U.S. Fish & Wildlife Service

Draft Revised RECOVERY PLAN

for the

Pallid Sturgeon (*Scaphirhynchus albus*)

Original Approved: November 1993

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For
Mountain-Prairie Region
U.S. Fish and Wildlife Service
Denver, CO
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(*Scaphirhynchus albus*)

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Denver, Colorado

Approved: ______________________________
Regional Director, U.S. Fish and Wildlife Service

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By approving this document, the Regional Director certifies that the information used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record, located at the U.S. Fish and Wildlife Service's Northern Rockies Fish and Wildlife Conservation Office, Billings, Montana.

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Recovery plans can be downloaded from: http://ecos.fws.gov/tess_public/SpeciesRecovery.do

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EXECUTIVE SUMMARY

CURRENT SPECIES STATUS: The pallid sturgeon was listed as endangered under the Endangered Species Act on September 6, 1990 (55 FR 36641-36647). Since listing, the status of the species has improved and is currently stable. New information related to habitat extent and condition, abundance, and potential recruitment in the Mississippi and Atchafalaya rivers has improved our understanding of the species in these areas. While the number of wild pallid sturgeon collected are higher in the Missouri, Mississippi and Atchafalaya rivers than initially documented when listed and evidence for some recruitment exists for the lower Missouri and Mississippi rivers, the population has not been fully quantified. This increase in the number of observations of the species is the result of increased monitoring efforts, improvements in sampling techniques, and greater emphasis on research in the impounded portion of the range. Despite these increased efforts, data regarding recruitment, mortality, habitat use, and abundance remain limited. Population estimates for wild pallid sturgeon within some inter-reservoir reaches of the Missouri River indicate the extant wild populations are declining or extirpated within these reaches. To prevent further extirpations, a conservation propagation program has been established. Hatchery and stocking programs appear to be successful in maintaining the species' presence in the Missouri River. However, if supplementation efforts were to cease, the species would once again face local extirpation within several reaches.

HABITAT REQUIREMENTS AND LIMITING FACTORS: The pallid sturgeon is native to the Missouri and Mississippi rivers and adapted to the pre-development habitat conditions that historically existed in these rivers. These conditions generally can be described as large, free-flowing, warm-water, and turbid rivers with a diverse assemblage of physical habitats that were in a constant state of change. Limiting factors include: 1) activities which affect connectivity and the natural form, function and hydrologic processes of rivers; 2) illegal harvest; 3) impaired water quality and quantity; 4) entrainment in water diversion structures; and 5) life history attributes of the species (i.e., delayed sexual maturity, females not spawning every year, and larval drift requirements). The degree to which these factors affect the species varies among river reaches.

RECOVERY STRATEGY: The primary strategy for recovery of pallid sturgeon is to: 1) conserve the range of genetic and morphological diversity of the species across its historical range; 2) fully quantify population demographics and status within each management unit; 3) improve population size and viability within each management unit; 4) reduce threats having the greatest impact on the species within each management unit; and, 5) use artificial propagation to prevent local extirpation within management units where recruitment failure is occurring.

Achieving our recovery strategy will require an increased understanding of the status of pallid sturgeon throughout its range; developing information on pallid sturgeon life history, ecology, mortality, and habitat requirements; improving our understanding of some poorly understood threat factors potentially impacting the species; and using that information to implement management actions in areas where recovery can be achieved (see Recovery Outline/Narrative).

RECOVERY GOAL: The ultimate recovery goal is achieving species recovery and delisting. An intermediate goal is downlisting the species from endangered to threatened.

RECOVERY OBJECTIVES: Across the species' range, the objectives are to develop adequate information on pallid sturgeon abundance, population structure, life history, ecology, mortality, and habitat requirements and use this information to implement management activities that will reduce or alleviate the effects from threats within each management unit.

RECOVERY CRITERIA: Pallid sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria (p. 5) are sufficiently addressed such that a self-sustaining genetically diverse population is realized and maintained within each management unit for 2 generations (20-30 years). Delisting will be considered when the listing/recovery factor criteria are sufficiently addressed and adequate protective and conservation measures are established to provide reasonable assurance of long-term persistence of the species within each management unit in the absence of the Act's protections.

In this context, a self-sustaining population is described as one that experiences natural spawning, as well as recruitment of naturally-produced fish into the adult population at levels sufficient to maintain a genetically diverse wild adult population (see *Criteria for Reclassification to Threatened Status* p. 50). Additionally, in this context a genetically diverse population is defined as one in which the effective population size (N_e) is sufficient to maintain adaptive genetic variability into the foreseeable future. These criteria should be achieved within each management unit. Because each management unit will likely achieve these sustainability criteria individually, we will consider designating distinct population segments in the future, should data demonstrate this is warranted.

ACTIONS NEEDED (see *Recovery Outline/Narrative* pp. 55-69):

1. Obtain information on population genetics, status, and trends.
2. Conserve and restore pallid sturgeon habitats, individuals and populations.
3. Conduct research necessary to promote survival and recovery of pallid sturgeon.
4. Implement conservation stocking program where deemed necessary.
5. Coordinate and implement conservation and recovery of pallid sturgeon.

ESTIMATED COST OF RECOVERY TASK IMPLEMENTATION:
$250,170,000

DATE OF RECOVERY: Estimated earliest date for status reclassification from endangered to threatened is 2030 and from threatened to recovered is 2047 provided recovery tasks are implemented and recovery criteria are met. These estimates could change as new data become available.

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Part I: Background

History

Pallid sturgeon (*Scaphirhynchus albus*), as well as other sturgeon species, are often referred to as "living dinosaurs." Sturgeon believed to be precursors to or possibly common ancestors of contemporary *Scaphirhynchus* species coexisted with dinosaurs during the Cretaceous period of the Mesozoic era. Evidence for this coexistence is based on North American fossil sturgeon specimens (*Priscosturion longipinnis* and *Protoscaphirhynchus squamosus*) which date up to 78 million years before present (Grande and Hilton 2006; Hilton and Grande 2006; Grande and Hilton 2009). Today, eight species and one subspecies of sturgeon in North America belong to the family Acipenseridae; specifically these are:

- pallid sturgeon (*Scaphirhynchus albus*) - *E*;
- shovelnose sturgeon (*Scaphirhynchus platorynchus*) – *T-SOA*;
- Alabama sturgeon (*Scaphirhynchus suttkusi*) - *E*;
- white sturgeon (*Acipenser transmontanus*) - *E*;
- green sturgeon (*Acipenser medirostris*) - *T*;
- lake sturgeon (*Acipenser fulvescens*);
- shortnose sturgeon (*Acipenser brevirostrum*) - *E*;
- Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*);
- Gulf sturgeon (*Acipenser oxyrinchus desotoi*) - *T*;

Six of these species are on the Federal list of endangered and threatened wildlife and plants, of which two species are listed as threatened (*T*), four are listed as endangered (*E*), and one is treated as threatened due to its similarity of appearance (T-SOA) to the listed pallid sturgeon (detail provided under Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes).

The pallid sturgeon was listed as endangered on September 6, 1990 (55 FR 36641-36647).

Species Description and taxonomy

The pallid sturgeon was first recognized as a species different from shovelnose sturgeon by S. A. Forbes and R. E. Richardson in 1905 based on a study of nine specimens collected from the Mississippi River near Grafton, Illinois (Forbes and Richardson 1905). They named this new species *Parascaphirhynchus albus*. Later reclassification assigned it to the genus *Scaphirhynchus* where it has remained (Bailey and Cross 1954; Campton et al. 2000).

General Description

Pallid sturgeon have a flattened shovel-shaped snout; a long, slender, and completely armored caudal peduncle (the tapered portion of the body which terminates at the tail); and lack a spiracle (small openings found on each side of the head) (Forbes and Richardson 1905). As with other sturgeon, the mouth is toothless, protrusible (capable of being extended and withdrawn from its natural position), and ventrally positioned under the head. The skeletal structure is primarily composed of cartilage rather than bone.

Pallid sturgeon are similar in appearance to the more common shovelnose sturgeon. Both species inhabit overlapping portions of the Missouri and Mississippi River basins. In their original description, Forbes and Richardson (1905) noted that pallid sturgeon differed from shovelnose sturgeon in size, color, head length, eye size, mouth width, barbel length ratios, ossification, gill raker morphology, number of ribs, and size of the air bladder. Bailey and Cross (1954) identified several additional differences between the two species, including barbel arrangement and position, barbel structure (i.e., diameter and papillae), and both dorsal and anal fin ray counts. They also developed a suite of diagnostic measurement ratios to eliminate the effects of size, age, and, possibly geographic variation. In general, mature pallid sturgeon grow to larger sizes than mature shovelnose sturgeon, and they have longer outer barbels and shorter inner barbels, with inner barbels originating anterior to outer barbels. Additionally, pallid sturgeon have wider mouths and unscaled or lightly scaled bellies compared to shovelnose sturgeon that have bellies with large embedded scales.

Several of these diagnostic characters and ratios change with age of the fish (allometric growth), making identification of juvenile and subadult fish difficult. Fishery biologists have found that in most cases the seven morphometric ratios described in Bailey and Cross (1954) as well as subsequent indices developed by Wills et al. (2002) were not mutually exclusive when used to compare pallid to shovelnose sturgeon in the middle Mississippi River (Bettoli et al. 2009) or when used to compare both species from different geographic reaches (Murphy et al. 2007a). Also, these indices do not work well on smaller-sized specimens (Kuhajda et al. 2007). This lack of uniform applicability of morphometric indices may be attributable to greater morphological differences documented between the upper Missouri River pallid sturgeon and pallid sturgeon samples in the middle and lower Mississippi and Atchafalaya rivers (Murphy et al. 2007a). Additionally, pallid sturgeon from the upper Missouri River live longer and grow larger than those found in the lower Missouri and Mississippi rivers (Figure 1).

Figure 1 Adult pallid sturgeon: the larger northern specimen is from the upper Missouri River and the smaller southern specimen is from the lower Mississippi/Atchafalaya Rivers. Both specimens represent the larger specimens from each region. (Photo courtesy Dr. Bernard Kuhajda, Tennessee Aquarium).

Historical Distribution and Abundance

The historical distribution of the pallid sturgeon (Figure 2) includes the Missouri and Yellowstone rivers in Montana downstream to the Missouri-Mississippi confluence and the Mississippi River possibly from near Keokuk, Iowa[1] downstream to New Orleans, Louisiana (Coker 1929; Bailey and Cross 1954; Brown 1955; Carlson and Pflieger 1981; Kallemeyn 1983; Keenlyne 1989 and 1995).

Pallid sturgeon also were documented in the lower reaches of some of the larger tributaries to the Missouri, Mississippi, and Yellowstone rivers including the Tongue, Milk, Niobrara, Platte, Kansas, Big Sioux, St. Francis, Grand and Big Sunflower rivers (Bailey and Cross 1954; Brown 1955; Keenlyne 1989; Ross 2001; Snook et al. 2002; Braaten and Fuller 2005; Peters and Parham 2008). The total length of the pallid sturgeon range historically was about 5,656 River kilometers (Rkm) (3,515 River miles (Rmi)).

Because the pallid sturgeon was not recognized as a species until 1905, little detailed information is available concerning early abundance. Forbes and Richardson (1905) suggested that the lack of prior recognition of the species might have been attributable to scarcity, noting that pallid sturgeon accounted for about one in five hundred individuals of the *Scaphirhynchus* sturgeon collected from the central Mississippi River. The species was reported to be more abundant in the lower Missouri River where some fishermen reported one in five sturgeon as pallid sturgeon (Forbes and Richardson 1905). However, it is probable that commercial fishermen failed to accurately distinguish the species in their sturgeon catches. As late as the mid-1900s, it was common for pallid sturgeon to be included in commercial catch records as either shovelnose or lake sturgeon (Keenlyne 1995). Correspondence and notes of researchers suggest that pallid sturgeon were often encountered in portions of the Missouri River as late as the 1960s (Keenlyne 1989). While there are fewer than 40 historical (pre-listing) records of pallid sturgeon from the Mississippi River (Kallemeyn 1983, Keenlyne 1989), this may be attributed to a lack of historical systematic fish collections from that portion of the range.

Present Distribution and Abundance

Since listing in 1990, wild pallid sturgeon have been documented in the Missouri River between Fort Benton and the headwaters of Fort Peck Reservoir, Montana; downstream from Fort Peck Dam to the headwaters of Lake Sakakawea, North Dakota; downstream from Garrison Dam, North Dakota to the headwaters of Lake Oahe, South Dakota; from Oahe Dam downstream to within Lake Sharpe, South Dakota; between Fort Randall and Gavins Point Dams, South Dakota and Nebraska; downstream from Gavins Point Dam to St. Louis, Missouri; in the lower Yellowstone River, Montana and North Dakota; the lower Big Sioux River, South Dakota; the lower Platte River, Nebraska; the lower Niobrara River, Nebraska; and the lower Kansas River, Kansas. Pallid sturgeon observations and records have increased with sampling effort in the middle and lower Mississippi River. Additionally in 1991the species was identified in the Atchafalaya River, Louisiana (Reed and Ewing 1993) and in 2011 pallid sturgeon were documented entering the lower reaches of the Arkansas River (Kuntz in litt., 2012) (Figure 3).

[1] Bailey and Cross (1954) considered observations near Keokuk, Iowa as “dubious” and remark the species is likely represented by “stragglers from down river.”

Figure 2 Map of prominent rivers in the Mississippi River basin. Bold line approximates historical range of pallid sturgeon (Coker 1929; Bailey and Cross 1954; Brown 1955; Carlson and Pflieger 1981; Kallemeyn 1983; Keenlyne 1995).

Figure 3 Post-development map of prominent rivers in the Mississippi River basin. Bold line approximates current range of pallid sturgeon, and includes both wild and hatchery-reared fish. (Data: National Pallid Sturgeon Database, U.S. Fish and Wildlife Service, Bismarck, North Dakota).

Approximately 50 wild adult pallid sturgeon are estimated to exist in the Missouri River upstream of Fort Peck Reservoir (U.S. Fish and Wildlife Service (USFWS) 2007). An estimated 125 wild pallid sturgeon remain in the Missouri downstream of Fort Peck Dam to the headwaters of Lake Sakakawea as well as the lower Yellowstone River (Jaeger et al., 2009). Current abundance estimates are lacking for the Missouri River between Gavins Point Dam and St. Louis, MO. Garvey et al. (2009) generated an estimate of 1600 to 4900 pallid sturgeon for the middle Mississippi River (i.e., mouth of the Missouri River Downstream to the Ohio River confluence). No estimates are available for the remainder of the Mississippi River. Since 1994, supplementation with hatchery-reared pallid sturgeon has occurred throughout the Missouri River and sporadically in the Mississippi River. Supplementation data are summarized in the stocking plan (USFWS 2008).

Habitat Preferences

Pallid sturgeon are a bottom-oriented, large river obligate fish inhabiting the Missouri and Mississippi rivers and some tributaries from Montana to Louisiana (Kallemeyn 1983). 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 met the habitat and life history requirements of pallid sturgeon and other native large-river fishes.

Habitat Use

In many portions of the pallid sturgeon's range, research into habitat usage has produced some useful insights. However, it should be cautioned that much of these data are based on habitat characterizations in altered environments, in some cases substantially altered environments, including an altered hydrograph, suppression of fluvial processes, stabilized banks, loss of natural meanders and side channels, fragmented habitats, and increased water velocities. Thus, the following information and current understanding of habitat use may not necessarily reflect preferred habitats for the species, but rather define suitable habitats within an altered ecosystem.

Within their range, pallid sturgeon have been collected from a variety of locations. These observations help inform habitat usage, but vary by age class and geographic location. In the upper portions of the species' range, sub-adult hatchery-reared pallid sturgeon select main-channel habitats (Gerrity 2005). Conversely, adult pallid sturgeon select areas with frequent islands and sinuous channels while rarely occupying areas without islands or with straight channels (Bramblett and White 2001; Snook et al. 2002; Peters and Parham 2008). In the middle Mississippi River, pallid sturgeon select for areas downstream from islands that are often associated with channel border habitats and select against main-channel habitats (Hurley et al. 2004). Other Mississippi River capture locations tend to be near the tips of wing-dikes (an engineered channel training structure), steep sloping banks, and channel border areas (Killgore et al. 2007b; Schramm and Mirick 2009).

Substrate

Pallid sturgeon have been documented over a variety of available substrates, but are often associated with sandy and fine bottom materials (Bramblett and White 2001; Elliott et al. 2004; Gerrity 2005; Snook et al. 2002; Swigle 2003; Peters and Parham 2008; Spindler 2008). Substrate association appears to be seasonal (Kochet al. 2006a; Koch et al. 2012). During winter and spring, a mixture of sand, gravel and rock substrates are used and during the summer and fall, sand substrate is most often used (Koch et al. 2006a). In the middle Mississippi River, pallid sturgeon transition from predominantly sandy substrates to gravel during May which may be associated with spawning (Koch et al. 2012). In these river systems and others, pallid sturgeon appear to use underwater sand dunes (Bramblett 1996; Constant et al. 1997; Snook et al. 2002; Elliott et al. 2004; Jordan et al. 2006).

Depths and Velocity

Across their range, pallid sturgeon have been documented in waters of varying depths and velocities. Depths at collection sites range from 0.58 meter (m) to > 20 m (1.9 to > 65 feet (ft)), though there may be selection for areas at least 0.8 m (2.6 ft) deep (Bramblett and White 2001; Carlson and Pflieger 1981; Constant et al. 1997; Erickson 1992; Gerrity 2005; Jordan et al. 2006; Peters and Parham 2008; Wanner et al. 2007). Despite the wide range of depths associated with capture locations, one commonality is apparent: this species is typically found in areas where relative depths (the depth at the fish location divided by the maximum channel cross section depth expressed as a percent) exceed 75% (Constant et al. 1997; Gerrity 2005; Jordan et al. 2006; Wanner et al. 2007).

Bottom water velocities associated with collection locations are generally < 1.5 m/s (4.9 ft/s) with reported averages ranging from 0.58 m/s to 0.88 m/s (1.9 ft/s to 2.9 ft/s) (Carlson and Pflieger 1981; Elliott et al. 2004; Erickson 1992; Jordan et al. 2006; Swigle 2003; Snook et al. 2002).

Turbidity

Pallid sturgeon have been collected from a variety of turbidity conditions, including highly altered areas with consistently low turbidities (i.e., 5-100 nephelometric turbidity units (NTU)) to comparatively natural systems like the Yellowstone River with seasonally high turbidity levels (> 1,000 NTU) (Braaten and Fuller 2002, 2003; Erickson 1992; Jordan et al. 2006; Peters and Parham 2008). Currently, the effects from altered turbidity levels are poorly understood. Given the species' small eye structure, presence of barbels with taste buds, taste buds on lips, and ampullary electroreceptors on the underside of the snout, the species appears to be highly adapted to low-visibility environments. It is reasonable to infer that the historically high turbidity levels in the Missouri and Mississippi rivers was a component of the natural ecological processes under which the species evolved. Thus, rivers defined by high turbidity levels that fluctuate seasonally and annually are considered important because the species' life history traits (i.e., predator avoidance or feeding mechanisms) evolved in low visibility environments.

Life History

Pallid sturgeon can be long-lived, with females reaching sexual maturity later than males (Keenlyne and Jenkins 1993). Based on wild fish, estimated age at first reproduction was 15 to 20 years for females and approximately 5 years for males (Keenlyne and Jenkins 1993). However, like most fish species, water temperatures can influence growth and maturity. Female hatchery-reared pallid sturgeon maintained in an artificially controlled environment (i.e., near constant 16 to 20^{o}C temperatures) reached sexual maturity at age 6, whereas female pallid sturgeon subject to colder winter water temperatures reached maturity around age 9 (Webb in litt., 2011). Thus, age at first reproduction could vary based on local conditions.

Females do not spawn each year (Kallemeyn 1983). Observations of wild pallid sturgeon collected as part of the conservation stocking program in the northern part of the range indicates that female spawning periodicity is 2-3 years (Rob Holm, USFWS Garrison Dam Hatchery, unpublished data).

Fecundity is related to body size. The largest upper Missouri River fish can produce as many as 150,000-170,000 eggs (Keenlyne et al. 1992; Rob Holm, USFWS Garrison Dam Hatchery, unpublished data), whereas smaller bodied females in the southern extent of the range may only produce 43,000-58,000 eggs (George et al. 2012). Spawning appears to occur between March and July, with lower latitude fish spawning earlier than those in the northern portion of the range. Adult pallid sturgeon can move long distances upstream prior to spawning, and females likely are spawning at or near the apex of these movements (Bramblett and White 2001; DeLonay et al. 2009). This behavior can be associated with spawning migrations (U.S. Geological Survey (USGS) 2007; DeLonay et al. 2009). Spawning appears to occur over firm substrates, in deeper water, with relatively fast, turbulent flows, and is driven by several environmental stimuli including flow, water temperature, and day length (USGS 2007; DeLonay et al. 2009).

Incubation rates are governed by and depend upon water temperature. In a hatchery environment, fertilized eggs hatch in approximately 5-7 days (Keenlyne 1995). Incubation rates may deviate slightly from this in the wild. Newly hatched larvae are predominantly pelagic, drifting in the currents for 11 to 13 days and dispersing several hundred km downstream from spawn and hatch locations (Kynard et al. 2002, 2007; Braaten et al. 2008, 2010, 2012).

Diets
Data on food habits of age-0 pallid sturgeon are limited. In a hatchery environment, exogenously feeding fry (fry that have absorbed their yolk and are actively feeding) will readily consume brine shrimp suggesting zooplankton and/or small invertebrates are likely the food base for this age group. Data available for age-0 *Scaphirhynchus* indicate mayflies (Ephemeroptera) and midge (Chironomidae) larvae are important (Sechler et al. 2012).

Juvenile and adult pallid sturgeon diets are generally composed of fish and aquatic insect larvae with a trend toward piscivory as they increase in size (Carlson and Pflieger 1981; Hoover et al. 2007; Gerrity et al. 2006; Grohs et al. 2009; Wanner 2006; French 2010)

Based on the above diet data and habitat utilization by prey items, it appears that pallid sturgeon will feed over a variety of substrates (Hoover et al. 2007; Keevin et al. 2007). However, the abundance of Trichoptera in the diet suggests that harder substrates like gravel and rock material may be important feeding areas (Hoover et al. 2007).

Population structure
Genetic information suggests evolutionary differences across the range. Campton et al. (2000) used approximately 500 base pairs of the mitochondrial DNA control region to examine genetic variation within and among three pallid sturgeon groups; two from the upper Missouri River and one from the Atchafalaya River. The pallid sturgeon from the upper Missouri River and Atchafalaya Rivers did not share any haplotypes (P <0.001), and the genetic distance between these two groups (0.14%) was nearly as great as the genetic distance between pallid and

shovelnose sturgeon in the upper Missouri River (0.15%). The authors note that this may represent reproductive isolation and genetic divergence between these two populations of pallid sturgeon that is nearly as old as the isolation between pallid and shovelnose sturgeon.

Tranah et al. (2001) examined genetic variation within and among the same three pallid sturgeon groups as Campton (2000) using five microsatellite loci. The two upper Missouri River groups, separated by Ft. Peck Dam, did not differ significantly from each other. However, pallid sturgeon genetic samples from the upper Missouri River population did differ from samples collected from the Atchafalaya River (F_{st} = 0.13 and 0.25; both $P < 0.01$). Thus pallid sturgeon collected from the Missouri River in Montana (the northern fringe of their range) are reproductively isolated from those sampled from the southern extreme of their range and should be treated as genetically distinct populations (Tranah et al. 2001).

Subsequent work on allele frequencies at 16 microsatellite loci identified significant differences between upper Missouri River pallid sturgeon samples when compared with samples from the lower Missouri, Mississippi, and Atchafalaya rivers (Schrey 2007). While samples from the middle Missouri River (i.e., collected between Gavins Point Dam, South Dakota, downstream to Kansas City, Missouri) appeared to be genetically intermediate between the northern and southern samples (Schrey 2007).

These data indicate that genetic structuring exists within the pallid sturgeon's range consisting of two distinct groups at the extremes of the species' range with an intermediate group in the middle Missouri River (Campton et al. 2000; Tranah et al. 2001; Schrey 2007). These data suggest a pattern of isolation by distance, with gene flow more likely to occur between adjacent groups than among geographically distant groups, and thus, genetic differences increase with geographical distance. Additionally, data indicate that these genetic differences translate into biological differences (i.e., differences in growth rates, metabolic rates, and consumption rates) indicative of local adaptations (Meyer 2011). However, pallid sturgeon from the upper Missouri River are the most distinct from the other groups sampled (Schrey and Heist 2007). Anthropogenic changes to the upper Missouri River have affected migratory opportunities and thus gene flow; main-stem dams have reduced or eliminated both emigration and immigration. The genetic structuring detected within the range likely predates these anthropogenic features (Schrey and Heist 2007) suggesting that before the dams, historical reproductive isolating mechanisms were present within the range or at least portions of the range.

Reasons for listing/current threats

Section 4(a)(1) of the Act requires that reclassification decisions be based on the five factors outlined below. These threats are explained here to provide a context for actions necessary to restore the species to healthy population levels no longer meeting the definition of endangered, and ultimately, no longer meeting the definition of threatened. Section 3 of the Act defines a species as "endangered" if it is in danger of extinction throughout all or a significant portion of its range and as "threatened" if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range

The following known and potential threats that affect the habitat or range of pallid sturgeon are discussed in this section, and include: 1) large river habitat alterations, including river channelization, impoundment, and altered flow regimes; 2) water quality; 3) entrainment; and 4) climate change.

RIVER CHANNELIZATION, BANK STABILIZATION, IMPOUNDMENT, AND ALTERED FLOW REGIMES

Modification and curtailment of pallid sturgeon habitat and range are attributed to large river habitat alterations, including river channelization, bank stabilization, impoundment, and altered flow regimes. Following is a brief summary of these activities by river system.

MISSOURI RIVER

Historically, the Missouri River was dynamic, ever-changing, and composed of multiple channels, chutes, sloughs, backwater areas, side channels, and migrating islands and sandbars. As early as 1832, Congress endorsed an act approving the removal of snags from the river (Funk and Robinson 1974). In 1884, the Missouri River Commission was formed to improve navigation on the river (Funk and Robinson 1974). The Commission used revetments of woven willow and rock to stabilize banks, and dikes to narrow the channel and close off chutes during its 18 years of development and maintenance of the Missouri River. However, the need for barge traffic declined with the expansion of railroad networks, and in 1902 the Missouri River Commission was dissolved and responsibility for the Missouri River was given directly to the U.S. Army Corps of Engineers (COE) (Funk and Robinson 1974). In 1912, Congress approved a navigation channel 1.8 m (6 ft) in depth from Kansas City, Missouri to the mouth near St. Louis, Missouri. Subsequently, the Rivers and Harbors Act of 1945 authorized an increase in channel depth to 2.7 m (9 ft) and width to 91.4 m (300 ft) from Sioux City, Iowa to the mouth and by 1967 a self-scouring channel was largely completed (Funk and Robinson 1974).

During the last century, the Missouri River was altered as a result of the Flood Control Act of 1944 to address societal needs. The most obvious habitat changes were the installation of dams in the upper Missouri River and some tributaries (Figure 4) as well as channelization/stabilization of the lower Missouri River for navigation. These anthropogenic modifications greatly reduced the river's ability to satisfy the life cycle requirements of pallid sturgeon by blocking movements to spawning and feeding areas; decreasing turbidity levels by 1) trapping sediment in reservoirs; 2) reducing distances available for larvae to drift; 3) altering water temperatures; 4) altering conditions and flows in spawning areas; and 5) possibly reducing food sources by lowering productivity (Hesse et al. 1989; Keenlyne 1989; USFWS 2000a; Bowen et al. 2003).

Water levels in the reservoirs impounded by Fort Peck Dam (Fort Peck Reservoir), Montana and Garrison Dam (Lake Sakakawea), North Dakota (Figure 4) may be impediments to larval pallid sturgeon survival. In laboratory studies, *Scaphirhynchus* larvae were found to passively drift upon hatching (Kynard et al. 2002). Subsequent work was conducted with larval pallid sturgeon released downstream of Fort Peck Dam as part of a larval drift study. Combined, these data indicate that pallid sturgeon larvae can drift 245 to 530 km (152 to 329 mi) depending on water column velocity and temperature (Kynard et al. 2002; Braaten et al. 2008). This drift distance would likely result in naturally-spawned larvae from the two occupied reaches of the upper Missouri River drifting into the headwaters of either Fort Peck Reservoir or Lake Sakakawea where survival is believed to be minimal. Braaten et al. (2008) speculate that differences in larval drift rates found between shovelnose and pallid sturgeon might explain why the two species experience different recruitment levels in the upper Missouri River. As part of this study, pallid sturgeon fry of various ages (in days) were released. Subsequently, in 2005 4 recaptured pallid sturgeon were genetically traced back to the 11- to 17-day-old fry released in 2004 (Patrick Braaten, USGS Columbia Environmental Research Center, unpublished data). This indicates that fry released between 11 and 17 days post-hatch are able to survive to age-1 in the Missouri River between Fort Peck Dam and Lake Sakakawea supporting the Kynard et al. (2007) hypothesis that implicates total drift distance as a limitation on natural recruitment in this reach of the Missouri River.

In addition to limiting drift distance and inundating habitat, an altered hydrograph also affects downstream temperature profiles and reduces sediment transport. Cold water releases have been attributed to spawning delays in several native riverine fishes and changing fish community composition downstream (Wolf 1995; Jordan 2000). Canyon Ferry, Hauser, and Holter dams are upstream of Great Falls, Montana. Though they do not impose any migratory barriers for pallid sturgeon, these structures, like the main-stem Missouri River dams, can affect sediment and nutrient transport and maintain an artificial hydrograph. Thus, the main-stem and tributary dams upstream of Fort Peck Dam (Figure 4) affect downstream reaches by reducing both sediment input and transport. The results are a reduction of naturally occurring habitat features like sandbars. Discharge and sediment load, together with physiographic setting, are primary factors controlling the morphology of large alluvial rivers (Kellerhals and Church 1989). Seasonally high turbidity levels are a natural component of pre-impoundment ecological processes. Reduced sediment transport and the associated decrease in turbidity could affect pallid sturgeon recruitment and feeding efficiency.

The relationship between high turbidity levels and larval pallid sturgeon survival is unclear. Increased predation on white sturgeon yolk sac larvae at low turbidity levels suggest that high turbidity levels associated with a natural hydrograph and natural sediment transport regimes may offer concealment for free drifting sturgeon embryos and larvae (Gadomski and Parsley 2005). Given that the diet of pallid sturgeon is generally composed of fish and aquatic insect larvae with some preference for piscivory as they mature (see *Life History* section, above), higher pre-impoundment turbidity levels may have afforded improved foraging effectiveness by providing older juveniles and adults some level of concealment. From Garrison Dam, North Dakota to Gavins Point Dam, South Dakota (Figure 4), the Missouri River retains little of its historical riverine habitat; most of this reach is impounded in reservoirs. However, within these reservoirs, pallid sturgeon have been documented in the more riverine reaches, some of which have been identified as useful for recovery efforts (Erickson 1992; Jordan et al. 2006; Wanner et al. 2007). Despite these data, most of these inter-reservoir reaches are poorly understood and further research is needed to evaluate and define their significance to species' recovery.

The Missouri River downstream of Gavins Point Dam (Figure 4) is over 1,296 Rkm (800 Rmi) in length, is unimpeded by dams, and is biologically and hydrologically connected with the Mississippi River. However, this reach is not immune from past and present anthropogenic modifications. For example, in the unchannelized reach extending from Gavins Point Dam downstream for approximately 95 Rkm (59 Rmi) side channel and backwater habitats have changed (Yager et al. 2011). Changes include a decrease of 77% and 37%, respectively, in total and mean area of side channels, as well as decrease of 79% and 42%, respectively, in total and mean length of side channels (Yager et al. 2011). Channelization of the Missouri River downstream from this reach has reduced water surface area by half, doubled current velocity, decreased habitat diversity, and decreased sediment transport (Funk and Robinson 1974; USFWS 2000a).

Although the Missouri River downstream of Gavins Point Dam is not impounded, it is influenced by the operation of upstream dams. Additionally, nearly all major tributaries to this reach have one or more dams which cumulatively affect flows and sediment transport. Damming and channelizing the Missouri River and tributaries adversely affects pallid sturgeon (USFWS 2000a and 2003).

MISSOURI RIVER TRIBUTARIES

At the time of listing, few observations of pallid sturgeon occurred in waters outside of the main-stem Mississippi, Missouri, and Yellowstone rivers; tributary observations were attributed to special circumstances associated with high-flow conditions (55 FR 36641-36647). While historical captures of pallid sturgeon occurred near the mouths of tributaries or within close proximity to tributary confluences with the Missouri River, more recent observations indicate that Missouri River tributaries may be more important than originally recognized when the species was listed. These habitats appear to be important to the pallid sturgeon during certain times of the year or perhaps during certain life stages. Tributaries identified below are based on documented observations of pallid sturgeon and should not be considered a definitive list. This list may be revised if new data become available.

Yellowstone River

The Yellowstone River is the largest tributary to the Missouri River (Figure 4). While often referred to as "the last undammed river," this descriptor is a misnomer. At about the same time that Forbes and Richardson (1905) were describing pallid sturgeon as a species, the first and lowermost of six low-head diversion dams was being constructed across the river. This structure, Intake Dam (figure 4), was constructed by the Bureau of Reclamation (BOR) approximately 115 Rkm (71 Rmi) from the confluence with the Missouri River and effectively blocks upstream movements of pallid sturgeon (Bramblett and White 2001) and entrains fish from the river into the irrigation delivery canal (Jaeger et al. 2005).

Adult pallid sturgeon use the lower Yellowstone River (Bramblett 1996). Aggregations of pallid sturgeon during spawning season strongly suggest that spawning occurs in the lower Yellowstone River (Bramblett 1996). Recent evidence of spawning success in the lower Yellowstone River has been documented (Fuller et al. 2007), but detectable levels of recruitment remain absent.

Upstream movements of both adult and juvenile pallid sturgeon are blocked by Intake Dam. This barrier appears to be limiting adult fish from accessing upstream habitats which may be suitable for spawning (Bramblett and White 2001; Jaeger et al. 2005). Additionally, about half of juvenile study fish stocked upstream of Intake Dam did not emigrate during the study period, suggesting suitable habitats for juvenile fish exist upstream of Intake Dam (Jaeger et al. 2005). Naturally-produced larvae in the lower Yellowstone River will drift into Lake Sakakawea as long as spawning occurs downstream of Intake Dam (Braaten et al. 2008). This information indicates that available drift distance for larvae is artificially truncated by Intake Dam on the upstream end and water levels in Lake Sakakawea at the downstream end. This lack of drift distance is an ongoing threat limiting recruitment from the Yellowstone River.

Pallid sturgeon also have been entrained in the irrigation canal associated with Intake Dam (Jaeger et al. 2004). In 2012, a new canal water headworks was completed that incorporates fish screens intended to eliminate entrainment losses. To date, upstream passage has not been provided at Intake Dam. Available data indicate that providing fish passage at Intake Dam remains necessary to facilitate pallid sturgeon recovery.

Yellowtail Dam on the Bighorn River and Tongue River Dam on the Tongue River (Figure 4), both major tributaries to the Yellowstone River, have altered sediment transport and flows into the lower Yellowstone River. Other anthropogenic modifications on the Yellowstone River include bank stabilization projects to protect private property and transportation infrastructure, as well as municipal, industrial, and agricultural water withdrawal projects.

Milk River
The Milk River (Figure 4) is ecologically important to the Missouri River downstream of Fort Peck Dam as it contributes flows, sediment, and warmer water temperatures. The Milk River is subject to irrigation diversions that can substantially alter the hydrograph in this system. Correspondingly, several barriers would effectively block migrations within this system. The lowermost is Vandalia Diversion Dam (Figure4) located near Rkm 188 (Rmi 117). In 2004, a wild adult pallid sturgeon was documented in the Milk River approximately 4 Rkm (2.5 Rmi) above the confluence with the Missouri River (Braaten and Fuller 2005; Fuller in litt., 2011). Subsequently in 2011, 4 males and 1 female migrated into the Milk River; the furthest upstream location was approximately 57.9 Rkm (36 Rmi) (Fuller in litt., 2011).

Marias River
Historically, the Marias River (Figure 4) influenced the Missouri River downstream from their merger. During 1805 when the Lewis and Clark Expedition arrived at the confluence with the Marias River, they could not decide which river was the Missouri River (Moulton 1987). The influence of the Marias River on the Missouri River is not only limited to physical features but also affects the fish communities. Several large migratory species such as paddlefish (*Polyodon spathula*), blue sucker (*Cycleptus elongatus*), and shovelnose sturgeon presently or historically were known to migrate up the Marias River presumably to spawn (Gardner and Jensen 2007). It is possible that in the past, pallid sturgeon also may have migrated up the Marias River to spawn. Operations of Tiber Dam (Figure 4) on the Marias River at Rkm 132 (Rmi 82) have now altered the natural flow and sediment regime of the Marias River and may have affected its use by fish

species including pallid sturgeon (Gardner and Jensen 2007). While historical data documenting occupation by pallid sturgeon are absent, hatchery-reared pallid sturgeon recently have been captured in the lower 1 Rkm (0.6 Rmi) (Gardner 2010).

Niobrara River

Wild pallid sturgeon were documented in the Niobrara River (Figure 4) around the mid-1900s (Mestl *in litt.*, 2011). Since that time, the lower reach of the Niobrara River has been affected by rapid aggradation due to the siltation at the head of Lewis and Clark Lake on the Missouri River. Approximately 2.2 to 2.8 m (7.5 to 9.5 feet) of aggradation observed since the 1950s has changed the lower Niobrara River from a "relatively deep, stable channel with large, bank-attached braid bars to a relatively shallow aggrading channel with braid bars" (Skelly et al. 2003). It is not known to what degree channel aggradation has affected habitats for pallid sturgeon.

Pallid sturgeon habitat in the lower Niobrara River also may be affected by water withdrawals. The Nebraska Department of Natural Resources has declared a portion of the lower Niobrara River as fully appropriated (Nebraska 2007). Although habitat suitability has changed substantially over the last five decades, the Niobrara River still retains braided channels with shifting sand bars representative of pre-channelization conditions of rivers throughout the pallid sturgeon's historical range (Peters and Parham 2008). Recently, three hatchery-reared pallid sturgeon released in the Missouri River were documented in the Niobrara River; two were approximately 1.6 Rkm (1 Rmi) upstream of the confluence with the Missouri River while the other was approximately 9.6 Rkm (6 Rmi) upstream of the confluence (Wanner et al. 2010).

Big Sioux River

The Big Sioux River (Figure 4) is a north to south flowing prairie river that originates in South Dakota and drains into the Missouri River downstream of Gavins Point Dam, the lowermost dam on the Missouri River. Historical observations of pallid sturgeon in this system are absent. However, one tagged pallid sturgeon moved upstream 21.1 Rkm (13.1 Rmi) into this river from the Missouri River (DeLonay et al. 2009).

Platte River

The Platte River (Figure 4) is a Missouri River tributary downstream of Gavins Point Dam. Increasing numbers of both hatchery-reared and presumed-wild pallid sturgeon have been observed in the Platte River since the species was listed. One observation was approximately 158 Rkm (98.4 Rmi) upstream from the Missouri River confluence (Snook et al. 2002; Swingle 2003; Peters and Parham 2008; Hamel *in litt.*, 2009, 2010). Additionally, limited data indicate that the lower Platte River (defined as the Platte River from the confluence with the Missouri River upstream to the Elkhorn River) could be used for spawning (Swigle 2003). These data indicate the Platte River provides suitable habitat and can help support multiple life stages of the species.

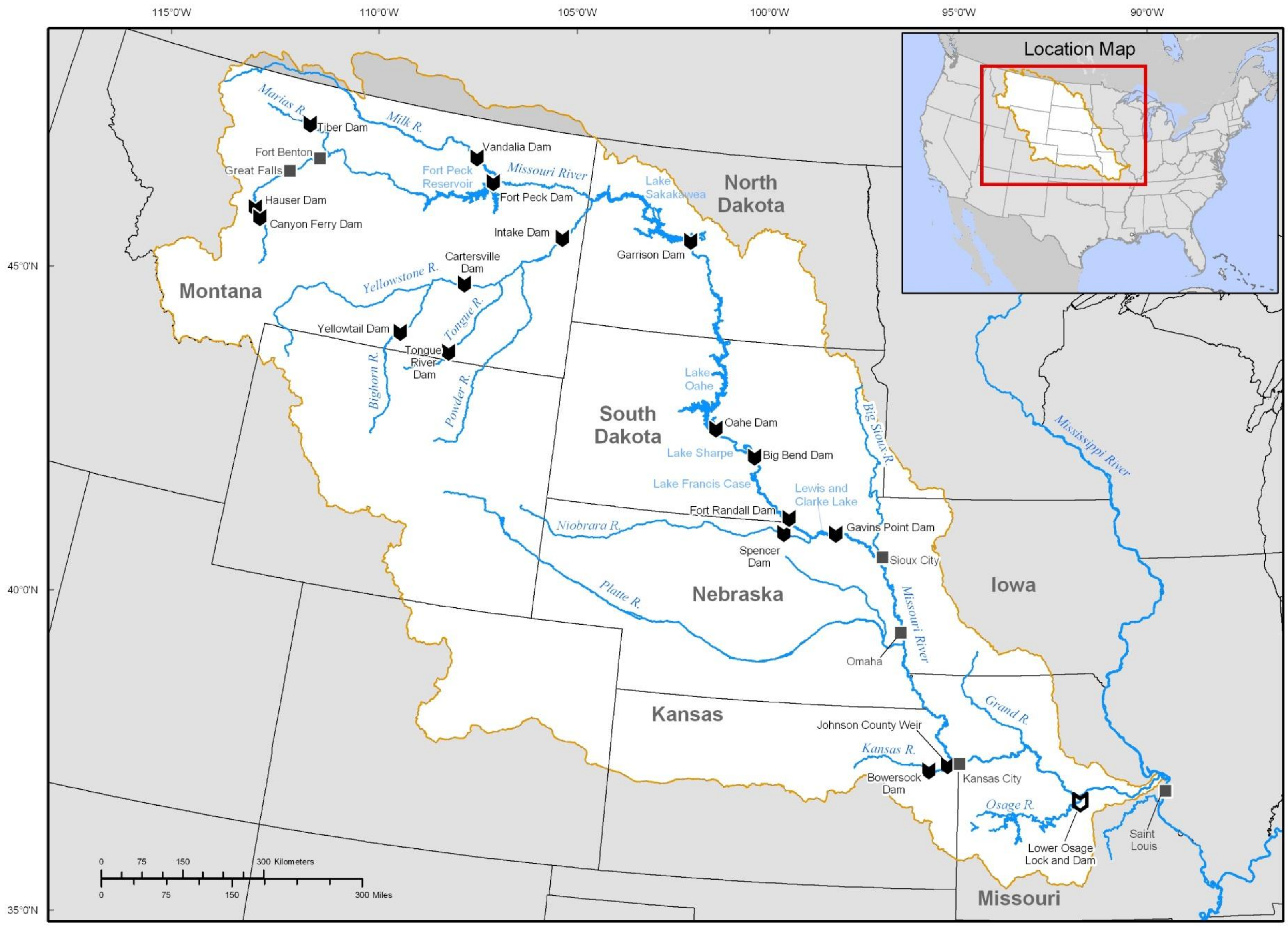

Figure 4 Map of prominent structures within the Missouri River Basin.

Although not developed as a navigation corridor, the Platte River has been influenced by anthropogenic alterations that likely affect pallid sturgeon habitat. Water demands for industrial, municipal, and agricultural purposes led to construction of low-head diversion dams on the upper Platte River and large impoundments on the Platte River and its tributaries. Eschner et al. (1983) state that the Platte River and its tributaries "…have undergone major changes in hydrologic regime and morphology since 1860." These authors describe a process where islands eventually attached to the floodplain, became vegetated, and eventually fixed in place resulting in decreased channel widths. These authors attribute many of these changes in channel morphology to water development and diversions. Similarly, Rodekohr and Englebrecht (1988) noted the Platte River is more constricted than it was in 1949. Despite some of these changes, there appears to be sufficient beneficial qualities within the lower Platte River, such that pallid sturgeon will occupy it (Swigle 2003; Peters and Parham 2008). Sampling within the Missouri River near the confluence of the Platte River results in substantially more pallid sturgeon captures when compared against other Missouri River sampling sites downstream to the Kansas River confluence (Steffensen and Hamel 2007 and 2008). This suggests that the Platte River also provides some positive benefits to pallid sturgeon habitat in the Missouri River.

Kansas River
The Kansas River (Figure 4) has anthropogenic alterations that likely affect some aspects of pallid sturgeon life history. Bowersock Dam (Rkm 82, Rmi 51) near Lawrence Kansas was constructed in the 1870s (Figure 4). Because this barrier was installed prior to pallid sturgeon being identified as a species, there is little historical occupancy data for reaches upstream. The Johnson County Weir is another potential barrier to pallid sturgeon movement in the lower Kansas River (Rkm 23.7, Rmi 14.7). This structure was built in 1967 to maintain sufficient water delivery for municipal purposes. To date, 15 pallid sturgeon, most confirmed to be of hatchery origin (Niswonger, *in litt*., 2011), have been collected from the lower Kansas River. All known hatchery fish were originally stocked in the Missouri River.

Osage River
The Osage River is one of the larger Missouri River tributaries in Missouri (Figure 4). Pallid sturgeon have been documented near the confluence of the Osage and Missouri rivers, including three hatchery-reared pallid sturgeon in the lower Osage River between Lock and Dam #1 (Rkm 19.4; Rmi 12.1) and the confluence with the Missouri River in 2010 (USFWS 2010, 2012).

Grand River
The Grand River (Figure 4) is a turbid tributary that was highly channelized during the same period that pallid sturgeon were likely declining. However, this system continues to supports a predominantly native fish assemblage with species such as lake sturgeon occasionally being captured. While historical data documenting occupation by pallid sturgeon are absent, hatchery-reared pallid sturgeon have been captured in the lower 3 Rkm (1.8 Rmi) (DeLonay et al. 2009).

MISSISSIPPI RIVER
The Mississippi River (Figure 5) is often divided into upper, middle and lower reaches. Like the Missouri River, the Mississippi River has been anthropogenically altered, beginning in the early portions of the 18^{th} century as the French began to settle along the Mississippi River (Cowdrey

1977). These earlier efforts were generally localized and limited in scope. It was not until the 19th century that large-scale efforts to improve navigation and flood control began to have more substantial impacts. Snagging (removing dead trees from the river) was one of the first efforts to facilitate using the river as a transportation corridor. In the early 1800s with Federal appropriations, snag boats removed large woody debris from the middle and lower Mississippi River between St. Louis, Missouri and New Orleans, Louisiana (Simons et al. 1974; Cowdrey 1977).

The next major efforts to improve navigation involved maintaining navigable channels. In the mid-1800s, construction of jetties and dredging provided the first successful large-scale reduction of sediment deposition and the subsequent forming of sandbars that blocked shipping routes (Cowdrey 1977). Flood control became an increasingly important focus of Congress as more people settled in the Mississippi River valley and the human costs of flood damage increased. Small and localized levee systems were in existence in the 1700s; however, it was not until the 19th and 20th centuries that levee networks increased in size and scope. As the levee system was completed, flood stages increased resulting in the need to shunt flood waters from the river (Cowdrey 1977). The Flood Control Act of 1928 included provisions for strengthening and raising existing levees and including floodways and spillways (Cowdrey 1977); examples include the Bonnet Carré spillway, the Morganza floodway, and the Old River Control Complex (Figure 5).

In addition to the dams on the upper Missouri River, flows into the middle and lower Mississippi River also are influenced by a series of locks and dams in the upper Mississippi River, as well as the Ohio River. The earliest lock and dam structures were constructed in 1867 at the Keokuk Rapids, Iowa. By 1940, the locks and dams from Minneapolis, Minnesota down to Alton, Illinois, were in place and operational. Finally, revetments and various structures have been used to reduce erosion and restrict flows in many areas. Willow mattresses and cypress pilings, later replaced by articulated concrete mats and rock riprap, were used to prevent loss of riparian land and control flow patterns (Cowdrey 1977). This reduction in river bank erosion has reduced the amount of sediments and large woody debris entering the system. Subsequent loss of connectivity and channel sinuosity occurred as habitats were channelized and off-channel habitats became isolated from normal riverine flow. Modifications to the Mississippi River occurred largely from construction of the locks and dams, levees, and channel maintenance structures.

Upper Mississippi River

The upper Mississippi River, as it relates to pallid sturgeon, is defined as being upstream of the confluence of the Missouri and Mississippi rivers to Lock and Dam 19 near Keokuk, Iowa (Figure 5). This reach is approximately 260 Rkm (162 Rmi) in length. The lower most lock and dam (Lock and Dam 26 near Alton, Illinois) is located approximately 8 Rkm (5Rmi) upstream of the Missouri-Mississippi river confluence (Figure 5). Although fish passage through the six lock and dam structures is impeded for many species, it can occur through the lock chamber or the dam gates during flood events. Historical pallid sturgeon observations in the upper Mississippi River near Keokuk, Iowa (Coker 1929) are reported as "dubious" (Bailey and Cross 1954). However, pallid sturgeon have been documented to move from the middle Mississippi River into the pools of the upper Mississippi River (Herzog *in litt*., 2009; Herzog 2010), but, the extent of use within this impounded reach of the upper Mississippi River is poorly understood, and further research is needed to assess its role in species recovery.

Middle Mississippi River

The middle Mississippi River is defined as the Missouri-Mississippi river confluence near St. Louis, Missouri to the Mississippi-Ohio river confluence near Cairo, Illinois (Figure 5). This reach is approximately 313 Rkm (195 Rmi) in length.

In 1881, Congress approved plans to regulate the middle Mississippi River, and by 1973 this reach of the Mississippi River had experienced levee construction, more than 160 km (100 mi) of revetments, and installation of more than 800 dikes to maintain a minimum navigation channel depth of 2.7 meters (9 feet) (Simons et al. 1974). Lock and Dam 27, (Chain of Rocks dam and canal) is located at Rkm 298.5 (Rmi 185.5) near Granite City, Illinois. The canal structure was completed to facilitate navigation around the shallow bedrock that occurred in this reach. Large quantities of rock were dumped over the existing bedrock to create a low-head dam necessary to make the lock canal navigable. Although no pallid sturgeon have been documented in the canal, both pallid and shovelnose sturgeon concentrate below the Chain of Rocks dam during fall and winter low-flow events (Killgore et al. 2007a).

The cumulative effects of these alterations include an average reduction in river width, river bed degradation, a slight increase in the maximum river stage, a reduction in minimum river stage, and a constricted flood plain (Simons et al. 1974).

Lower Mississippi River

The lower Mississippi River (LMR) is defined as the Mississippi River from the Mississippi-Ohio rivers confluence to the Gulf of Mexico (Figure 5). This reach is approximately 1,541 Rkm (958 Rmi) in length, and based on proportion of river size to anthropogenic alterations, represents one of the least modified reaches within the pallid sturgeon range.

Between 1929 and 1942, bendway cutoffs shortened the LMR by 245 Rkm (152 Rmi) over a 809 km (503 mile) reach (Winkley 1977). The LMR was reduced an additional 88.5 Rkm (55 Rmi) between 1939 and 1955 by constructing artificial channels that bypassed natural river meanders (Winkley 1977). This channel length reduction resulted in the river entrenching in steeper gradient reaches and eroding large amounts of material from the channel banks and bed. Deposition of this material in the lower gradient reaches resulted in a semi-braided channel, and by the 1970s, the river was attempting to reestablish a meandering condition (Winkley 1977). Dikes and bank armoring have been employed in the LMR to stabilize the channel and direct flows to reduce the need for dredging.

Levee construction began in the New Orleans area in the 1700s. Today, excluding a few tributary mouths, levees line the west side of the river and fill in low areas between natural bluffs on the east side (Cowdrey 1977; Baker et al. 1991). These levees are estimated to have reduced the floodplain area by as much as 90% depending on flood magnitude (Baker et al. 1991). Although the LMR channel has been enclosed by levees, numerous and extensive sandbars, vegetated and seasonal islands, and secondary channels remain, equating to a 1.6 million acre floodplain that retains floodplain backwaters and sloughs that are seasonally connected to the river (Schramm et al. 1999).

MISSISSIPPI RIVER TRIBUTARIES

As previously stated, data post-listing indicate that main-stem tributaries and tributary confluences are more important than previously recognized. Several captures of pallid sturgeon have occurred within tributaries, near the mouth of tributaries, and within close proximity to tributary confluences with the Mississippi River. These habitats appear to be important to the pallid sturgeon during certain times of the year or perhaps during certain life stages.

Arkansas River

The Arkansas River (Figure 5) confluences with the Mississippi River near Rkm 933 (Rmi 580). To date, three pallid sturgeon have been documented entering the lower reaches of the Arkansas River. All observations were downstream from the Wilbur D. Mills Dam (Figure 5) in the late-winter through spring (February – April) (Kuntz in litt., 2012). Additional efforts are ongoing to better understand usage of this tributary by pallid sturgeon and what role this tributary serves for the recovery of pallid sturgeon.

Saint Francis River

The Saint Francis River (Figure 5) flows through south-east Missouri into Arkansas where it confluences with the Mississippi River. In 1994 hatchery fish were documented in the lower Saint Francis River (Graham in litt., 1994) downstream from the W. G. Huxtable Pumping Plant (Figure 5). Additional data are necessary to better understand use of this river by pallid sturgeon and what role this river serves in pallid sturgeon recovery efforts.

Meramec River

This tributary to the middle Mississippi River, located near Rkm 254 (Rmi 158) (Figure 5), is a large river within Missouri that contains transitional habitats within its lower reaches. There are no historical accounts of pallid sturgeon in this river; however, pallid sturgeon have been documented in the Mississippi River near the Meramec River confluence (Koch et al. 2006a). It is not known whether pallid sturgeon historically migrated within this system, and additional data are necessary to determine what role this tributary serves for the recovery of pallid sturgeon.

Kaskaskia River

The Kaskaskia River is located near Rkm 188 (Rmi 117) near Chester, Illinois (Figure 5). This is Illinois' second largest river system at 515 Rkm (320 Rmi) long draining about 10% of the State. Several pallid sturgeon have been documented at the confluence with the Mississippi River (Koch et al. 2006a), although movement into the Kaskaskia River by pallid sturgeon has not been documented. However, these movements are likely impeded because of a lock and dam near the mouth. In addition, the watershed of the Kaskaskia River has been modified over the last 100 years by urbanization, channelization, and levee and dam construction. It is unknown whether pallid sturgeon historically migrated within this system, and additional data are needed to determine if this tributary serves any role for the recovery of pallid sturgeon.

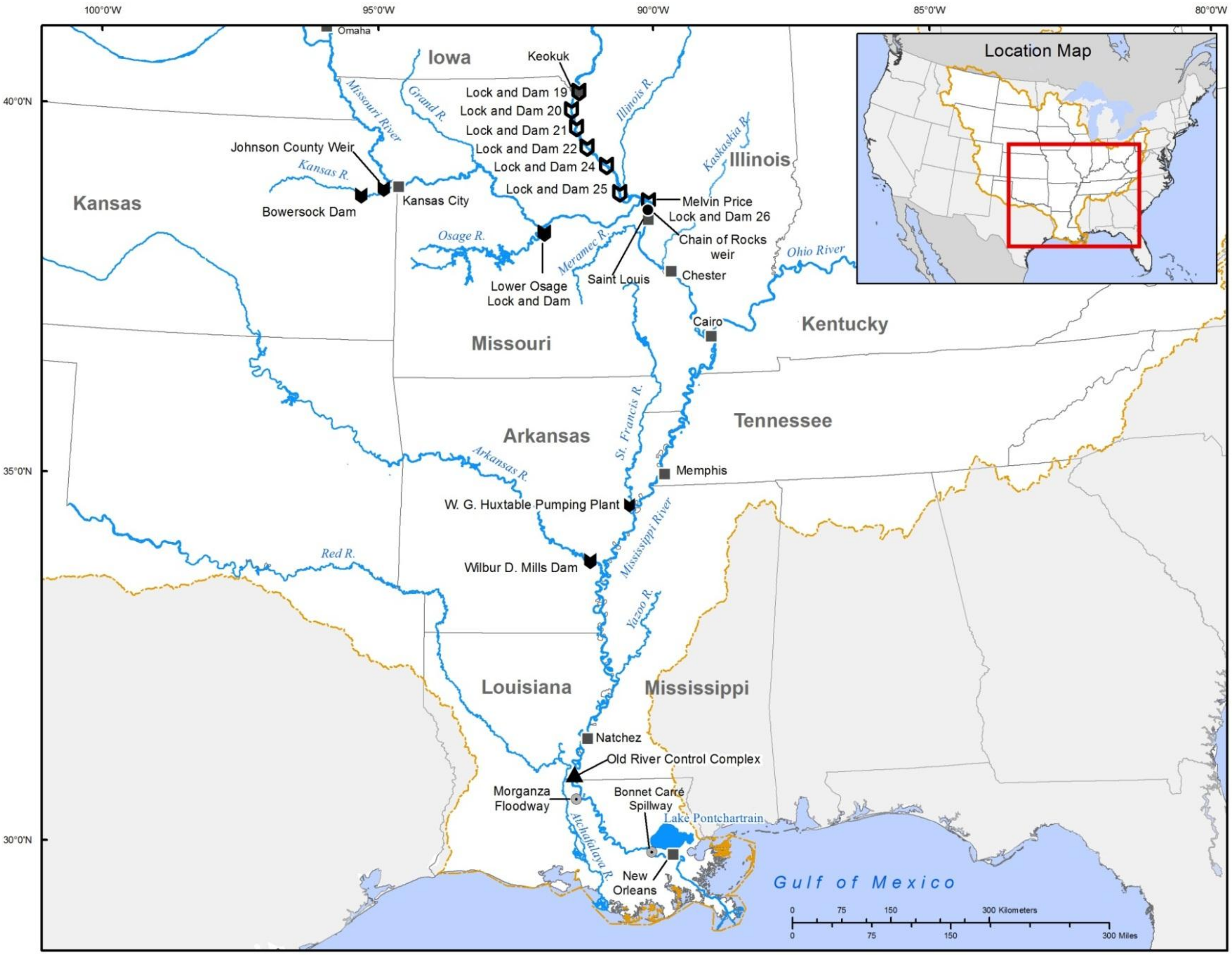

Figure 5 Map of prominent structures in the Mississippi River Basin.

Kaskaskia River
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Ohio River
The Ohio River (Figure 5) is the largest tributary to the Mississippi River system within the range of pallid sturgeon. However, there are no recent reports of pallid sturgeon and no confirmed records of presence in this system, and additional data are needed to determine if this tributary serves any role for the recovery of pallid sturgeon.

Atchafalaya River
The Atchafalaya River (figure 5) is a distributary of the lower Mississippi River that begins just south of Cochie, Louisiana and extends downstream to Morgan City, Louisiana (Rkm 180/Rmi 112), where it flows into the lower Atchafalaya River and ultimately to the Gulf of Mexico. At approximately Atchafalaya River Rkm 156 (Rmi 97), the Wax Lake Outlet was constructed in 1942, providing a shorter route for flood waters to leave the Atchafalaya River. Prior to 1859, the Atchafalaya River received Mississippi River water from overbank flooding. Snagging and channel excavation in support of navigation during the late 19th and early 20th centuries resulted in channel enlargement and increased flows into the Atchafalaya River from the Mississippi and Red rivers. By the 1950s the Atchafalaya River threatened to capture most of the lower Mississippi River flow, and in 1963 the COE constructed the Old River Control Complex (figure 5) to prevent this capture by regulating flows into the Atchafalaya River.

The Old River Control Complex (i.e., Low Sill, Overbank, and Auxiliary) at approximately Mississippi Rkm 505 (RM 314) can carry a combined maximum discharge of 700,000 cfs. Since the completion of the Sidney A. Murray, Jr. Hydroelectric Station in 1990, just upstream of the Old River Control Complex, the flows are now split between the hydroelectric station and the Old River Control Complex structures with flows released to maximize hydro-power production. The Old River Control Complex, in coordination with the hydro-power plant, carries 30% of the combined discharge from the Mississippi and Red rivers, maintaining Mississippi River discharge into the Atchafalaya River at levels comparable to the 1950s. The Atchafalaya River has been leveed to prevent flooding of communities and agricultural lands from Rkm/Rmi 0 to Rkm 85 (Rmi 53). Downstream of Rkm 85, the river levees only contain flows less than the average annual discharge; all greater discharges flow overbank. Most pallid sturgeon reported from this river have been captured immediately below the Old River Control structures where almost all sampling occurs (Reed and Ewing 1993). However, pallid sturgeon use of the middle and lower Atchafalaya River has been documented (Constant et al. 1997; Schramm and Dunn 2007, Herrala and Schramm 2011).

There is no evidence that pallid sturgeon occupied the Atchafalaya River distributary prior to the mid-20th century capture of Mississippi River flows. To date, hatchery fish (2 specimens) released in the Mississippi River below Natchez, Mississippi, and above Memphis, Tennessee (1 specimen), have been captured in the Atchafalaya River, indicating that pallid sturgeon can be entrained from the Mississippi River into the Atchafalaya River. It is possible that many of the pallid sturgeon observations in the Atchafalaya River are the result of entrainment from the Mississippi River; the magnitude of which has not been quantified.

Summary of Impacts from River Channelization, Bank Stabilization, Impoundment, and Altered Flow Regimes

The species was essentially extirpated from approximately 28% of the historical range due to impoundment, and the remaining unimpounded range has been modified by channelization and bank stabilization, or is affected by upstream impoundments that alter flow regimes, turbidity, and water temperatures (Hesse et al. 1989; Keenlyne 1989; USFWS 2000a). River channelization, bank stabilization, impoundment, altered flow regimes, and their effects are documented throughout the range of the pallid sturgeon and each can negatively affect pallid sturgeon life-history requirements. The most obvious effects to habitat are associated with the six main-stem Missouri River dams. These dams and their operations have: 1) truncated drift distance of larval pallid sturgeon (Kynard et al. 2007; Braaten et al. 2008), 2) created physical barriers that block normal migration patterns, 3) degraded and altered physical habitat characteristics, 4) greatly altered the natural hydrograph (Hesse et al. 1989), and 5) reulted in subtle changes in river function that influence both the size and diversity of aquatic habitats, connectivity (Bowen et al. 2003), and benthos abundance and distribution (Morris et al. 1968). Moreover, these large impoundments have replaced large segments of riverine habitat with lake conditions. Damming of the upper Missouri River has altered river features such as channel morphology, current velocity, seasonal flows, turbidity, temperature, nutrient supply, and paths within the food chain (Russell 1986; Unkenholz 1986; Hesse 1987). In addition to the main-stem Missouri River dams, important tributaries like the Yellowstone River, Platte River, and Kansas River have experienced similar affects due to dams and water resource development in their respective watersheds. Other issues that have influenced habitat formation and maintenance are associated with maintaining navigation channels on portions of the Missouri River as well as efforts to control flooding. The Mississippi River has received a substantial amount of anthropogenic modification through time, and some changes resulting from those modifications have likely been detrimental to pallid sturgeon. These anthropogenic habitat alterations likely adversely affect pallid sturgeon by altering the natural form and functions of the Mississippi River (Simons et al. 1974; Baker et al. 1991; Theiling 1999; Wlosinski 1999). Anthropogenic alterations to tributaries may have contributed to habitat degradation in the Mississippi River as well. Impoundment of major tributaries reduced sediment delivery to the main channel (Fremling et al. 1989) resulting in channel degradation and reduction in shallow water habitats (Simons et al. 1974; Bowen et al. 2003). Thus dams, bank stabilization, and channelization activities, individually and cumulatively when implemented within the range of pallid sturgeon, should be considered threats to the species.

WATER QUALITY

Contaminants /Pollution

Much of the information we have regarding the likely effects to pallid sturgeon from contaminants comes from information obtained for shovelnose sturgeon, which can be used as a surrogate species to evaluate environmental contaminant exposure. Shovelnose sturgeon are considered a suitable surrogate species for pallid sturgeon in that they live for 20 years or longer, inhabit the same river basins, spawn at similar intervals and locations, and accumulate similar inorganic and organic contaminants (Ruelle and Keenlyne 1994; Buckler 2011). However, while inferences can be drawn from data related to shovelnose sturgeon, limitations of using this species as a surrogate for pallid sturgeon are based on life history differences between the two species. Pallid sturgeon have a longer life-span, attain a larger size, are more piscivorous, and contain a higher percentage of body fat (Ruelle and Keenlyne 1994). These differences may contribute to different contaminant effects or pathways; pallid sturgeon may be at greater risk than shovelnose sturgeon to contaminants that bioaccumulate and cause reproductive impairment because they have a more piscivorous diet, greater maximum life-span, and a longer reproductive cycle than shovelnose sturgeon.

Contaminants detected in shovelnose sturgeon throughout the Missouri, Mississippi, Platte, and Atchafalaya rivers include: organochlorines, metals, aliphatic hydrocarbons, polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), and elemental contaminants (Allen and Wilson 1991; Welsh 1992; Welsh and Olson 1992; Ruelle and Henry 1994b; Palawski and Olsen 1996; Conzelmann et al.1997; Coffey et al. 2003; Schwarz et al. 2006).

A few field studies have included shovelnose sturgeon health assessments in an effort to evaluate environmental contaminant exposure and effects to pallid sturgeon (Coffey et al. 2003; Schwarz et al. 2006). Organochlorine pesticides and PCBs were detected at concentrations of concern in Mississippi River shovelnose sturgeon tissue samples. Adverse health problems observed included abnormal reproductive biomarkers and enlarged livers (Coffey et al. 2003). A similar evaluation in the lower Platte River identified PCBs, selenium, and atrazine as contaminants that may adversely affect sturgeon reproduction (Schwarz et al. 2006).

Shovelnose sturgeon collected from the Platte, lower Missouri and Mississippi rivers have exhibited intersexual characteristics (having both male and female gonad tissue) (Harshbarger et al. 2000; Wildhaber et al. 2005; Koch et al. 2006b; Schwarz et al. 2006). Intersexual shovelnose sturgeon from the middle Mississippi River were found to have higher concentrations of organochlorine compounds when compared to male shovelnose sturgeon (Koch et al. 2006b). One pallid sturgeon exhibited both male and female reproductive organs (DeLonay et al. 2009). Although the effects of intersex on sturgeon reproduction are unknown, intersex in other fish species has been linked to decreased gamete production, lowered sperm motility, and decreased egg fertilization (Jobling et al. 2002). Koch et al. (2006b) observed reduced numbers of spermatozoa in highly contaminated and intersexual shovelnose sturgeon that may suggest limited reproductive success.

Laboratory studies also have evaluated environmental contaminant exposure and effects to shovelnose sturgeon. Papoulias et al. (2003) injected unhatched shovelnose sturgeon larvae with PCB 126 and Tetrachlorodibenzo-p-dioxin (TCDD). They found yolk sac and pericardial swelling, hemorrhaging of the eyes and head, shortened maxillaries, and delayed development. While the experimental exposure concentrations of PCB 126 was at levels beyond what might be found in the wild, the negative effects from TCDD exposure concentrations were at levels that are conceivable in the Mississippi River (Papoulias et al. 2003)

To date, few studies have measured environmental contaminant concentrations in pallid sturgeon. Tissue samples from three Missouri River pallid sturgeon and 13 other pallid sturgeon, mostly collected from the Mississippi River had metals (e.g., mercury, cadmium, and selenium), PCBs, and organochlorine pesticides (e.g., chlordane, DDT, DDE, and dieldrin) at concentrations of concern (Ruelle and Keenlyne 1993; Ruelle and Henry 1994a). In addition to the previously mentioned reports on contaminants in pallid sturgeon, raw contaminants data for pallid sturgeon from North Dakota, Illinois, and Louisiana are currently being compiled.

Point-source discharges may adversely affect pallid sturgeon and their habitat. Wastewater treatment plant effluent can contain hormonally active agents. Endocrine disruption in fish exposed to estrogenic substances discharged by wastewater treatment plants is well documented (Purdom et al. 1994; Routledge et al. 1998; Cheek et al. 2001; Schultz et al. 2003). In addition to wastewater treatment plants, drinking water treatment plants also are a concern. In April 2004, several radio-tagged pallid sturgeon were repelled from the mouth of the Platte River immediately following a milky discharge from a drinking water treatment facility upstream (Parham et al. 2005). Further investigation found that the facility was not in compliance with its discharge permit which expired in 1993, and that the discharge likely contained several toxic irritants including ferric sulfate, calcium oxide, hydrofluosilicic acid, chlorine, and ammonia.

Several fish consumption advisories within the range of pallid sturgeon are attributable to contaminants (Buckler 2011). The State of Tennessee closed commercial fishing on portions of the Mississippi River because of concerns over chlordane and other contaminants (Tennessee 2008 a and b). The Missouri Department of Health and Senior Services has issued a "do not eat" advisory for shovelnose sturgeon eggs and recommends consuming no more than one shovelnose sturgeon per month because of concerns over PCB, mercury, and chlordane levels (Missouri 2010). Illinois issued a sturgeon consumption advisory due to PCBs and chlordane levels on the Mississippi River between Lock and Dam 22 to Cairo, Illinois (Illinois 2010). The Kansas Department of Health and Environment (2010) has issued a consumption advisory for bottom-feeding fish, including sturgeon, due to PCB levels in the Kansas River downstream of Bowersock Dam to Eudora. Fish consumption advisories have been issued for the Missouri River from Omaha to Rulo, Nebraska (Nebraska 2010). Although fish consumption advisories are for the protection of human health, river segments with such designations also have been associated with adverse health effects in the shovelnose sturgeon themselves, including enlarged livers, abnormal ratios of estrogen to testosterone, and intersexual characteristics (Coffey et al. 2003; Schwarz et al. 2006). Further assessments should be targeted in these areas to evaluate the exposure and effects of the impairing contaminants on pallid sturgeon and their reproductive physiology.

Additionally, injuries resulting from chance encounters with discarded human-made objects like gaskets and rubber bands have been documented in the Mississippi River; approximately 5% of shovelnose sturgeon and 9% of pallid sturgeon exhibit scars or deformities from such injuries (Murphy et al. 2007b). Mortalities have not been reported or estimated.

Dissolved Oxygen

While the tolerances of low dissolved oxygen concentrations have not been quantified for all life stages of pallid sturgeon, data from other sturgeon species are insightful. In general, sturgeon are not as tolerant of hypoxic conditions as are other fishes (Secor and Gunderson 1998; Niklitschek and Secor 2005). Temperature and dissolved oxygen levels can affect sturgeon survival, growth and respiration with early life stages being more sensitive than adults (Secor and Gunderson 1998).

Like many sturgeon species, pallid sturgeon are primarily benthic (living on or near the bottom) organisms within 10-12 days post hatch (Kallemeyn 1983; Kynard et al. 2007). This benthic life history strategy can result in sturgeon encountering areas with low oxygen levels (hypoxia). Like most organisms that encounter unsuitable habitats, juvenile and adult sturgeon have some ability to avoid unfavorable environmental conditions via migration (Auer 1996). In reservoirs, white sturgeon will avoid those areas where riverine features become more lake like (transition zone) and oxygen levels approach 6 mg/l (Sullivan et al. 2003). Under hypoxic conditions, juvenile Atlantic sturgeon will move upward in the water column to access more oxygen-rich water (Secor and Gunderson 1998).

Anthropogenic changes within the range of pallid sturgeon that affect dissolved oxygen concentrations could be affecting survival and recruitment. Dissolved oxygen levels of 3 mg/l and water temperatures of 22-26 ^{o}C (71.6-78.8 ^{o}F) appeared lethal for juvenile Atlantic sturgeon and shortnose sturgeon (Secor and Gunderson 1998; Campbell and Goodman 2004). Reduced growth was observed in Atlantic sturgeon at lower non-lethal levels (Secor and Gunderson 1998). In the upper Missouri River basin, larval pallid sturgeon are likely transported into or through reservoir transition areas. Because they are weak swimmers at this early life stage (Kynard et al. 2007), they are less able to migrate away from any encountered hypoxic conditions. Study efforts have been initiated to better evaluate the effects of riverine to reservoir transition areas on pallid sturgeon survival.

Summary of Impacts related to Water Quality

Overall water quality can have both immediate and long-term effects on the species. New information, post-listing suggests that water quality can affect individuals during many life phases and localized and/or regionally poor or degraded water quality should be viewed as a threat to the species. More information is needed to evaluate the exposure and effects of environmental contaminants to pallid sturgeon. In response to this need, in 2008, a basin-wide contaminants review for pallid sturgeon was initiated. To date, this investigation has identified pesticides, metals, organochlorines, hormonally active agents, and nutrients as contaminants of concern throughout the species' range. However, additional data are needed to quantify and qualify the magnitude of this threat.

ENTRAINMENT

Another issue that can cumulatively have negative consequences for pallid sturgeon range-wide is entrainment loss. The loss of pallid sturgeon associated with cooling intake structures for power facilities, dredge operations, irrigation diversions, and flood control points of diversion has not been fully quantified, but entrainment has been documented for both pallid and shovelnose sturgeon.

Adult shovelnose sturgeon (and likely adult pallid sturgeon) exhibit relatively high prolonged swimming speeds (Adams et al. 1997; Parsons et al. 2003) and would be at lower entrainment risk than young fish. Juvenile pallid and shovelnose sturgeon exhibit comparable swimming abilities (Adams et al. 2003). They are not strong swimmers relative to other species and are at greater risk of entrainment (Adams et al. 1999a), but they also exhibit a variety of complex swimming behaviors which may increase their ability to resist flow (Hoover et al. 2005). *Scaphirhynchus* larvae are weak swimmers and experience high rates of mortality under simulated propeller entrainment and high rates of stranding under simulated vessel-induced drawdown (Adams et al. 1999b; Killgore et al. 2001).

Water Cooling Intake Structures: Preliminary data on the Missouri River indicate that these structures may be a threat that warrants more investigation. Initial results from work conducted by Mid-America at their Neal Smith power facilities located downstream of Sioux City, Iowa, found hatchery-reared pallid sturgeon were being entrained (Burns & McDonnell Engineering Company, Inc. 2007a and 2007b). Over a 5-month period, four known hatchery-reared pallid sturgeon were entrained, of which two were released alive and two were found dead.

Dredge Operations: The COE has initiated work to assess dredge entrainment of fish species and the potential effects that these operations may have on larval and juvenile *Scaphirhynchus.* Available data indicate that shovelnose sturgeon can be entrained, and this entrainment is relatively lethal (Ecological Specialists, Inc. 2010). Thus, dredging in locations where pallid sturgeon congregate could result in entrainment and mortality. Small pallid sturgeon likely are at risk of being entrained in dredges and additional data for escape speed, position-holding ability, orientation to the current and response to noise, and dredge flow fields are being used to develop a risk assessment model for entrainment of sturgeon by dredges (Hoover et al. 2005).

Irrigation Diversions: Entrainment of hatchery-reared pallid sturgeon has been documented in the irrigation canal associated with the BOR's Lower Yellowstone Project Intake Diversion Dam on the Yellowstone River where some of these fish are believed to have perished (Jaeger et al. 2004).

Flood control points of diversions: Two hatchery-reared juvenile pallid sturgeon released in the Mississippi River and one adult hatchery-reared pallid sturgeon released in either the lower Missouri or middle Mississippi river were entrained by the Old River Control Complex as they were subsequently collected in the Atchafalaya River. During May and June 2008, 14 pallid sturgeon were collected behind the Bonnet Carre' spillway (Reed *in litt.*, 2008; USFWS 2009a), indicating that entrainment occurs at this facility during the rare occasions when flood waters need to be shunted from the Mississippi River to Lake Pontchartrain. Additional smaller structures exist or are planned for diverting water and sediments from the Mississippi River for marsh enhancement and hurricane protection in coastal Louisiana. Pallid sturgeon entrainment potential and significance is unknown.

Summary of Impacts of Entrainment

Entrainment of juvenile and adult pallid sturgeon has been documented to occur in the few instances it has been studied. Thus it is a greater threat than anticipated in the original version of this plan. The level of larval sturgeon entrainment is unknown. The overall effects from entrainment are variable and depend on population demographics, exposure time, quantity of un-screened diversion points, and duration of diversion point usage, (i.e., year-round versus seasonal or sporadic operation). Further evaluation of entrainment associated with dredging operations, water diversion points, and commercial navigation is necessary across the pallid sturgeon's range to adequately evaluate and quantify this threat.

CLIMATE CHANGE

Although not a threat specifically identified in the pallid sturgeon listing package (55 FR 36641-36647), our analyses under the Endangered Species Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of climate interactions with other variables (e.g., habitat fragmentation) (IPCC 2007). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change. Both the Intergovernmental Panel on Climate Change and U.S. Global Change Research Program (GCRP) identify that the trend in global climate patterns is one of warming; average temperatures in the United States are at least 1.1^{o}C (2^{o}F) higher than they were 50 years ago (IPCC 2007; GCRP 2009).

Within the range of pallid sturgeon, predicted affects appear to be shifts in runoff patterns: discharge peaks are anticipated to occur earlier and potentially be larger, late season river flows may be reduced, and water temperatures may rise (IPCC 2007). These changes to the water cycle are anticipated to affect water use (GCRP 2009), which may alter existing reservoir operations. Broadly, these potential effects to pallid sturgeon could be altered spawning behavior (i.e., movement and timing) and reduced late-season habitat suitability due to reduced flows and presumably warmer temperatures. Another predicted outcome is increased or prolonged periods of drought (IPCC 2007; GCRP 2009). Increased water demand coupled with reduced late-season flows could significantly affect in-channel habitats which in turn may affect other species that are food items for pallid sturgeon.

These effects would likely occur first, or be most pronounced, in the more northern portion of the pallid sturgeon range; the IPCC (2007) study suggests that in general, temperature increases correlate with latitude. Thus, higher northern latitudes appear to have relatively higher predicted warming trends. However, reduced annual runoff predicted in the Missouri River basin may be offset by the anticipated increased runoff in the upper Mississippi River basin (GCRP 2009) resulting in minimal effects within the middle and lower Mississippi River basins.

Summary of Impacts of Climate Change

At this time, it is difficult to evaluate long-term effects from climate change as there have been many anthropogenic influences across the species' range. Assessing this potential threat and teasing out relationships associated with climate change will be difficult without careful consideration of other already confounding factors.

Factor A Summary

The present or threatened destruction, modification or curtailment of its habitat or range, remains a threat. However, the magnitude of this threat varies across the species range, due in part to on-going efforts to mitigate anthropogenic effects and the proportion of perturbations relative to the volume of habitat available. For example, the effects from dams (i.e., altered hydrographs and temperature profiles, altered ecologic processes, habitat fragmentation, and conversion of riverine reaches to reservoir) may be the single greatest factor affecting the species in the upper Missouri River basin. While in the middle and lower Missouri River as well as the middle Mississippi River, water quality, entrainment, and maintenance of the channel for navigation purposes and the associated impacts are significant threats. Additionally, the effects from other threats described below, may be more limiting to the species in these areas. The same applies to the lower Mississippi River. Currently main-stem riverine habitat is not fragmented by dams and many natural ecological processes can still create a diversity of physical habitats believed important for the species. However, data are limited related to water quality and the potential effects from hydrokinetic energy development described in Factor E below.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for commercial, recreational, scientific, or educational purposes is one of the threats to pallid sturgeon identified in the listing determination (55 FR 36641-36647). Given the endangered status of pallid sturgeon, use for scientific or educational purposes is regulated under section 6 cooperative agreements or under section 10 of the Act. All recreational and commercial harvest of pallid sturgeon is prohibited by Section 9 of the Act as well as State regulations throughout its range.

While these regulations effectively protect pallid sturgeon from recreational harvest and overutilization for scientific and educational purposes, they do not prevent lethal take of pallid sturgeon as a result of species misidentification associated with commercial shovelnose sturgeon fishing. To address this threat, beginning in 2010, shovelnose sturgeon are treated as threatened where the two sturgeon species coexist, under the similarity of appearance provisions of the

Endangered Species Act (75 FR 53598-53606). This rule extends take prohibitions to shovelnose sturgeon, shovelnose-pallid sturgeon hybrids, and their roe when associated with a commercial fishing activity in areas where pallid sturgeon and shovelnose sturgeon commonly coexist. Continued monitoring will provide data on the effectiveness of this regulation.

Factor B Summary

Current State regulations and protections afforded under the Endangered Species Act, including the similarity of appearance rule, coupled with adequate enforcement, appear sufficient to manage, to the maximum extent practicable, the threat from overutilization for commercial, recreational, scientific, or educational purposes. However, absent protections under the Endangered Species Act, adequate State harvest regulations and enforcement will be necessary to protect the species from overharvest.

Factor C: Disease or Predation

DISEASE

Fish pathogens have the potential to produce severe epizootics of clinical disease but also are known to exist in a carrier State. They include viral, bacterial, and parasitic agents. In some instances, disease outbreaks can severely deplete local populations, but these extreme events have not yet been documented in wild pallid sturgeon populations. Some pathogens of notable importance for pallid sturgeon recovery are a rhabdovirus, Viral Hemorrhagic Septicemia Virus (VHSv), and the Missouri River sturgeon iridovirus (MRSIV).

Viral Hemorrhagic Septicemia Virus is a fish disease that has caused large-scale mortalities in numerous species (Kim and Faisal 2010) and has been described as an "extremely serious pathogen of fresh and saltwater fish" (APHIS 2006). While it has not been documented to affect pallid sturgeon, it also has not been found within the range of the species. However, VHSv has been documented in the Great Lakes (APHIS 2006). Various shipping canals have created a connection between the Great Lakes and the Mississippi River so it is possible that through time, this virus could reach areas occupied by pallid sturgeon. Because this pathogen can cause large-scale mortalities in fish populations, and it has a wide range of potential carriers, we believe it is important to monitor for VHSv within the range of pallid sturgeon.

Missouri River sturgeon iridovirus is a concern in the context of pallid sturgeon recovery because it causes mortality in hatchery-reared pallid sturgeon (Kurobe et al. 2011) and its effect on free-ranging sturgeon populations is unknown. The MRSIV was originally documented during artificial propagation efforts of shovelnose sturgeon at the Gavins Point National Fish Hatchery in 1999. However, this iridovirus also can infect pallid sturgeon (Kurobe et al. 2011). This disease is known to cause substantial mortality in hatchery-rearing environments (Kurobe et al. 2011). Study fish surviving initial viral outbreaks still harbor the virus even though they may appear healthy (Hedrick et al. 2009; Kurobe et al. 2011). While initially identified in a hatchery environment, additional testing has documented that this virus is found in the wild; of 179 *Scaphirhynchus* tested from the Atchafalaya River between November 2003 and May 2004, 8 (4%) were identified as positive for the virus and 5 (2.8%) were suspected of carrying the virus. Subsequent testing with more sensitive methods also confirmed the presence of the virus in the wild (Hedrick et al. 2009), suggesting that it may be endemic in the Missouri River. The effect of the virus on wild populations is not known.

PREDATION

Little information is available implicating piscivory as a threat affecting the pallid sturgeon. Predation on larval and juvenile fishes of all species occurs naturally. However, habitat modifications that increase water clarity and artificially high densities of both nonnative and native predatory fishes could result in increased rates of predation. Pallid sturgeon larvae and fry passively drift post-hatch (Kynard et al. 2007; Braaten et al. 2008). This behavior likely exposes naturally-spawned pallid sturgeon to predation but was moderated historically by high fecundity and turbid waters. However, anthropogenic changes that affect habitats could result in increased vulnerability to predation. In the impounded areas of the upper Missouri River, larvae may be transported into the clear headwaters of reservoirs like Fort Peck and Lake Sakakawea. These reservoirs are or have been artificially supplemented with predatory species like walleye (*Sander vitreus*).

Maintaining artificially elevated populations of certain species in these reservoirs has been hypothesized as a contributing factor in poor survival of larval and juvenile pallid sturgeon. Walleye and sauger (*S. canadensis*) are capable of eating wild paddlefish up to 167 mm (6.6 inch (in.) body length (305 mm/12 in. total length) and, thus, likely could consume naturally-produced pallid sturgeon larvae, fry and fingerlings (Parken and Scarnecchia 2002). When looking at data for sample locations closest to reservoir headwaters, it appears that no age-0 paddlefish were found in walleye, but were present in sauger, a native species closely related to walleye. Yet, Braaten and Fuller (2002, 2003) examined 759 stomachs from 7 piscivore (fish eating) fishes in Montana, they found no evidence of predation on sturgeon. Predation vulnerability of pallid sturgeon (> 40 mm) by channel catfish (*Ictalurus punctatus*), smallmouth bass (*Micropterus dolomieu*), and walleye appears to be low, provided other prey species are available (French 2010; French et al. 2010). More data are needed to adequately assess predation effects on eggs and larval pallid sturgeon in order to evaluate implications on recruitment success (see also Invasive Species/Aquatic Nuisance Species under Factor E Other Natural or Manmade Factors Affecting its Continued Existence).

Factor C Summary

When listed, neither disease nor predation were discussed as threats, primarily due to limited information. New data have highlighted both disease and predation as issues of potential concern and they should be considered as likely threats. At this writing, data are inadequate to quantify the magnitude of the threat either may pose.

Factor D: Inadequacy of Existing Regulatory Mechanisms

Regulatory mechanisms are required for pallid sturgeon recovery and to ensure long-term conservation of the species. These mechanisms affect many aspects of legal protection, such as habitat and flow protection, regulation and/or control of nonnative fishes, regulation of hazardous-materials spills, and harvest. In determining whether the inadequacy of existing regulatory mechanisms constitutes a threat to pallid sturgeon, our analysis focused on existing

State and Federal laws and regulations that could potentially address the main threats to the species described under Factors A and B, and potential new threats described under Factor E.

State Regulations

Water Quality
All States whose waters are occupied by pallid sturgeon have enacted legislation intended to preserve water quality. Generally these State regulations (see Appendix A) parallel comparable Federal legislation; in some cases, State statutes may impose requirements that are more stringent than the Federal law. In all cases, Clean Water Act requirements must be adhered to and are enforced in conjunction with State statutes and regulations implemented by the State administrative agencies.

Water Quantity
Many States have enacted legislation and processes specifically to allocate water resources (see Appendix A). Generally, water use permits are obtained from the appropriate State or local administrative agencies. Most States have instream-flow laws intended to maintain "beneficial use" of water left in streams for wildlife. However, these laws typically only protect minimum flows believed necessary to maintain the fishery and, in some states, may afford little protection. For example, water development/usage in Montana is governed by western water law. Under this system, in-stream water rights held by Montana Fish Wildlife and Parks are newer (junior) to many water users with an older (senior) water right. As a result, during extreme drought situations, senior water right owners have priority rights to water, in other words, their rights will be met prior to those of Montana Fish Wildlife and Parks. Once senior rights are satisfied, the remainder can be left in the river and used for fish and wildlife. This could lead to a water depletion situation in areas occupied by pallid sturgeon. Additionally lacking in many states, are completion of adjudication processes and full inventories of all water allocations. Without these data it is difficult to determine if important rivers and tributaries for pallid sturgeon have been or could become over-allocated resulting in future adverse effects.

Harvest
In addition to Federal protection under the Endangered Species Act, pallid sturgeon are protected by State designations such as "endangered," "threatened," or "sensitive." These designations typically prohibit intentional take and harvest of any pallid sturgeon. Depending on local demographic conditions, these designations may need to remain in place within some States after the species is delisted. When delisted, States within the pallid sturgeon's range have the authority to continue State protections or to manage and establish commercial and recreational harvest limits for the species within their borders. Long-range migratory species are often considered 'interjurisdictional' and may be co-managed with neighbor States or through organizations like the Mississippi Interstate Cooperative Resources Association; an organization of 28 State agencies that formed a partnership to improve management of aquatic resources in the Mississippi River Basin. State regulations currently provide protections against take of pallid sturgeon associated with commercial, recreational, scientific, and educational purposes. For the most part, these regulations are adequate to protect pallid sturgeon from direct intentional taking. However, in 2010 incidental harvest of pallid sturgeon during commercial shovelnose sturgeon harvest was documented in several States where pallid and shovelnose sturgeon are sympatric.

This resulted in a Federal rule treating shovelnose sturgeon as threatened under the Act due to similarity of appearance to pallid sturgeon (75 FR 53598-53606). To be delisted, State regulatory mechanisms and/or designations will need to ensure continued long-term management and protection for the species.

Summary of State Regulations

While States have implemented many regulations to protect and conserve resources through a mechanism of project proposal review and permitting, these efforts likely are limited by a lack of biological and/or ecological data on pallid sturgeon and their ecological thresholds. For example, levels of contaminants that generate negative effects in pallid sturgeon have not been fully quantified, limiting the ability to establish protective State standards. Another limitation of State permitting processes is cumulative effects evaluations. Considering cumulative environmental effects in the permitting process requires an understanding of ecological thresholds, baseline conditions, and life history requirements for many species, as well as their response to multiple environmental stressors. Unfortunately, with respect to the pallid sturgeon, much of this remains unknown. Finally, when the species is delisted, State regulations will be necessary to manage and protect the species.

Federal Regulations

In addition to State regulations, activities that affect either pallid sturgeon or its habitat are regulated under Federal laws. Notable Federal regulations that address pallid sturgeon and their habitat are; the Clean Water Act (CWA), River and Harbors Act of 1899, Federal Power Act, National Environmental Policy Act (NEPA), and the Fish and Wildlife Coordination Act (FWCA).

The Clean Water Act (CWA) (33 U.S.C. §§1251 et seq.) regulates pollutant discharges into the nation's waters. This is accomplished through defining, monitoring, and regulating water quality standards for all surface waters, establishing industry wastewater standards, and protecting aquatic life and habitats through permitting. Pertinent regulations can be found at 40 C.F.R., CH 1, subchapter D-water programs (§§ 110, 112, 116, 117, 122-125, 129-133), 40 C.F.R., CH 1, subchapter N-effluent guidelines and standards (§§ 401-471), and 40 C.F.R., CH 1, subchapter O-Sewage sludge (§§ 501, and 503). The CWA affords substantial protections to the pallid sturgeon, its habitat, and life-history requirements through establishing water quality standards and reducing the effects from the discharge of harmful pollutants, contaminants and discharge of dredge or fill material. However, residual effects from historical practices and a lack of species specific information on the sensitivity of the pallid sturgeon to common industrial and municipal pollutants may be limiting the full conservation potential of the CWA as it relates to pollutant discharge and water quality standards.

In addition to regulating pollutant discharges, the CWA also allows the U.S. Environmental Protection Agency (EPA) to establish regulations for cooling water intake structures (§ 316b). Losses of pallid sturgeon through impingement or entrainment from these structures have been documented (see Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range, above). Section 316(b) of the CWA requires the Environmental Protection

Agency to provide reasonable assurances that aquatic organisms are protected from impingement or entrainment. In 2004, the EPA issued regulations (69 FR 41575-41624) to minimize entrainment and impingement mortality associated with cooling water intakes at power production facilities. However, EPA suspended these regulations in 2007 (72 FR 37107-37109). In 2011, the EPA reopened the public comment period for proposed Section 316(b) requirements for all existing power generating facilities and existing manufacturing and industrial facilities (76 FR 43230-43231). While data are limited or lacking, providing EPA with reach-specific information on pallid sturgeon population size, habitat use, and behavior would be necessary to expect reasonable assurances that the species is protected under subsequent 316(b) provisions of the CWA. For example, local effects to pallid sturgeon associated with entrainment loss may be proportional to species abundance and/or habitat use, as well as intake design and/or location. Additionally, at low population levels or in areas heavily used by the species, the threat from entrainment may be highest. Conversely, entrainment losses may have little or no impact when population levels are robust or in areas seldom frequented by the species.

The Rivers and Harbors Act (33 U.S.C. §§401,403,407 et seq.) prohibits the construction of any bridge, dam, dike or causeway over or in navigable waterways of the U.S. without Congressional approval. Structures authorized by State legislatures may be built if the affected navigable waters are totally within one State, provided that the plan is approved by the Chief of Engineers and the Secretary of Army (33 U.S.C. 401).

The Federal Power Act (16 U.S.C. §§791-828) provides for cooperation between the Federal Energy Regulatory Commission (FERC) and other Federal agencies, including resource agencies, in licensing and relicensing power projects. The FERC is authorized to issue licenses to construct, operate and maintain dams, water conduits, reservoirs, and transmission lines to improve navigation and to develop power from any streams or other bodies of water over which it has jurisdiction which includes many of the rivers inhabited by pallid sturgeon. An amendment in1986, the Electric Consumers Protection Act, required several provisions to benefit fish and wildlife. Specifically, each license is to contain conditions to protect, enhance, and mitigate fish and wildlife affected by the project (16 U.S.C. §§803 et seq.). These conditions are to be based on recommendations received from the USFWS, the National Marine Fisheries Service, and State fish and wildlife agencies pursuant to the Fish and Wildlife Coordination Act. Additionally, there are requirements under 16 U.S.C. §81, related to operation of navigation facilities, they specify " The Commission shall require the construction, maintenance, and operation by a licensee at its own expense …such fishways as may be prescribed by the Secretary of the Interior or the Secretary of Commerce, as appropriate." The Federal Power Act has facilitated conservation of pallid sturgeon and their habitats through improved coordination with fish and wildlife management agencies and has the ability, where applicable, to restore connectivity for pallid sturgeon through mandated fish passage requirements.

The National Environmental Policy Act (NEPA) (42 U.S.C. §§4321-4347 as amended) requires all Federal agencies in the executive branch to consider the effects of their actions on the environment. This act allows cooperating agencies and interested parties to assess proposed Federal projects and their potential significant impacts to the human environment. In general, participants review proposed actions and provide recommendations to the action agency to minimize or avoid environmental impacts. Affects to endangered species are commonly included in these environmental assessments or environmental impact statements; however, endangered status is not required for such considerations. As such, the processes necessary to comply with NEPA would include considerations of pallid sturgeon and their habitats in project planning. However, NEPA provides for disclosure of environmental impacts but does not require minimization. Thus, the degree to which NEPA offers protection to the pallid sturgeon is variable and based upon voluntary adoption of conservation measures. Compliance with NEPA would be improved and provide increased benefit with better information on habitat use and needs of pallid sturgeon within the Missouri and Mississippi river basins.

The Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. §§661-667e as amended) requires Federal agencies funding, sponsoring, or permitting activities give consideration and coordination of wildlife conservation with respect to water resources development programs. Under FWCA, Federal agencies must consult with the USFWS and the State fish and wildlife agencies where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified" under a Federal permit or license. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources." Through the FWCA, pallid sturgeon and their habitats are given due consideration in water development activities. However, while the FWCA may result in implementation of conservation measures (i.e., screening of water diversion structures) on new water projects, the FWCA does not afford protections for projects implemented or permitted prior to its enactment.

Summary of Federal Regulations

Federal environmental regulations have substantially increased environmental protections throughout the pallid sturgeons' range. However, there are instances where these regulations may not have been adequately followed (US Government Accountability Office (GAO) 2011), possibly resulting in negative effects for the species. In other instances, the implementation of these laws does not offer adequate protection to the pallid sturgeon in that it does not address the specific threats that the species faces. In some cases, lack of empirically derived data, specific to pallid sturgeon or lack of access to available data may be limiting the efficacy of existing Federal regulations.

Factor D Summary

Federal, State, and local regulatory protections have been developed to minimize and mitigate known and potential threats to fish and other aquatic species, as well as their habitats, from anthropogenic activities. While some of these regulatory mechanisms have been helpful and benefited the species, recovery progress made to date is the result of the Endangered Species Act and its enforceable provisions to ensure conservation of listed species. Absent protections under the Endangered Species Act, current existing State and Federal regulations may be inadequate to ensure long-term protection for the species. However, some of this perceived inadequacy of existing regulatory mechanisms to conserve pallid sturgeon primarily relates to a lack of specific information on population size, habitat use, and sensitivity or vulnerability to contaminants, entrainment, and other threats or a lack of easy access to these data where available. As examples:

- State and Federal environmental regulations enacted to reduce or eliminate environmental contaminants and preserve water quality provide regulatory authority to develop and establish standards and implement pollution control programs. The standards established pursuant to these regulations and through State and Federal permitting processes have benefitted the pallid sturgeon by protecting and improving water quality. However, data suggest that residual contaminants or their derivatives are still negatively affecting the species (see Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range, above). Developing specific information on the sensitivity of the pallid sturgeon to common industrial and municipal pollutants and their derivatives will allow for reviewing and if necessary modifying water quality standards specifically to benefit the species.

- Hydrokinetic projects have been proposed throughout the Mississippi River, and there is some degree of risk to pallid sturgeon from entrainment through hydrokinetic turbines, as well as concerns for electromagnetic fields and noises disrupting normal behavior of the fish (see *Factor E: Other Natural or Manmade Factors Affecting its Continued Existence*, below). Hydrokinetic projects are regulated by the Federal Energy Regulatory Committee. Through this permitting and licensing process, FERC helps provide reasonable assurances that hydroelectric projects minimize environmental damage, and are coordinated with Federal and State Natural Resources agencies, Indian tribes, and State water quality agencies. Reach-specific information on pallid sturgeon population size, habitat use, and behavior, as well as assessing the cumulative effects of these projects is necessary to establish reasonable assurances the species is protected under FERC regulations from risks associated with development of hydrokinetic energy.

- Hybridization was identified as a threat to the species when it was listed (55 FR36641-36647). At the time, the prevailing hypothesis related hybridization with habitat alteration that resulted in a breakdown of natural reproductive isolating mechanisms. However, more recent information suggests that additional data are needed to fully understand the extent and magnitude of hybridization as a threat (USFWS 2007). If hybridization is related to habitat alterations, conserving and restoring habitats may be the only method to reverse this trend. Use of available regulatory mechanisms to address the threat of hybridization are currently limited by lack of information on the natural reproductive isolating mechanisms between shovelnose and pallid sturgeon.

- A number of invasive aquatic species have been introduced into the range of pallid sturgeon (see Factor E: Other Natural or Manmade Factors Affecting its Continued Existence, below); however, the threats they may pose to its conservation are poorly known. Numerous State and Federal regulations, including but not limited to, the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (as amended), Injurious Wildlife provisions of the Lacey Act (18 U.S.C. 42; 50 CFR 16), Asian Carp Prevention and Control Act, and Clean Boating Act of 2008, have been developed to: 1) prevent introduction of new invasive species into the wild; 2) halt the spread of invasive species to unoccupied areas; and 3) to control them in areas where they were introduced. Information on the spread and abundance of invasive species, as well as their effects on reach specific pallid sturgeon populations is necessary to determine whether these regulatory mechanisms are adequate to protect the species.

As our knowledge of the species increases, existing regulatory mechanisms can be more effectively evaluated, improved, and implemented.

Factor E: Other Natural or Manmade Factors Affecting its Continued Existence

Potential new threats identified subsequent to the 5-year review (USFWS 2007) or new information has resulted in additional evaluation of: 1) energy development, 2), hybridization, and 3) invasive species/aquatic nuisance species.

ENERGY DEVELOPMENT

In-channel Power Generation

Hydrokinetic power generation (i.e., projects using an array of in-river turbines to generate electricity) could pose a threat to pallid sturgeon. Individually, an in-river turbine may have minimal affects, but cumulatively, hydrokinetic projects could have adverse effects if they become widely developed and are built in a manner or location that is inconsistent with the life history requirements of pallid sturgeon.

According to the Federal Energy Regulatory Commission (Figure 6), valid preliminary permits for hydrokinetic projects on the Mississippi River have been issued. Preliminary permits only allow the permitted party to study or evaluate projects at the described site.

At the writing of this revision, no licensed hydrokinetic projects exist in the range of the pallid sturgeon. However, as the project sites mentioned above are evaluated, some may prove to be feasible and licensing pursued. Concerns over placement of these structures, relative to pallid sturgeon, include potential effects on movement patterns and habitat alterations needed to maintain flow to these structures. More information will be needed to assess this potential threat.

Gas and Oil Exploration

Exploration of natural gas and oil deposits occurs in portions of the pallid sturgeon's range. Preliminary assessment of the impacts of seismic air guns, a tool used for exploration, suggests that they may have negative effects on larval pallid sturgeon (Kretnz in litt. 2010). Additional research is necessary to fully evaluate the extent and magnitude of these effects.

Summary of Impacts From Energy Development

Increased demand for energy resources has led to an increased interest in new technology development and exploration. Of particular interest will be the potential effects on all life-stages associated with placement and quantity of hydrokinetic power generators within the habitats occupied by pallid sturgeon. Additionally, oil and gas exploration techniques have the potential to take pallid sturgeon yet the ability to evaluate these takings will be nearly non-existent given the nature of the river systems these fish live in. Strict adherence to existing environmental laws will be necessary to minimize effects and more data will be needed to adequately evaluate and monitor impacts related to energy development.

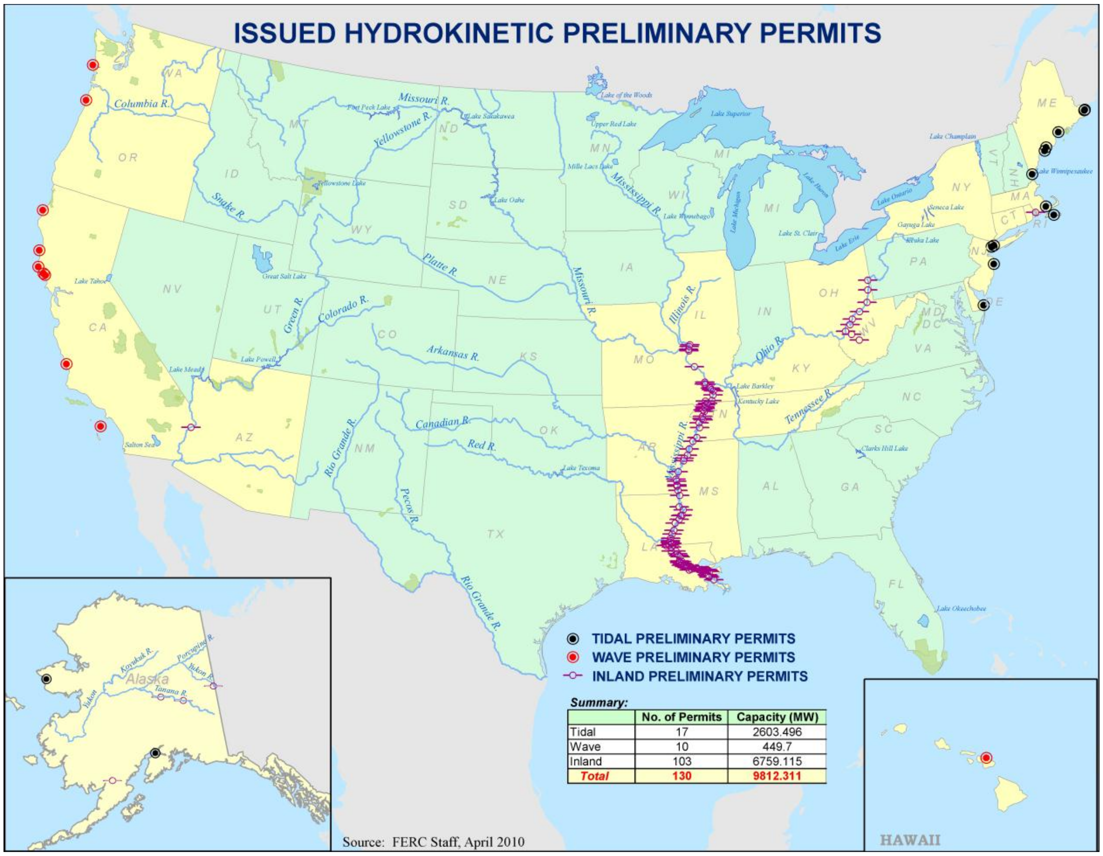

Figure 6 Federal Energy Regulatory Commission Map depicting issued inland preliminary permits for potential hydrokinetic projects in the Mississippi River.

HYBRIDIZATION

The original version of this recovery plan (USFWS 1993) identified hybridization as a threat to pallid sturgeon. This was, in part, based on limited observations of sturgeon (N=12) collected from the middle Mississippi River that appeared morphologically-intermediate to shovelnose and pallid sturgeon (Carlson and Pflieger 1981; Carlson et al. 1985) and the belief that hybridization was contemporary (i.e., post 1960 and influenced by anthropogenic changes to habitat). Subsequent genetic and morphological studies have been conducted to explore hybridization between pallid and shovelnose sturgeon (Phelps and Allendorf 1983; Carlson et al 1985; Campton et al. 2000; Tranah et al. 2001 and 2004; Kuhajda et al. 2007; Ray et al. 2007; Murphy et al. 2007a). Below is a brief review of the current literature regarding the treatment of intermediate-character sturgeon and putative pallid/shovelnose hybridization in the Mississippi River basin.

Carlson et al. (1985) used principal components analysis based on morphometric measures described in Bailey and Cross (1954) and found that morphologically-intermediate specimens fell in between the pallid and shovelnose sturgeon groups leading to their hybridization origin hypothesis. Efforts to confirm hybridization used a suite of allozyme markers (Phelps and Allendorf 1983). These results neither supported nor refuted the hybridization origin hypothesis and only suggested that pallid and shovelnose sturgeon share close taxonomic affinities. Tranah et al. (2004) assessed the genetic origins of 10 morphologically intermediate sturgeon collected from the Atchafalaya River. These results were consistent with the hypothesis that hybridization occurs between pallid and shovelnose sturgeon. However, this study simply demonstrated that morphologically-intermediate fish had intermediate genotypes. Schrey (2007) analyzed 529 *Scaphirhynchus* samples from the upper Missouri, lower Missouri, middle Mississippi, and Atchafalaya rivers using sixteen microsatellite loci. Like Tranah et al. (2004), the author also found that genetically-intermediate fish tended to also be morphologically-intermediate.

While there are competing hypotheses that may explain morphologically intermediate fish (Murphy et al. 2007a; Ray et al. 2007), there appears to be a positive correlation between genotype and phenotype (Tranah et al. 2004; Schrey 2007). The latest genetic analysis confirms inrrogressive hybridization between pallid and shovelnose sturgeon occurs and likely has been occurring for several generations, perhaps as many as 60 years (Schrey et al. 2011). However, the significance of hybridization as a factor in the status of pallid sturgeon is poorly understood. Hybridization between two species could result in the eventual loss of one or both parental forms (Arnold 1992; Allendorf et al. 2001; Rosenfield et al. 2004). Conversely, hybridization has been postulated to have played a role in sturgeon speciation (Birstein et al. 1997; Vasil'ev 1999; Robles et al. 2005), indicating that hybridization may have always been a process occurring in the evolution of these species and it can lead to the creation of new species (Arnold 1992). Understanding the benefits and threats that hybridization may impose on pallid sturgeon recovery remains uncertain because the mode and rate of *Scaphirhynchus* hybridization are difficult to assess.

Summary of Impacts Related to Hybridization

While we know that experimental mating of pallid sturgeon with shovelnose sturgeon can produce living offspring (Kuhajda et al. 2007), accurate assessment of hybridization in the evolution of *Scaphirhynchus* and its perceived threats to pallid sturgeon recovery will require statistically testing the hypothesis of hybridization against alternatives. Since hybridization is accepted as a process occurring in *Scaphirhynchus* and likely has been occurring for many decades (Schrey et al. 2011), it is important to determine the cause (i.e., historical/natural or contemporary) and extent of hybridization. Once these processes are elucidated, simulation/modeling exercises can address the actual risks associated with pallid/shovelnose hybridization. If it is determined that alteration of habitats has influenced temporal or spatial reproductive isolating mechanisms resulting in increased rates of hybridization, addressing this threat will likely rely on both site-specific and ecosystem improvement efforts; many of which are identified in the Recovery Outline/Narrative section below.

INVASIVE SPECIES/AQUATIC NUISANCE SPECIES

Although not a threat specifically identified in the pallid sturgeon listing package (55 FR 36641-36647), the potential impact of invasive and aquatic nuisance species can be applied to Listing Factor A- The present or threatened destruction, modification, or curtailment of its habitat or range and Listing Factor C- Disease or Predation. Several species with the potential for impacting pallid sturgeon have become established in parts of the species' range. These include the Asian carps (common (*Cyprinus carpio*), grass (*Ctenopharyngodon idella*), silver (*Hypophthalmichthys molitrix*), bighead (*Hypophthalmichthys nobilis*) and black (*Mylopharyngodon piceus*)) as well as the zebra mussel (*Dreissena polymorpha*). Populations of Asian carp appear to be expanding exponentially in parts of the Mississippi River basin as the range of the zebra mussel continues to expand (Kolar et al. 2005).

According to the American Fisheries Society (AFS Policy 15), potential negative impacts by nonnative species have been categorized into five broad categories: habitat alteration, trophic alteration, spatial alteration, gene pool deterioration and disease transmission. Documenting these impacts in large river ecosystems is especially difficult. Few studies have documented the impacts from these species in the Mississippi Basin. However, data are available from other watersheds that shed insight into potential effects from invasive species.

If food resources were limited from the presence of large populations of planktivores (e.g., Asian carps), early life-stage pallid sturgeon could face increased competition with native planktivorous fishes such as gizzard shad (*Dorosoma cepedianum*), bigmouth buffalo (*Ictiobus cyprinellus*) and paddlefish (Kolar et al. 2005). Several authors have expressed concern that, because nearly all fish feed on zooplankton as larvae and juveniles, Asian carps have high potential to impact native fishes of the Mississippi Basin (Laird and Page 1996; Chick and Pegg 2001; Chick 2002). The diets of bighead and silver carp have significant overlap with those of gizzard shad and bigmouth buffalo (Sampson et al. 2009). In addition to directly competing for food resources, Asian carps also could affect recruitment by predation on pallid sturgeon eggs or drifting larvae. Miller and Beckman (1996) have documented white sturgeon eggs in the stomachs of common carp. Additionally, disease or parasites can be spread by Asian Carp. Goodwin (1999) noted that channel catfish became infested with anchorworm when cultured with bighead carp. Heckmann et al. (1986 and 1995) reported that this tapeworm was spread to two endangered species when baitfishes were released into Lake Mead, Arizona and Nevada. Currently, the Asian tapeworm is known to infest native fishes in five States; however, none are in the Mississippi River drainage (Kolar et al. 2005).

Zebra mussel colonization has occurred in areas occupied by pallid sturgeon but data are limited on direct effects. In juvenile lake sturgeon, data show that zebra mussel occupancy changes the nature of the bottom substrates and reduced foraging effectiveness of with mussel presence resulting in avoidance of those areas by study fish more than 90% of the time (McCabe et al. 2006).

Summary of Impacts From Invasive and Aquatic Nuisance Species

Potential threats from invasive or aquatic nuisance species include increased predation on eggs, larval, or juvenile life stages, competition for food in the case of the carps, exclusion of native species from preferred habitats, spread of diseases or parasites, and alteration of habitat quality. Further study is needed to fully qualify and quantify the magnitude of this probable threat to pallid sturgeon.

Factor E Summary

Energy development and invasive species are two threats that may have substantial deleterious effects on pallid sturgeon populations. Strict adherence to existing environmental laws will be necessary to minimize effects from these threats and more data will be needed to adequately evaluate the extent and magnitude of these effects.

Conservation Measures

Numerous planning and conservation measures have been implemented range-wide to reduce localized effects from identified threats. The following is not intended to provide a comprehensive list of all conservation activities range-wide, but rather highlight projects and efforts that have been or will be implemented to address some of the threats previously described.

MISSOURI RIVER

Within the upper Missouri River basin, where dams have fragmented habitats and altered natural riverine processes and no evidence for pallid sturgeon recruitment exists, many efforts are being explored or implemented to restore ecological function, as well as a conservation stocking program developed to prevent local extirpation. Restoration efforts include, but are not limited to: creating side channel habitats, restoring connectivity to backwater areas, notching dikes, providing fish passage, and manipulating flows through the dams. In addition to habitat restoration efforts and the stocking program, a basin-wide pallid sturgeon population monitoring program has been established to track improvements in species abundance and status.

FORT BENTON TO FORT PECK RESERVOIR, MONTANA

Reservoir operations on tributaries within this reach have been modified from past practices. Releases from Tiber Dam (Figure 4) were modified to occasionally accommodate a high flow discharge period. During 1995, 1997, and 2002, the BOR provided a June peak release of 4,080, 4,500, and 5,300 cfs, respectively, to benefit downstream fisheries. A response by pallid sturgeon was not detected; however, present numbers of pallid sturgeon in this reach may be too low to detect or elicit a response. An indirect response to these increased discharges may be the recent establishment of sturgeon chub in the lower Marias River. Sturgeon chub are an important prey species of pallid sturgeon (Gerrity et al. 2006) and were documented only recently in the Marias River in 2002.

Augmentation and monitoring efforts continue to support and evaluate the pallid sturgeon population within this reach.

FORT PECK DAM, MONTANA TO LAKE SAKAKAWEA, NORTH DAKOTA

In addition to artificial supplementation with hatchery-reared pallid sturgeon, discussions and exploratory designs have been ongoing in an effort to increase water temperatures in the Missouri River immediately downstream of Fort Peck Dam. Several options have been considered ranging from releasing surface water over the spill-way to modifying the intake structures such that they draw warmer surface waters. To date, warm water releases have not been implemented due in part to insufficient water levels.

The Yellowstone River is the largest tributary to the Missouri River in this reach. A multi-agency effort has been ongoing since the early 2000s to develop and implement fish passage and entrainment protection at Intake Dam. In 2007, the Water Resources Development Act provided the COE the authority to assist the BOR with design and implementation of fish passage and entrainment protection at Intake Dam. A new water diversion structure, complete with fish screens, was initiated in 2010 and operational in 2012. Final passage options, intended to maximize pallid sturgeon passage probabilities to areas upstream of Intake Dam, are still being developed.

FORT RANDALL DAM TO GAVINS POINT DAM, SOUTH DAKOTA AND NEBRASKA

Augmentation efforts are being implemented to help reestablish a population in this reach. The Niobrara River is the largest tributary in this reach. Spencer Dam is a fish passage barrier on the Niobrara River. To date, preliminary discussions among interested parties have begun to explore passage options at this structure, but there are no substantial efforts yet to address this issue.

GAVINS POINT DAM SOUTH DAKOTA/NEBRASKA TO THE MISSISSIPPI RIVER CONFLUENCE

At over 1,296 Rkm (800 Rmi), this is the longest unimpounded reach of the Missouri River. Stocking of hatchery-reared pallid sturgeon was initiated in 1994 and has occurred annually since 2002 in this reach. Additionally, by 2011 an estimated 1,393 hectares (ha) (3,443 acres (ac)) of shallow water habitat has been created by constructing site-specific projects like chutes and revetment chutes, dredging to connect back-water areas, as well as side-channel construction (U.S. Army Corp of Engineers 2012). Based on current and anticipated commitments, habitat restoration in this reach will continue and should produce increased quantity and quality of potential sturgeon habitats.

The Platte River is an important tributary to the Missouri River in this reach. The largest factor affecting habitat in the lower Platte River is upstream water withdrawals. A Cooperative Agreement between Nebraska, Colorado, Wyoming, and the U.S. Department of Interior was developed forming the Platte River Recovery Implementation Program to improve and maintain habitat for species including pallid sturgeon. Evaluation of the success of this program is needed to determine if program efforts are indeed meeting the needs of the species.

MISSISSIPPI RIVER

Limited conservation stocking efforts have sporadically occurred in the Mississippi River; however, all stocking was discontinued due to increasing numbers of wild pallid sturgeon being collected and evidence for some level of natural recruitment (i.e., Columbo et al., 2007; Killgore et al., 2007a, b). Conservation efforts in the Mississippi River include land procurement; habitat conservation and restoration; sturgeon surveys; population quantification, modeling and monitoring; and habitat use studies. Additionally, commercial shovelnose sturgeon fishing has been closed by State and Federal regulations to prevent incidental harvest of pallid sturgeon in areas previously open to sturgeon caviar harvest.

MIDDLE MISSISSIPPI RIVER

The COE has initiated a program to restore side channel connectivity and improve habitat diversity in this reach. Projects include dike modifications, construction of chevron dikes, side channel enhancement, placement of woody debris piles, and incorporation of woody debris into dikes. More than 1,700 ha (4,200 ac) of flood-prone land have been purchased from willing sellers (USFWS 2009b). This land has been placed into conservation status by inclusion into the National Wildlife Refuge System (NWR). The Middle Mississippi NWR has resulted in improved floodplain connectivity along 96 km (60 mi) of the Mississippi River downstream from St. Louis, MO. Pallid sturgeon population quantification and monitoring efforts have been conducted in the Middle Mississippi River over the past decade, adding greatly to knowledge of habitat use and species abundance in this river reach.

LOWER MISSISSIPPI RIVER

During the 1980s, the COE established the Lower Mississippi River Environmental Program (LMREP) to develop methods to minimize effects of channel maintenance activities on fisheries and other natural resources in the lower Mississippi River. This program evaluated and modified revetment design, as well as dike design and placement to increase fishery habitat complexity. In 2001, the COE Mississippi Valley Division, initiated informal consultation with the USFWS under section 7(a)(1) of the Endangered Species Act to use LMREP designs and additional measures to conserve and manage listed species associated with the lower Mississippi River navigation channel. Annual meetings with the COE, the USFWS, and State agencies are held to evaluate planned construction and maintenance activities, and to identify habitat restoration and improvement opportunities.

In addition, the Mississippi Valley Division and the Districts work with the Lower Mississippi River Conservation Committee (LMRCC, a Federal and State agency partnership) to identify and initiate secondary channel restoration opportunities within the leveed floodplain. Under its Mississippi River Conservation Initiative, the LMRCC has identified approximately 220 priority restoration opportunities in the Lower Mississippi River. Over the past decade, more than 32 km (20 mi) of secondary channel habitats have been rehabilitated; hundreds of acres of seasonally flooded habitats, important to one or more pallid sturgeon life stages, have been enhanced; and over 200 dike notches have been constructed to maintain and increase in-channel habitat complexity (DuBowy 2010). Other construction modifications implemented to protect and enhance habitats include the construction of hardpoints in lieu of revetment and chevrons to encourage small island formation.

The COE's Engineer Research and Development Center (ERDC) has been conducting distribution and abundance studies on pallid sturgeon for more than 10 years. The ERDC has evaluated susceptibility of sturgeon to entrainment through dredging and diversion structures, and identified engineering modifications to minimize entrainment potential.
Other research and monitoring efforts include a multi-agency, multi-year telemetry study to identify pallid sturgeon habitat associations and movements in the Atchafalaya River and in a short reach of the Mississippi River. Additionally, the USFWS is funding and coordinating research efforts to improve identification of river sturgeon species, and to quantify hybridization levels and trends in sturgeon of the Lower Mississippi River.

Part II: Recovery

Recovery Strategy

The primary strategy for recovery of pallid sturgeon is to: 1) conserve the range of genetic and morphological diversity of the species across its historical range; 2) fully quantify population demographics and status within each management unit; 3) improve population size and viability within each management unit; 4) reduce threats having the greatest impact on the species within each management unit; and, 5) use artificial propagation to prevent local extirpation within management units where recruitment failure is occurring. Pallid sturgeon recovery will require an increased understanding of the status of the species throughout its range; developing information on life history, ecology, mortality, and habitat requirements; improving our understanding of some poorly understood threat factors potentially impacting the species; and using that information to implement management actions in areas where recovery can be achieved (see *Recovery Outline/Narrative*).

Management Units

Suitable habitat for pallid sturgeon is typically found within the flowing reaches of the Missouri, Yellowstone, lower Platte, middle and lower Mississippi, and Atchafalaya rivers. However, some recovery tasks include actions at main stem dams/reservoirs and in other major tributaries when those actions would benefit pallid sturgeon in downstream reaches.

Originally, the U.S. Fish and Wildlife Service established six recovery priority management areas to focus recovery efforts at locales believed to have the highest recovery potential in 1993(USFWS 1993). Since that time, our understanding of the species has improved and warrants redefining those management areas into four management units. These management unit boundaries are based on: 1) genetic data (Campton et al. 2000; Tranah et al. 2001; Schrey and Heist 2007); 2) morphological differences (Kuhajda et al. 2007; Murphy et al. 2007a); 3) biogeography of other fish species and speciation associated with physiographic provinces (Metcalf 1966; Wiley and Mayden 1985; Burr and Page 1986; Cross et al. 1986); 4) common threats; and 5) the potential need and ability to implement differing management actions to address varying threats within a management unit. As genetic and stock structure data are further refined, these management units may be correspondingly adjusted.

Like the original recovery priority management areas, these management units possess riverine reaches that are currently occupied habitats and typically represent the least degraded areas that retain the highest configuration of sandbars, side channels, and varied depths (Pallid Sturgeon Recovery Team 2006 and 2007). However, differing threats may affect each management unit independently (e.g., main-stem impoundments are a threat in the upper portion of the species' range but are not implicated as a threat in the most downstream reaches of the species' range). All river reaches within the species' historical range not specifically identified in the following management unit descriptions should not immediately be excluded from recovery activities if new information indicates these areas are deemed necessary to either prevent local extirpation or to facilitate recovery.

The management units (Figure 7) identified in the recovery strategy described above are defined as:

> The Great Plains Management Unit (GPMU) (Figures 7 and 8) is defined as the Great Falls of the Missouri River, Montana to Fort Randall Dam, South Dakota. This unit includes important tributaries like the Yellowstone River, as well as the Marias and Milk rivers. The upper boundary is at the Great Falls of the Missouri River as this is a natural barrier above which pallid sturgeon could not migrate historically. The lower boundary was defined as Fort Randall Dam to ensure consistent management practices on an inter-reservoir reach of the Missouri River.
>
> The Central Lowlands Management Unit (CLMU) (Figures 7 and 9) is defined as the Missouri River from Fort Randall Dam, South Dakota to the Grand River confluence with the Missouri River in Missouri and includes important tributaries like the lower Platte and lower Kansas rivers.
>
> The Interior Highlands Management Unit (IHMU) (Figures 7 and 10) is defined as the Missouri River from the confluence of the Grand River to the confluence of the Mississippi River, as well as the Mississippi River from Keokuk, Iowa to the confluence of the Ohio and Mississippi rivers.
>
> The Coastal Plain Management Unit (CPMU) (Figures 7 and 11) is defined as the Mississippi River from the confluence of the Ohio River downstream to the Gulf of Mexico including the Atchafalaya River distributary system.

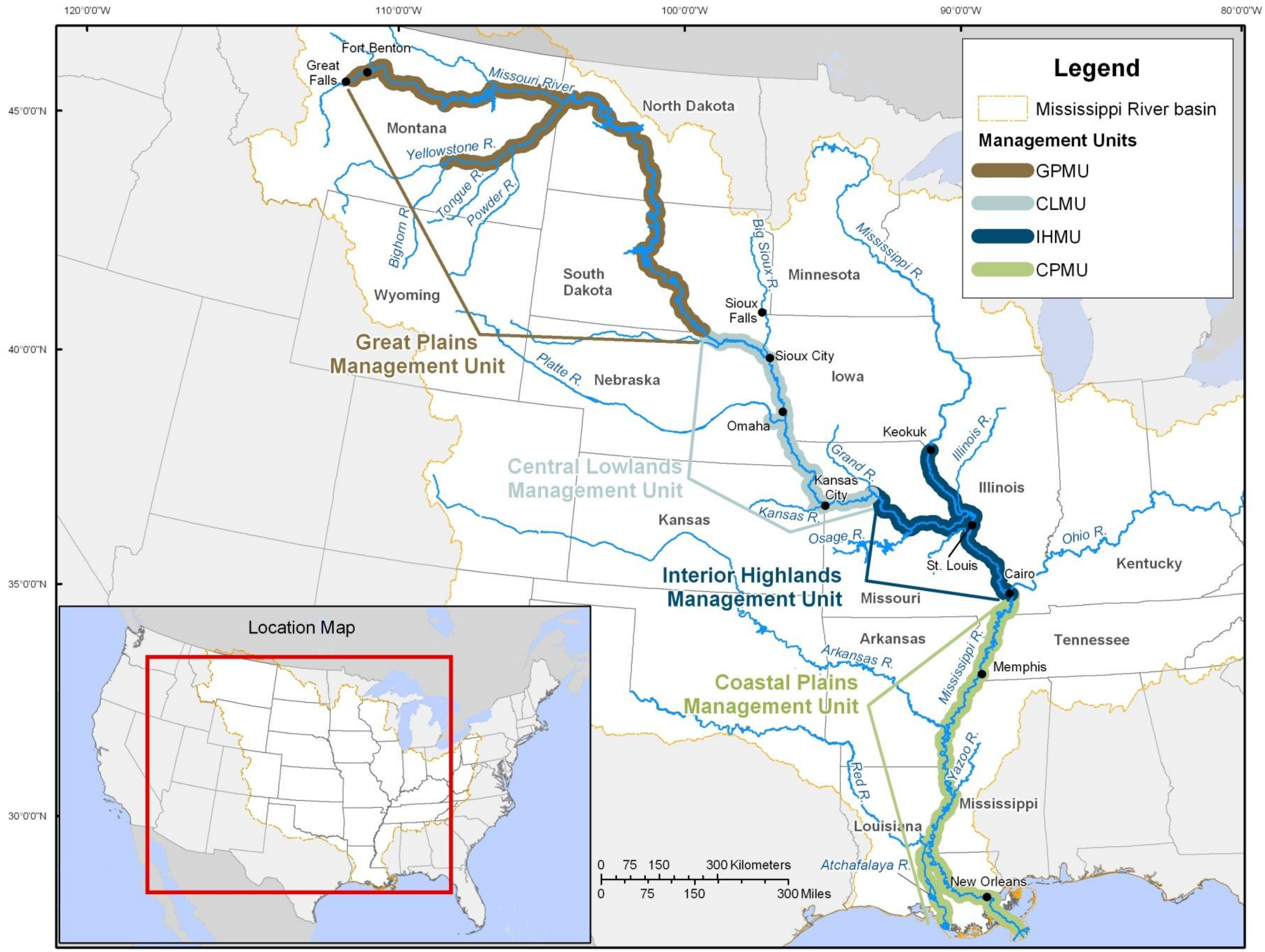

Figure 7 Map depicting pallid sturgeon management units.

Figure 8 Map depicting the Great Plains Management Unit.

Figure 9 Map depicting the Central Lowlands Management Unit.

Figure 10 Map depicting the Interior Highlands Management Unit.

Figure 11 Map depicting the Coastal Plains Management Unit.

Recovery Criteria
Section 3 of the Endangered Species Act, defines an endangered species as one that is in danger of extinction throughout all or a significant portion of its range, and a threatened species as one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Accordingly, a recovered species is one that no longer meets these definitions. Determining whether a species should be reclassified from endangered to threatened or delisted requires assessment of the same five categories of threats which were considered when the species was listed.

Recovery criteria define those conditions that are believed necessary to indicate that a species should be reclassified from endangered to threatened or delisted. Thus, when satisfied, recovery criteria are mileposts that measure progress toward recovery. Recovery criteria are provided below. Because the appropriateness of downlisting or delisting is assessed by evaluating the five threat factors identified in the Endangered Species Act, the recovery criteria below pertain to and are organized by these factors. These recovery criteria are our best assessment at this time of what needs to be completed so that the species may be downlisted to threatened status or removed from the list entirely. Because we cannot envision the exact course that recovery may take and because our understanding of the vulnerability of a species to threats is very likely to change as more is learned about the species and its threats, it is possible that a status review may indicate that downlisting or delisting is warranted although not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met and a status review may indicate that downlisting or delisting is not warranted; for example, a new threat may emerge that is not addressed by the recovery criteria below that causes the species to remain threatened or endangered.

Criteria for Reclassification to Threatened Status
Pallid sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria are sufficiently addressed such that a self-sustaining genetically diverse population of 5,000 adult pallid sturgeon is realized and maintained within each management unit for 2 generations (20-30 years). In this context, a self-sustaining population is described as one that experiences spawning and recruitment of naturally-produced fish into the adult population at levels sufficient to maintain a genetically diverse minimum wild adult population (i.e., incremental relative stock density of stock-to-quality-sized naturally produced fish (Shuman et al. 2006) being 50-85 over each 5-year sampling period, catch-per-unit-effort data indicative of a stable or increasing population, and survival rates of naturally produced sub-adult fish (age 2+) equal to or exceeding those of the adults; see Justification for Population Criteria below for details). Additionally, in this context a genetically diverse population is defined as one in which the effective population size (N_e) is sufficient to maintain adaptive genetic variability into the foreseeable future ($N_e \geq 500$).

Criteria for Delisting Species
Pallid sturgeon will be considered for delisting when the criteria for reclassification to threatened status have been met and sufficient regulatory mechanisms are established to provide reasonable assurances of long-term persistence of the species within each management unit in the absence of the Act's protections.

Listing/Recovery Factor Criteria

The following listing factors (A through E) are applicable to the reclassification and delisting criteria described above, although differences may apply in the methods used to achieve them. Addressing these criteria to sufficient levels can be facilitated by implementing the recovery tasks described under the RECOVERY NARRATIVE section.

Listing Factor A: **Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range.**

This factor will be considered addressed when:

(1) Habitat conservation and restoration efforts establish and maintain riverine habitats capable of meeting and sustaining all life-history requirements of the species (i.e., sufficient habitat is available to support a self-sustaining population within each management unit as described under "Criteria for Reclassification to Threatened Status");

(2) Regulations and enforcement provide reasonable assurances that water quality parameters and contaminants of concern meet national recommended water quality criteria (USEPA 2009) or are improved;

(3) Entrainment losses from all sources (i.e., water cooling intake structures, dredge operations, irrigation diversions, etc.) are minimized such that attributable mortality does not impair maintenance of self-sustaining populations;

(4) The potential effects associated with changes in climate are assessed and mitigated or minimized.

Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.

This factor shall be considered addressed when take of pallid sturgeon associated with commercial, recreational, scientific or educational uses is fully controlled by State regulation, and has little to no effect upon the sustainability of the species within each management unit.

Listing Factor C: Disease or Predation

Disease and Predation were not implicated in the reduction of the species. Existing State and Federal regulations have been established to minimize pathogen introduction from outside the pallid sturgeon's range. The threat from predation will be considered addressed when sufficient data to assess the effects of intraspecific competition from nonnative/invasive species are available, and, if needed, regulations and management measures are established to minimize competition and predation threats to the species.

Listing Factor D: Inadequacy of Existing Regulatory Mechanisms

This factor shall be considered addressed when regulatory mechanisms and enforcement provide reasonable assurance that excessive non-natural mortality is reduced to sustainable levels and adequate regulations protect habitat and habitat forming processes sufficient to maintain self-sustaining populations within each management unit. For example, overutilization must be addressed for either downlisting or delisting to occur. Under the current protections afforded by the Act and similarity of appearance regulations, existing protections may be sufficient to support downlisting. However, delisting will require State harvest regulations that will provide adequate protection from overutilization in the absence of the Act's protections.

Listing Factor E: Other Natural or Manmade Factors Affecting its Continued Existence
This factor shall be considered addressed when:

(1) Energy development and new technologies are evaluated and assessed and, if necessary, measures are implemented to minimize any adverse effects from these activities;

(2) Once simulation studies can assess if alterations of habitats have influenced temporal or spatial reproductive isolating mechanisms resulting in increased rates of hybridization, this threat will likely be addressed by both site-specific and ecosystem improvement efforts such that actual risks associated with pallid/shovelnose hybridization are mitigated.

(3) Invasive species or aquatic nuisance species are regulated and reduced such that deleterious effects (i.e., predation and competition) are minimized.

Justification for Population Criteria

The following targets, when met, should provide sufficient assurances that the population criteria for recovery have been met.

ADULT POPULATION TARGETS:
The requirements of a minimum adult population capable of maintaining adaptive genetic variability long-term will need an effective population size (N_e) of at least 500 (Franklin and Frankham 1998) to perhaps as high as 5000 (Lande 1995). To estimate the census size (N) necessary to meet these criteria, one needs to understand how N_e relates to N. The relationship between N_e and N can be affected by a variety of factors, however, values for N_e /N averaged 0.10-0.11 based on published estimates from 102 species (Frankham 1995). Using Frankham's average values (1995) and the following formula, a theoretical minimum estimate of breeding adults can be obtained.

$$\frac{Ne}{N} = 0.1 \text{ or } N = \frac{Ne}{0.1}$$

If the desired N_e is 500 to 1,000 as suggested by Franklin and Frankham (1998) or 5000 as described in Lande (1995), a theoretical range of 5,000-50,000 adults would constitute a desired adult pallid sturgeon population. Reed et al. (2003) used population viability analysis to estimate minimum viable population sizes of many vertebrate taxa (n=102). They found, on average, that 7,000 breeding adults, along with sufficient habitat to support them, was a minimum requirement for long-term maintenance of a species.

Based on the above data, the minimum desired adult pallid sturgeon population within each management unit will be 5,000.

Because empirically derived data have not been analyzed for pallid sturgeon, this minimum target should be considered interim until pallid sturgeon specific data are evaluated and incorporated into an appropriate population viability analysis to derive management unit or, if designated, DPS specific minimum viable adult population estimates. In this fashion, the delisting and downlisting targets will be modified in an adaptive fashion based on available data and analyses.

Measuring Natural Recruitment

Recruitment failure has been documented in the Great Plains Management Unit, and only limited evidence of recruitment exists for the other management units (USFWS 2007). Concerns over limited recruitment (i.e., potential for local extirpation) resulted in the establishment of an artificial propagation and stocking program. While these artificial measures are helping to maintain the species, to recover pallid sturgeon we must have successful natural spawning and recruitment. To evaluate when this has been achieved, we need reliable population trend estimates.

Annual survival rates of hatchery-reared pallid sturgeon are relatively high ($\geq$ 0.8) for age 2+ fish (Hadley and Rotella 2009; Steffensen et al. 2010). These rates likely are comparable to those of age 2+ wild fish given that most age 2+ hatchery-reared fish were at large for at least 1 year and subject to comparable selection pressures as wild fish; the presence of wild sub-adult pallid sturgeon (age 2+) can provide inferences into potential adult recruitment levels. Thus, documenting presence or absence of wild sub-adult pallid sturgeon in annual survey efforts is one approach to help assess if short-term natural recruitment is occurring within a management unit.

Because length frequency data are commonly collected in fishery surveys, these data remain useful and provide a cost-effective index to monitor a fish population and are more suitable long-term than the short-term presence/absence method described above. The general applicability and limitations of using stock density indices as a tool for assessment of length frequency data are described by Willis et al. (1993). The applicability of stock density indices to pallid sturgeon data are discussed in Shuman et al. (2006 and 2011). Additionally, stock density indices also have been applied to monitor trends in shovelnose sturgeon (Quist et al. 2002). In the context of long-term fish population monitoring, incremental relative stock densities (RSD) are appropriate to use (Willis et al. 1993); thus, incremental RSD values of stock-sized fish as described by Shuman et al. (2006) likely will provide a useful measure to monitor recruitment. In addition to length frequency data, catch-per-unit effort data and survival rates also will be important data (Willis et al. 1993) to identify when natural recruitment is sufficient to sustain the species long-term.

Interim long-term targets for pallid sturgeon recruitment will be based on indices indicative of adequate recruitment; (i.e., incremental-RSD of stock to quality-sized naturally produced fish (Shuman et al. 2006) being 50-85 over each 5-year sampling period, catch-per-unit-effort data indicative of a stable or increasing population, and survival rates of naturally produced sub-adult fish (age 2+) equal to or exceeding those of the adults).

Distinct Population Segment Overview

We may consider splitting this species-level listing into multiple Distinct Population Segments (DPSs) in the future. Section 3 of the Act defines "species" to include "any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." Pursuant to the Act, the USFWS considers if information is sufficient to indicate that listing, reclassifying, or delisting any species, subspecies, or, for vertebrates, any DPSs of these taxa may be warranted. In 1996, the USFWS and National Marine Fisheries Service published a joint policy guiding the recognition of DPSs of vertebrate species (61 FR 4722-4725). Under this policy, we consider two factors to determine whether the population segment is a valid DPS—
1) discreteness of the population segment in relation to the remainder of the taxon, and 2) the significance of the population segment to the taxon to which it belongs. If a population meets both tests, it is a DPS, and then the population segment's conservation status is evaluated according to the standards in section 4 of the Act for listing, delisting, or reclassification (i.e., is the DPS endangered or threatened).

Analysis for Discreteness

A population segment of a vertebrate taxon may be considered discrete if it satisfies either one of the following conditions—(1) is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (quantitative measures of genetic or morphological discontinuity may provide evidence of this separation); or (2) is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

Analysis for Significance

If we determine a population segment is discrete, we next consider available scientific evidence of its significance to the taxon to which it belongs. The DPS policy states that this consideration may include, but is not limited to, the following factors: 1) persistence of the discrete population segment in an ecological setting unusual or unique for the taxon; 2) evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon;
3) evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; and/or 4) evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

If DPS are designated in the future, the criteria for reclassification and delisting would then be applicable to each designated DPS rather than to all management units as now indicated. Any determination to divide the currently listed entity into DPSs would go through the rulemaking process, which means that we would request public comments and peer review on our proposed course of action before we would make a final determination.

Recovery Outline/Narrative

The following recovery tasks were developed in concert with the Upper, Middle, and Lower Basin Pallid Sturgeon Workgroups and depict those items believed necessary to recover pallid sturgeon within each management unit. The following section is written to cover both broad scale approaches and, where possible, provide management unit specific details.

1. CONSERVE AND RESTORE PALLID STURGEON HABITATS, INDIVIDUALS AND POPULATIONS

1.1 RESTORE HABITATS AND FUNCTIONS OF THE MISSOURI AND MISSISSIPPI RIVER ECOSYSTEMS AT SUFFICIENT LEVELS AND QUALITY TO MEET THE LIFE HISTORY REQUIREMENTS OF THE SPECIES.

Anthropogenic alterations to the Missouri and Mississippi Rivers and their tributaries have affected natural riverine processes that pallid sturgeon evolved with. These anthropogenic habitat alterations adversely affect pallid sturgeon by altering the natural form and functions of these rivers (Simons et al. 1974; Fremling et al. 1989; Baker et al. 1991; Theiling 1999; Wlosinski 1999; Bowen et al. 2003). Restoration activities that return lost ecological process are necessary for the species to satisfy its life history requirements. However, the extent needed to accomplish this is currently not quantifiable. Thus, it will be necessary to improve our understanding of critical life history needs and tailor restoration efforts that will improve ecological conditions to address them.

1.1.1 DETERMINE EFFECTS OF DAMS ON LIMITING RECRUITMENT AND SURVIVAL OF PALLID STURGEON

Modifying current operations to lower pool elevations in Fort Peck Reservoir and Lake Sakakawea could increase the amount of available habitat for drifting larvae and provide additional rearing habitat for juvenile pallid sturgeon (Bramblett 1996; Gerrity 2005). Because drift rates of larval pallid sturgeon are related to water velocity (i.e., larval pallid sturgeon drift distance increases with increased velocity) (Kynard et al. 2007; Braaten et al. 2008), reducing dam releases during the larval drift period to levels that mimic the natural hydrograph may benefit pallid sturgeon by reducing channel velocities with a corresponding decrease in total larval drift distance. Additional features that may reduce drift distances are slower velocity seasonal secondary channels or other off channel low velocity areas. A reduction in drift rate and distance could help retain larvae in suitable riverine habitats rather than them being transported into downstream reservoirs.

Additional studies are needed to understand the effects from main-stem COE and BOR dams have on disrupting various life history requirements of the species and to implement actions to mitigate these effects. Spillway releases and altered flow scenarios should be evaluated to assess their ability to improve habitats (i.e., flow conditions, increase sediment transport, and normalize temperature profiles) in downstream reaches. Areas specifically identified for study are:

GPMU

(1) Determine reservoir pool elevations at Fort Peck Reservoir and Lake Sakakawea necessary to provide adequate larval drift distance.
    (a) If pool level elevation modifications will increase larval survival, adjust reservoir operations to maintain pool elevations necessary to provide adequate larval drift distances and to maximize juvenile rearing habitat.
(2) Evaluate spillway releases from Fort Peck Dam to improve flow, turbidity, and temperature conditions downstream.
    (a) If necessary, implement spillway releases to improve flow, turbidity, and temperature conditions downstream.
(3) Evaluate flow scenarios from Fort Peck Dam to increase retention times (i.e., reduce drift rates) for larval pallid sturgeon.
    (a) If necessary, modify releases from Fort Peck Dam to increase retention times (i.e., reduce drift rates) of larval pallid sturgeon.
(4) Evaluate temperature control options on Fort Peck Dam to improve temperature conditions downstream.
    (a) If necessary, implement temperature control options to improve temperature conditions downstream.
(5) Evaluate flow scenarios from dams (Canyon Ferry, Tiber and others) upstream of Fort Peck Reservoir to improve habitat conditions and drift rates for larval pallid sturgeon.
    (a) If necessary, modify flows from dams (Canyon Ferry, Tiber and others) upstream of Fort Peck Reservoir to improve habitat conditions and drift rates for larval pallid sturgeon.

CLMU

(1) Evaluate spillway releases from Fort Randall Dam to improve turbidity and temperature conditions in downstream reaches.
    (a) If necessary, implement spillway releases to improve turbidity and temperature conditions in downstream reaches.
(2) Evaluate temperature control options on Fort Randall Dam to improve temperature conditions downstream.
    (a) If necessary, implement temperature control options on Fort Randall Dam to improve temperature conditions downstream.
(3) Evaluate the feasibility of increasing sediment transport downstream from Gavins Point Dam (i.e., assess the feasibility of: moving Gavins Point Dam to a point upstream of the Niobrara River confluence, re-routing the Niobrara River to confluence with the Missouri River downstream of Gavins Point Dam, or removing Gavins Point Dam).
    (a) If feasible and necessary, implement method of increasing sediment transport downstream from Gavins Point Dam.

1.1.2 RESTORE HABITAT CONNECTIVITY WHERE BARRIERS TO FISH MOVEMENT OCCUR

Evaluating the degree to which a structure may impede movements is necessary to determine if passage is needed at a particular structure. Additionally, existing structures that are barriers to fish movement likely prevent spread of aquatic nuisance species so we need to consider the tradeoffs associated with removing barriers. Passage assessments must consider this as well as the importance for recovery. Following is a list of barriers by management unit that either have been assessed for passage needs or need to be further evaluated.

GPMU

(1) Restore fish passage at Intake Diversion Dam, Yellowstone River.
    (a) Evaluate success of fish passage at Intake Dam once completed.
(2) Evaluate need for passage of pallid sturgeon at Cartersville Diversion Dam, Yellowstone River.
    (a) Restore passage at Cartersville Dam if deemed necessary for pallid sturgeon recovery.
(3) Evaluate need for passage of pallid sturgeon at Vandalia Diversion Dam, Milk River.
    (a) Restore passage at Vandalia Diversion if deemed necessary for pallid sturgeon recovery.

CLMU

(1) Evaluate need for passage of pallid sturgeon at Spencer Dam, Niobrara River, Nebraska.
    (a) Restore passage at Spencer Dam if deemed necessary for pallid sturgeon recovery.
(2) Evaluate need for passage of pallid sturgeon at the, Johnson County Weir, Kansas River, Kansas.
    (a) Restore passage at Johnson County weir if deemed necessary for pallid sturgeon recovery.
(3) Evaluate need for passage of pallid sturgeon at the Bowersock Dam, Kansas River, Kansas.
    (a) Restore passage at Bowersock Dam if deemed necessary for pallid sturgeon recovery.

IHMU

(1) Evaluate need for passage of pallid sturgeon at Chain of Rocks weir, Mississippi River.
    (a) Restore passage at Chain of Rocks Weir if deemed necessary for pallid sturgeon recovery.
(2) Evaluate need for passage of pallid sturgeon at Melvin Price Locks and Dam, Mississippi River.
    (a) Restore passage at Melvin Price Locks and Dam if deemed necessary for pallid sturgeon recovery.

(3) Evaluate need for passage of pallid sturgeon at Lower Osage Lock and Dam #1, Osage River.
   (a) Restore passage at Lower Osage Lock and Dam #1if deemed necessary for pallid sturgeon recovery.

CPMU
(1) Evaluate need for passage of pallid sturgeon at the Wilbur D. Mills dam on the Arkansas River, Arkansas.
   (a) Restore passage at the Wilbur D. Mills dam if deemed necessary for pallid sturgeon recovery.
(2) Evaluate need for passage of pallid sturgeon at the W. G. Huxtable Pumping Plant on the St. Francis River, Arkansas.
   (a) Provide passage at the W. G. Huxtable Pumping Plant if deemed necessary for pallid sturgeon recovery.
(3) Evaluate the potential need for passage at the Old River Control Complex.
   (a) Restore passage at the Old River Control Complex if deemed necessary for pallid sturgeon recovery.

1.1.3 CREATE PHYSICAL HABITAT AND RESTORE RIVERINE FUNCTION

The loss of physical habitat needed by pallid sturgeon has been documented. However, not all efforts to restore habitat will generate equal benefits. Thus, it is essential to evaluate existing efforts to physically construct habitat as compared to using natural processes associated with flow and sediment manipulation from dams to form instream habitats. Additionally, when habitat restoration sites are cleared and grubbed, it may be beneficial to leave clearing and grubbing material in the project site as a source of woody debris. Important activities by management unit are identified below. Finally, operation of dams upstream of spawning areas can influence total drift distance needed for larval fish (Kynard et al. 2007). Reduction in flows at Fort Peck Dam also may assist with reducing total drift distance of larval fish.

GPMU, CLMU, IHMU
(1) Assess relationship of discharge to physical habitat creation and larval fish drift (shallow water habitat, sand bars) in river reaches important for recovery.
   (a) Monitor the outcomes of flow manipulations from dams, and use resulting information to improve techniques, using adaptive management principles.
   (b) Decrease releases from Fort Peck Dam during the larval drift period (based on monitoring and research, this drift likely occurs in late June to early July) to reduce larval drift rates.
(2) Maintain lower reservoir pool levels downstream from important spawning areas to increase larval drift distance and provide both sub-adult and adult habitats (see also Recovery Task 1.1.1).

GPMU, CLMU, IHMU, CPMU
(1) Protect, enhance, and restore habitat diversity and connectivity.

(a) Pursue options to incorporate levee setbacks to increase flood plain connectivity.
(b) Reconnect perched or disconnected side channels.
(c) Develop programs that increase woody debris in these systems.

(2) Develop and maintain standardized monitoring programs to evaluate effect of habitat manipulation and annual variations to determine degrees of response in pallid sturgeon.
(a) Monitor the outcomes of habitat manipulations, and use resulting information to improve habitat restoration and construction techniques, using adaptive management principles.

1.1.4 PROVIDE AND PROTECT INSTREAM FLOWS

Instream flows can be affected by water withdrawal resulting in a general overall reduction in the hydrograph. Instream flows also can be affected daily and seasonally through reservoir operations. The following tasks are intended to increase the understanding of the effects of water depletion and reservoir operations on pallid sturgeon and their habitats and may be useful in better understanding the effects of climate change.

GPMU, CLMU, IHMU

(1) Develop an instream flow plan for riverine reaches important to pallid sturgeon recovery.
(a) Assess tributary water allocations to determine depletion effects on habitat formation and maintenance.
(b) Determine what flows are necessary to meet pallid sturgeon life history requirements.
(i) Consider precipitation pattern models and climate change forecasts when developing flow requirements.
(c) Implement flow protection strategies based on instream flow plan.

(2) Evaluate dam discharges during spring, summer, and fall (both main-stem and tributaries) to protect instream flows.
(a) Manipulate reservoir releases if needed to protect or restore flows for recovery of pallid sturgeon.

1.1.5 QUANTIFY AND MINIMIZE EFFECTS OF ENTRAINMENT

Studies at water diversion points have documented entrainment of pallid sturgeon. However, not all sites have been assessed to determine and quantify entrainment effects. Thus, it will be necessary to assess and quantify entrainment losses of pallid sturgeon at industrial, municipal, and agricultural water intakes, pumping facilities, and other diversion structures. The U.S. Environmental Protection Agency administers the Clean Water Act and should develop and implement section 316 (b) standards that will minimize entrainment of adult and juvenile pallid sturgeon. The BOR and Natural

Resources Conservation Service develop and operate many irrigation projects within the range of pallid sturgeon. Where necessary these projects should be fitted with screens that will minimize or prevent entrainment.

GPMU, CLMU, IHMU, CPMU

(1) Assess potential for entrainment losses at industrial, municipal, and agricultural water intakes, pumping facilities, and other diversion structures.
    (a) Implement strategies to prevent/minimize entrainment.
(2) Inventory and assess potential for entrainment losses associated with dredging and gravel mining operations.
    (a) Implement strategies to prevent/minimize entrainment.

1.1.6 PROVIDE PROTECTION FOR IMPORTANT HABITAT FORMING PROCESSESS

Natural erosion and deposition processes create dynamic and diverse riverine habitats. Protecting these ecological processes will facilitate naturally creating habitats important for pallid sturgeon. There are tools being developed that can help guide these actions. Examples include the land Capability Potential Index (Jacobsen et al. 2007) and the Channel Migration Zone delineation being developed as part of the cumulative effects study on the Yellowstone River (Thatcher et al. 2009) This measure will involve developing new programs and expanding existing ones to develop partnerships necessary to conserve these important areas.

GPMU, CLMU, IHMU, CPMU

(1) Develop and implement non-regulatory mechanisms to retain natural riverine ecological processes.
    (a) Develop programs that provide conservation incentives to willing participants.
        (i) Establish easements to reduce bank armoring in reaches important for pallid sturgeon.
        (ii) Enroll adjacent riparian lands from willing participants in long-term conservation easements.
        (iii) Purchase land from willing sellers and place in public trust (i.e., refuges, State parks).
        (iv) Establish water conservation programs to offset anticipated lower late-season flows associated with climate change.
    (b) Develop additional landscape-level tools to improve assessment and prioritization of non-regulatory conservation efforts.

1.2 MINIMIZE THREATS FROM EXISTING AND PROPOSED HUMAN-CAUSED ACTIVIES

Current State and Federal regulations generally benefit pallid sturgeon by providing oversight on anthropogenic activities. However, not all State and Federal regulations have established standards that are applicable to pallid sturgeon. In many instances, necessary data are lacking to establish thresholds or for comprehensive review. However where empirically derived pallid sturgeon data exist, improving data exchange, (i.e., a centralized easily accessible repository for pallid sturgeon data accessible by agency regulatory personnel) will allow for improved evaluation of effects within the permitting processes.

1.2.1 ENSURE COMPLIANCE WITH EXISTING STATE AND FEDERAL ENVIRONMENTAL REGULATIONS

The U.S. Environmental Protection Agency and State environmental divisions have rules and regulations designed to maintain water quality standards. These standards may need to be modified to protect pallid sturgeon based on Task 2.1.4.

The COE is responsible for administering Section 404 of the Clean Water Act. Efforts conducted to fulfill components of Tasks 1.1.1-1.1.3 will need to be considered in future 404 permits to limit inputs into those areas where habitats have been restored or protected to benefit pallid sturgeon.

The Federal Energy Regulatory Commission (FERC) regulates interstate transmission of electricity as well as licensing hydropower projects. As part of the licensing process, FERC should evaluate projects and their potential effects on pallid sturgeon life history requirements.

Any future introductions of nonnative fish species (i.e., aquaculture) may introduce diseases, increase competition, or result in predation on pallid sturgeon. Stocking new nonindigineous species anywhere in the Missouri and Mississippi river watersheds must not occur until after a risk assessment is completed that considers potential adverse effects to pallid sturgeon.

GPMU, CLMU, IHMU, CPMU

(1) Develop a viable data sharing platform that will enable both regulatory and action-agencies access to the best available science for improved species consideration in consultations, permit issuance, and restoration efforts.

(2) Work with States to develop a policy that will establish risk assessment evaluations prior to introduction of new nonindigenous and exotic species in the Missouri and Mississippi river basins. Only introductions proved not to be deleterious to pallid sturgeon should be allowed.

(3) Continue to enforce State and Federal water quality standards.

1.2.2 EVALUATE PROPOSED HYDROKINETIC PROJECTS PRIOR TO INSTALLATION

In channel power generation (i.e., hydrokinetic) projects are being proposed for development in the Mississippi River between St. Louis, Missouri to New Orleans, Louisiana (Figure 4). These projects are subject to the Federal Energy Regulatory Commission licensing. Because this is a relatively new technology the potential effects, both individually and cumulatively, on pallid sturgeon are unknown. Prior to installing these facilities, it is recommended that additional data be collected in order to assess this potential threat. The results of these investigations should be used to design projects that are consistent with pallid sturgeon recovery.

IHMU, CPMU

(1) Determine if larval, juvenile, and adult pallid sturgeon survive entrainment through hydrokinetic turbines.
   (a) If warranted, identify design modifications or establish protective mechanisms to minimize adverse effects.

(2) Determine if electromagnetic fields will affect local movements as well as migrations.
   (a) If warranted, identify design modifications or establish protective mechanisms to minimize adverse effects.

(3) Evaluate and assess effects on local habitat use.
   (a) If warranted, identify design modifications or establish protective mechanisms to minimize adverse effects.

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

2.1 RESOLVE SPECIES IDENTIFICATION ISSUES IN THE LOWER MISSOURI AND MIDDLE MISSISSIPPI RIVERS.

The lower Missouri and Mississippi rivers contain sturgeon specimens that appear phenotypically and genotypically intermediate between pallid and shovelnose sturgeon. Development of accurate species classification indices and genetic tests are essential to ensure correct species assignment for population status evaluations.

2.1.1 DEVELOP METHODS FOR ACCURATE SPECIES ASSIGNMENT

IHMU, CPMU

(1) Use genetic and morphological data to test for significant agreement among these methods.

(2) If no association exists, reevaluate morphological characters in light of the genetic data.
   (a) Use this information to develop improved morphological based identification methods.

2.2 OBTAIN INFORMATION ON LIFE HISTORY AND HABITAT REQUIREMENTS OF ALL LIFE STAGES OF PALLID STURGEON

While much has been learned about the species since it was listed, data gaps still exist that prevent us from understanding how to recover the pallid sturgeon. Filling these gaps will facilitate management actions and improve efforts to address the five listing factors. Where spawning has been found to occur, spawning habitats must be characterized. If spawning habitats are limited or found to be excessive due to system alterations in certain reaches, this information should be considered when habitat restoration projects are developed (see Task 1.1.3). After spawning success has been documented, spawning success/failure should be quantified in each management unit based on collections of eggs, larvae and young-of-year. These data will help guide adaptive programs to improve efficiency in habitat conservation and restoration efforts.

2.2.1 EVALUATE SEXUAL MATURITY AND SPAWNING LIFE HISTORY PARAMETERS

GPMU, CLMU, IHMU, CPMU

(1) Evaluate if spawning occurs, identify spawning areas, and characterize spawning habitat within each management unit.

(2) Estimate sex ratios, spawning periodicity, and reproductive structure of adult population.

(3) Identify and evaluate spawning site fidelity.

2.2.2 FILL INFORMATION GAPS FOR AGE-0 TO AGE-1 PALLID STURGEON

GPMU, CLMU, IHMU, CPMU

(1) Develop methods to better distinguish larvae and sub-adult pallid sturgeon from larvae and sub-adult shovelnose sturgeon.

(2) Quantify spawning success/failure in the Missouri and Mississippi rivers and tributaries based on collections of larvae and/or young-of-year.

(3) Quantify drift-transport distance/retention of larvae in the Missouri and Mississippi rivers and tributaries.

(4) Test the hypothesis that larvae and fry cannot survive in reservoirs.

(5) Investigate imprinting during the early life history stages as a mechanism to stimulate homing/spawning site fidelity.

(6) Quantify growth and survival rates from hatch through the transition to exogenous feeding, and from the onset of exogenous feeding through the termination of the growing season as related to environmental conditions (e.g., temperature, dissolved oxygen, food type, and ration size).

(7) Identify and describe habitat requirements for larvae and age-0 juveniles.

    (a) Use this information to determine if habitat is limiting this life stage.

2.2.3 FILL INFORMATION GAPS FOR AGE-1 TO SEXUAL MATURITY PALLID STURGEON

GPMU, CLMU, IHMU, CPMU

(1) Identify and describe habitat requirements for juvenile pallid sturgeon.

    (a) Use this information to determine if habitat is limiting this life stage.

(2) Using existing diet information;

    (a) Quantify diets and describe trophic linkages.

    (b) Assess if food/feeding is limiting this life stage.

2.2.4 INVESTIGATE EFFECTS OF ENVIRONMENTAL CONTAMINANTS ON ALL PALLID STURGEON LIFE HISTORY STAGES

Current data are lacking to adequately quantify this threat under existing environmental laws. Research suggests a link between environmental contaminants and potential reproductive problems in several sturgeon species (Feist et al. 2005; Koch et al. 2006b). Research on the effects of contaminants on pallid sturgeon reproductive mechanisms should continue as part of pallid sturgeon recovery efforts. Once contaminants affecting pallid sturgeon are identified and their effects are understood, plans may need to be developed to eliminate point and non-point sources into the Missouri and Mississippi river watersheds. These actions will need to be coordinated with the U.S. Environmental Protection Agency, State agencies with jurisdiction over water quality, and the USFWS' contaminants program. These data will be necessary to evaluate current water quality parameters and contaminants of concern relative to pallid sturgeon. If necessary, these data will help establish water quality standards sufficient to meet the life history requirements of the species.

GPMU, CLMU, IHMU, CPMU

(1) Monitor contaminant levels in wild populations to identify problem contaminants.

(2) Determine effects of problem contaminants on growth, survival, and reproduction of pallid sturgeon.

    (a) Evaluate contaminant effects on adult fish, gamete development, and reproductive success.

    (b) Evaluate contaminant effects on embryo/larval and juvenile development and survival.

(3) Identify and remedy sources of problem contaminants.

3. OBTAIN INFORMATION ON POPULATION GENETICS, STATUS, AND TRENDS

Having adequate information on this species' demographic structure and trends through time is fundamental to evaluate when recovery criteria requirements have been met. Consistent range-wide monitoring efforts are essential to evaluating the species responses to recovery tasks as well as threats as they are addressed.

3.1 DEVELOP AND IMPLEMENT STANDARD MONITORING PROCEDURES FOR PALLID STURGEON THROUGHOUT THE RANGE

Monitoring is essential to understanding the species' status, evaluating responses to management actions, and tracking recovery progress (Campbell et al. 2002). Currently, there is no funded systematic monitoring program. Existing monitoring efforts on the Missouri River are focused on detecting changes in pallid sturgeon and other species' population trends in response to habitat restoration practices. Data from this effort also may be useful in evaluating success of some recovery tasks like stocking; however, minor adaptations to this program could provide much or all of the data necessary to facilitate evaluating delisting and downlisting criteria. While assessment efforts on the Missouri River are a good foundation for monitoring, large river reaches fall outside of existing funded monitoring efforts, including; the middle and lower Mississippi River, the

Atchafalaya River, the Missouri River upstream of Fort Peck Dam, and the Yellowstone River. Thus, large portions of the range have limited or no standardized monitoring.

GPMU, CLMU, IHMU, CPMU

(1) Develop and implement a range-wide pallid sturgeon monitoring program that will provide adequate data to evaluate progress toward downlisting and delisting criteria.

(2) Implement range-wide standardized reporting requirements for population monitoring projects.

(3) Continue to update as needed and implement "Biological procedures and protocols for researchers and managers handling pallid sturgeon" range-wide.

3.2 MONITOR GENETIC MAKEUP OF PALLID STURGEON

Additional research is necessary to evaluate genetic differences across the species' range. Currently, there is a data gap in the lower Mississippi River and portions of the lower Missouri River. These data are essential for defining genetically meaningful management units and for understanding evolutionary trends, reproductive exchange among areas, and hybridization.

GPMU, CLMU, IHMU, CPMU

(1) Develop and implement a range-wide monitoring program that will provide adequate genetic data to guide stocking practices.

(2) Implement range-wide standardized among genetic labs work with pallid sturgeon.

(3) Implement range-wide standardized analysis and reporting requirements for all genetic data.

(4) Continue to assess relationship and justification of management units.

(5) Continue to maintain a range-wide tissue sample archiving as described in the "Biological procedures and protocols for researchers and managers handling pallid sturgeon".

3.3 ASSSESS STRUCTURE OF PALLID STURGEON POPULATION RANGE-WIDE FOR CONSIDERATION OF DISTINCT POPULATION SEGMENTS.

When pallid sturgeon were listed in 1990 (55 FR 36641-36647), data were not available regarding range-wide population structure, and policies on distinct population segments (DPS) did not exist. Subsequently, the Departments of Interior and Commerce jointly developed a DPS policy in 1996 (61 FR 4722-4725). This policy describes elements necessary to identify a DPS: 1) population discreteness and 2) population significance.

Data indicate that the population of pallid sturgeon in the upper Missouri River may meet the DPS policy criteria of discreteness (61 FR 4722-4725). They are genetically distinct from pallid sturgeon in the middle and lowermost portions of the range (Campton et al. 2000; Tranah et al. 2001; Schrey 2007; Schrey and Heist 2007), and they are physically separated by multiple dams. However, these studies lack adequate samples from portions of the Mississippi River, making it difficult to discern if additional discrete populations exist.

GPMU
(1) Evaluate population significance as defined in the DPS policy
(2) Evaluate conservation status as defined in the DPS policy.
(3) Identify and list appropriate DPS, if appropriate.

CLMU, IHMU, CPMU
(1) Continue collection and evaluation of genetic, ecological, behavioral, and physiological data to identify if additional populations meet the discreteness criteria as defined in the DPS policy.
(2) If additional discrete populations exist, evaluate their significance as defined in the DPS policy.
(3) If additional discrete and significant populations exist, evaluate their conservation status as defined in the DPS policy.
(4) Identify and list appropriate DPS(s), if appropriate.

3.4 CONDUCT A POPULATION VIABILITY ANALYSIS

A population viability analysis (PVA) should be conducted to further quantify population levels for recovery goals.

Criteria addressing minimum viable population size and demography will be useful in assessing if populations can persist through natural reproduction and thus will be an important component to evaluate the criteria for downlisting or delisting pallid sturgeon. A PVA also can be a useful tool for developing minimum viable population size estimates (Reed et al. 2003). Monitoring activities (see task 3.1) should consider the data requirements necessary to conduct PVA and should be designed to provide these data (Morris et al. 2002).

GPMU, CLMU, IHMU, CPMU
(1) Identify and collect data necessary to develop management unit or DPS (if designated) specific PVAs.
(2) Estimate management unit or DPS (if designated) specific minimum viable population size.
(2) Update PVA models as new data are available to facilitate downlisting and delisting criteria evaluations.

4. IMPLEMENT AND EVALUATION A CONSERVATION PROPAGATION AND STOCKING PROGRAM

4.1 IMPLEMENT CONSERVATION PROPAGATION AND STOCKING PROGRAM

Current stocking efforts are conducted in accordance with a range-wide stocking plan (USFWS 2008). This plan should be amended if necessary using adaptive management principles as new data become available from Tasks 3.1-3.3 and 4.2.

GPMU, CLMU, IHMU, CPMU

(1) Annually review, update if necessary, and implement range-wide stocking and propagation plans using the most recent information.

(2) Annually review and update the tagging plans with the most recent information.
  - (a) Improve tagging mechanisms to minimize tag loss/failure in hatchery produced fish.
    - (i) Ensure that genetic samples are collected from all fish used in propagation efforts,
    - (ii) Continue to evaluate tag tagging location for improved PIT tag retention,
    - (iii) Ensure that all monitoring crews have appropriate tag reading equipment.
  - (b) Ensure that all field crews throughout the Missouri and Mississippi River drainages have appropriate equipment to read tags.
  - (c) Implement tagging plan.

4.2 EVALUATE SUCCESS OF PROPAGATION AND STOCKING PROGRAM

GPMU, CLMU, IHMU, CPMU

(1) Evaluate pallid sturgeon supplementation using various age classes of progeny.
  - (a) Use data to derive pallid sturgeon specific survival rates where stocking occurs.
  - (b) Use data to refine stocking strategies:
    - (i) Determine optimal stocking numbers,
    - (ii) Determine optimal stocking size,
    - (iii) Determine optimal stocking time and location.
  - (c) Evaluate dispersal of hatchery progeny.
  - (d) Evaluate effectiveness of hatchery products within each management unit.
  - (e) Determine when stocking is no longer needed.

4.3 RESEARCH METHODS TO IMPROVE SPAWNING, CULTURING, REARING, AND STOCKING OF PALLID STURGEON

GPMU, CLMU, IHMU

(1) Continue to refine efficient, effective spawning techniques in the hatcheries and in the field.

(2) Conduct trials to determine spawning requirements of broodstock (e.g. optimal spawning temperature) and methods for maximizing survival and growth of progeny collected from broodstock.
(3) Continue to refine techniques to improve hatchery product quality and survivability.
(4) Continue to refine and improve cryopreservation techniques.
    (a) Insure cryopreservation program is adequately funded to maintain preserved sperm as long as necessary.

5. COORDINATE AND IMPLEMENT CONSERVATION AND RECOVERY OF PALLID STURGEON

5.1 WORK WITH STAKEHOLDERS/PARTNERS TO MAINTAIN AND / OR INCREASE PALLID STURGEON NUMBERS RANGE-WIDE (IN ALL MANAGEMENT UNITS).

GPMU, CLMU, IHMU, CPMU

(1) Collaborate with governmental agencies at all levels; local universities, land managers; private land owners, industry, and the general public to recover the pallid sturgeon.
    (a) Enlist State agencies / State managers in regional and range-wide recovery efforts for the pallid sturgeon.
    (b) Determine ways to improve communication and find innovative methods to work closely with Federal and State regulatory partners to improve upon recovery efforts for this fish.
    (c) Engage local communities, businesses, aquariums, non-governmental organizations, and others to support pallid sturgeon.

5.2 COMMUNICATE WITH STURGEON RESEARCHERS, MANAGERS, AND THE PUBLIC

GPMU, CLMU, IHMU, CPMU

(1) Develop a method to integrate and incorporate information from all researchers and biologists working with pallid sturgeon.
    (a) Ensure that Federal endangered species permits are reviewed in a timely manner and coordinated such that annual reporting requirements are met and that pallid sturgeon collection and morphologic data and genetic tissue samples are provided to the appropriate repositories.
    (b) Identify disparate data sources necessary to evaluate progress toward downlisting and delisting criteria.
        (i) Develop a range-wide data management and archiving strategy/plan to relationally link data necessary to evaluate progress toward downlisting and delisting criteria.
        (ii) Implement data management and archiving strategy/plan.
        (iii) Review and update data management and archiving strategy/plan as data needs and as technology changes.
    (c) Annually update central database using permit reporting data.

(d) Improve and maintain central clearinghouse of pallid sturgeon bio-data and encounter history.

(2) Develop a web-based application related to pallid sturgeon life history that has direct links to scientific literature and current research.

(3) Improve dissemination of up-to-date information on pallid sturgeon (including research, new program updates, etc.).
(a) Hold a range-wide "*Scaphirhynchus*" conference at least every 5 years.
(b) Produce and share basin specific reports on pallid sturgeon through a user friendly outlet.
(c) Encourage and support publication of research, management, and other recovery-related information.

(4) Collaborate with partners and develop an outreach program that highlights the pallid sturgeon and its ecosystem and the importance of protecting this fish
(a) Develop and distribute information and education materials on pallid sturgeon and its ecosystem.
(b) Increase public awareness of the laws and needs for protecting pallid sturgeon and their habitats.
(c) Provide cultured pallid sturgeon to aquaria and comparable facilities where they can be viewed by the public.
(d) Develop activities and materials for grade, middle, and high school teachers.
(e) Establish signs at all public boat ramps accessing the Missouri and Mississippi rivers describing pallid sturgeon.

6.0 POST DOWNLISTING OR DELISTING PLANNING

(1) Work with partners (including State and Federal agencies and others) to develop a post delisting monitoring strategy as progress is gained toward full recovery of this species.

Part III: Implementation Schedule

Recovery plans are intended to assist the USFWS and potential Federal, State, and private partners in implementing actions to recover and/or protect endangered species. The following Implementation Schedule outlines recovery tasks, task priorities, task descriptions task duration, and estimated task costs for the first 3 years of this recovery plan.

Parties with authority, responsibility, or expressed interest to implement specific recovery tasks are identified in the Implementation Schedule. The identification of agencies within the Schedule does not imply a requirement or that prior approval has been granted by that party to participate nor does it constitute and additional legal responsibilities beyond existing authorities, i.e., Endangered Species Act, Clean Water Act, Federal Land Policy and Management Act, etc. Recovery plans do not obligate other parties to implement specific tasks and may not represent the views, official positions, or approval of any individuals or agencies involved with developing the plan, other than the USFWS.

Recovery tasks are assigned numerical priorities to highlight the relative contribution they may make to species recovery. Priority numbers in column 1 of the schedule are defined as follows:

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 action necessary to provide for reclassification or full recovery of the species.

The cost estimates provided in the Schedule identify foreseeable expenditures that could be made to implement the specific recovery tasks during a 5-year period. Actual expenditures by identified agencies/partners will be contingent upon appropriations and other budgetary constraints.

Key to acronyms used in Implementation Schedule

BOR	U.S. Bureau of Reclamation
COE	U.S. Army Corps of Engineers
ES	Ecological Services Division (USFWS)
EPA	U. S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FR	Fisheries Division (USFWS)
NRCS	Natural Resources Conservation Service, U.S. Department of Agriculture
LE	Law Enforcement (USFWS)
RF	Refuge Division (USFWS)
STATES	State agencies located within the range of the species
USGS	U. S. Geological Survey
WAPA	Western Area Power Administration

Implementation Schedule

Pallid Sturgeon Recovery Plan Implementation Schedule												
Priority	Task #	Task Description*	Task Duration	RESPONSIBLE PARTY			COST ESTIMATES (thousands of dollars)					COMMENTS/NOTES
				USFWS		OTHER	FY 1	FY 2	FY 3	FY 4	FY 5	
				REGION	DIVISION							
1	1.1.1	Determine effects of dams on limiting recruitment and survival of pallid sturgeon	3	6	FS, ES	BOR, COE, STATES	300	300	300			Costs estimate based on focused research projects for evaluation of identified structures.
1	1.1.2	Restore habitat connectivity where barriers to fish movement occur	5+	6	FS, ES, RF	BOR, COE,	43,000	40,000	27,000			Cost estimates impossible to derive as each barrier will likely require a unique solution.
1	1.1.3	Create physical habitat and restore riverine function	5+	3,4,6	FS, ES	COE, BOR,	3,000	3,000	3,000	3,000	3,000	
2	1.1.4	Provide and protect instream flows	5+	3,4,6	FS, ES	COE, BOR, NRCS,USFWS, STATES						Cost estimates impossible to derive.
1	1.1.5	Quantify and minimize effects of entrainment	5+	3,4,6	FS, ES	COE, BOR, EPA, NRCS, FERC, STATES	27,000	13,000	12,000	5,000	5,000	
1	1.1.6	Provide protection for important habitat forming processes	5+	3,4,6	FS, ES, RF	COE, BOR, EPA, NRCS,STATES	5,000	5,000	5,000	5,000	5,000	
1	1.2.1	Ensure compliance with existing State and Federal environmental regulations	ongoing	3,4,6	ES	COE, BOR, EPA, FERC, STATES						Cost may be absorbed under existing programs.
2	1.2.2	Evaluate proposed hydrokinetic projects prior to installation	3	3, 4	ES	FERC, USFWS, STATES						Cost may be absorbed under existing programs.
1	2.1.1	Develop methods for accurate species assignment	3	3,4,6	FR, ES	USFWS, COE	100	100	100			
1	2.2.1	Evaluate sexual maturity and spawning life history parameters	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	500	500	500			
1	2.2.2	Fill information gaps for - Age-0 to Age-1 pallid sturgeon	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	500	500	500			
1	2.2.3	Fill information gaps for - Age-1 to sexually mature pallid sturgeon	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	500	500	500			

Implementation Schedule (continued)

Pallid Sturgeon Recovery Plan Implementation Schedule												
Priority	Task #	Task Description*	Task Duration	RESPONSIBLE PARTY			COST ESTIMATES (thousands of dollars)					COMMENTS/NOTES
				USFWS		OTHER	FY 1	FY 2	FY 3	FY 4	FY 5	
				REGION	DIVISION							
1	3.1	Monitor pallid sturgeon population	5+	3,4,6	FR	COE, BOR, USGS	3,000	3,000	3,000	3,000	3,000	
1	3.2	Monitor genetic makeup of pallid sturgeon	5+	3,4,6	FR, ES	COE, USFWS	200	200	200	200	200	
3	3.3	Assess population for consideration of distinct population segments	2-Jan	3,4,6	FR,ES	USFWS	10	10				Some cost may be absorbed under existing programs.
2	3.4	Conduct a population Viability Analysis	4	3,4,6	FR, ES	USGS, COE, BOR	50	50	50	50		Data analysis. Data collection costs absorbed under existing programs
1	4.1	Conservation propagation and stocking program	5+	3,6	FR	COE, BOR, STATES	450	475	500	525	550	
1	4.2	Evaluate success of propagation and stocking program	5+	3,4,6	FR	COE, BOR,	50	50	50	50	50	Data analysis. Data collection costs absorbed under existing programs
2	4.3	Research to improve spawning, culturing, rearing and stocking	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	100	100	100			Cost may be absorbed under existing programs
1	5.1	Work with stakeholders/partners to maintain and/or increase pallid sturgeon numbers range-wide.	ongoing	3,4,6	FR, ES, RF	USGS, COE, BOR, STATES	200	200	200	200	200	Cost may be absorbed under existing programs
3	5.2	Communicate with sturgeon researchers, managers, and the public.	5+	3,4,6	FR, ES	USGS, COE, BOR, STATES	200	200	200	200	200	Cost may be absorbed under existing programs
3	6.1	Post downlisting or delisting planning.	3	3,4,6	FR, ES	USGS, COE, BOR, USFWS, STATES, WAPA, NRCS	100	50	50			

*detailed description available in Recovery Narrative

Part IV: References

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APPENDIX A: *State Regulatory Requirements*

The table that follows lists the major state laws that establish requirements, permits, approvals, or consultations that may apply to projects in or near waterways that may affect water quality or quantity.

The citations in this table are those of the general statutory authority that governs the indicated category of activities to be undertaken.
Under such statutory authority, the lead state agencies may have promulgated implementing regulations that set forth the detailed procedures for permitting and compliance.

Definitions of abbreviations used in the table are provided here.

ACA Arkansas Code, Annotated
IAC Iowa Code
ILCS Illinois Compiled Statutes
KAR Kentucky Administrative Regulations
KSA Kansas Statues Annotated
LAC Louisiana Administrative Code
MCA Montana Code Annotated
MSC Mississippi Code
MRS Missouri Revised Statutes
NDCC North Dakota Century Code
NRS Nebraska Revised Statute
SDAR South Dakota Administrative Rules
TCA Tennessee Code Annotated

Table B State Statues Related to Water Quality and Usage.

	AUTHORITY	CITATION
Arkansas	Arkansas Water and Air Pollution Control Act (ACA §§ 8-4-101 et seq.) Arkansas Water Resources Development Act of 1981 (ACA §§ 15-22-601 to 15-22-622) Arkansas Natural and Scenic Rivers System Act (ACA §§ 15-23-301 to 15-23-315) Flood Control (ACA §§ 15-24-101 et seq,)	
Illinois	Environmental Protection Act (ILCS §§ 415-5-1 et seq.) Water Pollutant Discharge Act (ILCS §§ 415-25-.01 et seq.) Watershed Improvement Act (ILCS §§ 505-140-.01 et seq.) Water Use Act of 1983 (ILCS §§ 525-45-1 et seq.)	
Iowa	Surface Water Protection and Flood Mitigation Act (IAC §§ 466B.1 to 466B.9) Initiative on Improving Our Watershed Attributes (I on IOWA) (IAC §§ 466-1 to 466-9) Protected Water Area Systems (IAC §§ 462-B.1 to 462-B.16) Public Lands and Waters (IAC §§ 461-A.1 to 462-A.80) Soil Conservation Districts Law (IAC §§ 161-A.1 to 161-A.80)	
Kansas	State Water Resource Planning (KSA §§ 82a-901 to 82a-954) Bank Stabilization Projects (KSA §§ 82a-1101 to 82a-1103)	
Kentucky	Designation of uses of surface waters (401 KAR 5:206) Anti-degradation policy (401 KAR 5:030) Surface Water Standards (401 KAR 5:031)	
Louisiana	Louisiana Environmental Quality Act (LAC §§30-II-2001 to 2566) Surface Water Quality Standards (LAC §§ 33-IX-1101 et seq.)	
Mississippi	Mississippi Air and Water Pollution Control Law (MSC §§ 49-17-1 to 49-17-43)	
Missouri	Missouri Clean Water Law (MRS §§ 640.010 et seq. and §§ 644.006 et seq.)	
Montana	Aquatic Ecosystem Protections (MCA §§ 75-7-101 et seq.) Flood Plain and Floodway Management (MCA §§ 76-5-101 et seq.) Surface Water and Groundwater (MCA §§ 85-2-101 et seq.) Public Water Supplies, Distribution and Treatment (MCA §§ 75-6-101 et seq.) Water Quality (MCA §§ 75-5-101 et seq.) Montana Water Use Act (MCA § 85-2-101 et seq.).	
Nebraska	Environmental Protection Act (NRS §§ 81-1501 et seq.)	
North Dakota	Control, prevention, and abatement of pollution of surface waters (NDCC §§ 61-28-01 et seq.)	
South Dakota	Surface Water Quality Standards (SDAR §§ 74-51-01 et seq.)	
Tennessee	Tennessee Water Quality Control Act of 1977 (TCA §. 69-3-101 et seq.) General Water Quality Criteria (§§1200-4-3-01 et seq.) Use Classification for Surface Waters (§§1200-4-4-01 et seq.)	