salmon, and smaller tailwater fisheries for rainbow trout and brown trout (Table 1). In addition to the coldwater adapted species, two other sight-feeding predators, smallmouth bass and white bass, as well as the lentic adapted prey species, spottail shiner, have been stocked and become established into the mainstem of the Missouri River.

Pallid Sturgeon Predation

Nonnative fish species contribute to the decline of the native species in the Columbia and Colorado Rivers. However, caution should be used when making generalizations about the impacts of nonnative species in these rivers and imputing similar harm to fishes in the Missouri River. There are relatively small icthyofaunal assemblages in the Colorado and Columbia Rivers relative to the large and diverse assemblage in the Missouri River. The Columbia River is reported to have 27 native species (McPhail and Carveth 1994), while the Missouri River is home to 108 mainstem species in the mainstem alone (Cross et al. 1986). The following excerpt from Johnson et al. (1993) discusses the native assemblage in the Colorado River and aptly describes why the linkage between predation issues in the Colorado and Columbia Rivers to the Missouri River is untenable:

> The native freshwater fish assemblage of the Colorado River drainage consists of about 32 species (Minckley et al. 1986), but many species are confined to small, isolated waters and have little or no association with the 12 or so species of the big-water, mainstream fishes. The Colorado squawfish *Ptychocheilus lucius* is described as the only obligatory piscivore of the system (Vanicek and Kramer 1969; Minckley 1973; Tyus 1991), but some minnows of the genus *Gila,* especially roundtail chub *G. robusta,* may also consume fish (Minckley 1973). We suggest native larval fishes of the Colorado River basin evolved with relatively low predator pressure, resulting in fish that are predator naïve (Minckley 1983; Marsh and Brooks 1989; Magurran 1990; Minckley and Douglas 1991). By contrast, the Mississippi River drainage contains more than 260 native species of fish (Robison 1986) that evolved with high predator contact (Fraser and Cerri 1982; Power et al. 1985; Heins and Matthews 1987; Fraser et al. 1987). Many fishes introduced into the Colorado River basin are piscivorous game species that evolved in predator-rich environments. We hypothesize that the razorback sucker, endemic to predator-poor waters, is inherently less predator wary than ecologically equivalent species from the Mississippi River drainage and will not avoid predators as readily.

The Johnson et al. (1993) hypothesis was proven correct. The study documented that the northern hog sucker *Hypentelium nigricans*, from the predator rich environment in the Mississippi drainage, had a significantly higher initial avoidance rate of predators compared with the razorback suckers, from the predator poor environment Johnson et al. (1993). Not only did pallid sturgeon evolve in a predator-rich environment, many of the most damaging nonnative piscivores in the Colorado River, such as channel catfish *Ictalurus punctatus* and flathead catfish *Pylodictis olivaris* (Marsh and Langhorst 1988; Marsh and Brooks 1989), not only coevolved with pallid sturgeon but are considered big river fishes sharing the same habitat niches and prey items of the unaltered Missouri River. The same holds true for the Columbia River, as walleye, smallmouth bass and channel catfish, which are native to all or portions of the Missouri River (Cross et al. 1986; Galat et al. 2004), predate on native salmonids in the Columbia River (Vigg et al. 1991).

Several of the species listed in Table 1 are native to the Missouri River in South Dakota, paddlefish, northern pike, yellow perch and walleye, and should be discounted as impacting pallid sturgeon populations. This is simply because they coexisted with pallid sturgeon (although, with the exception of paddlefish, they existed at relatively low abundance levels in the previously unaltered Missouri River). Habitat changes led to increased abundance of northern pike, yellow perch and especially walleyes. One could make the argument that the increased abundance of these sight-feeding predators in the altered Missouri River now pose a greater threat because of their increased abundance. However as was discussed by Keenlyne (2003), the selection of turbid flowing waters would negate predation by sight-feeding predators. Moreover, if predation by a percid such as a walleye were detrimental to pallid populations it is more likely that the sauger, which is more adept in lower light conditions and selects for demersal prey items (Swenson 1977) would have had an even greater impact on pallid sturgeon in the historic Missouri River, yet both species coexisted.

White bass and smallmouth bass are both introduced to the upper Missouri yet are considered native within the lower portions of the Missouri River, (Cross et al. 1986; Galat et al. 1986). Excessive turbidity reduces either the population size and/or feeding efficiency of these sight-feeding predators negating them as damaging predators to pallid sturgeon in their natural environment. Spottail shiners as a forage species could predate on eggs, however the eggs would likely be inaccessible in turbid waters (Keenlyne 2003) to nearly all species especially a sight-feeder.

Coldwater adapted species such as salmonids, rainbow smelt and lake herring are discounted as impacting pallid sturgeon populations because of thermal segregation.

Additionally, they are primarily sight feeders and would avoid turbid waters and have difficulty feeding in turbid waters occupied by pallid sturgeon. because of the turbid waters occupied by pallid sturgeon.

Lastly, there has been no documentation in the literature cited in this paper, of any of the species in Table 1 preying on pallid sturgeon.

Summary

Habitat changes to the Missouri River in South Dakota led to increased abundance of several native species which were previously rare or low in abundance in the unaltered Missouri River. These same habitat alterations allowed for successful introductions of other species preadapted to the altered habitat. Some of the introduced species are native to other portions of the Missouri River. While the altered habitat has allowed certain species to flourish, it is this same altered habitat that has led to the endangered status of the pallid sturgeon. The preadaptation of these species to a lacustrine environment precludes such species from impacting pallid sturgeon populations either by preying on them or competing with them. Pallid sturgeon are native to and survived for millions of years in a turbid, dynamic riverine environment with annual flooding events, coexisting with many “big river” piscivorous fishes. If pallid sturgeon and other native Missouri River fauna are going to recover, large portions of the Missouri River will need to be returned to the natural form and function of the unaltered Missouri. The conditions under which pallid sturgeon spawn, where pallid sturgeon eggs develop, the rearing habitat for young pallid sturgeon, the habitat of native riverine prey species which pallid sturgeon consumed (Keenlyne 2003) are all inhospitable to the introduced species in Table 1 because of one or more of the following: turbidity, temperature, predatory habits and/or current velocities

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Appendix E

December 4, 2005 *Argus Leader* newspaper article

GF&P biologists seeking rare fish in Missouri

From Wire Reports
Article Published: 12/4/05, 7:45 am

Three biologists are trying to track the pallid sturgeon, an endangered fish, as well as other species.

“Our top goal is to look for the endangered pallid sturgeon, but we are also closely monitoring several other native fishes, such as the sauger, blue sucker, big and smallmouth buffalos and several chubs,” said Jason Kral of Princeton, Minn., one of the biologists.

“We will also be monitoring the ’before and after’ effects of the potential 2006 spring rise, plus long-term effects on fish reproduction and population trends,” he said. “All in all, we have 59 miles of the Missouri River we sample from Gavins Point Dam here in Yankton down to Ponca, Neb.”

The other biologists are the crew leader, Sam Stukel of Gregory and Steve LaBay of Willow Lake. They’re headquartered at Yankton and are new fisheries biologists with the state Game, Fish and Parks Department.

Also taking part in the project are teams in North Dakota, Nebraska, Missouri and South Dakota. Each group monitors their designated river segment.

“Our group specializes in aging blue suckers and bigmouth buffalos for the entire Missouri River,” Kral said. “In addition to GFP staff working on pallids in South Dakota, there also is a U.S. Fish and Wildlife Service crew working on the river below Fort Randall Dam doing similar work.”

Kral said the most recent pallid sturgeons successfully netted were released in good shape.

“The larger wild pallid sturgeon was the first wild sturgeon collected by a biologist below Gavins Point Dam possibly since the 1970s.” he said. “This sturgeon was a very significant finding, and we all knew right away we had something special, even before we got it on the boat.”

“Working as a biologist on the pallid sturgeon assessment program has truly been a dream come true," said LaBay. "The privilege of working with an imperiled species such as the pallid sturgeon is a very unique opportunity, in that very few who walk the earth will ever get a chance to do so."

"There is very little unchannelled and undammed Missouri River left today, which makes it so exciting to study the ecology of such a rare environment," Stukel said. "We actually get a little taste of what the old Missouri was like."

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

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

09/08/2005

Due to their endangered status and the fact that individual fish are important to recovery of the species, extra care is required in handling pallid sturgeon.. The following protocol was developed by the U.S. Fish and Wildlife Service in cooperation with the Pallid Sturgeon Recovery Team for activities involving collecting, tagging, holding, handling, and transporting pallid sturgeon.

Prior to performing any work with pallid sturgeon, researchers and managers are required to obtain a Federal endangered species permit or sub-permit. For Louisiana, Mississippi, Arkansas, Tennessee and Kentucky: contact 404-679-4176. For Missouri, Illinois and Iowa: contact 612-713-5343. For Nebraska, South Dakota, North Dakota, and Montana: contact 303-236-7400 ext. 227. Questions, comments or suggested changes to the protocol should be directed to, Pallid Sturgeon Recovery Team Leader, at U.S. Fish and Wildlife Service, 2900 4th Ave North, Suite 301, Billings, MT 59101 or at (406) 247-7365. Proposed activities should also be coordinated with appropriate State agencies where a State permit may also be required.

Deviations from the protocol may be requested during the application or renewal process. Researchers and managers should use their best judgement in cases where guidelines are not directly applicable, or if in question, contact the Pallid Sturgeon Recovery Team Leader.

The following guidelines will be followed to ensure that modern and peer accepted techniques are used regarding collecting, tagging, sampling, holding, culture, transporting, and data recording of pallid sturgeon.

The primary intent of these guidelines and procedures is to reduce the risks of loss of pallid sturgeon by reducing the severity, duration, and the number of stressors, while still allowing for the data collection to expand our knowledge of these fish. All personnel that work with pallid sturgeon will be trained to handle the fish.

Record Keeping

All permittees will maintain a copy of the Endangered Species Act permit and this protocol during all field operations as well as on file. Tagging and sampling records shall contain specific information on each individually tagged pallid sturgeon such as that listed on the data sheet provided (Appendix 1).

Personnel and training requirements

Collection: Minimum qualifications include training in appropriate fisheries management collection techniques. Additional activities may also require specific experience and knowledge such as implanting transmitters, culturing, and sexing.

Tagging and sampling: Minimum qualifications include training in fisheries management tagging and sampling techniques and stress mitigation. Specific training will be required for genetic sampling.

Fish Culture: One FTE will be designated and required to care for pallid sturgeon at Garrison Dam NFH, Gavins Point NFH, Natchitoches NFH, Blind Pony SFH and Miles City SFH, or in any facility that maintains fish in culture conditions. The minimum qualifications include training in warmwater fish culture and stress mitigation.

Handling and transportation: All personnel must be trained in the collecting and handling procedures described in this protocol. Drivers must be informed of and follow a specific route. Personnel at the receiving point must be informed to expect the shipment. Before transporting, the shipper should make detailed arrangements with the receiver. Arrangements should include where and when fish will be delivered, and the need for any specialized equipment at the receiving point. Arrangements should be verified before the vehicle leaves the site and again while in route, if possible. Water quality information should be exchanged and matched as closely as possible.

Trainees: Those individuals not meeting minimum qualifications will be considered to be trainees and will not be allowed to independently work with pallid sturgeon. They will be trained in protocols and procedures under the direct supervision of a qualified biologist.

Collection Methods: Two weeks prior to actual field work, all field personnel, the Regional Fish Health Center, and hatchery personnel will be notified. All pallid sturgeon are to be collected non-lethally. A fish holding container on the boat shall be of sufficient size to cover the fish completely.

Gill Nets/Trammel Nets - Monofilament and multi filament mesh nets may be used to collect pallid sturgeon. There are no mesh size restrictions for gill and trammel nets. Drifting sets should be monitored continuously. Time and position of net sets are recorded using a stopwatch and global positioning system (GPS). This will provide positional data and time for each set. Total numbers of each species is then noted and recorded with the GPS way points to apply to a Geographic Information System (GIS). Drift distance starts and stops with the clock. Indicate net length, mesh size, and mesh type in reports. Stationary sets may be used for pallid sturgeon, but must not be left unattended for more than 3 hours. If water temperatures are less than 55 F, then overnight sets may be used cautiously, but for no more than 24 hours. Weather conditions must be watched to insure that nets can be picked up as soon as possible the next day. Calculate CPUE as fish per-net-hour for stationary sets. For drifting sets, CPUE shall be reported as fish per-net-hour and number of fish per-meter of the drifted area.

Trot Lines/Angling - Larger hooks are more desirable to guard against pallid sturgeon swallowing them. Mustad Tuna Circle Hooks in sizes up to 14/0 have proven successful in capturing larger pallid sturgeon in Montana. Trot lines must be checked at least once every 18 hours. Calculate CPUE as fish-hook- hour. Indicate line length and number of hooks per set in reports.

Electrofishing -Electrofishing must not be used to stun and capture pallid sturgeon. Low power electrofishing (max. 100 volts DC and 3 amperes) may be used to move pallid sturgeon from heavy cover and direct them into nearby nets for capture.

SCUBA -Pallid sturgeon collected using this method are to be captured by hand. Contact should be made with the snout as quickly as possible after carefully grasping the fish by the caudal peduncle. Once in hand, the fish should be enclosed in a large, preferably small-mesh bag and brought slowly to the surface, while maintaining the fish in a horizontal position. SCUBA is used to capture pallid sturgeon primarily during the winter. Exposure of the fish to freezing air temperatures shall be avoided by keeping the fish submerged in water. Record sightings per hour of dive time in reports.

Trawls - Trawls have been effectively used to collect juvenile sturgeon. However, due to the nature of the trawling, a potential for serious injury to the fish is possible. Therefore, trawling efforts should be kept to a maximum of ten minutes under optimal conditions (low debri collection, sand substrate). When conducted in habitats with rock/cobble or when high densities of fish are present, trawling time should be reduced to limit incidental injuries. Calculate CPUE as fish per trawl and number of fish per-meter of the trawled area.

Data collected -The Pallid Sturgeon Data Sheet (Appendix 1), dated May, 2000 lists the physical data to be recorded from each specimen, as well as general data about the collection. While collecting morphometric data, pallid sturgeon should be kept moist and held out of the water for no longer than 2 minutes, unless the gills are irrigated. It is preferred to hold the fish in the water in a stretcher or in a “stock” tank large enough to accommodate the fish. For procedures on taking measurements refer to: Bailey, R.M., and F.B. Cross. 1954. River sturgeons of the American genus Scaphirhynchus: Characters, distribution, and synonymy. Michigan Academy of Science, Arts and Letters, Vol XXXIX.

Copies of completed data sheets must be mailed to the Missouri River FWMAO attn: Project Leader, U.S. Fish and Wildlife Service, 3425 Miriam Ave., Bismarck, ND 58501 during or at the end of each field season for recording into the Range-wide Pallid Sturgeon Catch Record Database. Copies of the Catch Record Database can be obtained from the above address.

Tagging, sampling methodologies and sampling protocols

Fish tagging and marking - All captured pallid sturgeon should be carefully examined for previously implanted PIT, elastomere and coded wire tags, external tags, and evidence of external tag loss. Make several passes with the PIT and coded wire tag reader along both sides of the dorsal fin when checking for PIT tags and around the rostrum tip and scute area with the coded wire tag reader. Some fish may have two PIT tags, one on either side of the dorsal the fin with the left side being the primary location.

1) Identification Tags

a) PIT Tags - All adult pallid sturgeon must be implanted with a PIT tag prior to release. PIT tags should be inserted horizontally or front to back along the left anterior, fleshy base of the dorsal fin. A second PIT tag on the right side of the dorsal fin if the first tags is unreadable. Tags should be scanned prior to implantation for recording and after to ensure it is working properly.

PIT tags provide reliable, long-term identification of individuals. Several companies are now providing tags and readers that work; Biomark (www.biomark.com), AVID (www.avidid.com) or Destron Fearing (www.destronfearing.com). There are basically two types of tags available; encrypted and un-encrypted.

In order to enhance recognition of recaptures and maintain consistency in readability of tags, only un-encrypted, 125 kHz tags will be used for pallid sturgeon work, unless a specific recovery area is already committed to specific format.

b) External Tags - External tags have met with little success when applied to sturgeon and are therefore no longer permitted on adult pallid sturgeon until further field evaluation and laboratory studies can recommend an acceptable tagging method. Various external tag types (dangler, cinch, dart, disc) have been used on shovelnose sturgeon and juvenile pallid sturgeon with limited success. Disc tags have had higher long-term retention on sturgeon than other external tags. However, the majority of recaptured adult pallid sturgeon that had previously been externally tagged exhibit tissue inflammation severe enough to be concerned about infection. In some cases, severe inflammation was still evident 2 years after the fish had been tagged. External tags can be used on shovelnose sturgeon, shovelnose X pallid hybrids, as well as on pallid sturgeon stocked for research purposes as well as wild caught pallid sturgeon. Utilization of external markers on wild-caught fish will be evaluated on a case by case basis.

2) Radio/Sonic Transmitters

a) Internal Transmitters - Internal transmitters are preferred over external transmitters; however, implanting should be performed only by individuals with experience in surgical procedures. Transmitters with external antennas protruding from the body cavity are generally not permitted and will be evaluated on a case by case basis. During surgery, the head either should be placed in water or the gills flushed with water. Transmitters should have a biologically inert coating to prevent expulsion. An incision, only slightly larger than the tag to be used, should be made in the ventral body wall, one to one and a half inch off the midline and anterior to the pelvic fins. Care should be taken to prevent severing blood vessels and damaging organs while making the incision. The incision should be closed with individually knotted sutures. Before and after surgery, the incision site should be wiped with an antiseptic to prevent infection. This same small incision should be used for sexing the fish. For additional information and guidance on surgical procedures refer to: Conte et al. 1988. Hatchery manual for the white sturgeon. University of California, Division of Natural Resources, Cooperative Extension Publication 3322. The duration of surgical procedures should be limited to a maximum of 15 minutes per fish.

b) External Transmitters - Use of external transmitters are not recommended, but will be carefully reviewed and authorized on a case-by-case basis. Concerns are that attachment methods create inflammation and cause infection until the tag is shed.

Handling and fish transportation

Truck transport: When the objectives of field work are to capture pallid sturgeon broodstock, a hauling truck and tank should be on site for immediate transport. Use a circular hauling tank for larger specimens (>10 pounds), that is equipped with oxygen and a fresh-flow aerator system. Transportation times should not exceed 12 hours and may need to be less depending upon number of fish and water/air temperature. Maintain temperature of hauling-tank water within + 3°F (± 1.6°C) of ambient water temperature of origin. Temper the fish when moving them between bodies of water. Pallid sturgeon should not be transported when ambient water temperatures are greater than 60°F (15.6°C). To reduce stress during transport, non-iodized salt should be added to water in the hauling tank to provide a 0.25 percent salt solution for juveniles and 0.5 percent solution for adults.

For transport of pallid sturgeon that will exceed six hours, arrangements will be made to have a back-up vehicle and haul trailer available in the event of a mechanical breakdown. Pallid sturgeon should be visually inspected a minimum of every two hours on trips exceeding two hours.

Box and bag shipping equipment: Shipping of fish or eggs in boxes containing plastic bags is recommended for larval and juvenile sturgeon, exceeding 5 inches total length. Industry standard boxes and square bottomed shipping bags should be used. If possible, withhold food for 24 hours prior to shipment. Use two bags in the box. The box should be cardboard with a Styrofoam box insert with fit lid. Check the bags for leaks prior to use. Fill the inside bag with about 2 gallons of water, water additives, and fish. Deflate the bag of air and inflate the bag with oxygen. Twist the top of the bag to put pressure in the bag. Fold over the twisted top and seal with a docking ring (preferred) or two heavy duty rubber bands. Separately, twist the top of the outer bag and double it over prior to sealing with a docking ring or two rubber bands. Place the styrofoam lid on the styrofoam box and seal with shipping tape. Then seal the cardboard box with two complete rounds of shipping tape. Load and ship with the 'up' arrows pointing up at the lid. If needed, temperature can be maintained by placing cold packs on the sides of the bags. Smaller plastic bags such as ziplock heavy duty freezer bags can be used but care must be taken to inflate and pack these in such a manner that the fish cannot be crushed or sharp edges are exposed to create a puncture. Bags used for shipping must not have corners that could trap and crush the fish. The water temperature should be similar to or slightly lower than that used to rear the fish and the bag temperature should be lowered to less than 60° F (15.6° C) prior to shipping. The hauling density should not exceed 0.5 pounds of fish per gallon of water.

Fish acclimatization and therapeutants:

Following transfer from the field to a controlled environment such as Garrison Dam NFH or other appropriate facilities, measures will be taken to mitigate for stress of transfer. Prior to transport, the following therapeutic agents may be used to combat infections.

oxytetracycline (LA200, Bio-Mycin) - shall be injected into muscle tissue of the pectoral fin or muscle tissue of the back at a rate of 0.045 cc/lb of body weight to provide the fish with some defense against bacterial infection due to stress. The injection should occur at the capture site prior to transport or immediately following significant handling.

fluorophenicol (Nuflor) - shall be injected into muscle tissue of the back at a rate of 0.03 cc/lb of body weight to provide the fish with some defense against bacterial infection due to stress. The injection should occur at the capture site prior to transport or immediately following significant handling.

tetracycline hydrochloride - Fry and fingerling pallid sturgeon can be treated with tetracycline hydrochloride soluble powder at a rate of 10 ppm and up to 60 ppm for up to four hours per day. This can be done daily for up to five consecutive days with no major problems when holding conditions or stress may be induce a systemic infection.

Following transport, stress reduction techniques will include adding non-iodized salt at 0.5% (18.9 grams per gallon) levels to holding water for at least two days following transfer. Water temperatures will be similar to that at the location and time of capture. Water turnover rates will be between 2 and 4 times per hour in all culture tanks. If parasites have been found in the water supply, the supply will be filtered (15-20 micron) and disinfected using UV irradiation with a minimum of 100,000 microwatts per square centimeter of ultraviolet light intensity. Photo period will approximate levels similar to environmental conditions. Variations in photoperiod should be submitted in the permit application. Oxygen levels will be maintained at > 6.0 mg/L or saturation as measured with an oxygen meter. pH will range from > 6.5 to <7.5. Ammonia levels will be maintained at less than 0.0125 parts per million (ppm) and nitrite levels will be kept below 0.1 ppm for soft water and 0.2 ppm for hard water. Nitrogen supersaturation levels will be maintained below 100 - 102%.
Wound relief protocols and drugs and therapeutants will be administered as recommended by the Fish Health Center. Prophylactic drug and therapeutant treatments, other than salt, will be recommended by the Fish Health Center. Therapeutic protocols will be initiated prior to transport and assessed after arrival at the facility and shall follow strict recommended schedules.

Health plans will be initiated on a case by case basis. These health plans will consider physical check-ups, intervals between check-ups, personnel training, specific treatments, drugs, chemicals, and therapeutants to be used. The plan should also address salts to be used equipment decontamination, facility decontamination, immunization, vaccination. The Fish Health Center will determine on a case by case basis if quarantine is required.

<u>Fish Culture/Holding procedures:</u>

1) Short-term (1 week or less) Holding Facilities

   a) Field Holding Tanks - Holding tanks should be circular, covered, located in an area free from disturbances, and have provisions for fresh-water circulation. Pallid sturgeon should be maintained in water from the capture location, when possible. Holding tank water temperatures should be maintained within + 5°F (2.8°C) of ambient water temperature. A standby power supply must be provided in the event of a power failure, unless the fish are monitored every 3 hours.

   b) Modified Hoop Nets/Underwater Keeps - Modified hoop nets/underwater keeps can be used as a temporary holding facility, but for no more than 16 hours. Holding pallid sturgeon in hoop nets or keeps might be necessary for a short period if one or more pallid sturgeon are incidentally captured and field crews are not set up with a holding tank. Commercial fishermen, who are previously authorized by permit, may keep incidentally captured pallid sturgeon in hoop nets until personnel who are previously authorized by permit to obtain the pallid sturgeon arrive. Commercial fishermen must notify their contact within 2 hours of capturing a pallid sturgeon. Mesh size must be 1½-inch (3.81-cm) bar measure or smaller to prevent gilling and keeps should be circular. Hoop nets or keeps should be located such that adequate temperature and oxygen conditions vary little from ambient conditions at the capture location. Flow-through is very important if conditions permit and the structure will not be jeopardized. Hoop nets or keeps must be checked every eight hours and posted with a sign or float cautioning against disturbance.

2) Long-term Holding Facility Requirements and Rearing Facilities

a) Hatchery or Aquarium - Pallid sturgeon have been held for more than 8 years in circular tanks with water circulation. Tanks should be covered and located in an area free from disturbances. An automatic standby power and water supply must be provided to maintain the fish in the event of a failure. These facilities must have a "contaminant-free" water supply. Fish health must be regularly monitored. If signs of disease are noted or if a 20 percent loss of body weight occurs during holding, fish health personnel at the Service's Fish Disease Control Center in Bozeman, Montana (406-582-8656) should be contacted for treatment recommendations. Long-term holding facilities must be within the historical range of pallid sturgeon or be designed to prevent escapement. Water temperatures should be maintained between 40 and 70 degrees Fahrenheit. Densities for adults should not exceed 1.0 pound per square foot of surface area. Densities for juveniles should be maintained at less than 0.5 pounds per square foot of surface area.

Propagation and Stocking

Prior to any spawning activities, propagation plans must be prepared and activities coordinated with the Pallid Sturgeon Recovery Team and the U.S. Fish and Wildlife Service. Before any release of pallid sturgeon to the wild, a comprehensive reintroduction plan must first be developed and then approved by the Pallid Sturgeon Recovery Team and the U.S. Fish and Wildlife Service. Guidelines of propagation and stocking plans are available by contacting the Recovery Team Leader.

Disposal of incidental take

Pallid sturgeon mortalities should be left fully intact and frozen immediately to prevent decomposition. Legal chain-of-custody documentation should be maintained for each specimen to facilitate contaminant analysis reporting. Deaths should be reported to the Recovery Team Leader by phone and in writing as soon as possible. Describe all available information regarding the circumstances under which the fish died. The Service's Fisheries Assistance Office in Bismarck, North Dakota, will coordinate the transfer of specimens to the University of Alabama repository. If personnel are trained in the collection of tissue samples and if equipment for collection is available, the following samples shall be collected prior to freezing.

Fish Health Samples -Refer to Fish Health Protocols (Appendix 2) for proper procedures and data sheet. These samples are only to be taken if part of another study evaluating fish health. All samples shall be labeled with the PIT tag number. Please notify before shipping and forward all samples labeled with the PIT tag number to:

Bozeman Fish Health Center U.S. Fish and Wildlife Service 920 Technology Blvd., Suite G Bozeman, MT 59718 Crystal Hudson, 406-582-8656

Contaminants Samples -Refer to Standard Operating Procedures for Collection, Storage, and Shipment of Pallid Sturgeon Tissue Samples for Analysis of Organic and Trace Element Contaminants (Appendix 3). These samples should only be collected if on a mortality and part of a study evaluating contaminant levels. All samples shall be labeled with the PIT tag number and sent to:

U.S. Fish and Wildlife ServiceEcological Services 3425 Miriam Ave Bismarck, ND 58501 Contaminants, 701-250-4481

Age Analysis (mortalities) -All morphological and meristic data will be collected along with PIT number. The right pectoral fin and spine will be cut off at or below the hinge point of the 1st spine for age analysis before freezing. Fin samples and data shall be shipped to the Service's Fisheries Assistance Office in Bismarck, North Dakota. All samples shall be labeled with the PIT tag number and include a copy of data sheet.

Protocol for Taking Sturgeon Genetic Samples

Equipment you will need:

1) Two screw cap tubes filled with 95% NON-denatured ethanol
2) Surgical scissors and forceps
3) Sturgeon genetic card (See example below)

Procedure:

1) Record genetic vial # and corresponding PIT # on the genetic card (this step is critical for pallid sturgeon). Record all biological data. Please note if the fish is a recapture.

2) To avoid sample to sample contamination keep your hands, sampling instruments and work area clean. Vigorously wash scissors and forceps in fresh water prior to taking each genetic sample. Wipe the scissors and forceps with the clean section of a rag or a new tissue to insure residual tissue from the last sampled fish is removed.

3) Use the scissors to cut two small pieces of tissue off of the caudal fin (approximately $1cm^2$ each). When it is not possible to obtain samples as large as $1\ cm^2$ a smaller piece of $0.5cm^2$ should be adequate.

4) Place one piece of tissue into each of the two screwcap tubes (a and b) filled with alcohol and tightly screw on the caps (If the lids are not tight the alcohol will evaporate).

5) Place both samples back in the plastic bag with the completed genetic card. Samples should be stored at room temperature.

6) Contact William Ardren via e-mail before sending samples to the USFWS genetics repository. He will provide details on sending the samples via FedEx to:

All samples should be sent to :

William Ardren, U.S. Fish and Wildlife Service, Abernathy Fish Technology Center, 1440 Abernathy Creek Rd. , Longview, WA 98632, Phone (360) 425-6072, e-mail: William_Ardren@fws.gov

Genetic data card example:

Sturgeon Genetic Card

Circle **Pallid** **Shovelnose** **Lake**

Genetics vial # Strug-__________ PIT Tag #________________________
(Sample vial number, include photos head w/side and ventral views)

Capture Location____
Latitude __________________Decimal degrees
Longitude ________________Decimal degrees
River _______________________ River Mile____________________
State _______________________ Date _________________________

Interrostral Length _________mm Mouth - Inner Barbel ________mm
Outside Barbel ____________ mm Inside Barbel ______________mm
Head Length _____________ mm Fork Length _______________mm
Weight ________________ lbs/kg Sex Male Female Unknown

Captured by____

Comments____

USFWS Conservation Genetics Program, 1440 Abernathy Creek Rd., Longview, WA 98632. TEL: (360) 425-6072 FAX: (360) 636-1855

Pallid Sturgeon Data Sheet

Capture Location

Latitude ___________ Decimal degrees Longitude
Decimal degrees
River ______________________________________ River Mile
State __________ Method: Gill/Trammel/Hoop
Net/Trotline/Fishing/Other
Duration of Set/Drift: ___________________ hrs/min Mesh Size

Habitat Data:
Water Depth: _____________________ m/ft Turbidity:
Secchi/NTU
Water Velocity: __________________ mps/fps Substrate:
Water Temperature: ___________________ ☜F/☜C Date ________/
/

(Sketch river channel, main current, sandbars, capture location, and

i
ndicate
north
in the
box
above)

Schematics of Sturgeon Capture Location

Physical Data:
Interrostral Length
mm
Mouth - Inner Barbel
mm
Outside Barbel
mm
Inside Barbel
mm
Head Length
mm_Fork Length
mm

Dorsal fin rays (optional)__________ Anal fin rays (optional)
Weight____________________ lbs/kg
Sex: M / F / U: Ripe / Green / U
PIT Tag #:
Other Tag Information:
Recapture: Yes / NO
Comments:
Genetics Sample #____________________(same as PIT tag number, include photos head w/ side and ventral views)

Captured by:

FISH HEALTH PROTOCOLS

The initial detection of an iridoviral agent in cultured shovelnose and pallid sturgeon prompted the development of specific guidelines for health sampling. Due to the tropism of the iridovirus for epithelial cells, it is extremely important to handle fish samples delicately. All samples should be handled to ensure that skin surfaces have as little contact with equipment and sampling surfaces. This outline will provide detailed instruction for health sampling of both juvenile and adult sturgeon. The primary means of sampling pallid sturgeon as an endangered species will be by non-lethal methods. However, lethal sampling instruction will also be provided for situations or facilities requiring inspection sampling.

NON-LETHAL SAMPLING TECHNIQUES: (Please contact USFWS Fish Health Biologist for specifics)

Collection of fin punches, barbel clips:

<u>General:</u>

* Label and track each fish individually with unique numbers (i.e. PIT #) for easy reference.
* Utilize only sterilized dissection equipment for collecting samples.
* Disinfect dissecting tools and DNA sampling tools between fish samples.
* Make sure fish are well oxygenated during fin punch collection. <u>Collection for histology:</u>
* Individual fin punches will be collected from pectoral and caudal fins using a small paper hole puncher. Fins can also be clipped or notched using scissors or pig ear notcher. Refer to sturgeon anatomy picture for proper location of fin samples.
* Barbel clips may be collected by clipping the distal end of the barbel with sharp scissors.
* Both fin punches and barbel clips will be immediately placed into Davidson's fixative for a minimum of 48 hours, followed by immediate transfer to 70% ethanol.
* Place fish tissues into the Davidson's fixative at a ratio of 1 part tissue to 5 parts fixative.
* All histology samples should be collected in chemically resistant plastic containers or glass collection jars for transportation and storage. Seal jars tightly before transport.

Appendix 2

Collection for Viral DNA analysis:

* Collect fin punches from the caudal and pectoral fins using a paper hole punch. Scissors may be used to clip the edge of the fins.
* Collect a portion of barbels with sharp scissors.
* Place each tissue type from individual fish in small 1 ml plastic tubes.
* These samples should be immediately frozen for transportation and then maintained at -70 F ultra-cold temperature for DNA analysis.
* Change gloves between each fish to be sampled.
* Disinfect sample collection instruments between fish.
* Refer to sturgeon diagram for sample locations. Collection of Virology Cell Culture Samples:
* Collect both fin punches and barbel clips aseptically with sterilized dissection tools. Sample collectors should wear protective examination gloves.
* Refer to sturgeon diagram for sample location.
* Sample collection for virology may be as individual fish or pooled not to exceed a five fish pool.
* Samples will immediately be placed in small whirlpak sample bags. These bags should be chilled, not frozen. They can be kept in the refrigerator before transportation and should be transported chilled, insulated from ice packs. At no time should samples be allowed to become warm.
* These samples must be forwarded to receiving laboratory within 48 hours from collection.
* It is very important to sterilize dissecting tools between fish samples. An appropriate virucidal agent should be used.

Appendix 2

LETHAL SAMPLING TECHNIQUES

(Only on mortalities): Collection of

complete internal and external fish tissue

samples. General:
* Label all containers, showing species, and date collected.
* Maintain fish sample collection report with:

** fish source
** fish condition
** water temperature
** fish handling
** fish culture information
** mortality records

* All dissecting tools should be sterilized prior to collection and should be disinfected between individual fish
* Sample collectors should wear protective gloves during collection procedure.
* Fish should be euthanized with Tricaine Methane Sulfonate (MS-222) prior to sampling.Collection of Histology Samples:
* Fish should be dead no longer than 15 minutes for good histological sample collection.
  * Fish smaller than 60mm can be preserved as whole fish. Slit fish ventrally along the belly, from the vent to the gills. Pull viscera away from the kidney area and puncture the air bladder to facilitate fixation of the kidney.
  *Fish larger than 100mm will require thin sections of each organ for fixation. Tissues for histology: gill, heart, liver, spleen, kidney, muscle, ceca, digestive tract, fins, barbels, nares, rostrum, mouth parts, any lesions that are visible.
* The tissue pieces may be as large as 25 mm (1 inch square), but no thicker than 5 mm (about 1/4 inch).
* Histology tissues should be immediately placed in Davidson's fixative. One fish per collection jar. Do not combine tissues from other fish.
* Sample tissues should be placed in fixative at a ratio of 1 part fish to 10 parts fixative.
* After specimens have been in fixative for 48 hours, transfer to 70% ethyl alcohol.
* Samples can be transported in ethyl alcohol and stored for histology processing.
* Sample containers can be glass or chemical resistant plastic.

Appendix 2

Collecting Tissues For DNA Analysis:

* Please refer to previous protocols on taking of genetic samples.

Collecting Virology Cell Culture Samples:

* Collect both external and internal samples: caudal fin, pectoral fin, barbel, nares, rostrum, mouth, spleen, kidney, gill, ceca, heart, kidney, gut.
* Maintain separate virology bags for external and internal samples. Samples can be taken individually or five fish pooled.
* Always use sterilized dissecting tools. Wear appropriate gloved protection while sampling.
* Collect in whirlpak plastic bags and immediately chill samples. Do not freeze. Do not allow samples to become warm.
* Transport samples to receiving laboratory within 48 hours.

Appendix 3

STANDARD OPERATING PROCEDURES FOR COLLECTION, STORAGE, AND SHIPMENT OF PALLID STURGEON TISSUE SAMPLES FOR ANALYSIS OF ORGANIC AND TRACE ELEMENT CONTAMINANTS (mortalities)

1. Wash hands throughly and rinse completely. Wear vinyl or latex gloves (powder less). Final rinse with distilled water.

2. Rinse fish clean of any debris.

3. Dissection surface should be a chemically inert substance such as a stainless steel solvent (pesticide grade acetone, hexane, or isopropanol) rinsed pan, or solvent rinsed heavy duty aluminum foil placed shiny side down and dull side towards fish. Take care that sample does not contact potentially contaminated surfaces (plastics, identifying labels, printed papers, uncleaned work surface or tools, etc).

4. Use previously cleaned dissection tools which were decontaminated under the following guidelines: 1) non-phosphate detergent wash. Liquinox or Alconox brand detergents are recommended. 2) tap water rinse. 3) distilled/deionized water rinse. 4) solvent rinse (pesticide grade acetone, isopropanol or hexane). 5) air dry. 6) distilled/deionized water rinse. 7) wrap instruments in aluminum foil (shiny side out) for storage until use. Scales for sample weights should also be clean or covered with solvent rinsed aluminum foil.

5. Separate, clean dissection tools are to be used for each individual fish. And instruments used to collect tissue samples should be separate from instruments used to make initial opening in abdominal cavity.

6. Complete a Fish Health Examination Sheet (attached)

7. Do not let dissected samples remain exposed to the air. Exposure can dry samples and reduce the natural percentage of moisture. Prepare each dissected sample for shipping or freezing as it is dissected.

8. Tissue samples to be collected should include: kidneys, gonads, liver, and muscle with skin.

9. Samples should be placed in a chemically-cleaned glass jar and sealed with a teflon-lined lid. Lids are then to be sealed with tape (electrical or packing). Jars should be pre-labeled with a permanent, waterproof marking pen. As an alternative, solvent (pesticide grade acetone, hexane or isopropanol) rinsed, heavy-duty aluminum foil may be used to wrap the sample (remember, shiny side out). After double-wrapping, place the sample (with sample identification label) inside an air-tight zip-lock or whirl-pak bag.

10. Complete a Chain of Custody Record (attached)

11. Samples are to be sent to US Fish and Wildlife Service, Ecological Services, 3425 Miriam Ave., Bismarck, ND 58501 (701) 250-4481. All coolers should be shipped via OVERNIGHT service. Always call before shipping to ensure personnel will be available to handle incoming samples. Upon receipt in Bismarck, samples will be stored in an Environmental Contaminants freezer until authorization to ship samples to a pre-approved analytical laboratory.

12. Samples not shipped to Bismarck within 24 hours after collection need to be frozen and then shipped on dry ice. For frozen samples, dry ice to sample weight ratio should be 1 to 1. Samples shipped to the Bismarck Field Office within 24 hours of collection need to be chilled immediately and can then be shipped on wet ice. However, chemical coolants such as blue ice packs are preferable to wet ice because their packaging prevents leakage should they thaw. Regardless, coolants such as wet ice or blue ice should be sealed in plastic bags. Sample containers (jars or whirl-paks) should also be separately contained in plastic bags. Samples should be properly packed in the cooler with bubble wrap.

The following three lists contain items that you may find useful when working with pallid sturgeon in the field. Individual activities may need additional items necessary for particular work dependant on field conditions and activities, therefore these lists should only serve as a guide.

List for Field Collection

Crew trained in netting and trawling procedures
Crew trained in best handling procedures
Nets and sampling gear
Holding tank on boat, must be at least six feet in length for larger specimens
Bucket or bilge pump available for filling holding tank and for circulating water
Pit tag reader, tag injectors, and tags
Crews trained in proper tagging procedures
Water proof field notebooks and data sheets
Measuring tape (a quilting tape works well) and weighing scale
Stretcher for moving fish and weighing
Cellular phone for emergencies
Appropriate therapeutic antibiotics, syringes and dosage chart
Global positioning system
Black light for examination of elastomer tags in stocked fish

List for Genetic Samples

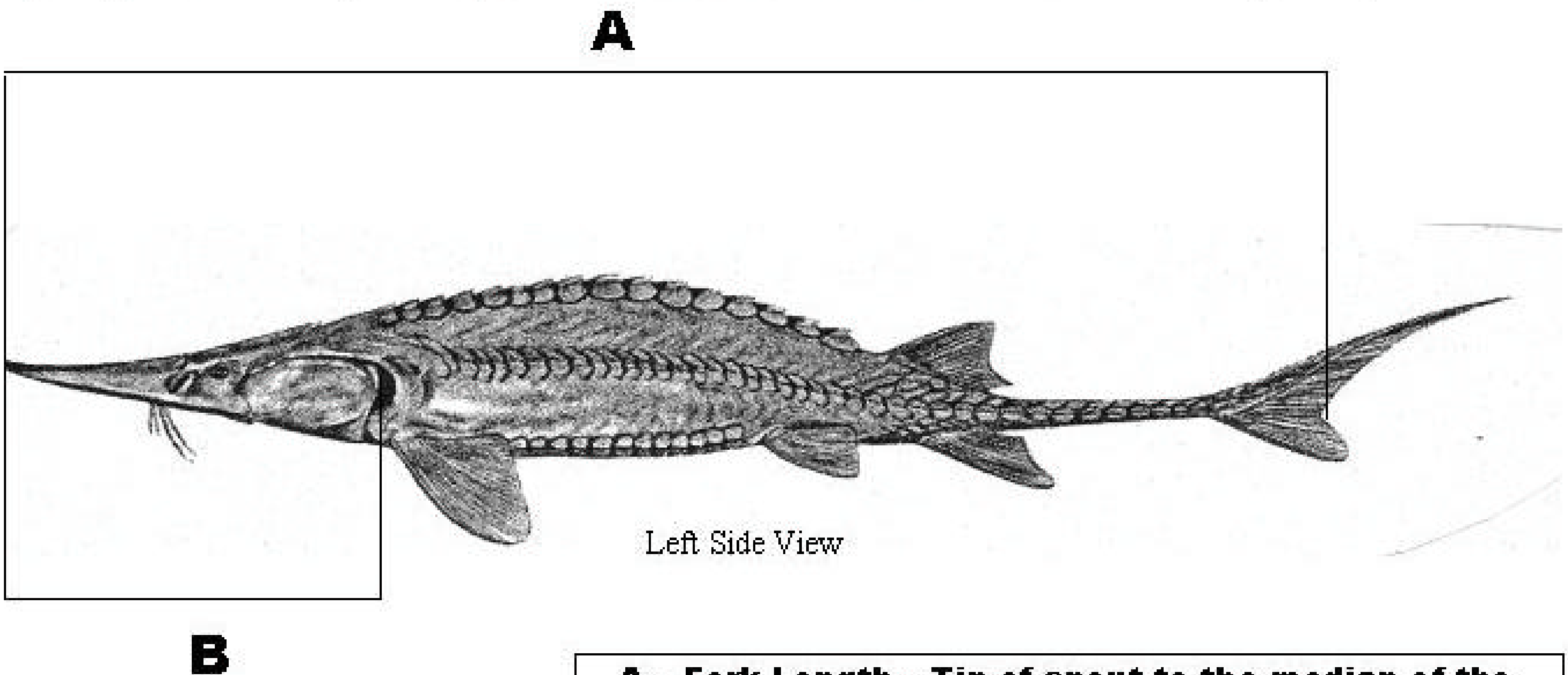
95% NON-denatured alcohol
Tissue Forceps
Scissors
Screw-cap tubes
Permanent marker
Data sheets
Butane lighter
Latex gloves
Single use razor blades

Hauling truck check list

Crew trained in hauling procedures loading crew trained in best handling procedures.
Drivers know the route and maps available.
Personnel at receiving point are expecting shipment.
Cellular phone tanks properly mounted.
Adequate fuel, adequate tires and emergency equipment.
Oil and other fluid levels checked.
Tank filled to proper level with water.
Water temperature in tank similar to host water (within 3 degrees Fahrenheit).
Water additives in tank water (salt).
Stretchers and nets in place.
Oxygen/temperature meter calibrated, in place, and operating.
Primary aeration system functioning oxygen bottles full - adequate supply for trip.
Emergency aeration system in place and workable filling pump present and functioning.
Receiving facility/tanks ready and filled.
Two large buckets available.
Salt bucket pre-marked for non-iodized NaCl.
Pit tag reader, injectors and tags waterproof field notebooks and data sheets.

01/03/2003

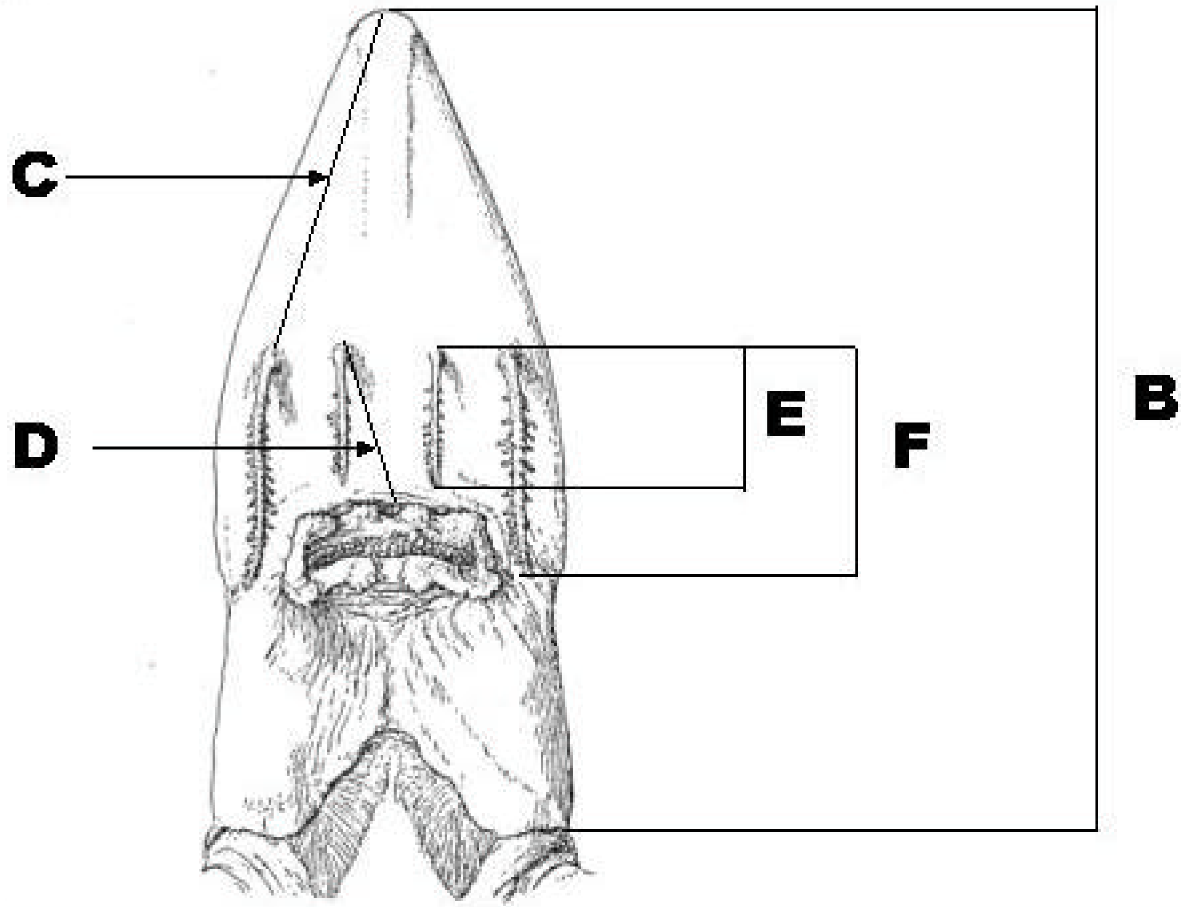
Required Morphological Measurements for Pallid Sturgeon



A – Fork Length – Tip of snout to the median of the caudal fin rays. (Note: on larger fish, it may be easier to lay tape along bottom of tank to get a straight line measurement)

B – Head Length – Tip of snout to back edge of opercle flap.

01/03/2003



Line drawing taken from:

S. A. Forbes and R. E. Richardson. On A New Shovelnose Sturgeon from the Mississippi River. Bulletin Illinois State Laboratory of Natural History 737-44, 1905.

B – Head Length (see previous page)

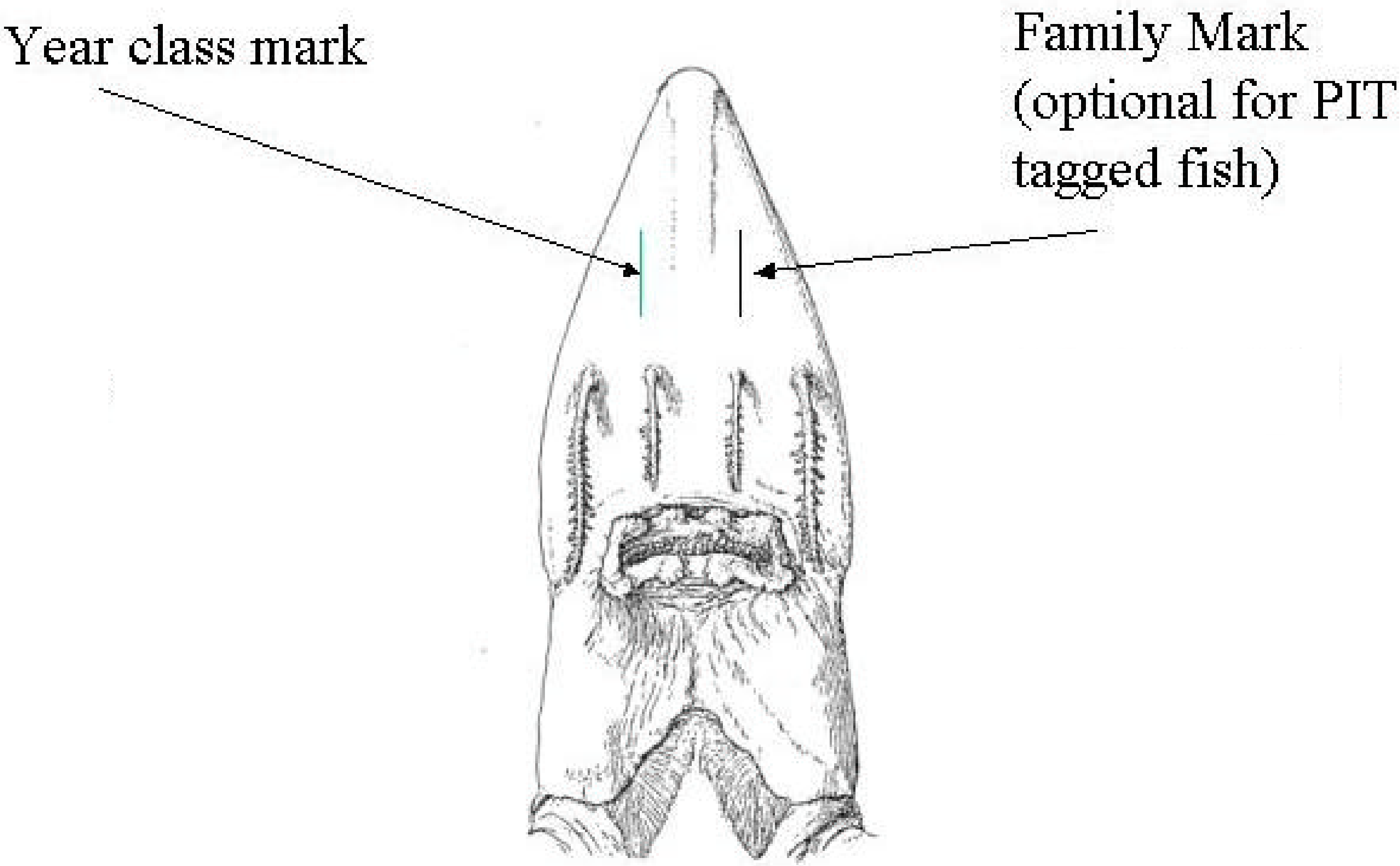
C – Interrostral Length – Tip of snout to front edge of the outer barbel.

D – Mouth to Inner Barbel Length – Leading edge of mouth to front edge of inner barbel.

E – Inner Barbel Length – Front leading edge of inner barbel to it's tip.

F – Outer Barbel Length – Front leading edge of outer barbel to it's tip.

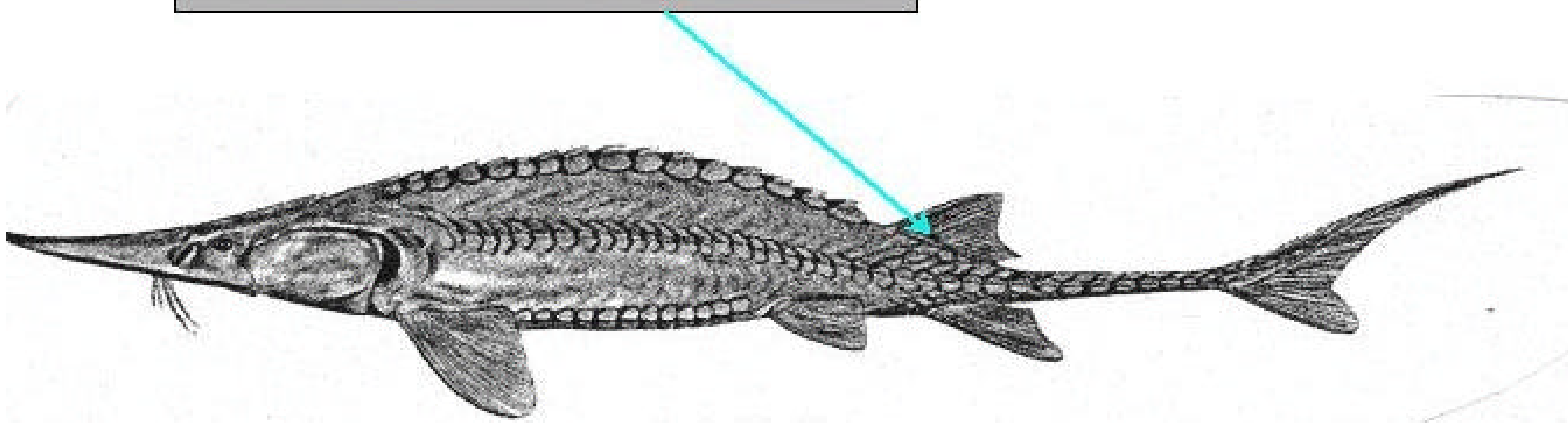
01/03/2003



01/03/2003

<u>Required Tagging Location for Passive Integrated Transponder (PIT) for Pallid Sturgeon</u>

Insert tag from front to back on fishes left side, into tissue at base of dorsal fin.



Left Side View

01/03/2003

Ventral view of pallid sturgeon photo for genetic sample.

Appendix F

01/03/2003

Side view of pallid sturgeon photo for genetic sample.