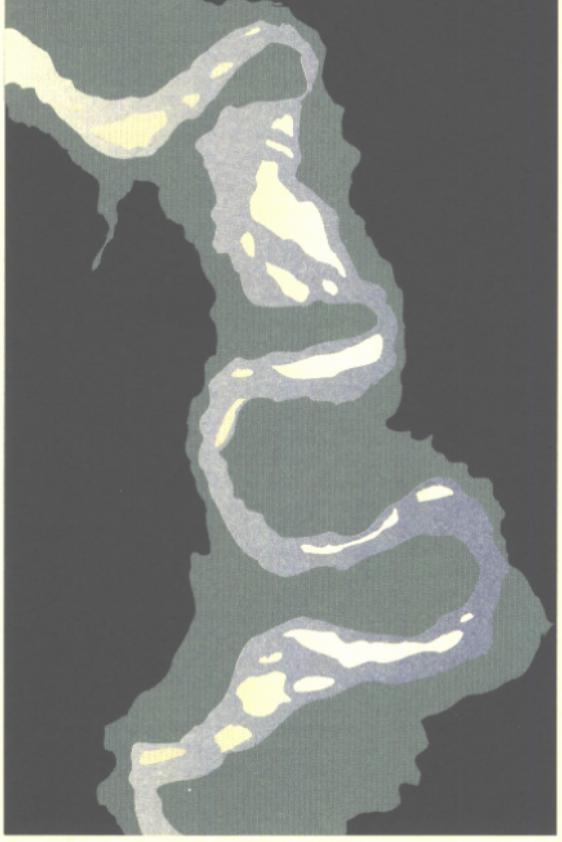
PALLID STURGEON

(*Scaphirhynchus albus*)

RECOVERY PLAN



Department Of The Interior • U.S. Fish & Wildlife Service

Recovery Plan

for the

Pallid Sturgeon (*Scaphirhynchus albus*)

Prepared by the Pallid Sturgeon Recovery Team

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RECOVERY BACKGROUND AND STRATEGY

The pallid sturgeon (*Scaphirhynchus albus* Forbes and Richardson) was listed as an endangered species on September 6, 1990 (55 FR 36641) pursuant to the Endangered Species Act (Act) of 1973 (16 U.S.C. 1531 et seq.) as amended. The range of the pallid sturgeon overlays three U.S. Fish and Wildlife Service (Service) Regions: Region 3, Region 4, and Region 6, with Region 6 having been designated the lead Region for recovery (research functions are provided to all Service Regions by Region 8). Because of the wide range of the pallid sturgeon, its believed extreme rarity, numerous threats to species survival, and paucity of information on species life history and habitats, an eight-member, multi-disciplinary recovery team was established to develop this Pallid Sturgeon Recovery Plan (Recovery Plan). In development of the Recovery Plan, the recovery team utilized the expertise of other sturgeon researchers and managers and published literature.

The Introduction section, Part I, of this Recovery Plan describes the distribution, status, life history, and habitat-association information that is known about the pallid sturgeon. Reasons for listing and threats to the species are also described.

The Recovery section, Part II, provides the short- and long-term recovery objectives and actions needed to achieve recovery. Recovery tasks, which can be independently funded and carried out, are described for each action.

The Implementation Schedule, Part III, of the Recovery Plan is essentially a summary table that indicates task priorities, task descriptions, duration of tasks, the agency or entity with the responsibility or administrative authority to fund or carry out the task, and lastly, estimated costs. All priority 1 tasks are listed first, followed by priority 2 and priority 3 tasks. Because of the immediacy for implementation of recovery actions to prevent extinction of the species, most tasks are assigned priority 1.

This Recovery Plan is subject to modification as needed by new findings, changes in species status, and the completion of recovery tasks.

PALLID STURGEON RECOVERY TEAM

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DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service with the assistance of recovery teams, contractors, State agencies, and others. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not necessarily represent the views or the official positions or approvals of individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved.

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EXECUTIVE SUMMARY

Current Species Status: The pallid sturgeon was listed as endangered on September 6, 1990 (55 FR 36641). Although the species range is large, catch records are extremely rare. The species may be close to extinction.

Habitat Requirements and Limiting Factors: The pallid sturgeon is native to the Missouri and Mississippi Rivers and, therefore, adapted to the pre-development habitat conditions that existed in these large rivers. These conditions generally can be described as large, free-flowing, warmwater, turbid habitat with a diverse assemblage of physical habitats that were in a constant state of change. Modification of the pallid sturgeon's habitat by human activities has blocked fish movement, destroyed or altered spawning areas, reduced food sources or ability to obtain food, altered water temperatures, reduced turbidity, and changed the hydrograph of the river system. Overfishing, pollution, and hybridization that occurs due to habitat alterations also have probably contributed to the species' population decline.

Recovery Objectives and Criteria: The short-term recovery objective is to prevent species extinction by establishing three captive broodstock populations in separate hatcheries that are initially composed of five to seven wild adult males and five to seven wild adult females each by 1998. The long-term objective is to downlist and delist the species through protection, habitat restoration, and propagation activities by 2040. Downlisting and delisting would be initiated when pallid sturgeon are reproducing naturally and populations are self-sustaining within designated river reaches. Delisting criteria are undeterminable at this time. Preliminary downlisting criteria have been identified, however these criteria may be modified or expanded in the future. Under the current preliminary criteria, downlisting may be considered when (1) a population structure with at least 10 percent sexually mature females occurring within each recovery-priority management area has been achieved, and when (2) sufficient population numbers are present to maintain stability.

Actions Needed:

1. Restore habitats and functions of the Missouri and Mississippi River ecosystems while minimizing impacts on other uses of the rivers.

2. Protect pallid sturgeon and their habitat, and minimize threats from existing and proposed human activities.

3. Increase public awareness of the laws and needs for protecting pallid sturgeon.

4. Establish refugia of pallid sturgeon broodstock.

5. Obtain information on life history and habitat requirements of all life stages of pallid sturgeon.

6. Research additional solutions to the impacts of human activities on pallid sturgeon and their habitat.

7. Obtain information on genetic makeup of hatchery-reared and wild *Scaphirhynchus* stocks.

8. Obtain information on population status and trends.

9. Obtain information on chemical contamination of pallid sturgeon and their habitat.

10. Obtain information on biological threats.

11. Develop policy on a pallid sturgeon propagation and stocking program.

12. Research methods to improve spawning, culture, and rearing of pallid sturgeon in hatcheries.

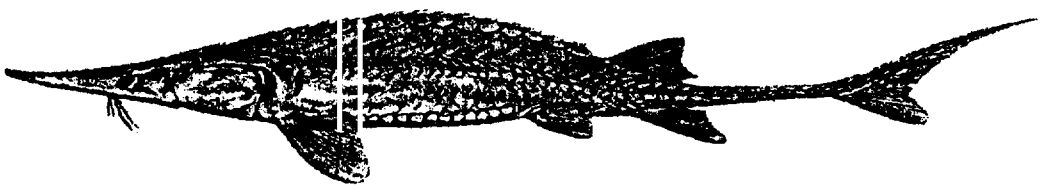
13. Reintroduce pallid sturgeon and/or augment existing populations.

14. Communicate with sturgeon researchers and managers.

15. Support implementation of the Pallid Sturgeon Recovery Plan.

Recovery Cost: Undeterminable at this time.

Date of Recovery: 2040, if recovery criteria are met.



Pallid Sturgeon (*Scaphirhynchus albus*)

Part I

INTRODUCTION

History:

Pallid sturgeon (*Scaphirhynchus albus*) evolved from an ancient group of bony fishes, the subclass Paleopterygii, which was dominant during the Paleozoic Era. This group continued to flourish through the late Paleozoic Era and early Mesozoic Era. Most species in this subclass became extinct sometime in the Mesozoic Era. The living descendants of this group in North America include paddlefish (Polyodontidae), and eight species of sturgeon (Acipenseridae).

The North American species of sturgeon, in addition to pallid sturgeon, are the shovelnose sturgeon (*Scaphirhynchus platorynchus* Rafinesque); white sturgeon (*Acipenser transmontanus* Richardson); green sturgeon (*Acipenser medirostris* Ayres); Atlantic sturgeon (*Acipenser oxyrhynchus* Mitchill); shortnose sturgeon (*Acipenser brevirostrum* LeSueur); and lake sturgeon (*Acipenser fulvescens* Rafinesque). An eighth species, the Alabama sturgeon (*Scaphirhynchus suttkus* Williams), was recently described from the Mobile Basin in Alabama and Mississippi (Williams and Clemmer 1991). This location is outside the range of pallid sturgeon and is not included in further discussions of *Scaphirhynchus* species in this plan.

The pallid sturgeon was first described by S.A. Forbes and R.E. Richardson in 1905 from nine specimens collected from the Mississippi River near Grafton, Illinois, in June 1904 (Forbes and Richardson 1905). Known locally as the white sturgeon, they named it *Parascaphirhynchus albus* and suggested it be considered as its own genus. Later classifications, however, placed it in the genus *Scaphirhynchus* where it has remained (Bailey and Cross 1954).

Electrophoretic analysis of the two species of *Scaphirhynchus* have suggested a very close genetic relationship. Phelps and Allendorf (1983), using electrophoretic techniques, were unable to distinguish the species by looking at 37 enzyme systems. Pallid sturgeon from the Missouri River in Missouri and shovelnose sturgeon from the Missouri, Yellowstone, and Mississippi Rivers were analyzed. The authors concluded that the close genetic similarity of pallid sturgeon and shovelnose sturgeon was due to recent or incomplete reproductive isolation.

General Description:

Pallid sturgeon have a flattened, shovel-shaped snout; long, slender, and completely armored caudal peduncle; and lack a spiracle (Smith 1979). As with other sturgeon, the mouth is toothless, protrusible, and ventrally positioned under the snout. The skeletal structure is primarily cartilaginous (Gilbraith et al. 1988). Pallid sturgeon are similar in appearance to the more common, darker shovelnose sturgeon. Pflieger (1975) reports the principal features distinguishing pallid sturgeon from shovelnose sturgeon are the paucity of dermal ossifications on the belly, 24 or more anal fin rays, and 37 or more dorsal fin rays.

Bailey and Cross (1954) measured morphological characteristics of pallid sturgeon collected from the middle and lower Missouri River and middle Mississippi River. They found the ratio between the lengths of the inner and outer barbels of pallid sturgeon and shovelnose sturgeon to be one of the quickest and most reliable means for separation of these two *Scaphirhynchus* species: the outer barbel is 1.2-1.5 times longer than the inner barbel in the shovelnose and 1.7 to 2.4 times longer in the pallid. Bailey and Cross (1954) also found that the inner barbels of pallid sturgeon typically lie ahead of the outer barbels, unlike on shovelnose sturgeon, where they are typically in-line. Furthermore, in pallid sturgeon, all the barbels are further back on the lower surface of the snout than in shovelnose sturgeon: the "snout tip to outer barbel/mouth to inner barbel" ratio varies from 2.3 to 3.3 in pallid sturgeon and 1.3 to 2.2 in shovelnose sturgeon (Bailey and Cross 1954) (Figure 1).

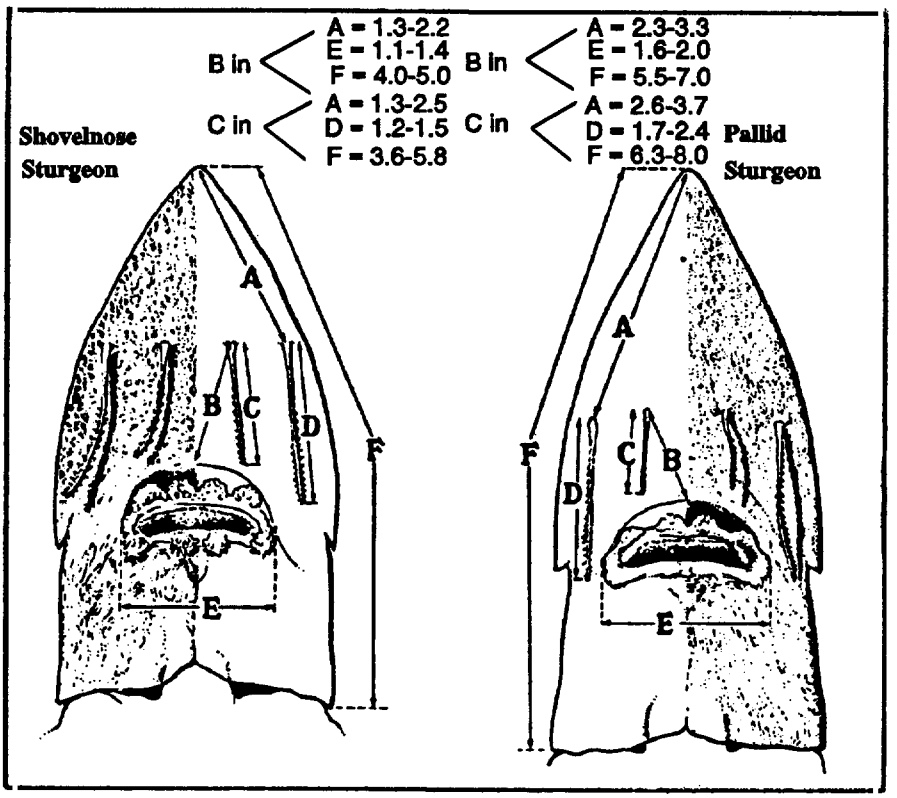


Figure 1: Comparative diagrams of the ventral surface of the head of shovelnose sturgeon and pallid sturgeon, showing several measurement ratios of value for identification. Redrawn from Bailey and Cross (1954).

Fishery researchers and managers have found that in most cases the ratios shown in Figure 1 more clearly separated the species in the upper basin States than they did in the lower basin States. They also found that upper basin specimens of both species are typically larger in average weight and length than species collected from the lower Missouri River and Mississippi River.

Although in most instances pallid sturgeon are lighter in color than shovelnose sturgeon, coloration cannot consistently be relied upon as a means of separating the two species (Kallemeyn 1983).

The pallid sturgeon is one of the largest fish species found in the Missouri/Mississippi River drainage, with specimens approaching 39 kilograms (kg) (86 lbs) reported (Gilbraith et al. 1988). Adult pallid sturgeon collected from the upper Missouri River are generally larger than adults collected from the middle Missouri River and Mississippi River. The maximum recorded weight of a pallid sturgeon collected from the Missouri River in Montana and North Dakota is approximately 39 kg (86 lbs). From the Missouri River in South Dakota and Nebraska, the maximum weight recorded is approximately 21 kg (46 lbs). In the Mississippi River the maximum weight recorded is approximately 12 kg (26 lbs).

Historical Distribution and Abundance:

The historic range of pallid sturgeon as described by Bailey and Cross (1954) encompassed the middle and lower Mississippi River, the Missouri River, and the lower reaches of the Platte, Kansas, and Yellowstone Rivers (Figure 2).

The pallid sturgeon was not recognized as a species until 1905, therefore little is known concerning its early abundance and distribution (Pflieger 1975), but available information suggests a probable decline since the species was described. Forbes and Richardson (1905) and Bailey and Cross (1954) indicated that the species was always uncommon. Of the 250 pallid sturgeon reported by Bailey and Cross (1954), approximately 76 percent were collected from the Missouri River in Montana and the Dakotas; most were collected in the upper ends of the five main stem reservoirs as they were filling.

At the time of their original description, pallid sturgeon composed 1 in 500 river sturgeon captured in the Mississippi River at Grafton, Illinois (Forbes and Richardson 1905). Pallid sturgeon were more abundant in the lower Missouri River near West Alton, Missouri, where they composed one-fifth of the river sturgeon captured (Forbes and Richardson 1905). Bailey and Cross (1954) provided additional information on the proportions of pallid sturgeon in the total commercial catch of river sturgeon from various parts of the species' range as follows: Kansas River at Lawrence, Kansas (8 percent); Missouri River in South Dakota, 3 of 62 specimens (5 percent); and Mississippi River at New Orleans, 3 of 4 specimens (75 percent). Fisher (1962) recorded 4 of 13 river sturgeons (31 percent) from the Missouri River in Missouri as pallid sturgeon. Comparable commercial catch records are not available for the upper river reaches where commercial fishing was light or nonexistent.

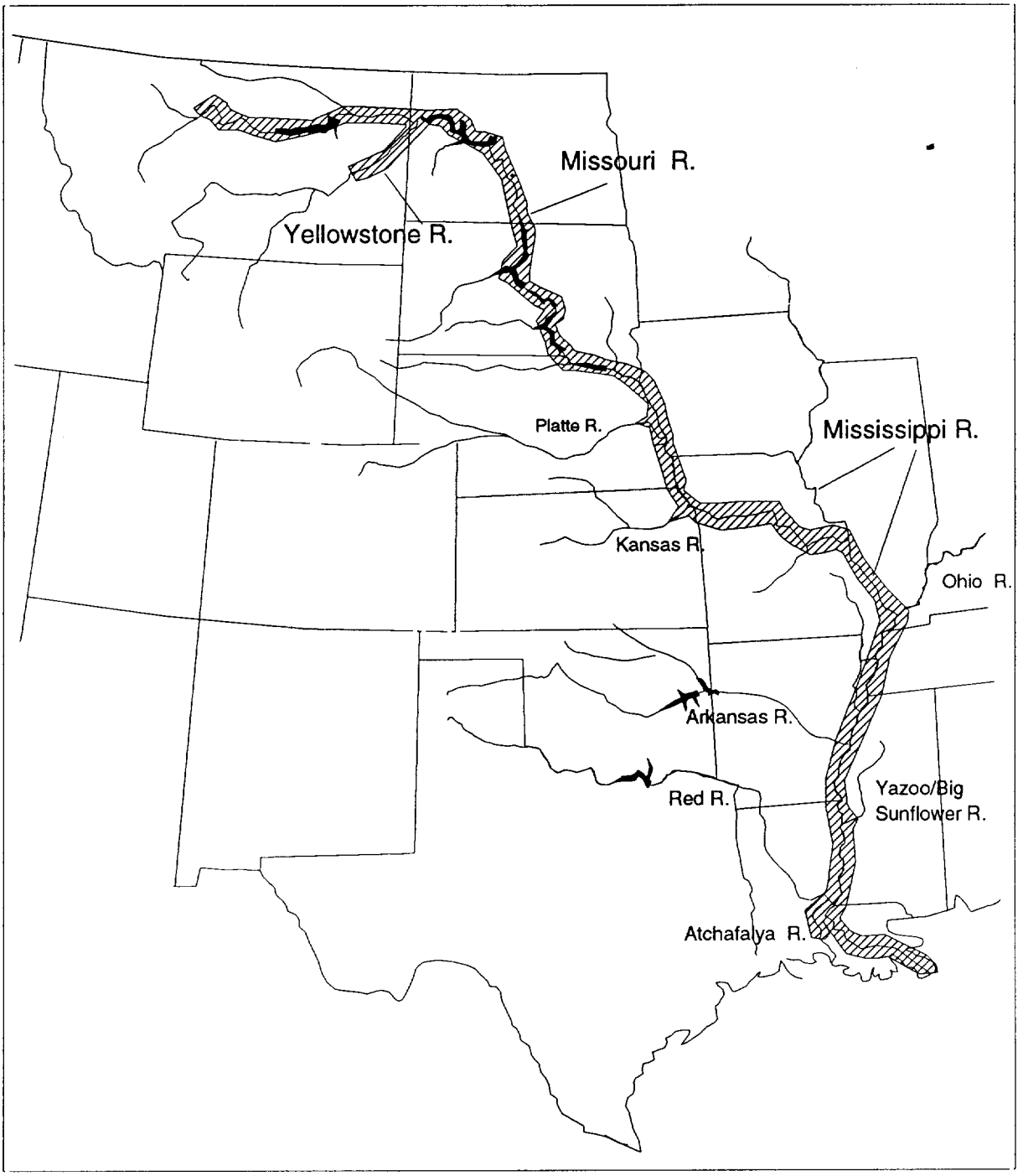


Figure 2. Historic range of pallid sturgeon. ---

Present Distribution and Abundance:

Pallid sturgeon remain one of the rarest fish of the Missouri and Mississippi River basins. Carlson and Pflieger (1981) stated that pallid sturgeon are rare, but widely distributed in the Missouri River and in the Mississippi River downstream from the mouth of the Missouri River. Keenlyne (1989) recently updated information on distribution of the pallid sturgeon. Keenlyne reported pre-1980 catch records in the Mississippi River from its mouth upstream to its confluence with the Missouri River, a length of 1,857 kilometers (km) (1,154 miles (mi)); in the lower 56 km (35 mi) of the Yazoo/Big Sunflower and St. Francis Rivers (tributaries to the Mississippi); in the Missouri River from its mouth to Fort Benton, Montana, a length of 3,323 km (2,065 mi); and in the lower 64 km (40 mi) of the Kansas River, the lower 34 km (21 mi) of the Platte River, and the lower 322 km (200 mi) of the Yellowstone River (tributaries to the Missouri River). The total length of the species' range is approximately 5,656 km (3,515 mi) of river. States within this range are Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, Missouri, Illinois, Kentucky, Tennessee, Arkansas, Mississippi, and Louisiana.

Since 1980, reports of most frequent occurrence (Figure 3) are from the Missouri River between the Marias River and Ft. Peck Reservoir in Montana; between Ft. Peck Dam and Lake Sakakawea (near Williston, North Dakota); within the lower 113 km (70 mi) of the Yellowstone River to downstream of Fallon, Montana; in the headwaters of Lake Sharpe in South Dakota; and from the Missouri River near the mouth of the Platte River near Plattsmouth, Nebraska. Areas of most recent and frequent occurrence on the Mississippi River are near Chester, Illinois; Caruthersville, Missouri; and in both the Mississippi and Atchafalaya Rivers in Louisiana at the Old River Control where the Atchafalaya diverges from the Mississippi River (Mark Dryer, U.S. Fish and Wildlife Service, pers. comm.).

Larval sturgeon of any species rarely have been collected from within the range of pallid sturgeon. This may be due to low reproductive success or the inability of standard sampling gear to capture larval sturgeon. Hesse and Mestl (1993a) collected two sturgeon larvae from the Missouri River adjacent to Nebraska between 1983 and 1991 (the species of sturgeon is not yet distinguishable at larval stages). These larvae were among 147,000 fish larvae collected during filtration of 519,400 cubic meters of river water. Gardner and Stewart (1987) collected no sturgeon larvae in 339 samples from the Missouri River or in 77 samples from tributary streams where 3,124 and 5,526 fish larvae were collected, respectively.

Habitat Preference:

Forbes and Richardson (1905), Schmulbach et al. (1975), Kallemeyn (1983), and Gilbraith et al. (1988) describe pallid sturgeon as being a fish well adapted to life on the bottom in swift waters of large, turbid, free-flowing rivers.

Figure 3. Frequent occurrences of pallid sturgeon. - -☆

Pallid sturgeon evolved in the diverse environments of the Missouri and Mississippi Rivers. Floodplains, backwaters, chutes, sloughs, islands, sandbars, and main channel waters formed the large-river ecosystem that provided macrohabitat requirements for pallid sturgeon and other native large-river fish, such as paddlefish and other sturgeon. These habitats were historically in a constant state of change. Today these habitats and much of the once naturally functioning ecosystem has been changed by human developments.

The historic floodplain habitat of the Missouri and Mississippi Rivers provided important functions for the native large-river fish. Floodplains were the major source of organic matter, sediments, and woody debris for the main stem rivers when floodflows crested the river's banks. The transition zone between the vegetated floodplain and the main channel included habitats with varied depths described as chutes, sloughs, or side channels. The chutes or sloughs between the islands and shore were shallower and had less current than the main channel. These areas provided valuable diversity to the fish habitat and probably served as nursery and feeding areas for many aquatic species (Funk and Robinson 1974). The still waters in this transition zone allowed organic matter accumulations, important to macroinvertebrate production. Both shovelnose sturgeon and pallid sturgeon have a high incidence of aquatic invertebrates in their diet (Carlson et al. 1985; Gardner and Stewart 1987). Floodflows connected these important habitats and allowed fish from the main channel to utilize these habitat areas and to exploit available food sources.

Floodflows also stimulated spawning migrations. Before impoundment behind reservoirs, there were two periods of peak discharge on the Missouri River; one in April resulting from spring runoff and snowmelt on the Great Plains and a second higher peak in late May to early June resulting from mountain snowmelt. Both shovelnose sturgeon and paddlefish spawning migrations occur in response to increased flows in June (Berg 1981). Although there is no information on pallid sturgeon spawning migrations, it is assumed these migrations would similarly occur in response to increased June flows.

Micro-habitat characteristics of pallid sturgeon are just recently being described. Much of the micro-habitat research to date has been a characterization of habitat where pallid sturgeon are being located in the significantly altered environments of today. This research does not necessarily indicate preferred or required habitats; instead it may only indicate which habitats of those presently available are used by the pallid sturgeon. Also capture locations may have conditions representing seasonal habitat preferences.

Current Velocity: Preliminary findings from a study on the Missouri River in South Dakota indicate that pallid sturgeon most frequently occupy river bottoms where velocity ranges from 10 to 30 centimeters per second (cps) (0.33 to 0.98 feet/sec), (J. Erickson, South Dakota State University, pers. comm. 1992). Studies on microhabitat selection of pallid sturgeon in Montana found that they are most frequently associated with water velocity ranging from 40 to 90 cps (1.3 to 2.9 feet/sec) (P. Clancey, Montana Dept. of Fish, Wildlife,

and Parks, pers. comm. 1992). These velocities are commonly found throughout the species' range.

Pallid sturgeon collected from the Missouri River above Garrison Reservoir in North Dakota during spring and fall seasons of 1988 to 1991 were found in deep pools at the downstream end of chutes and sandbars, and in the slower currents of near-shore areas (A. Sandvol, U.S. Fish and Wildlife Service, pers. comm. 1992). These areas may have been providing good habitat for energy conservation and feeding.

Turbidity: Pallid sturgeon historically occupied turbid river systems. Turbidity levels where pallid sturgeon have been found in South Dakota range from 31.3 Nephelometric turbidity units (NTU) to 137.6 NTU (J. Erickson, pers. comm. 1992).

Water Depth: The range of water depths where pallid sturgeon were frequently found in South Dakota are 2 to 6 m (7 to 20 ft) (J. Erickson, pers. comm. 1992). In Montana, pallid sturgeon were captured from depths that ranged from 1.2 to 3.7 m (3.9 to 12.1 ft) in the summer, but they were captured in deeper waters during winter (P. Clancey, pers. comm. 1992). During late summer in North Dakota, pallid sturgeon were captured at depths that ranged from 2.1 to 7.6 m (6.9 to 24.9 ft) (A. Sandvol, pers. comm. 1992). One pallid sturgeon collected on the Yellowstone River in July 1991 was captured at a depth of 1 to 2 m (3.3 to 6.6 ft) (Watson and Stewart 1991). One pallid sturgeon collected in the lower Platte River in May 1989 was captured at a depth of 1.5 m (4.9 ft) (M. Harberg, U.S. Army Corps of Engineers, pers. comm. 1992).

Substrate: Pallid sturgeon are most frequently caught over a sand bottom, which is the predominant bottom substrate within the species' range on the Missouri and Mississippi Rivers. The pallid sturgeon collected on the Yellowstone River in July 1991 by Watson and Stewart (1991) was over a bottom of mainly gravel and rock, which is the predominant substrate at that capture site.

Temperature: Pallid sturgeon inhabit areas where the water temperatures range from 0°C to 30°C (32°F to 86°F), which is the range of water temperature on the Missouri and Mississippi Rivers. There is no information to indicate temperature preference or the effects of temperature on the species. Curtis (1990) found no relation between surface water temperatures and depth used by shovelnose sturgeon on the Mississippi River and no indication that shovelnose sturgeon were moving into deeper, cooler water (if available) as water temperature increased.

Life History

Reproductive Biology: Little is known about reproduction or spawning activities of pallid sturgeon. Even basic parameters such as spawning locations, substrate preference, water temperature, or time of year have not been documented. No spawning beds have been located and larval pallid sturgeon have not been recorded by investigators. (There is presently no information available that distinguishes larval pallid sturgeon from larval

shovelnose sturgeon. All larval *Scaphirhynchus* spp. that have been collected have been classified as shovelnose sturgeon because of the rarity of pallid sturgeon.) Spawning reportedly occurs between June and August (Forbes and Richardson 1905). Females collected in June and July in Lake Sharpe, a reservoir on the Missouri River in South Dakota, contained mature ova and presumably were ready to spawn. However, there has been no evidence of successful reproduction during 10 years of sampling for young-of-the-year fish in Lake Sharpe (Kallemeyn 1983).

Kallemeyn (1983) reported that pallid sturgeon males reach sexual maturity at 53.3-58.4 cm (21 to 23 in), but size and age of females at sexual maturity are unknown. Conte et al. (1988) indicated that females of most sturgeon in North America do not mature until 7 years of age and typically require several years for eggs to mature between spawnings.

The age of sexual maturity and intervals between spawning were estimated for nine pallid sturgeon by recording what were interpreted to be spawning events from pectoral fin ray cross sections (L. Jenkins, U.S. Fish & Wildlife Service, pers. comm. 1991). Sexual maturity for males was estimated to be 7 to 9 years, with 2- to 3-year intervals between spawning years. Females were estimated to reach sexual maturity in 15 to 20 years, with 3- to 10-year intervals between spawning years. Time of sexual maturity and the intervals between spawning years is likely to be influenced by available forage, environmental conditions, and other factors.

Keenlyne et al. (1992) estimated fecundity for a female pallid sturgeon taken from the upper Missouri River. The authors found the mass of mature eggs weighed 1,952 g, which represented 11.4 percent of total body weight. Total fecundity was estimated at 170,000 eggs for this female.

While there may be differences in the spawning requirements between the pallid sturgeon and shovelnose sturgeon, the shovelnose sturgeon still provides the closest model for determining spawning requirements. Because there is little information available on pallid sturgeon spawning, spawning requirements are extrapolated from what is known regarding shovelnose sturgeon spawning. Shovelnose sturgeon spawn over substrates of rock, rubble, or gravel in the main channel of the Missouri/Mississippi Rivers and major tributaries, or on wing dams in the main stem of larger rivers (Christiansen 1975; Elser et al. 1977; Moos 1978; Helms 1974). Shovelnose sturgeon spawning occurs in the unchannelized Missouri River near Vermillion, South Dakota, when water temperatures reach 18°C to 19°C.(64°F to 66°F), which can be from late May through June. Spawning was suspected to occur in the relatively swift water in or near the main channel (Moos 1978). Shovelnose sturgeon spawning occurs in the Tongue River, Montana, a Yellowstone River tributary, from early June until mid-July at water temperatures of 16.9°C to 21.5°C (61°F to 70°F) (Elser et al. 1977). Initiation of shovelnose sturgeon spawning migrations have been associated with increased flows in June (Berg 1981).

Food and Feeding Habits: Carlson et al. (1985) determined composition of food categories, by volume and frequency of occurrence, in the diet of shovelnose sturgeon (n=234), pallid sturgeon (n=9), and presumed hybrids (n=9). Aquatic

invertebrates (principally the immature stages of insects) composed most of the diet of shovelnose sturgeon, while pallid sturgeon and presumed hybrids consumed a greater proportion of fish (mostly cyprinids). Other researchers also reported a higher incidence of fish in the diet of pallid sturgeon than in the diet of shovelnose sturgeon (Cross 1967; Held 1969).

Most piscivorous Missouri River species eat large quantities of aquatic insect larvae in early life and even as adults. Shovelnose sturgeon were found to consume large numbers of *Hydropsyche* spp. and *Psychomyiidae* (Tricopteran larvae) (Modde and Schmulbach 1977).

Age and Growth: Little is known about age and growth of pallid sturgeon. The total length of pallid sturgeon was significantly greater than that of shovelnose sturgeon in the lower Missouri and Mississippi Rivers for each age group in which comparable data were available (Carlson et al. 1985). Fogle (1963) estimated growth rates using cross sections of pectoral fin rays from six pallid sturgeon from Lake Oahe in South Dakota. He estimated that growth of these fish was relatively rapid during the first 4 years, but that growth decreased to approximately 70 mm (4 in) per year between ages 5 and 10. Carlson and Pflieger (1981) presented data (n=8) from the Missouri and Mississippi Rivers in Missouri, which showed slightly slower growths than from pallid sturgeon in South Dakota.

By interpreting cross sections of pectoral fin rays, L. Jenkins (pers. comm. 1991) estimated that pallid sturgeon can live more than 40 years.

Reasons for Decline

Habitat Loss: Destruction and alteration of habitats by human modification of the river system is believed to be the primary cause of declines in reproduction, growth, and survival of pallid sturgeon. It is unlikely that successfully reproducing populations of pallid sturgeon can be recovered without restoring the habitat elements (morphology, hydrology, temperature regime, cover, and sediment/organic matter transport) of the Missouri and Mississippi Rivers necessary for the species continued survival.

On the main stem of the Missouri River, approximately 36 percent of riverine habitat within the pallid sturgeon's range was eliminated by construction of six massive earthen dams between 1926 and 1952 and another 40 percent has been channelized. The remaining 24 percent has been altered due to changes in water flows caused by dam operations.

These dams also are believed to have adversely affected pallid sturgeon by blocking migration routes and by causing inundation of spawning and nursery areas.

Channelization of the Missouri and Mississippi Rivers began at the turn of the century and continues to the present. Channelization causes changes in water velocity, reduces the width of the river, and prevents water flow into backwaters. In the channelized reach downstream of Sioux City, Iowa, the Missouri River that was once a diverse assembledge of braided channels, sandbars, and backwaters is now confined within a narrow channel of rather

uniform width and swift current. Funk and Robinson (1974) calculated that the length of the Missouri River between Rulo, Nebraska, and its mouth (≈500 river miles) had been reduced by 8 percent and the water surface area had been reduced by 50 percent following channelization.

The Missouri River habitat between and downstream of main stem dams has been altered by removal of snags, reductions in sediment and organic matter transport/deposition, channel degradation, flow modification, hypolimnetic releases, and narrowing of the river through channelization. These activities have adversely impacted the natural river dynamics by reducing the diversity of bottom contours and substrate, slowing accumulation of organic matter, reducing overbank flooding, changing seasonal flow patterns, severing flows to backwater areas, and reducing turbidity and water temperature.

The middle Mississippi River from the mouth of the Missouri River to the mouth of the Ohio River is principally channelized with few remaining secondary channels, sandbars, islands, and abandoned channels. The middle Mississippi River has been extensively diked to maintain a 2.7 m (9 feet) navigation channel, and flood control levees have reduced the size of the floodplain by 39 percent. The surface area of the fluvial landscape in 1968 was 260 km^2 (100 mi^2) (17 percent islands, 83 percent riverbed), 39 percent less than in 1888 (Fremling 1989). The constricted channel and bed degradation have contributed to river fluctuations by as much as 15 m (50 feet) annually, effectively dewatering some secondary channels during low stages (Fremling 1989).

Levee construction on the lower Mississippi River from the Ohio River to near the Gulf have eliminated major natural floodways and reduced the land area of the floodplain by more than 90 percent (Fremling 1989). Fremling (1989) also reports that levee construction isolated many floodplain lakes and raised river banks. As a result of levee construction, 15 meander loops were severed between 1933 and 1942.

The pattern of flow velocity, volume, and timing of the predevelopment Missouri River provided the essential life requirements of native large-river fish like the pallid sturgeon and paddlefish. Hesse and Mestl (1993a) found a significant relationship between the density of paddlefish larvae and two indices (timing and volume) of discharge from Fort Randall Dam. When dam operations caused discharge to fluctuate widely during spring spawning, the density of drifting larvae was lower ($R = -0.3728$, $P = 0.17$). Also, when annual runoff volume was highest, paddlefish larval density was highest ($R = 0.4014$, $P = 0.13$). Hesse and Mestl (1987) modeled these same two indices of discharge from Fort Randall Dam with an index of year class strength. They demonstrated significant negative relationships between artificial flow fluctuations in the spring and poor year class development for several native fish species, river carpsucker (*Carpiodes carpio*), shorthead redhorse (*Moxostoma macrolepidotum*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), sauger, common carp (*Cyprinus carpio*), smallmouth buffalo (*Ictiobus bubalus*), and bigmouth buffalo (*I. cyprinellus*). The sample size of sturgeon was too small to model in that study; however,

there was a clear relationship between poor year class development in most native species studied and the artificial hydrograph.

Before impoundment behind Missouri River reservoirs (1926 to 1952), peak discharges generally occurred in April, and then again with a larger peak in June (Pflieger and Grace 1987). Today, dam operations reduce flows from April to July for flood control, and increase flows from July to April for navigation, water supply, and hydropower. In addition to such seasonal shifts in the flow patterns, main stem dams operating for daily hydropower needs can cause daily fluctuations in water levels in tailwater areas by as much as 2 to 3 m (6.6 to 9.8 ft). This fluctuation can disrupt the macroinvertebrate community and larval fish rearing areas for many miles downstream of the dam by alternately flooding and dewatering habitats.

Modde and Schmulbach (1973) observed that factors affecting shovelnose sturgeon prey availability within the unchannelized Missouri River include temperature, seasonal recruitment, and changes in density influenced by the timing and discharge rates from Gavins Point Dam. They hypothesized that the reduction in numbers of shovelnose sturgeon may be due to reduced availability of prey species caused by high discharges from Gavins Point Dam.

Before the Missouri River was channelized and impounded, it annually eroded 3.1 hectares/km of its floodplain (U.S. Army Corps of Engineers 1981). Most of this erosion has stopped due to channelization and impoundment. Erosion was a natural function of the river system, and through erosion, inorganic sediments, organic matter, and large woody debris were introduced into the river. This material import was essential to the habitat dynamics and nutrient cycling of the river system. Such sediment and nutrient discharge are the raw materials for habitat development in the Missouri and Mississippi River system. Construction of dams eliminated 80 percent of this material.

Fremling (1989) reports that the sediment load of the middle Mississippi River has declined 66 percent from pre-1935 levels, mainly due to sediment entrapment in Missouri River impoundments. This lack of sediment delivery upset the natural channel equilibrium and was replaced by a variety of nonequilibrium processes such as hydraulic sorting and bed paving, which eventually will eliminate all sediment movement. This has already occurred to some extent and has resulted in reduced bed roughness and, therefore, reduced substrate diversity. This has reduced the reproductive success of substrate spawners, such as sauger (*Stizostedion canadense*), sturgeon, and paddlefish (Hesse and Mestl 1993b).

The turbidity caused by suspended sediment also provided the pallid sturgeon and other native fish, adapted to living in a nearly sightless world, with cover while moving from one snag or undercut bank to another. Today, water clarity has increased dramatically, and this essential cover is gone. Under such conditions, predation by sight-feeding predators, such as northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), and smallmouth bass (*micropterus dolomieui*), can be expected to significantly impact native species not equipped by evolution with good eyesight.

It is also suspected that increased clarity of the Missouri River has affected food availability by changing species composition and by making it more difficult for pallid sturgeon, and other native species, to capture prey in the clearer water environment. In the Missouri River, pelagic planktivores and sight-feeding carnivores have increased in abundance, whereas species specialized for life in the turbid, predevelopment river (like the pallid sturgeon) have decreased in abundance (Pflieger and Grace 1987). This change in community structure is less apparent where changes in the natural hydrograph, temperature regime, and turbidity are less pronounced.

Flood flows were essential for the dynamic transport of sediment and the re-arrangement of these sediments into natural morphological channel features (fish habitat); it served to introduce and transport organic matter from the floodplain; and to maintain turbidity. Flood flows were the principle method for the introduction of large woody debris and carried nutrients to floodplain plant communities, which determined floodplain forest composition and structure. Invertebrate reproduction and behavioral migration was closely tied to the natural hydrograph (Hesse and Mestl 1993c).

Nearly all snags were removed from the Missouri River between 1838 and 1950. This, plus the cessation of flooding and meandering as a result of damming and channelizing the river has reduced the availability of organic matter supplies utilized by the aquatic invertebrate community (Hesse and Mestl 1993a). Snags influence sediment routing, thus creating pools, gravel bars, and depositional areas, which in turn reduce the rate of downstream transport of particulate organic matter (Bilby and Ward 1991; Bilby and Likens 1980).

Snags also provide habitat for aquatic insects that make up a large proportion of both the shovelnose and pallid sturgeon's diet. These insects are collector-filterer-gatherers (Merritt and Cummins 1984). They cling to large woody debris in high velocity areas, gathering drifting diatoms, algae, animals, and organic detritus. Mestl and Hesse (1993) documented a decline in the abundance of snag insect production of more than 65 percent in Nebraska's portion of the Missouri River between 1963 and 1980.

In spite of man's efforts to constrict and control the Missouri and Mississippi Rivers with reservoirs, stabilized banks, jetties, dikes, levees and reventments that result in impacts described above, remnant reaches of the Missouri River and the Mississippi River from the Missouri River confluence to the Gulf still provide habitat believed usable by pallid sturgeon. These remnants described later as Recovery-Priority Management Areas are priority areas for implementation of recovery actions.

Commercial Harvest: Historically, pallid, shovelnose, and lake sturgeon were commercially harvested on the Missouri and Mississippi Rivers (Helms 1974). The larger lake and pallid sturgeon were sought for their eggs which were sold as caviar, whereas shovelnose sturgeon were destroyed as a bycatch. Commercial harvest of all sturgeon has declined substantially since record keeping began in the late 1800's. Most commercial catch records for sturgeon have not differentiated between species. Combined harvests as high as 195,450 kg (430,889 lbs) were recorded in the Mississippi River in the early 1890's, but had declined to less than 9,100 kg (20,062 lbs) by 1950 (Carlander

1954). Lower harvests reflected a decline in shovelnose sturgeon abundance since the early 1900's (Pflieger 1975).

Today, mortality of pallid sturgeon occurs from both sport and commercial fishing activities. In 1990, the head of a pallid sturgeon was found at a sport-fish cleaning station in South Dakota, and in 1992 a pallid sturgeon was found dead in a commercial fisherman's hoop net in Louisiana.

The States of North Dakota, South Dakota, and Louisiana require the release of all sturgeon whether taken commercially or for sport. Neither Montana nor Kansas allow commercial harvest of sturgeon. Sturgeon continue to be harvested as a bycatch of commercial fishing operations in Nebraska, Iowa, Missouri, Illinois, Kentucky, Tennessee, Arkansas, and Mississippi.

Pollution/Contaminants: Although more information is needed, pollution is a likely threat to the species over much of its range. Pollution of the Missouri River by organic wastes from towns, packing houses, and stockyards was evident by the early 1900's and continued to increase as populations grew and additional industries were established along the river (Whitley and Campbell 1974). Due to the identified presence of a variety of pollutants, numerous fish-harvest and consumption advisories have been issued over the last decade or two from Kansas City, Missouri, to the mouth of the Mississippi River. This represents about 45 percent of the pallid sturgeon's range.

Polychlorinated biphenyls (PCB's), cadmium, mercury, and selenium have been detected at elevated concentrations in tissue of three pallid sturgeon collected from the Missouri River in North Dakota and Nebraska. Detectable concentrations of chlordane, DDE, DDT, and dieldrin also were found (Ruelle and Keenlyne 1991). Abandoned landfills, mines, sewage treatment plants, and industries have a high potential to contaminate pallid sturgeon habitats in several States. Some of these sites are currently listed as Superfund sites or are being studied by the Environmental Protection Agency for possible listing under Superfund or Resource Conservation and Recovery Act.

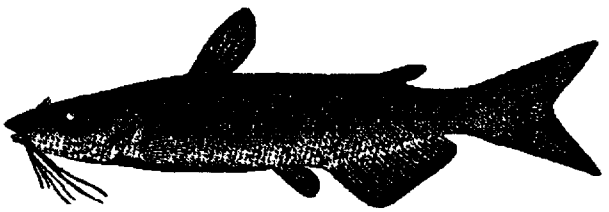
The prolonged egg maturation cycle of the pallid sturgeon (Conte et al. 1988), combined with an inclination for certain contaminants to be concentrated in eggs (Ohlendorf et al. 1981; Eisler 1986), could make contaminants a likely agent adversely affecting developing eggs, development of embryos, or survival of fry, and thereby reduce reproductive success (Ruelle and Keenlyne 1991).

Further investigations are needed to identify sources of contaminants in the Missouri and Mississippi Rivers and to assess the role of contaminants in the decline of pallid sturgeon populations.

Hybridization: Carlson et al. (1985) studied morphological characteristics of 4,332 sturgeon from the Missouri and middle Mississippi Rivers. Out of this group he identified 11 pallid sturgeon and 12 pallid/shovelnose hybrids. Suspected hybrids recently have been observed in commercial fish catches on the lower Missouri and the middle and lower Mississippi Rivers (K. Graham, Missouri Department of Conservation, pers. comm. 1992; B. Reed, Louisiana Dept. of Wildlife and Fisheries, pers. comm. 1992). Bailey and Cross (1954) did not report hybrids, which may indicate that hybridization is a recent

phenomenon resulting from environmental changes caused by human-induced reductions in habitat diversity and measurable changes in environmental variables such as turbidity, flow regimes, and substrate types (Carlson et al. 1985). A recent study by Keenlyne et al. (1993) concluded that hybridization may be occurring in half of the river reaches within the range of pallid sturgeon and that hybrids may represent a high proportion of remaining sturgeon stocks.

Hybridization is thought to be related to environmental degradation. Presumedly, the loss of habitat diversity caused by human-induced environmental changes inhibits reproductive isolating mechanisms naturally occurring among fish species. Also, the loss of total available spawning habitat forces sharing of suitable habitat areas by similar species, resulting in increased hybridization.



Channel Catfish (*Ictalurus punctatus*)

Part II

RECOVERY

Recovery Objectives and Criteria

Short-term: The short-term recovery objective for the pallid sturgeon is to prevent species extinction by establishing three captive broodstock populations in separate hatcheries that are initially composed of five to seven wild adult males and five to seven wild adult females each, by 1998. Immediate actions also will be undertaken to protect all wild individuals from harm, harassment, or death (take), protect remnant habitats, and to restore functions of the large-river ecosystem believed important to recover self-sustaining populations of pallid sturgeon.

Long-term: The long-term objective is to downlist and delist the species through protection and habitat restoration activities by 2040. Delisting may be considered when pallid sturgeon are reproducing naturally in the wild and populations are self-sustaining within each of six recovery-priority areas. Delisting criteria are undeterminable at this time. Preliminary downlisting criteria have been identified.

Downlisting may be considered when:

1. a population structure with at least 10 percent sexually mature females occurring within each recovery-priority management area has been achieved, and

2. when there are sufficient population numbers present in the wild to maintain stability. These population numbers are not yet quantifiable; additional biological and population information is needed.

These are interim criteria. These criteria may be modified or other downlisting criteria may be identified in the future as more information is obtained. Downlisting may be possible by 2025 if the required criteria are met.

Recovery-Priority Management Areas

Any remaining physical habitat for pallid sturgeon is typically now only found within the flowing reaches of the main stem Missouri, Yellowstone, and Mississippi Rivers. However, some recovery tasks include actions at main stem reservoirs and in major tributaries when those actions would benefit pallid sturgeon in downstream reaches. Six recovery-priority management areas are identified and will receive priority for implementation of appropriate recovery tasks. The recovery-priority areas were selected based upon most recent pallid sturgeon records of occurrence and the probability that these areas still provide suitable habitat for restoration and recovery of the species. These areas are typically the least degraded and have the highest habitat diversity, and in some reaches still exhibit a natural channel

configuration of sandbars, side channels, and varied depths. The confluence areas of major tributaries to the lower Missouri and Mississippi Rivers were emphasized in selecting recovery priority areas because of their importance as feeding and nursery areas for large-river fish.

River reaches outside the recovery-priority areas are not excluded from implementation of recovery actions, but are designated as lower priority because these areas have been altered to the extent that major modifications would be needed to restore their natural physical and hydrologic characteristics.

The recovery-priority areas (Figure 4) are (1) the Missouri River from the mouth of the Marias River to the headwaters of Ft. Peck Reservoir; (2) the Missouri River from Ft. Peck Dam to the headwaters of Lake Sakakawea, including the Yellowstone River upstream to the mouth of the Tongue River; (3) the Missouri River from 20 miles upstream of the mouth of the Niobrara River to Lewis and Clark Lake; (4) the Missouri River below Gavins Point Dam to its confluence with the Mississippi River; (5) the Mississippi River from its confluence with the Missouri River to the Gulf of Mexico; and (6) the Atchafalaya River distributary system to the Gulf of Mexico. Recovery priority areas 4 and 5 are further refined to encourage implementation of recovery tasks within 32 km (20 mi) upstream and downstream of major tributaries. In recovery priority area 4, the major Missouri River tributary areas include, but are not limited to, 32 km (20 mi) upstream and downstream of the Platte, Kansas, and Osage Rivers. In recovery priority area 5, the major Mississippi River tributary areas include, but are not limited to, 32 km (20 mi) upstream and downstream of the St. Francis, Arkansas, and Yazoo Rivers.

Recovery-priority areas may change as additional information on important habitats and spawning areas is obtained.

While there has been no evidence of pallid sturgeon reproducing within any of these areas, reproduction and recruitment of shovelnose sturgeon is occurring.

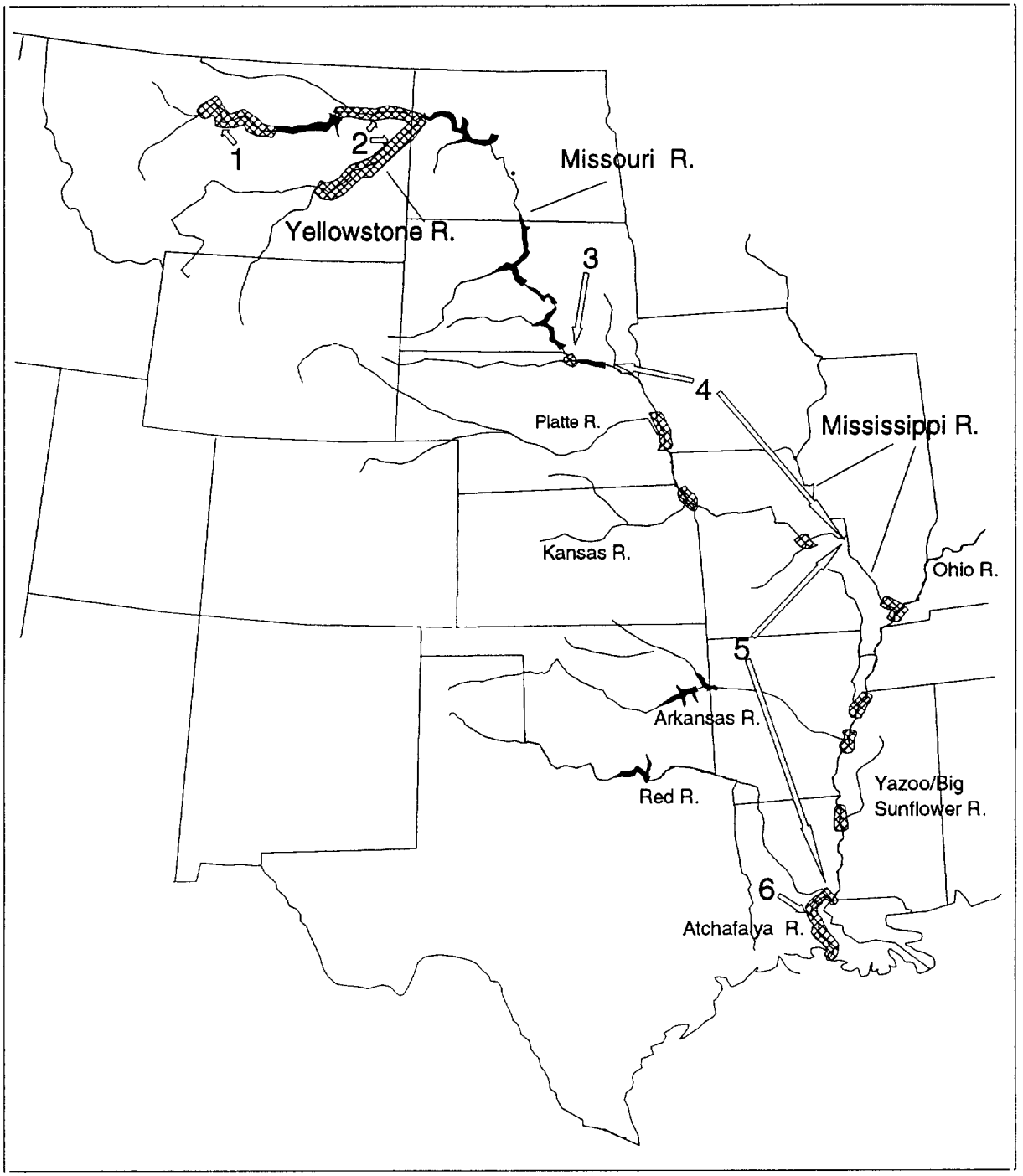


Figure 4. Recovery-priority management areas -

Recovery Outline

1. PROTECT AND RESTORE PALLID STURGEON POPULATIONS, INDIVIDUALS, AND THEIR HABITATS.

1.1.  **Restore habitats and functions of the Missouri and Mississippi River ecosystems, while minimizing impacts on other uses of the rivers.**

1.1.1. Restore the diversity of riverine habitats by reconnecting cut-off features along the Missouri and Mississippi Rivers.

1.1.2. Implement operational alternatives for main stem Missouri River and tributary dams using simulation models that will emulate precontrol hydrographs.

1.1.3. Restore the natural temperature regime of the Missouri River.

1.1.4. Restore large woody debris to the main stem Missouri and Mississippi Rivers and their larger tributaries.

1.1.5. Restore the dynamic equilibrium of sediment transport within the Missouri River.

1.1.6 Restore free movements of pallid sturgeon within high priority recovery areas.

1.2.  **Protect pallid sturgeon and their habitat and minimize threats from existing and proposed man-caused activities.**

1.2.1. Ensure Federal Agencies conduct section 7 consultations on all Federal actions that may affect pallid sturgeon.

1.2.2. Establish, maintain, and disseminate section 7 Biological Opinions evaluating impacts on pallid sturgeon.

1.2.3. Ensure water intakes and diversions are not adversely affecting pallid sturgeon populations.

1.2.4. Work with States within the pallid sturgeon's range to temporarily place a moratorium on commercial fishing of all sturgeon species.

1.2.5. Work with States to develop a policy that will ensure risk assessment prior to introductions of new nonindigenous and exotic species to the Missouri and Mississippi Rivers.

1.2.6. Include the pallid sturgeon in Appendix I to the Convention on International Trade in Endangered Species of Wildlife Fauna and Flora (CITES).

1.2.7. Remediate sources of environmental contaminants.

1.2.8. Provide protection for important habitat areas and needs of pallid sturgeon.

1.3.  **Increase public awareness of the laws and needs for protecting pallid sturgeon.**

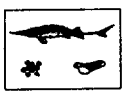
1.3.1. Develop and distribute information and education materials on the plight of the pallid sturgeon and its ecosystem.

1.3.2. Provide cultured pallid sturgeon to aquaria and comparable facilities where they can be viewed by the public.

1.4  **Establish refugia of pallid sturgeon broodstock.**

1.4.1. Collect pallid sturgeon broodstock from the wild and maintain refugia at three locations.

2. CONDUCT RESEARCH NECESSARY FOR SURVIVAL AND RECOVERY OF PALLID STURGEON.

2.1.  **Obtain information on life history and habitat requirements of all life stages of pallid sturgeon.**

2.1.1. Conduct investigations to determine age distribution, growth, and growth rates.

2.1.2. Conduct investigations to describe food habits and feeding behavior.

2.1.3. Conduct investigations to better define macro-habitat requirements.

2.1.4. Conduct investigations to describe microhabitat characteristics of spawning, feeding, staging, and rearing areas.

2.1.5. Conduct investigations to describe movements and behavior.

2.1.6. Map existing areas providing important habitat requirements.

2.1.7. Obtain an artist's descriptive key of developing larvae and early juveniles of pallid sturgeon, shovelnose sturgeon, and shovelnose X pallid hybrids.

2.1.8. Determine reliable, nonlethal aging techniques.

2.2.  **Research additional solutions to the impacts of man's activities on pallid sturgeon and their habitat.**

2.2.1. Identify priority areas and needs for restoring the diversity of riverine floodplain habitats.

2.2.2. Develop simulation models for operation of main stem Missouri River and tributary dams to benefit pallid sturgeon and provide for other uses.

2.2.3. Design multi-level releases from main stem Missouri River reservoirs.

2.2.4. Develop pilot projects on selected dams to transport sediment past the dam and into the river reaches downstream.

2.2.5. Determine the need for fish bypass facilities.

2.2.6. Determine the impact of sturgeon commercial and sport fishing on pallid sturgeon.

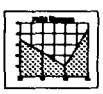
2.2.7. Determine the diagnostic characteristics to distinguish between eggs of sturgeon and paddlefish species.

2.3.  **Obtain information on genetic makeup of hatchery-reared and wild *Scaphirhynchus* stocks.**

2.3.1. Determine the degree of genetic divergence between *Scaphirhynchus* species within the range of pallid sturgeon.

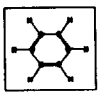
2.3.2. Identify genetically meaningful management units (stocks) of pallid sturgeon.

2.3.3. Determine the extent and management implications of hybridization between *Scaphirhynchus* species.

2.4.  **Obtain information on population status and trends.**

2.4.1. Establish sampling stations and monitor population status and trends.

2.4.2. Conduct a Population Viability Analysis to determine appropriate recovery numbers.

2.5.  **Obtain information on chemical contamination of pallid sturgeon and their habitat.**

2.5.1. Determine concentrations of organic and inorganic contaminants in pallid sturgeon, shovelnose sturgeon, their foods and habitats.

2.5.2. Determine effects of problem contaminants on growth, survival, and reproduction of pallid sturgeon.

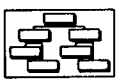
2.5.3. Identify all point and nonpoint sources of problem contaminants along the Missouri and Mississippi Rivers within the pallid sturgeon's range.

2.6.  **Obtain information on biological threats.**

2.6.1. Determine causes of hybridization.

2.6.2. Determine the extent of parasitism and disease, and the degree of competition and predation by introduced fishes.

3. DEVELOP AND IMPLEMENT A PALLID STURGEON CAPTIVE PROPAGATION PROGRAM.

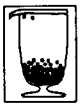
3.1.  **Develop policy on a pallid sturgeon propagation and stocking program.**

3.1.1. Develop a pallid sturgeon propagation plan.

3.1.2. Develop a pallid sturgeon stocking plan and plan for disposition of surplus fish.

3.1.3. Develop a tagging protocol for stocked fish.

3.1.4. Provide financial support to hatcheries for structural modifications, operation, and maintenance needed for a pallid sturgeon propagation program.

3.2.  **Research methods to improve spawning, culture, and rearing of pallid sturgeon in hatcheries.**

3.2.1. Determine protocol for collecting, handling, and transporting pallid sturgeon.

3.2.2. Determine efficient, effective spawning techniques in the hatchery and in the field.

3.2.3. Conduct trials to maximize survival of broodstock and progeny.

3.2.4. Develop cryopreservation techniques.

3.3.  **Reintroduce pallid sturgeon and/or augment existing populations.**

3.3.1. Conduct reintroduction/augmentation programs in accordance with the stocking plan.

4. COORDINATE AND IMPLEMENT CONSERVATION AND RECOVERY OF STURGEON SPECIES.

4.1.  **Communicate with sturgeon researchers and managers.**

4.1.1. Establish a clearinghouse for collection and dissemination of research and management information.

4.1.2. Communicate sturgeon recovery efforts.

4.1.3. Encourage and support publication of research, management, and other recovery-related information.

4.2.  **Support implementation of the Pallid Sturgeon Recovery Plan.**

4.2.1. Establish and fund a full-time position to serve as pallid sturgeon recovery coordinator.

4.2.2. Develop a long-term strategy for funding sturgeon recovery activities.

1. PROTECT AND RESTORE PALLID STURGEON POPULATIONS, INDIVIDUALS, AND THEIR HABITATS.

1.1. 

Restore habitats and functions of the Missouri and Mississippi River ecosystems while minimizing impacts on other uses of the rivers.

1.1.1. Restore the diversity of riverine habitats by reconnecting cut-off features along the Missouri and Mississippi Rivers.

Reservoirs on the upper Missouri River and bed degradation below dams have reduced the occurrence of overbank flows to the floodplain and through side channels, wetlands, and oxbows. Bankline modifications on the lower Missouri and Mississippi Rivers for navigation and flood control purposes have further confined river flows. Numerous side channels, wetlands, and oxbows that were once connected to the main channels are now separated. When connected, these floodplain habitats provided important nursery areas for native fishes and provided the primary source of carbon, nutrients, and the raw material for maintenance of the channel morphology. Any opportunities for restoring river flows to the floodplain and through separated aquatic habitats should be pursued vigorously, as it will benefit all flora and fauna endemic to the Missouri and Mississippi River ecosystem. Opportunities include the Missouri River Chutes Project proposed for the Missouri River in Nebraska and Iowa. Here side channels, oxbow wetlands, and floodplain woodlands would be restored in 137 river miles. Fee and/or easement acquisition of floodplain habitats may be necessary as part of restoration projects. See Task 1.2.8. Additional research is needed to identify priority areas and specific needs for restoration. See Task 2.2.1.

1.1.2. Implement operational alternatives for main stem Missouri River and tributary dams using simulation models that will emulate precontrol hydrographs.

River flows on the Missouri River and many of its tributaries are regulated by dams for economic benefits of flood control, hydropower, irrigation, navigation, water supply, and recreation. Agreements must be developed with the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and Western Area Power Administration to operate main stem dams so that seasonal habitat conditions are restored to simulate historic conditions while minimizing economic impacts.

All native big river fishes, including pallid sturgeon, evolved with the cycle of precipitation and runoff inherently part of the climate and geography of the basin or subbasin. Reproduction of predator and prey was timed with this pattern of water discharge. It is essential that the temporal and spatial patterns be restored, in part, if recovery of native fish species such as the pallid sturgeon will be realized. Additional research in development of simulation models will refine alternative operation scenarios that will best meet the needs of pallid sturgeon and other beneficial uses. See Task 2.2.2.

1.1.3. Restore the natural temperature regime of the Missouri River.

Main stem dams on the Missouri River operate with hypolimnetic releases that have significantly decreased water temperatures below dams during ice-free periods. These colder water temperatures have changed species composition and very likely have adversely affected spawning activities of pallid sturgeon. Opportunities to restore warmer water temperatures within high-priority recovery areas of the Missouri River should be investigated and implemented. Further research on design and practicality of multi-level releases from reservoirs is needed. See Task 2.2.3.

1.1.4. Restore large woody debris to the main stem Missouri and Mississippi Rivers and their larger tributaries.

Snags were physically removed from reaches of these rivers as a engineering tool to improve navigation. Also transport of trees from the floodplain has been reduced by control of overbank flows. This large woody debris originally provided by natural flood conditions provided essential instream habitat for native big river fishes and for the insect life that these fishes feed upon. Snags were instrumental in creating depositional areas with diverse conditions of depth and velocity within the main channels, slowing the transport of organic matter, reducing channel velocity, and maintaining diversity in bed substrates. Large woody debris should be reintroduced into the river system on a regular basis. A guideline for placement of snags and other large woody debris needs to be developed. Also ongoing snag removal programs need to be reviewed and reduced or terminated. Large woody debris can come from trees cut from riparian woodlots and/or using storm damaged trees from communities near rivers.

1.1.5. Restore the dynamic equilibrium of sediment transport within the Missouri River.

Main stem Missouri River dams have trapped sediments in reservoirs and bank stabilization has reduced erosion in riverine reaches. Additional sediment input, initially within

high-priority recovery areas, is necessary to restore instream habitats and turbid waters. Opportunities to restore the dynamic equilibrium of sediment transport should be pursued. Additional research is needed to determine mechanisms for transporting sediment past dams and into river reaches downstream. See Task 2.2.4.

1.1.6. Restore free movements of pallid sturgeon within high-priority recovery areas.

Dams and diversions impede pallid sturgeon from migrating to and from traditional spawning areas and other important seasonal habitats. Modifications may be needed at Ft. Peck Dam, a U.S. Army Corps of Engineers' dam on the Missouri River, and at the Intake diversion, a U.S. Bureau of Reclamation low-head diversion dam on the Yellowstone River, to allow free movement of pallid sturgeon within these recovery-priority areas. Modifications needed on other dams may be identified in the future.

Research on adult pallid sturgeon movements as described under Task 2.1.5 must be initiated as soon as possible to determine where, and if, bypass facilities are necessary. Additional research is needed on design of bypass facilities that sturgeon will use and their practicality. See Task 2.2.5.

1.2.  **Protect pallid sturgeon and their habitat and minimize threats from existing and proposed human activities.**

1.2.1. Ensure Federal Agencies conduct section 7 consultations on all Federal actions that may affect pallid sturgeon.

Section 7 of the Endangered Species Act will play a major role in the protection and recovery of pallid sturgeon. Federal Agencies must immediately consult with the U.S. Fish and Wildlife Service to ensure that actions they authorize, fund, implement, or permit are not likely to jeopardize the continued existence of pallid sturgeon. Recommendations will be made by the Service to preclude jeopardy and to conserve and recover the species.

1.2.2. Establish, maintain, and disseminate section 7 Biological Opinions evaluating impacts on pallid sturgeon.

A library of biological opinions should be established to facilitate interoffice consistency in determining a jeopardy threshold, alternatives, and conservation recommendations. This library will be maintained in the Bismarck Ecological Services Office.

1.2.3. Ensure water intakes and diversions are not adversely affecting pallid sturgeon populations.

The U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, Western Area Power Administration, other appropriate Federal or State agencies, and private industry need to undertake review of water intakes and diversions under their jurisdiction to ensure effectiveness in preventing loss of young and adult pallid sturgeon. New point-source water intakes serving industry, irrigation, and public water supply that may affect pallid sturgeon recruitment must be screened with a 1/4-inch (6.35 mm) mesh and have an intake velocity of less than 1/2 ft/sec (15.24 cm/sec), or be placed at water depths greater than 15 ft (4.575 m) to protect against entrainment or impingement of pallid sturgeon larvae and fingerlings. Existing intakes found to be adversely affecting pallid sturgeon populations should be redesigned on an as needed basis depending upon the magnitude of adverse affects.

1.2.4. Work with States within the pallid sturgeon's range to temporarily place a moratorium on commercial fishing of all sturgeon species.

Some loss of pallid sturgeon is occurring incidental to commercial and sport fishing for other sturgeon. The States of North Dakota, South Dakota, and Louisiana have established regulations to protect against incidental killing of pallid sturgeon by requiring release of all sturgeon. The States of Montana and Kansas do not allow commercial harvest of sturgeon.

The commercial fishing seasons for sturgeon in Mississippi, Arkansas, Tennessee, Kentucky, Missouri, Illinois, Iowa, and Nebraska should be temporarily closed until activities and techniques are evaluated to determine the impact of commercial fishing upon pallid sturgeon populations. See Task 2.2.6. Compliance by all States will be necessary for this recommendation to be effective.

1.2.5. Work with States to develop a policy that will ensure risk assessment prior to introductions of new nonindigenous and exotic species to the Missouri and Mississippi Rivers.

Any future introductions of nonnative sturgeon species and possibly other introduced fishes may introduce disease, cause competition, or result in predation upon the pallid sturgeon. Stocking of new nonindigenous and exotic species within the Missouri and Mississippi River basin must not occur until after a risk assessment is completed that verifies that the stocking will not adversely affect pallid sturgeon.

1.2.6. Include the pallid sturgeon in Appendix I to the Convention on International Trade in Endangered Species of Wildlife Fauna and Flora (CITES).

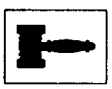
Pallid sturgeon are considered a fine eating fish, although its greatest value on the commercial market comes from its roe, which is suitable for caviar. The pallid sturgeon must be included in Appendix I to CITES as soon as possible, to further regulate foreign trade and impose additional penalties for illegal activities. Additional research may be needed to distinguish eggs of North American sturgeon species and paddlefish for enforcement of CITES. See Task 2.2.7.

1.2.7. Remediate sources of environmental contaminants.

After contaminants affecting pallid sturgeon recovery are determined through Tasks 2.5.1., 2.5.2., and 2.5.3., the source of problem contaminants must be removed, if possible. (Naturally occurring contaminants and those originating from nonpoint sources may be impossible to eliminate.) Eliminating sources of contaminants polluting the Missouri and Mississippi Rivers will not only help to recover pallid sturgeon, but will also help to reduce the human health risk associated with polluted water supplies and consumption of contaminated fish products. These actions will be conducted in coordination with the Environmental Protection Agency and with other Federal and State agencies responsible for control or remediation of environmental contamination.

1.2.8. Provide protection for important habitat areas and needs of pallid sturgeon.

High value habitats should be identified and given top priority for protection. Protection of water rights, through acquisition or formal agreements, may be needed to ensure that instream flows within important habitats are legally protected. Land acquisition or conservation easements also may be needed to help protect and restore the diversity of riverine habitats.

1.3.  **Increase public awareness of the laws and needs for protecting pallid sturgeon.**

1.3.1. Develop and distribute information and education materials on the plight of the pallid sturgeon and its ecosystem.

In order for pallid sturgeon recovery to be successful, an informational and educational program must be developed to inform the public of the importance of preserving pallid sturgeon and the Missouri and Mississippi River ecosystems upon which they depend. Educational materials such as brochures, newspaper and magazine articles, publications, poster displays,

videos, slide and television presentations, etc. specific to the pallid sturgeon and the effects of human alteration of the Missouri/Mississippi River ecosystem should be produced for dissemination to specific audiences, such as sport and commercial fishermen and private industry. This educational effort should increase public acceptance for recovery activities.

1.3.2. Provide cultured pallid sturgeon to aquaria and comparable facilities where they can be viewed by the public.

Hatchery produced pallid sturgeon that are not needed for broodstock, reintroduction, research, and other recovery efforts should be provided to aquaria, universities, or similar facilities for educational purposes. Educational exhibits utilizing these fish should inform the public that this species is an indicator of a deteriorating ecosystem.

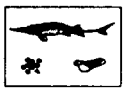
1.4.  Establish refugia of pallid sturgeon broodstock.

1.4.1 Collect pallid sturgeon broodstock from the wild and maintain refugia at three locations.

Adult pallid sturgeon must be removed from the wild to serve as future broodstock. This task is believed necessary to guard against species extinction while protection and restoration activities are being implemented for long-term recovery.

Wild broodstock/refugia must be established at three separate facilities to guard against catastrophic loss. These fish should be transplanted to the closest facility to minimize stress of being transported long distances from the point of capture. It is recommended that a total of five to seven females and five to seven males be removed from three separate river reaches spanning the pallid sturgeon's range. The river reaches are recommended to be: (A) the Missouri River from the mouth of the Marias River in Montana to Gavins Point Dam in South Dakota encompassing recovery-priority areas 1, 2, and 3, (B) the Missouri River from Gavins Point Dam to the Mississippi River and then the Mississippi River to the mouth of the Arkansas River in Arkansas encompassing recovery-priority areas 4 and part of 5, and (C) the Mississippi River from the mouth of the Arkansas River to the Gulf of Mexico including the Atchafalaya River, encompassing the remainder of recovery-priority area 5 and area 6. River reach A broodstock would go to Gavins Point National Fish Hatchery in South Dakota, river reach B broodstock to Blind Pony State Hatchery in Missouri, and river reach C broodstock to either Natchitoches National Fish Hatchery in Louisiana, or to a yet undetermined alternate facility.

2. CONDUCT RESEARCH NECESSARY FOR SURVIVAL AND RECOVERY OF PALLID STURGEON

2.1.  **Obtain information on life history and habitat requirements of all life stages of pallid sturgeon.**

2.1.1. Conduct investigations to determine age distribution, growth, and growth rates.

Investigations are needed rangewide on species longevity, age and size at sexual maturity, growth rates, and age structure within wild populations.

2.1.2. Conduct investigations to describe food habits and feeding behavior.

Little is known about the food habits or feeding behavior of pallid sturgeon. Further investigations are needed so management recommendations can be made. It is suspected that increased clarity of the Missouri River has affected food availability by changing prey species composition and by making it more difficult for pallid sturgeon to capture prey in the clearer water environment. Increased velocity in the channelized river reaches might also make it harder to forage.

2.1.3. Conduct investigations to better define macrohabitat requirements.

Physical habitat requirements and preferences for hydrograph, turbidity, water velocity, and temperature need to be determined for all life stages of pallid sturgeon. The modeling of historic environmental conditions on the Missouri and Mississippi Rivers can best characterize the macrohabitat requirements for native big river fish like the pallid sturgeon.

2.1.4. Conduct investigations to describe microhabitat characteristics of spawning, feeding, staging, and rearing areas.

Once these important areas are located, microhabitat characterizations should be made on parameters such as bottom substrate, water depth, velocity, temperature, turbidity, etc. Characterizing these areas of known use will assist managers with locating and protecting similar habitat outside the study area. This information also will be important for habitat restoration activities. The least altered portions of the pallid sturgeon's range (recovery priority areas 1 and 2) should receive priority for research.

2.1.5 Conduct investigations to describe movements and behavior.

Movements of adult pallid sturgeon need to be determined, especially prior to and during spawning periods. Ft. Peck Dam on the Missouri River and a low-head diversion dam on the Yellowstone River impede migration between upstream and downstream reaches within those priority recovery areas. The significance of these impediments to spawning migrations needs to be determined so corrective measures can be taken, if necessary. Migrations and movements during other seasons also might be occurring for food or staging and should be determined.

Environmental factors such as water temperature, food abundance, light intensity, and water velocity likely affect behavior of developing pallid sturgeon. Certain behavioral traits, such as habitat preference and phototaxis, are believed to be innate and less influenced by the natural elements. Laboratory tests involving innate behavior of pallid sturgeon should be conducted to assist in determining probable behavior in the natural environment. Study results may provide behavioral information, such as the timing and duration of migration after hatching, and may provide information on the effects of environmental variables on the behavior of young pallid sturgeon. The study results also may provide guidance to fish culturists to assist in maximizing conditions leading to successful reproduction behavior.

2.1.6. Map existing areas providing important habitat requirements.

Important habitats need to be identified and mapped to prioritize implementation of protection measures and management activities. Mapping of these important areas also will assist county planning or zoning departments and developers in early identification of potential conflicts between development projects and endangered species protection and recovery.

2.1.7. Obtain an artist's descriptive key of developing larvae and early juveniles of pallid sturgeon, shovelnose sturgeon, and shovelnose X pallid hybrids.

Much of the pallid sturgeon's range overlaps the range of other sturgeon. Research to document successful reproduction and determine abundance, distribution, and ecology of pallid sturgeon life stages depends on accurate identification of collected larvae and early juveniles. An artist's descriptive key of a development series for hatchery-reared pallid sturgeon, shovelnose sturgeon, and shovelnose X pallid hybrid larvae, documenting morphological development and diagnostic characteristics, is needed for identification of field-collected specimens. (An artist's descriptive key has been prepared for lake sturgeon.)

2.1.8. Determine reliable, nonlethal aging techniques.

Reliable, nonlethal aging techniques need to be developed. Age and growth information must be recorded from captive, reintroduced, and wild fish to ensure accurate estimates of age. Fish hatcheries presently holding pallid sturgeon should assist in obtaining this information from captive fish.

2.2.  **Research additional solutions to the impacts of human activities on pallid sturgeon and their habitat.**

2.2.1. Identify priority areas and needs for restoring the diverse riverine floodplain habitats.

The U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and States should determine priority areas for restoring the diverse riverine habitats by reconnecting cut-off features. This should be conducted first within priority recovery areas. Federal and State management areas and refuges along the rivers should be evaluated for restoration opportunities. The U.S. Army Corps of Engineers should then design restoration projects for each potential site.

2.2.2. Develop simulation models for operation of main stem Missouri River and tributary dams to benefit pallid sturgeon and provide for other uses.

The U.S. Army Corps of Engineers should continue to refine the simulation models created during the Missouri River Master Manual review process. The U.S. Bureau of Reclamation should initiate studies to develop simulation models for pallid sturgeon habitat and other uses below their dams on Missouri River tributaries.

2.2.3. Design multi-level releases from main stem Missouri River reservoirs.

The U.S. Army Corps of Engineers should design alternative measures for incorporating multi-level releases from the warmer, upper-water column of main stem reservoirs, and should investigate other means to restore the natural temperature regime of the Missouri River. This should be conducted first within priority recovery areas.

2.2.4. Develop pilot projects on selected dams to transport sediment past the dam and into the river reaches downstream.

The U.S. Army Corps of Engineers and U.S. Bureau of Reclamation should design and develop pilot projects to increase sediment transport past selected dams. Models should be used to predict

effects of increased sediment supply and changing hydrographs on bed condition.

2.2.5 Determine the need for fish bypass facilities.

The U.S. Army Corps of Engineers should determine the need and practicality of a bypass facility for pallid sturgeon at Ft. Peck Dam, thereby providing for migration between two recovery-priority areas. The U.S. Bureau of Reclamation should determine the need and practicality of a bypass facility around the low-head diversion dam at Intake, Montana, on the Yellowstone River thereby providing migration within that recovery-priority area.

2.2.6. Determine the impact of sturgeon commercial and sport fishing on pallid sturgeon.

States allowing commercial and sport fishing for sturgeon may be facilitating the incidental take of pallid sturgeon. In addition to hampering recovery efforts, this may also place fishermen in a situation of violating the Endangered Species Act should they fail to properly identify and protect pallid sturgeon. States should closely monitor sport and commercial sturgeon fishing to determine numbers of pallid sturgeon captured, locations, and gear or technique used.

2.2.7. Determine diagnostic characteristics to distinguish between eggs of sturgeon and paddlefish species.

Enforcement of protection regulations under the Endangered Species Act and CITES will require law enforcement agencies to distinguish between eggs of paddlefish and sturgeon and among sturgeon species. Legal trade in paddlefish and unprotected sturgeon eggs for caviar provide a market for eggs of protected species like pallid sturgeon.

2.3.  **Obtain information on genetic makeup of hatchery-reared and wild *Scaphirhynchus* stocks.**

2.3.1. Determine the degree of genetic divergence between *Scaphirhynchus* species within the range of pallid sturgeon.

Genetic analysis of *Scaphirhynchus* species within the range of pallid sturgeon is necessary to determine genetic divergence for management purposes. Pallid sturgeon and shovelnose sturgeon have been distinguished based upon morphometric and meristic characteristics and character ratios (Bailey and Cross 1954; Williams and Clemmer 1991). Hybridization between pallid sturgeon and shovelnose sturgeon has been proposed based upon these same characteristics. Phelps and Allendorf (1983) were unable to distinguish the species electrophoretically by

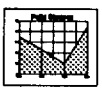
looking at 37 enzyme systems. Further genetics studies are needed using state-of-the-art analysis techniques such as mitochondrial DNA, nuclear DNA, and electrophoresis methods. Hatchery-reared pallid sturgeon, shovelnose sturgeon, and pallid X shovelnose sturgeon would be used in such an analysis. (Nonlethal means of obtaining genetic analysis material must be utilized on wild pallid sturgeon.) Federal and State agencies involved in collecting, handling, or holding pallid sturgeon should assist in obtaining this information.

2.3.2. Identify genetically meaningful management units (stocks) of pallid sturgeon.

Research is needed to determine whether or not significant genetic differences exist among pallid sturgeon from various parts of the species' range. Determining whether genetic differences exist among populations is essential in guiding reintroduction and/or population augmentation and in ensuring successful management and recovery of the species.

2.3.3. Determine the extent and management implications of hybridization between *Scaphirhynchus* species.

Genetic analysis of hybrids is needed to determine if hybridization has resulted in introgression and loss of genetic integrity of pallid sturgeon. The hybrids collected to date exhibit an unbalanced sex ratio with a preponderance of females. Hatchery-reared hybrids (F_1's, F_2's, and backcrosses) must be produced to determine genetic and physical characteristics, sex ratios, and fertility for comparison to wild-caught, presumed hybrids.

2.4.  **Obtain information on population status and trends.**

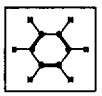
2.4.1. Establish sampling stations and monitor population status and trends.

Systematic monitoring of pallid sturgeon populations will be an essential element in measuring response to recovery tasks. Monitoring should be initiated first in recovery-priority areas. Monitoring will be a coordinated, cooperative effort between Federal and State agencies, and possibly even commercial fishermen. Population index stations, and criteria for measuring catch-per-unit-effort must be determined as soon as possible. In the short-term, populations will be monitored annually to determine population status and trends. Monitoring also will need to be conducted on reintroduced and augmented populations.

2.4.2. Conduct a Population Viability Analysis PVA to determine appropriate recovery numbers.

A (PVA) must be conducted to further quantify population levels for recovery goals.

Criteria addressing minimum viable population size and demography must be determined to ensure that the populations can persist through natural reproduction. Monitoring activities will be designed and results evaluated to define criteria for downlisting or delisting pallid sturgeon. Populations will be separated into genetically meaningful management units, if appropriate.

2.5.  **Obtain information on chemical contamination of pallid sturgeon and their habitat.**

2.5.1. Determine concentrations of organic and inorganic contaminants in pallid sturgeon and shovelnose sturgeon, their food, and habitats.

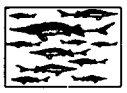
Shovelnose sturgeon should be used as a surrogate for contaminant analyses unless nonlethal means of obtaining analysis material from pallid sturgeon are determined. Contaminant analyses should be conducted on all pallid sturgeon mortalities, especially of reproductive tissues where contaminants are known to accumulate.

2.5.2. Determine effects of problem contaminants on growth, survival, and reproduction of pallid sturgeon.

Studies should be undertaken that expose excess hatchery produced pallid sturgeon, their eggs and larvae to potential "problem" contaminants identified in Task 2.5.1. to determine the effects of different contaminant concentrations on growth and survival. Long-term exposure to problem contaminants also must be conducted to evaluate these effects on growth and reproduction.

2.5.3. Identify all point and nonpoint sources of problem contaminants along the Missouri and Mississippi Rivers within the pallid sturgeon's range.

Work with the Environmental Protection Agency to identify all potential sources of "problem" contaminants. The cleanup of contaminant sources (Task 1.2.7.) will be prioritized based upon a case-by-case threat to pallid sturgeon recovery.

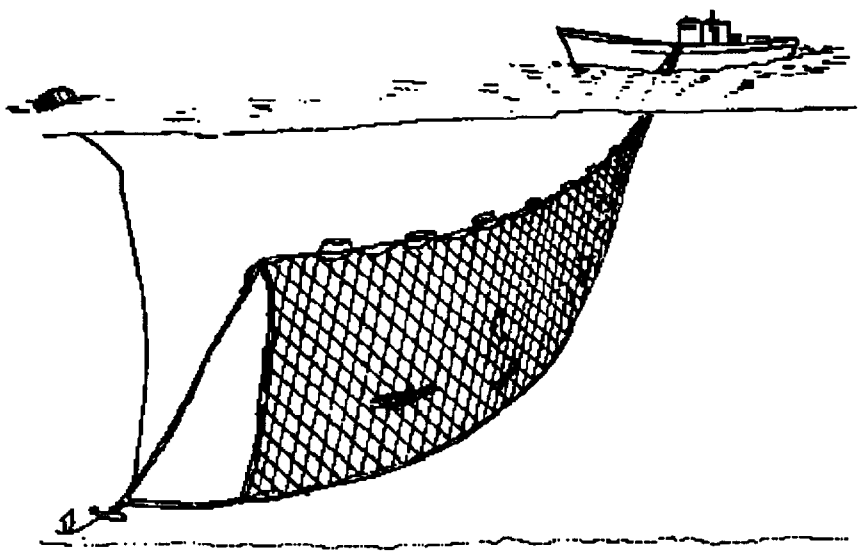
2.6.  Obtain information on biological threats.

2.6.1. Determine causes of hybridization.

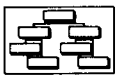
The factors that facilitate hybridization must be determined so management recommendations can be identified and implemented.

2.6.2. Determine the extent of parasitism and disease, and the degree of competition and predation by introduced fishes.

Although ongoing investigations have not indicated that disease or parasitism presently poses a threat to pallid sturgeon, wild populations should be monitored to determine if a problem exists or develops.



3. DEVELOP AND IMPLEMENT A PALLID STURGEON CAPTIVE PROPAGATION PROGRAM.

3.1.  **Develop policy on a pallid sturgeon propagation and stocking program.**

3.1.1. Develop a pallid sturgeon propagation plan.

A propagation plan must be developed to guide establishment and maintenance of genetically sound pallid sturgeon broodstock. This plan will detail numbers of broodstock, capture locations, protocol for spawning, holding, and rearing, and also numbers of young to be retained for broodstock. This plan will be followed by all Federal and/or State agencies participating in the propagation program. Information learned from stocking programs for other sturgeon and Colorado River rare fish work will be used in development of this plan.

3.1.2. Develop a pallid sturgeon stocking plan and a plan for disposition of surplus fish.

A stocking plan must be developed to guide restoration of pallid sturgeon populations in the wild through either population augmentation or reintroduction. Sturgeon will be stocked only where and when needed. Maintenance of genetic fitness must not be compromised through stocking efforts. The plan will recommend production goals to meet needs for both future broodstocks and future stocking projects and locations where stocking is needed to maintain or restore the genetic makeup of wild populations. The plan will also include recommendations on a release size, time, and rate that promotes good poststocking survival. This plan also will include policy on disposition of surplus fish and will be developed in coordination with states. The success of reintroduced and augmented populations will be monitored through implementation of Task 2.4.1.

3.1.3. Develop a tagging protocol for stocked fish.

All pallid sturgeon progeny released to the wild will be marked for future identification. A standard protocol is needed that describes tagging methods and ensures collection of required information.

3.1.4. Provide financial support to hatcheries for structural modifications, operation, and maintenance needed for a pallid sturgeon propagation program.

Prior to long-term holding of pallid sturgeon broodstock and implementation of a long-term propagation program, structural improvements are needed at Blind Pony State Hatchery, Gavins Point National Fish Hatchery, and potentially at other hatcheries that participate in the program. Costs for operation and maintenance, including feed, also should be supported.

3.2.  **Research methods to improve spawning, culturing, and rearing of pallid sturgeon in hatcheries.**

3.2.1. Determine protocol for collecting, handling, and transporting pallid sturgeon.

Standardized protocols, designed to give pallid sturgeon the greatest protection possible, are needed for all activities associated with collecting, handling, and transporting of pallid sturgeon, including research activities recommended in this plan. Proper handling protocols must be distributed to all agencies and individuals potentially handling pallid sturgeon.

Interim protocols have been developed by the Recovery Team; however, as new information becomes available through continued efforts, recommendations will be assessed, refined, and incorporated in collecting, handling, and transporting activities as necessary to minimize mortality. The "Hatchery Manual for White Sturgeon" by Conte et al. (1988) will be incorporated into the protocols when appropriate.

3.2.2. Determine efficient, effective spawning techniques in the hatchery and in the field.

Caesarean (C-section) techniques have been lethal on all shovelnose sturgeon females spawned. Handstripping is effective, but extremely inefficient. Improved techniques for C-section must be determined and may include pretreatment and posttreatments for disease and/or stress. All methods should be tested first on shovelnose sturgeon.

3.2.3. Conduct trials to maximize survival of broodstock and progeny.

Pallid sturgeon progeny first were raised in a hatchery in 1992. Adults have only been held for a little longer than 1 year. Rearing trials are necessary to determine the appropriate holding conditions (food, densities, water temperatures, etc.) needed to maximize survival and growth of

progeny and development of reproductive products in broodstock. Shovelnose sturgeon should be used as a surrogate in trials unless surplus pallid sturgeon progeny are available.

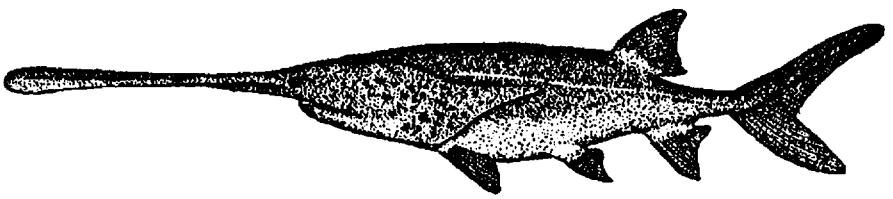
3.2.4. Develop cryopreservation techniques.

Cryopreservation of sperm will allow return of the males to the wild and later fertilization of eggs in the hatchery. Cryopreservation techniques also would be developed using shovelnose sturgeon as a surrogate species.

3.3.  Reintroduce pallid sturgeon and/or augment existing populations.

3.3.1. Conduct reintroduction/augmentation programs in accordance with the stocking plan.

Stocking of pallid sturgeon for reintroduction or for augmentation of existing populations will be done in accordance with the pallid sturgeon stocking plan prepared under Task 3.1.2. The plan will ensure that genetic integrity of wild populations be maintained, that all stocked fish are tagged, and that stocked populations are monitored.



Paddlefish (*Polyodon spathula*)

4. COORDINATE AND IMPLEMENT CONSERVATION AND RECOVERY OF STURGEON SPECIES.

4.1.  **Communicate with sturgeon researchers and managers.**

4.1.1. Establish a clearinghouse for collection and dissemination of research and management information.

A central clearinghouse for collection of pallid sturgeon catch records and dissemination of recovery-related information must be established to maintain records on recovery activities and to improve information exchange. The Service's Ecological Services Office in Bismarck, North Dakota, temporarily serves this function. The Pallid Sturgeon Recovery Coordinator position established by Task 4.2.1. ultimately would be responsible for meeting this need. The group formed under the Mississippi Interstate Cooperative Resource Agreement (MICRA) can assist with information dissemination.

4.1.2. Communicate sturgeon recovery efforts.

Federal and State agencies must facilitate communication among professional and managerial staffs to accelerate recovery efforts. Workshops or symposia should be conducted at least every 3 years to coordinate sturgeon recovery activities.

Also, various research and management efforts should be provided to all agencies and individuals involved in day-to-day work on pallid sturgeon recovery. This could be done in a newsletter or similar means of information exchange.

4.1.3. Encourage and support publication of research, management, and other recovery-related information.

All recovery managers and researchers are strongly encouraged to publish existing "gray" literature and research findings in peer-review technical publications intended for broad distribution. (Financial support will be necessary to pay for publishing costs.) Unpublished catch reports, bibliographies, and summaries of pallid sturgeon population data have been compiled over the years and should be published. An annotated bibliography of sturgeon references also should be published as part of this task.

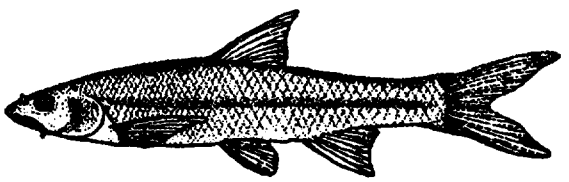
4.2. $ **Support implementation of the Pallid Sturgeon Recovery Plan.**

4.2.1. Establish and fund a full-time position to serve as pallid sturgeon recovery coordinator.

Achievement of pallid sturgeon recovery goals through cooperation of all 13 states, three Service Regions, numerous Federal Agencies, nongovernment organizations, and planning committees will require the leadership and full-time commitment of a Service fishery biologist assigned solely to that responsibility. This person would serve as a recovery coordinator and would establish and lead multidisciplinary recovery implementation committees, possibly organized on a Regional basis. The committees would include members with expertise in engineering and wildlife biology.

4.2.2. Develop a long-term strategy for funding sturgeon recovery activities.

The existing budgets of participating and responsible parties are not capable of fully funding recovery tasks. Strategies for funding, such as congressional appropriation, water-use fees, Federal mitigation programs, or establishing trust accounts, must be determined.



Flathead Chub (*Platygobio gracilis*)

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Part III

IMPLEMENTATION SCHEDULE

The Implementation Schedule (Part III) indicates task priorities, task numbers, task descriptions, duration of tasks, potential or participating parties, and lastly, estimated costs. These tasks, when accomplished, will bring about the recovery objectives for the pallid sturgeon as discussed in Part II of this Plan.

Parties with authority, responsibility, or expressed interest to implement a specific recovery task are identified in the Implementation Schedule. The listing of a party in the Implementation Schedule does not imply a requirement or that prior approval has been given by that party to participate or expend any funds. However, parties willing to participate will benefit by being able to show in their own budget submittals that their funding request is for a recovery task that has been identified in an approved recovery plan and is therefore part of the overall coordinated recovery effort to recover the pallid sturgeon. Also, section 7(a)(1) of the Endangered Species Act directs all Federal Agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of threatened and endangered species.

Following are definitions to column headings and keys to abbreviations and acronyms used in the Implementation Schedule:

Priority No.: All priority 1 tasks are listed first, followed by priority 2 and priority 3 tasks.

> Priority 1--All actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
>
> Priority 2--All actions that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.
>
> Priority 3--All other actions necessary to provide for full recovery (or reclassification) of the species.

Task No. & Task: Recovery tasks as numbered in the recovery outline. Refer to the Narrative for task descriptions.

Task Duration: Years to complete the corresponding task. Study designs can incorporate more than one task, which when combined can reduce the time needed for task completion.

Participating or Responsible Party: Federal or State government agencies, nongovernment organizations, or universities with responsibility and/or capability to fund or carry out the corresponding recovery task.

FWS Reg.--Fish and Wildlife Service Regions (Only states in the pallid sturgeon's range are listed);

3 - Minneapolis (IA, IL, MO)
4 - Atlanta (KY, TN, AR, LA, MS)
6 - Denver (MT, ND, SD, NE, KS)
8 - Research (Nationwide)

FWS Prog.--Division or program of the Fish and Wildlife Service

FFA Fisheries and Federal Aid
ES Ecological Services
LE Law Enforcement
RES Research Stations and Coop. Research Units
WR Wildlife Resources

Other Agencies/Organizations

BR	- Bureau of Reclamation
COE	- Corps of Engineers
EPA	- Environmental Protection Agency
FDA	- Food and Drug Administration
FERC	- Federal Energy Regulatory Commission
MDC	- Missouri Department of Conservation
MICRA	- Mississippi Interstate Cooperative Resource Agreement
States	- State Fisheries or Research Divisions (Some States are listed separately
Univ	- An as yet undetermined college or university
WAPA	- Western Area Power Administration

Cost Estimates: Estimated fiscal year cost, in thousands of dollars, to complete the corresponding task. The costs associated with a task or party represent the estimated dollar amount to complete the task and are not necessarily the fiscal responsibility of the associated party.

Study designs can incorporate more than one task, which when combined can reduce the cost from when tasks are conducted separately. Total costs for recovery do not reflect financial needs associated with implementing many of the tasks identified under group 1: Protect and Restore Pallid Sturgeon Populations, Individuals, and Their Habitat. These costs are undeterminable at this time.

Comments: Additional information if appropriate.

PALLID STURGEON
RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	PARTICIPATING OR RESPONSIBLE PARTY FWS Reg.	FWS Prog.	OTHER Agencies	COST ESTIMATES ($000) FY94	FY95	FY96	COMMENTS
1	1.1.1	Restore the diversity of riverine habitats by reconnecting cutoff features along the Missouri and Mississippi Rivers.	20	3,4, 6	ES,FFA WR	COE,BR, FERC	U N K N O W N			Costs dependent upon numbers of restorations.
1	1.1.2	Implement operational alternatives for main stem Missouri River and tributary dams using simulation models that will emulate precontrol hydrographs.	Perpet-ual	6	ES,FFA	COE,BR, WAPA, FERC	U N K N O W N			No direct costs associated with modifying operations; however, indirect costs from losses to other beneficial uses will be incurred.
1	1.1.3	Restore the natural temperature regime of the Missouri River.	5	6	ES,FFA	COE,BR	U N K N O W N			Cost for upper-reservoir discharge unknown until implementation of Task 2.2.3.
1	1.1.4	Restore large woody debris to the main stem Missouri and Mississippi Rivers and their larger tributaries.	5	3,4, 6	ES,FFA	COE,EPA	15	15	15	Local communities could benefit and provide cost-share funding.
1	1.1.5	Restore the dynamic equilibrium of sediment transport within the Missouri River.	15	6	ES,FFA	COE,BR, EPA,FERC	U N K N O W N			Costs unknown until implementation of Task 2.2.4.
1	1.1.6	Restore free movements of pallid sturgeon within high priority recovery areas.	20	6	ES,FFA	COE,BR	U N K N O W N			
1	1.2.1	Ensure Federal Agencies conduct section 7 consultations on all Federal actions that may affect pallid sturgeon.	Until delist-ed	3,4, 6	ES	COE,BR, WAPA, EPA, FERC	U N K N O W N			Costs dependent upon numbers of consultations.
1	1.2.2	Establish, maintain, and disseminate section 7 biological opinions evaluating impacts on pallid sturgeon.	1	6	ES		5			

PALLID STURGEON
RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK	TASK DURA-TION (YRS)	PARTICIPATING OR RESPONSIBLE PARTY FWS Reg.	FWS Prog.	OTHER Agencies	COST ESTIMATES ($000) FY94	FY95	FY96	COMMENTS
2	2.2.7	Determine the diagnostic characteristics to distinguish between eggs of sturgeon and paddlefish species.	1	6,8	RES		10			
2	2.4.2	Conduct a Population Viability Analysis to determine appropriate recovery numbers.	3	6,8	ES,FFA RES	Univ.	60	60	60	
2	3.2.3	Conduct trials to maximize survival of broodstock and progeny.	Ongoing 3	6,8	FFA,RES	MDC	10	10	10	
2	3.2.4	Develop cryopreservation techniques.	Ongoing 3	6,8	FFA,RES	MDC	10	10	10	
2	3.3.1	Conduct reintroduction/augmentation programs in accordance with the stocking plan.	15	3,4, 6	FFA	MICRA/ States	U N K N O W N			Cost dependent upon completion of Task 3.1.2.
3	2.6.2	Determine the extent of parasitism and disease, and the degree of competition and predation by introduced fishes.	2	6,8	FFA,RES	MICRA/ States	50	50		
3	4.1.3	Encourage and support publication of research, management, and other recovery-related information.	Until delist-ed	3,4, 6	ES,FFA RES	MICRA/ States, Univ.	10	10	10	

PALLID STURGEON
RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	PARTICIPATING OR RESPONSIBLE PARTY FWS Reg.	FWS Prog.	OTHER Agencies	COST ESTIMATES ($000) FY94	FY95	FY96	COMMENTS
1	1.2.3	Ensure water intakes and diversions are not adversely affecting pallid sturgeon populations.	2	3,4, 6	ES	COE,BR, WAPA, FERC	U N K N O W N			Costs dependent upon numbers of intakes or diversion needing modification.
1	1.2.4	Work with States within the pallid sturgeon's range to temporarily place a moratorium on commercial fishing of all sturgeon species.	3	3,4, 6	ES,FFA	MICRA/ States	15	15	15	
1	1.2.5	Work with States to develop a policy that will ensure risk assessment prior to introductions of new nonindigenous and exotic species to the Missouri and Mississippi Rivers.	3	3,4, 6	ES,FFA	MICRA/ States	50	50	50	
1	1.2.6	Include the pallid sturgeon in Appendix I to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	1/2	6	ES,FFA		5			
1	1.2.7	Remediate sources of environmental contaminants.	10	3,4, 6	ES	EPA	U N K N O W N			Costs unknown until implementation of Task 2.5.3.
1	1.2.8	Provide protection for important habitat areas and needs of pallid sturgeon.	Until delist-ed	3,4, 6	ES,FFA WR	COE,BR, WAPA, MICRA/ States	120	120	120	Unknown costs for acquisition.
1	1.3.1	Develop and distribute information and education materials on the plight of the pallid sturgeon and its ecosystem.	Until delist-ed	3,4, 6	ES,FFA	COE, WAPA,BR	10	10	10	
1	1.4.1	Collect pallid sturgeon broodstock from the wild and maintain refugia at three locations.	Ongoing 3	3,4, 6	FFA,ES	MDC	30	30	30	Costs represent only the amounts for collecting broodstock. See also Task 3.1.4.

PALLID STURGEON
RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	PARTICIPATING OR RESPONSIBLE PARTY FWS Reg.	FWS Prog.	OTHER Agencies	COST ESTIMATES ($000) FY94	FY95	FY96	COMMENTS
1	2.1.1	Conduct investigations to determine age distribution, growth, and growth rates.	5	3,4, 6	FFA,ES	COE,BR, WAPA, MICRA/ States	150	150	150	Cost includes $10k per State.
1	2.1.2	Conduct investigations to describe food habits and feeding behavior.	3	3,4, 6	FFA,ES	COE,BR, WAPA, MICRA/ States	150	150	150	Cost includes $10k per State.
1	2.1.3	Conduct investigations to better define macrohabitat requirements.	Ongoing 5	3,4, 6	FFA,ES	COE,BR, WAPA, MICRA/ States	120	120	120	Costs support two studies at two locations. Combining 2.1.3, 2.1.4, and 2.1.5 could reduce costs.
1	2.1.4	Conduct investigations to describe microhabitat characteristics of spawning, feeding, staging, and rearing areas.	Ongoing 5	3,4, 6	FFA,ES	COE,BR, WAPA, MICRA/ States	120	120	120	Costs support two studies at two locations. Combining 2.1.3, 2.1.4, and 2.1.5 could reduce costs.
1	2.1.5	Conduct investigations to describe movements and behavior.	Ongoing 5	3,4, 6	FFA,ES RES	COE,BR, WAPA, MICRA/ States	120	120	120	Costs support two studies at two locations. Combining 2.1.3, 2.1.4, and 2.1.5 could reduce costs.
1	2.1.7	Obtain an artist's descriptive key of developing larvae and early juveniles of pallid sturgeon, shovelnose sturgeon, and shovelnose X pallid hybrids.	Ongoing 2	6	ES,FFA	Univ.	20	20		
1	2.2.1	Identify priority areas and needs for restoring the diversity of riverine floodplain habitats.	5	3,4, 6	ES,FFA WR	COE,BR, WAPA, MICRA/ States	45	45	45	

PALLID STURGEON
RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	PARTICIPATING OR RESPONSIBLE PARTY FWS Reg.	FWS Prog.	OTHER Agencies	COST ESTIMATES ($000) FY94	FY95	FY96	COMMENTS
1	2.2.2	Develop simulation models for operation of main stem Missouri River and tributary dams to benefit pallid sturgeon and other uses.	Ongoing 5	6	ES,FFA	COE,BR, WAPA	80	80	80	Missouri River research is being conducted by the COE. Tributary research needs to be initiated by BR.
1	2.2.3	Design multi-level releases from main stem Missouri River dams.	5	6	ES	COE,BR, WAPA	50	50	50	
1	2.3.1	Determine the degree of genetic divergence between *Scaphirhynchus* species within the range of pallid sturgeon.	Ongoing 3	3,4, 6	ES,FFA	COE, MICRA/ States	120	120	120	States can assist with collections of samples.
1	2.3.2	Identify genetically meaningful management units (stocks) of pallid sturgeon.	Ongoing 3	3,4, 6	ES,FFA	COE, MICRA/ States	Cost included in Task 2.3.1.			States can assist with collections of samples.
1	2.3.3	Determine the extent and management implications of hybridization between Scaphirhynchus species.	Ongoing 3	3,4, 6	ES,FFA	COE, MICRA/ States	Cost included in Task 2.3.1.			States can assist with collections of samples.
1	2.4.1	Establish sampling stations and monitor population status and trends.	Until delist-ed	3,4, 6	FFA,ES	COE,BR, WAPA, MICRA/ States	200	200	200	Costs include $10k per state per year.
1	2.5.1	Determine concentrations of organic and inorganic contaminants in pallid sturgeon, shovelnose sturgeon, their foods, and habitats.	5	3,4, 6	ES,FFA RES	EPA	225	225	225	
1	2.5.2	Determine effects of problem contaminants on growth, survival, and reproduction of pallid sturgeon.	2	3,4, 6,8	ES,RES	EPA	225	225		

PALLID STURGEON
RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	PARTICIPATING OR RESPONSIBLE PARTY FWS Reg.	FWS Prog.	OTHER Agencies	COST ESTIMATES ($000) FY94	FY95	FY96	COMMENTS
1	2.5.3	Identify all point and nonpoint sources of problem contaminants along the Missouri and Mississippi Rivers within the pallid sturgeon's range.	3	3,4, 6	ES	EPA	100	100	100	
1	2.6.1	Determine causes of hybridization.	10	3,4, 6	FFA	COE	100	100	100	
1	3.1.1	Develop a pallid sturgeon propagation plan.	Ongoing 1	3,4, 6	FFA,ES	MICRA/ States	10			
1	3.1.2	Develop a pallid sturgeon stocking plan and plan for disposition of surplus fish.	Ongoing 1	3,4, 6	FFA,ES	MICRA/ States	10			
1	3.1.3	Develop a tagging protocol for stocked fish.	Ongoing 1	3,4, 6	FFA,ES	MICRA/ States	10			
1	3.1.4	Provide financial support to hatcheries for structural modifications, operation, and maintenance needed for a pallid sturgeon propagation program.	Until delist-ed	3,4, 6	FFA,ES	COE,BR, WAPA, MDC	1500	90	90	Redesign and expansion of existing facilities is needed the first year. O&M funds thereafter.
1	3.2.1	Determine protocol for collecting, handling, and transporting pallid sturgeon.	Ongoing 1	6	ES,FFA		5			
1	3.2.2	Determine efficient, effective spawning techniques in the hatchery and in the field.	Ongoing 3	6,8	FFA,RES	MDC	10	10	10	
1	4.1.1	Establish a clearinghouse for collection and dissemination of research and management information.	Until delist-ed	6	ES,FFA	MICRA/ States	5	5	5	

PALLID STURGEON
RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	PARTICIPATING OR RESPONSIBLE PARTY FWS Reg.	FWS Prog.	OTHER Agencies	COST ESTIMATES ($000) FY94	FY95	FY96	COMMENTS
1	4.1.2	Communicate sturgeon recovery efforts.	Until delisted	3,4,6	ES,FFA	COE,BR, WAPA, MICRA/ States	5	5	5	
1	4.2.1	Establish and fund a full-time position to serve as pallid sturgeon recovery coordinator.	Until delisted	6	ES,FFA	COE,BR, MICRA/ States	70	70	70	
1	4.2.2	Develop a long-term strategy for funding sturgeon recovery activities.	Until delisted	3,4,6	ES,FFA	COE,BR, WAPA, FERC, MICRA/ States	10	10	10	
2	1.3.2	Provide cultured pallid sturgeon to aquaria and comparable facilities where they can be viewed by the public.	Until delisted	3,4,6	FFA	MDC	Covered by agencies.			
2	2.1.6	Map existing areas providing important habitat requirements.	5	3,4,6	FFA,ES	COE,BR	150	150	150	
2	2.1.8	Determine reliable, nonlethal aging techniques.	1	3,4,6,8	FFA,RES		5			
2	2.2.4	Develop pilot projects on selected dams to transport sediment past the dam and into the river reaches downstream.	10	6	ES	COE,BR	250	250	250	
2	2.2.5	Determine the need for fish bypass facilities.	5	6	ES	COE,BR	50	50	50	
2	2.2.6	Determine the impact of sturgeon commercial and sport fishing on pallid sturgeon.	2	3,4,6	ES,FFA	MICRA/ States	20	20		

This recovery plan was made available to the public for comment as required by the 1988 amendments to the Endangered Species Act of 1973. The public comment period was announced in the Federal Register (57 F.R. 39237) on August 28, 1992 and closed on October 27, 1992. Press releases were sent to the print media located throughout the region surrounding the Missouri and Mississippi Rivers. During the public comment period 48 letters were received. The comments provided in these letters have been considered and incorporated, as appropriate.