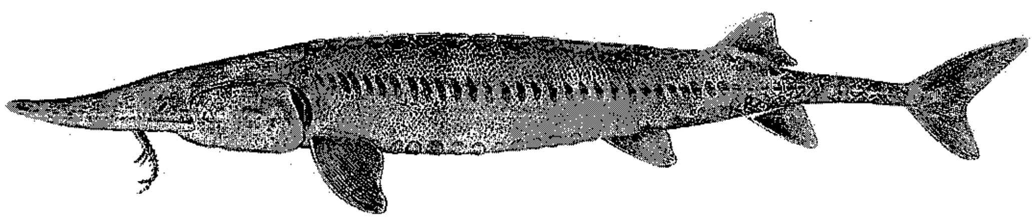
U.S. Fish & Wildlife Service

Revised RECOVERY PLAN

for the

Pallid Sturgeon (*Scaphirhynchus albus*)

Original Plan Approved: November 1993



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For

Mountain-Prairie Region
U.S. Fish and Wildlife Service
Denver, CO

January 2014

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Approved: ______________________________
Deputy Regional Director, Region 6, U.S. Fish and Wildlife Service

Date: 1.29.14

DISCLAIMER

Recovery plans delineate reasonable actions that are believed necessary to recover and/or protect listed species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Plans are reviewed by the public and subject to additional peer review before they are adopted by the U.S. Fish and Wildlife Service. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not obligate other parties to undertake specific tasks. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species' status, and the completion of recovery tasks.

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 Montana Fish and Wildlife Conservation Office, Billings, Montana.

Suggested literature citation:

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

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The Middle Basin Pallid Sturgeon Workgroup

The Lower Basin Pallid Sturgeon Workgroup

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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 numbers of wild Pallid Sturgeon collected in the Missouri, Mississippi and Atchafalaya rivers are higher than initially documented when listed and evidence for limited recruitment exists for the lower Missouri and Mississippi rivers, the population has not been fully quantified. This increase in observations is the result of increased monitoring efforts, improvements in sampling techniques, and greater emphasis on research in the impounded portion of the range. Despite 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. To prevent further extirpation, a conservation propagation program has been established. The Pallid Sturgeon Conservation Augmentation Program (PSCAP) appears to be successful in maintaining the species' presence within the Missouri River basin. 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 dynamic physical habitats. Limiting factors include: 1) activities which affect in-river connectivity and the natural form, function, and hydrologic processes of rivers; 2) illegal harvest; 3) impaired water quality and quantity; 4) entrainment; 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: 1) increased knowledge of the status of Pallid Sturgeon throughout its range; 2) better understanding of Pallid Sturgeon life history, ecology, mortality, and habitat requirements; 3) improve assessments of all potential threats affecting the species; and 4) application of information gained through research and monitoring to effectively implement management actions where recovery can be achieved (see Recovery Outline/Narrative).

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

RECOVERY OBJECTIVES: The recovery objectives include the implementation of effective management actions that will reduce or alleviate the impacts from threats to the species within each management unit and across the species' range. Recovery actions to address threats within management units should be informed by adequate knowledge of pallid sturgeon abundance, population structure, life history, ecology, mortality, and habitat requirements specific to those units.

RECOVERY CRITERIA: Pallid Sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria (p. 54) 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 Endangered Species Act's protections.

In this context, a self-sustaining population is described as a naturally spawning population that results in sufficient recruitment of Pallid Sturgeon into the adult population at levels necessary to maintain a genetically diverse wild adult population in the absence of artificial population augmentation (see *Criteria for Reclassification to Threatened Status* p. 54). 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 and adequately demonstrated within each management unit prior to consideration for reclassification. Because the nature of threats to the species and impediments to recovery vary among management units, it is likely that individual units may achieve population sustainability criteria earlier than others. As populations recover and the inter-relationships of populations on the landscape are better known, the data will be reviewed to determine whether the designation of distinct population segments (DPSs) is warranted.

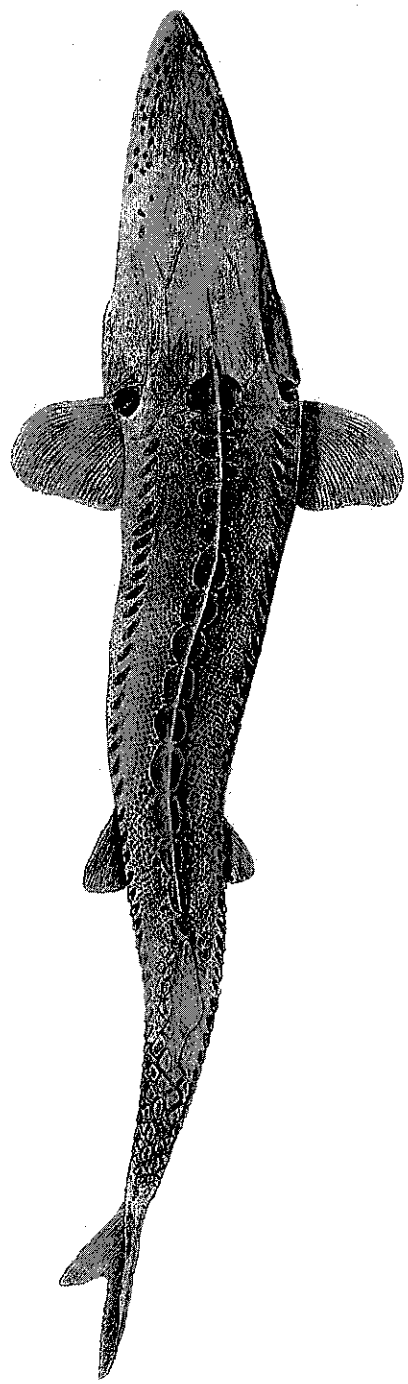
ACTIONS NEEDED (see *Recovery Outline/Narrative* pp. 58-74):

1. Conserve and restore Pallid Sturgeon individuals, populations, and habitats.
2. Conduct research necessary to promote survival and recovery of Pallid Sturgeon.
3. Obtain information on population genetics, status, and trends.
4. Maintain the Pallid Sturgeon Conservation Augmentation Program where deemed necessary.
5. Coordinate and implement conservation and recovery of Pallid Sturgeon.
6. Post downlisting or delisting planning.

ESTIMATED COST OF RECOVERY TASK IMPLEMENTATION (not adjusted for inflation): The estimated cost to implement this recovery plan and achieve species recovery is $239,170,000.

Of this amount, the estimated costs for downlisting from endangered to threatened is $221,820,000 and post reclassification costs are estimated to be $17,350,000. More detailed descriptions of the recovery tasks can be found in the *Recovery Outline/Narrative* (pp. 58-74) and a prioritized list of recovery tasks can be found in the *Implementation Schedule* (pp. 75-78).

DATE OF RECOVERY: The 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 may change as new data become available.



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Abbreviated units used in this plan

cfs	cubic feet per second
ft	foot (feet)
ft/s	foot (feet) per second
km	kilometer(s)
m	meter(s)
m/s	meter(s) per second
mg/l	milligram(s) per liter
mi	mile(s)
NTU	nephelometric turbidity units
Rkm	River kilometer(s)
Rmi	River mile(s)

Acronyms used in this plan

CLMU:	Central Lowlands Management Unit
CPMU:	Coastal Plain Management Unit
DPS:	Distinct Population Segments
GPMU:	Great Plains Management Unit
IHMU:	Interior Highlands Management Unit
PCB:	Polychlorinated Biphenyls
PSCAP:	Pallid Sturgeon Conservation Augmentation Program
RSD:	Relative Stock Density
USFWS:	U.S. Fish and Wildlife Service

Part I: Background

History

Pallid Sturgeon (*Scaphirhynchus albus*), as well as other sturgeon species, are often referred to as "living dinosaurs". This moniker results from existence of fossilized sturgeon believed to be precursors to, or possibly common ancestors of, contemporary *Scaphirhynchus* species that 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 belonging to the family Acipenseridae inhabit North America; 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*); – *E (4 DPS) and T (1 DPS)*
- Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) – *T*;

Seven 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*), one has DPSs that are either listed as threatened or endangered, 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). While the Lake Sturgeon is not federally listed, it has declined throughout its native range and receives special protections in most states and provinces where it occurs.

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 intended to eliminate the effects of size, age, and possibly geographic variation. In general, mature Pallid Sturgeon attain 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 naked bellies generally lack the mosaic of embedded scutes that armor the ventral surface of the Shovelnose Sturgeon.

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 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).

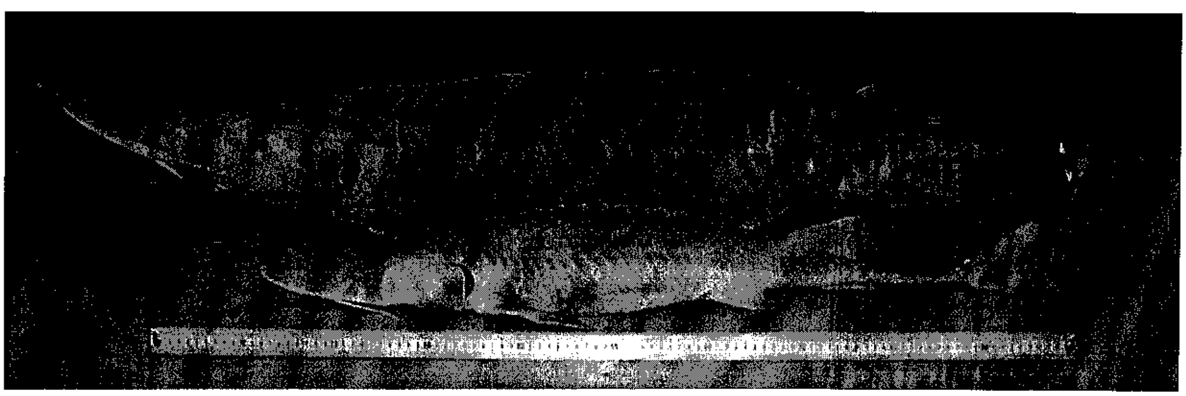

Figure 1 Preserved adult Pallid Sturgeon: the larger specimen (background) is from the upper Missouri River and the smaller specimen (foreground) is from the lower Mississippi/Atchafalaya Rivers. Both specimens are among the larger specimens recorded from each region. (Photo courtesy Dr. Bernard Kuhajda, Tennessee Aquarium Conservation Institute).

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's 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 turbid 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). Although considered to be nowhere common, Bailey and Cross (1954) indicated that Pallid Sturgeon were considerably more abundant in larger turbid rivers than in clear or moderately turbid waters.

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, Montana 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 Milk and Yellowstone rivers, 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 (Figure 3). Pallid Sturgeon observations and records have increased with

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

sampling effort in the Mississippi River basin. In 1991, the species was identified in the Atchafalaya River, Louisiana (Reed and Ewing 1993) (Figure 3).

The contemporary downstream extent of Pallid Sturgeon ends near New Orleans, Louisiana (Killgore in litt., 2008). Additionally, the species has been documented in the lower Arkansas River (Kuntz in litt., 2012), the lower Obion River, Tennessee (Killgore et al. 2007b), as well as navigation pools 1 and 2, i.e., downstream from Lock and Dam 3, in the Red River, Louisiana (Slack et al. 2012) (Figure 3).

In 1995, a preliminary estimate found about 45 wild Pallid Sturgeon existed in the Missouri River upstream of Fort Peck Reservoir (Gardner 1996). More recent data suggest that substantially fewer wild fish remain today. For example only three wild Pallid Sturgeon were collected during 2007 – 2013, indicating wild Pallid Sturgeon numbers in the Missouri River upstream of Fort Peck Reservoir are too low for a reliable population estimate (Tews in litt., 2013). An estimated 125 wild Pallid Sturgeon remain in the Missouri River downstream of Fort Peck Dam to the headwaters of Lake Sakakawea including the lower Yellowstone River (Jaeger et al. 2009). While current abundance estimates are lacking for the entire Missouri River downstream of Gavins Point Dam, Steffensen et al. (2012) generated annual population estimates for both wild and hatchery-reared Pallid Sturgeon for the reach of the Missouri River extending from the Platte River confluence downstream 80.5 Rkm (50 Rmi). Their results estimated wild Pallid Sturgeon at 5.4 to 8.9 fish/Rkm (8.7 to 14.3fish/Rmi) and hatchery produced Pallid Sturgeon at 28.6 to 32.3 fish/Rkm (46.1 to 52.0 fish/Rmi). Extrapolating these estimates to the entire lower Missouri River suggests that the wild population may consist of as many as 5,991 mature individuals (Steffensen et al. 2013). This population may be stabilizing as a result of the Pallid Sturgeon Conservation Augmentation Program (PSCAP), but remains neither self-sustaining nor viable (Steffensen 2012; Steffensen et al. 2013). Garvey et al. (2009) generated an estimate of 1,600 (5 fish/Rkm, 0.8 fish/Rmi) to 4,900 (15.2 fish/Rkm, 24.5 fish/Rmi) Pallid Sturgeon for the middle Mississippi River (i.e., mouth of the Missouri River Downstream to the Ohio River confluence). In 2009, a sturgeon survey in the Upper Mississippi River captured a single Pallid Sturgeon below lock and dam 25 near Winfield, Missouri (Herzog in litt., 2009). No estimates are available for the remainder of the Mississippi River. Since 1994, the PSCAP has released hatchery-reared Pallid Sturgeon within the Missouri River, portions of the Yellowstone River, and sporadically in the Mississippi River. Supplementation data are summarized within 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 river systems. Floodplains, backwaters, chutes, sloughs, islands, sandbars, and a dynamic main channel formed the large-river ecosystem that met the habitat and life history requirements of Pallid Sturgeon and other native large-river fishes.

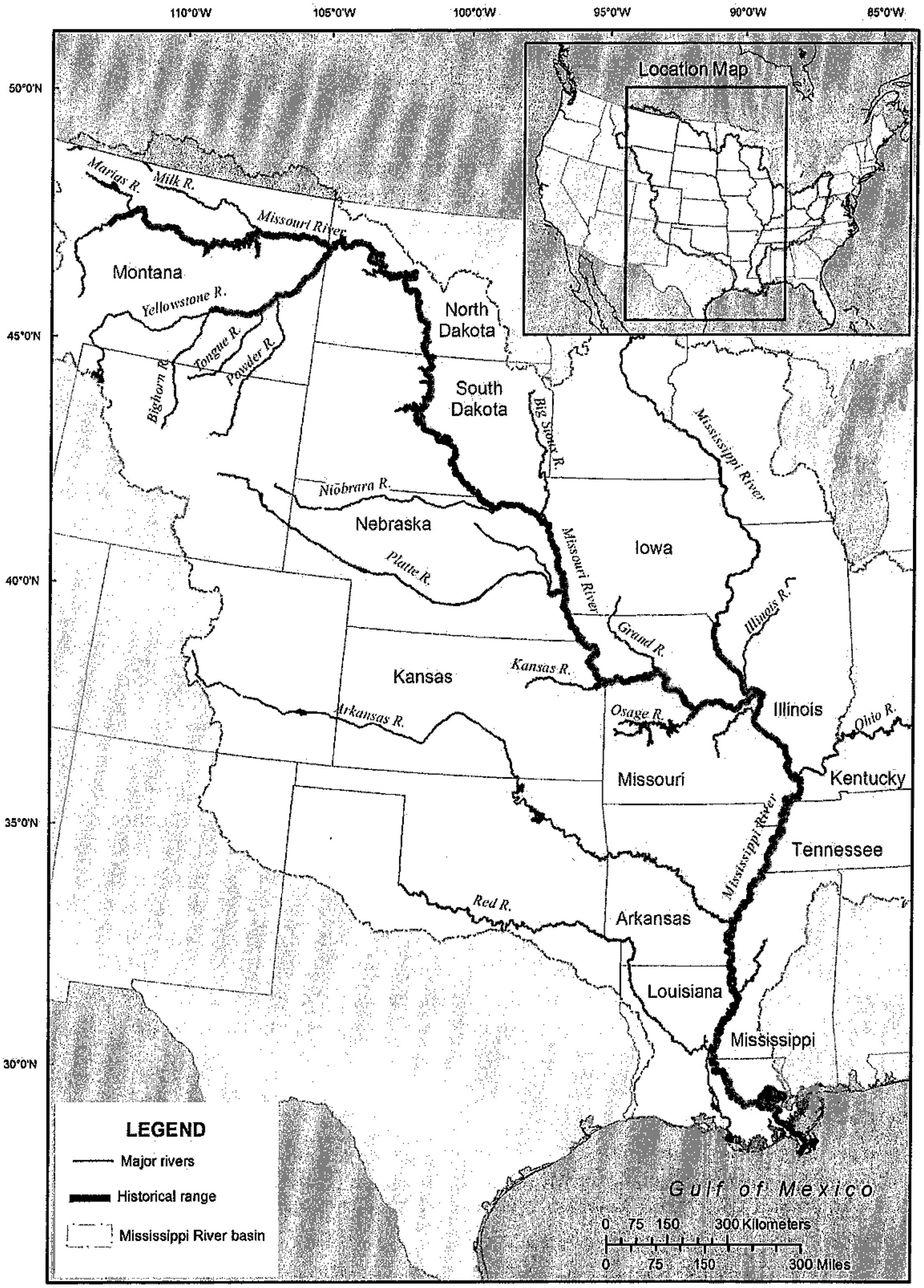

Figure 2 Map of prominent rivers in the Mississippi River Basin. Bold line approximates historical range of Pallid Sturgeon (Coker 1929; Bailey and Cross 1954; Brown 1955; Carlson and Pflieger 1981; Kallemeyn 1983; Keenlyne 1995).

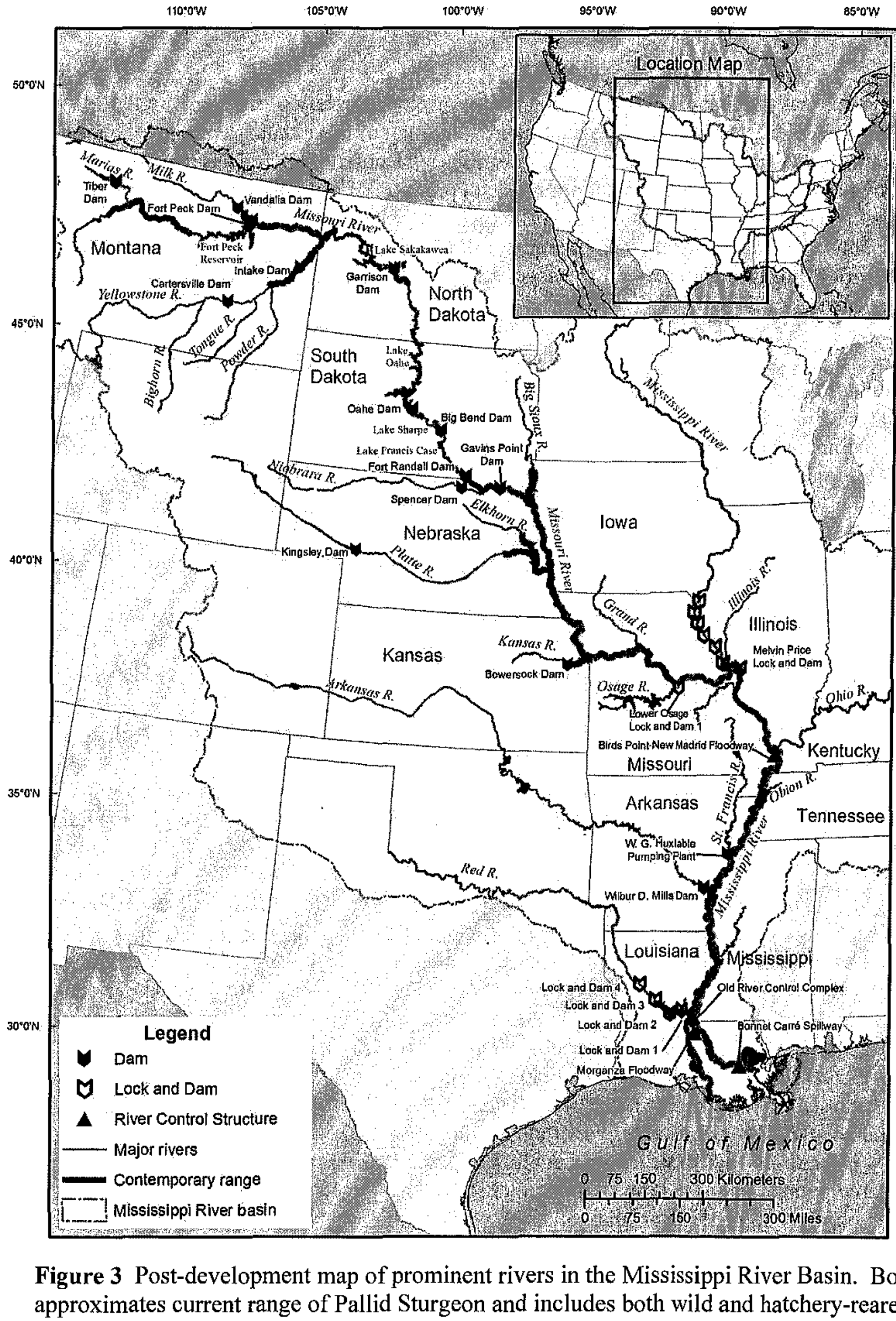

Figure 3 Post-development map of prominent rivers in the Mississippi River Basin. Bold line approximates current range of Pallid Sturgeon and includes both wild and hatchery-reared fish. (Data: National Pallid Sturgeon Database, U.S. Fish and Wildlife Service, Bismarck, North Dakota).

Habitat Use

Research into habitat usage has produced some useful insights in many portions of the Pallid Sturgeon's range. 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 and temperatures, suppression of fluvial processes, stabilized river 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.

Pallid Sturgeon primarily utilize main channel, secondary channel, and channel border habitats throughout their range. Juvenile and adult Pallid Sturgeon are rarely observed in habitats lacking flowing water which are removed from the main channel (i.e., backwaters and sloughs). Specific patterns of habitat use and the range of habitat parameters used may vary with availability and by life stage, size, age, and geographic location. In the upper portions of the species' range, juvenile hatchery-reared Pallid Sturgeon select main-channel habitats (Gerrity 2005). In the Yellowstone and Platte rivers, 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). While adult Pallid Sturgeon in the channelized lower Missouri River primarily use channel border habitats associated with engineered structures, they have been documented utilizing side channels, as well as newly inundated floodplain habitats with flowing water associated with historic discharges from Gavins Point Dam (Justin Haas in litt., 2013). 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).

Habitat requirements of larval and young-of-year Pallid Sturgeon remain largely undescribed across the species' range, primarily as a result of low populations of spawning adults and poor recruitment. However, some authors have postulated that early life-stage habitats in channelized river reaches may be similar among *Scaphirhynchus* species (Phelps et al. 2010; Ridenour et al. 2011). Young of year *Scaphirhynchus* in the lower Missouri River were found in habitats associated with the main channel border and moderate velocities (0.5-0.7 meters per second (m/s), 1.6-2.3 feet per second (ft/s)) (Ridenour et al. 2011). Age- 0 *Scaphirhynchus* sturgeon in the Middle Mississippi River were more often found in channel border and island-side channel habitats and positively associated with low velocities (~0.1 m/s, 0.33 ft/s), moderate depths (2-5 m, 6.6-16.4 ft), and sand substrate (Phelps et al. 2010). No Pallid Sturgeon were positively identified among the specimens collected in either study, thus, while these data offer useful insights, empirically derived larvae and young-of-year Pallid Sturgeon data are lacking.

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; Gerrity 2005; Snook et al. 2002; Swigle 2003; Peters and Parham 2008; Spindler 2008) and exhibit a selection for sand over mud, silt, or vegetation (Elliott et al. 2004). Substrate association appears to be seasonal (Koch et al. 2006a; Koch et al. 2012). During winter and spring, sand, sand and 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) which may serve as some form of holding, resting, or feeding area.

Depths and Velocity

Pallid Sturgeon are primarily benthic fishes, that is they spend the majority of their time at or near the river bottom. Across their range, Pallid Sturgeon have been documented in waters of varying depths and velocities. Depths at collection sites range from 0.58 m to > 20 m (1.9 to > 65 ft), though there may be selection for areas >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 their small eye structure, four 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). Like most fish species, water temperatures influence growth and maturity. Female hatchery-reared Pallid Sturgeon maintained in an artificially controlled hatchery environment (i.e., near constant

16 to 20° C, 61 to 68 ° F temperatures) can attain sexual maturity at age 6, whereas female Pallid Sturgeon subject to colder winter water temperatures reached maturity around age 9 (Webb in litt., 2011). Hatchery-reared Pallid Sturgeon in the lower Missouri River reached sexual material at ages 9 and 7 for males and females, respectively (Steffensen 2012). However, as of 2012, no 1997 year-class hatchery-reared Pallid Sturgeon, released in the upper Missouri River between Fort Peck Dam and Lake Sakakawea, have been found to be sexually mature. Thus, age at first reproduction can vary between hatchery-reared and wild fish and is dependent on local conditions.

Females do not spawn each year (Kallemeyn 1983). Observations of wild Pallid Sturgeon collected as part of the Pallid Sturgeon Conservation Augmentation Program (PSCAP) 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; a behavior that can be associated with spawning migrations (U.S. Geological Survey 2007; DeLonay et al. 2009). Females likely spawn at or near the apex of these movements (Bramblett and White 2001; DeLonay et al. 2009). Spawning appears to occur adjacent to or over coarse substrate (boulder, cobble, gravel) or bedrock, in deeper water, with relatively fast, converging flows, and is driven by several environmental stimuli including day length, water temperature, and flow (U.S. Geological Survey 2007; DeLonay et al. 2009).

Incubation rates are governed by and dependant 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 likely dispersing several hundred km downstream from spawn and hatch locations (Kynard et al. 2002, 2007; Braaten et al. 2008, 2010, 2012a; Phelps et al. 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 wild 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 2013).

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 of fish studied in some reaches suggests that harder substrates like gravel and rock material may have become important feeding areas (Hoover et al. 2007), though it remains unknown if this was historically the case or a contemporary response to stabilization and channel maintenance activities increasing the abundance of localized rock material.

Population Genetic 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 likely represent 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, altered, 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 Endangered Species 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 Endangered Species 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). Revetments of woven willow and rock were used to stabilize banks, and dikes were built to narrow the channel and close off chutes. However, commercial navigation declined with the expansion of railroad networks. 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 (Funk and Robinson 1974). In 1912, Congress approved a navigation channel 1.8 m (6 ft) in depth from Kansas City, Missouri downstream to the confluence with the Mississippi River 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 downstream to the confluence. A self-scouring channel was largely completed by 1967 (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 and stabilization of the lower Missouri River for navigation. These anthropogenic modifications greatly reduced the river's ability to satisfy the life history requirements of Pallid Sturgeon by: 1) blocking movements to spawning and feeding areas; 2) affecting historical genetic exchange among reaches, (i.e., reducing or eliminating emigration and immigration); 3) decreasing turbidity levels by trapping sediment in reservoirs; 4) reducing distances available for larvae to drift; 5) altering water temperatures; 6) altering conditions and flows in spawning areas; 7) altering flows and temperatures associated with spawning movements; and 8) possibly reducing food sources by lowering productivity (Hesse et al. 1989; Keenlyne 1989; USFWS 2000a; Bowen et al. 2003).

Flows in the Missouri and Yellowstone rivers between Fort Peck Dam and Lake Sakakawea influence Pallid Sturgeon spawning movements and migrations within this reach. In general, Pallid Sturgeon reside in the Missouri River downstream from the confluence of the Missouri and Yellowstone rivers during fall and winter months (Fuller and Braaten 2012). As discharge increases in the spring, adult Pallid Sturgeon respond by migrating upstream. Typically, radio-tagged adult Pallid Sturgeon migrate into the unregulated Yellowstone River (Fuller and Braaten 2012) to spawn. Spawning adults are believed to avoid the colder, less turbid flows in the Missouri River above the Yellowstone confluence. However, during the spring of 2011, a disproportionate number of adult Pallid Sturgeon migrated up the Missouri River and remained upstream of Wolf Point, Montana (Figure 4) during the spawning period (Fuller and Haddix 2012). This change in migration behavior coincided with exceptionally higher than normal releases at Fort Peck Dam, as well historically high discharge from the Milk River. Following this spawning migration, a genetically confirmed wild Pallid Sturgeon larva was collected (Fuller and Haddix 2012). This is the first documented confirmation of spawning success in the Missouri River downstream from Fort Peck Dam; confirming that suitable spawning areas exist in this reach of the Missouri River and that Pallid Sturgeon can and will utilize this reach for spawning if conditions are suitable.

Water levels in the reservoirs impounded by Fort Peck Dam (Fort Peck Reservoir) and Garrison Dam (Lake Sakakawea) (Figure 4) may be impediments to larval Pallid Sturgeon survival by limiting the amount of riverine habitat available for Pallid Sturgeon to complete the transition from free embryos to exogenously feeding larvae. Pallid Sturgeon free embryos and larvae can passively drift as much as 245 to 530 km (152 to 329 mi) depending on water column velocity and temperature (Kynard et al. 2002; Braaten et al. 2008). Studies to assess larval Pallid Sturgeon drift dynamics (Braaten et al. 2008, 2010) released hatchery-reared Pallid Sturgeon free embryos and larvae in 2004 and 2007. Subsequent sampling has collected juvenile Pallid Sturgeon derived from these releases (Braaten et al. 2012b). Survivorship of released embryos and larvae to age-1 is related to age at release (days post-hatch) and correlated with release location; survivorship of the younger free embryos (i.e., 5 days post hatch) to age-1 was only observed from the most upstream release site (Braaten et al. 2012b). These data indicate that free embryos, as young as five days post-hatch, are able to survive to age-1 in the Missouri River between Fort Peck Dam and Lake Sakakawea, provided they have adequate dispersal distance to complete the developmental transition to feeding larvae. These observations support the hypothesis by Kynard et al. (2007) which implicates total drift distance as a limitation on natural recruitment in this reach of the Missouri River. Thus, within a given reach of river the distance required to complete the early life history requirements is dependent on reach length, river discharge, velocity, habitat complexity, and temperature.

In addition to limiting drift distance and duration, affecting spawning cues for adults, and inundating habitats, an altered hydrograph also affects downstream temperature profiles and reduces sediment transport. Cold water releases from dams 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 other 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. In laboratory studies, increased predation on White Sturgeon yolk-sac larvae was observed at low turbidity levels, suggesting 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 the headwaters of Lake Sakakawea above 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, some Pallid Sturgeon persist in the more riverine reaches within a few of these reservoirs, though successful spawning and recruitment is unlikely. Because of the presence of Pallid Sturgeon in some inter-reservoir reaches, those occupied reaches have been included in 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 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 highly impacted be 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 77% and 37% reductions, respectively, in total and mean area of side channels, as well as decreases 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, 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.

Marias River

Historically, the Marias River (Figure 4) influenced the Missouri River downstream from their merger. 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 Pallid Sturgeon also may have historically 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 wild Pallid Sturgeon are absent, hatchery-reared Pallid Sturgeon recently have been captured in the lower 1 Rkm (0.6 Rmi) (Gardner 2010).

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 effectively block migrations within this system. The lowermost is Vandalia Diversion Dam (Figure 4) located near Rkm 188 (Rmi 117). In 2004, a radio-tagged 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). Additionally, a radio-tagged adult was reported entering the Milk River in 2010 (Fuller and Haddix 2012), and 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; Fuller and Haddix 2012)

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 approximately 115 Rkm (71 Rmi) from the confluence with the Missouri River and effectively limits 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 seasonally, moving upstream from the Missouri River in early spring as water temperatures rise and discharge increases (Bramblett 1996; Fuller and Braaten 2012). Aggregations of adult Pallid Sturgeon in the lower Yellowstone River during late June through mid-July have been attributed to spawning activity (Bramblett 1996; Bramblett and White 2001; Fuller and Braaten 2012). Recent evidence confirms spawning occurs in the lower Yellowstone River. Fuller et al. (2008) documented a gravid female Pallid Sturgeon released her eggs where a large congregation of males were present. However, no Pallid Sturgeon larvae were documented in sampling efforts. Subsequently, in 2012, reproductive success was confirmed with the collection of a wild Pallid Sturgeon larvae (Braaten in litt., 2013). While it is suspected that spawning occurs in the lower Yellowstone River in most years (Fuller and Braaten 2012), recruitment remains undetected.

Upstream movements of both adult and juvenile Pallid Sturgeon are affected by Intake Dam. This barrier appears to be prohibiting adult fish from accessing upstream habitats which may be suitable for spawning (Bramblett and White 2001; Jaeger et al. 2005). However, to date, two hatchery-reared juvenile Pallid Sturgeon, released below Intake Dam, have been documented upstream of the dam (Backes in litt., 2013). While the specific mechanisms of migration over or around the dam are unknown, these collections suggest that Pallid Sturgeon may utilize habitats upstream of Intake Dam if they are accessible. Additionally, about half of juvenile hatchery-reared study fish released upstream of Intake Dam did not emigrate during the study period, suggesting that habitats upstream of Intake Dam may be capable of supporting Pallid Sturgeon (Jaeger et al. 2005). The prevailing hypothesis suggests that naturally-produced Pallid Sturgeon 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 in the upper Missouri River.

Pallid Sturgeon also have been entrained in the irrigation canal associated with Intake Dam (Jaeger et al. 2004). In 2012, a new irrigation water-control structure was completed that incorporates fish screens intended to eliminate entrainment losses. However, to date, upstream fish passage concerns at Intake Dam remain unresolved. Providing fish passage at Intake Dam can facilitate Pallid Sturgeon recovery by improving access to historically occupied habitats and providing the potential for increased larval drift distances.

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.

Niobrara River

Wild Pallid Sturgeon were documented in the lower Niobrara River (Figure 2) 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 ft) 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 declared a portion of the lower Niobrara River as fully appropriated (Nebraska 2007), but the Nebraska Supreme Court reversed the fully appropriated designation in 2011 (Nebraska in litt., 2011). 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 originally released in the Missouri River were documented in the Niobrara River downstream of Spencer Dam (located at approximately Rkm 63 (Rmi 39) (Figure 3)); two were approximately 1.6-1.9 Rkm (1.0-1.2 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). Additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

James River

The James River (Figure 4) is a north to south flowing prairie river that joins the Missouri River near Yankton, South Dakota. While historical data documenting occupation by Pallid Sturgeon are absent, a telemetry tagged adult pallid sturgeon moved 5.3 Rkm (3.3 Rmi) up the James River during its upstream spawning migration in 2011. It was subsequently recaptured downstream after spawning, though it is uncertain whether it spawned in the James River or in the Missouri River downstream of the confluence (DeLonay in litt., 2013). Additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

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, there is one contemporary report of an angler caught Pallid Sturgeon approximately 112 Rkm (70 Rmi) upstream of the confluence with the Missouri River (Stukel in litt., 2009) as well as documentation of one tagged Pallid Sturgeon that moved upstream 21.1 Rkm (13.1 Rmi) into this river from the Missouri River (DeLonay et al. 2009). Additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

Platte River

The Platte River (Figure 4) is a Missouri River tributary downstream of Gavins Point Dam. With increased sampling efforts, a corresponding increase in the numbers of both hatchery-reared and presumed-wild Pallid Sturgeon have been observed in the lower Platte River (i.e., the Loup River Power Canal outlet near Columbus, Nebraska downstream to the confluence with the Missouri River) since the species was listed. Pallid Sturgeon have been well documented within the lower-most reaches of this river (i.e., up to the Elkhorn River confluence) (Snook et al. 2002; Swingle 2003; National Research Council 2005; Peters and Parham 2008). More recently there have been increased observations of Pallid Sturgeon upstream of the confluence of the Platte and Elkhorn rivers; effectively extending the contemporary range up to near Columbus, Nebraska (Hamel in litt, 2010; Hamel and Pegg 2013). Additionally, Pallid Sturgeon have been documented in the Platte River during the spring, summer and fall periods (Hamel in litt., 2009; Hamel and Pegg 2013). Finally, limited data indicate that the lower Platte River is likely used for spawning (Swigle 2003; Chojnacki in litt., 2012). These data indicate the lower Platte River provides suitable habitat, supports multiple life stages of the species, and should be viewed as important for species recovery.

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 as well as 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 occupy and utilize this reach (Swigle 2003; National Research Council 2005: Peters and Parham 2008; Hamel and Pegg 2013). However, the availability and quality of habitat within the lower Platte River can be affected by water withdrawal in conjunction with periods of drought (National Research Council 2005). Sampling within the Missouri River near the confluence of the Platte River also 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, 2008). This suggests that the Platte River not only provides suitable habitat, but it also provides some positive benefits to Pallid Sturgeon habitat in the Missouri River.

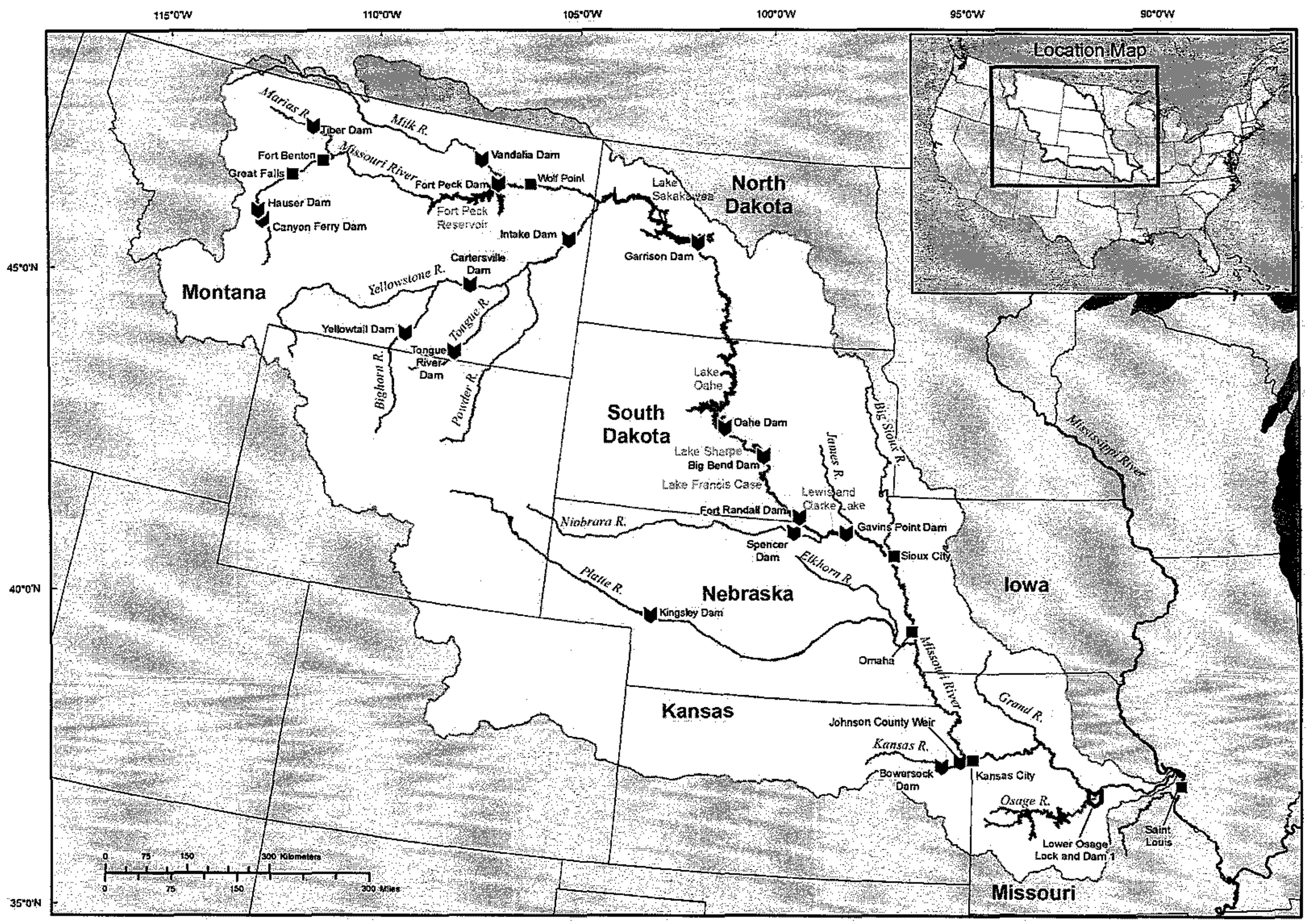

Figure 4 Map of prominent structures within the Missouri River Basin.

Elkhorn River

The Elkorn River is a north-west to south-east flowing tributary to the lower Platte River (Figure 4). When Pallid Sturgeon were listed, this river served merely as a reference point demarking its confluence with the Platte River as the upstream extent of Pallid Sturgeon in the Platte River. However, this river possesses many characteristics of streams currently used by Pallid Sturgeon and there are documented occurrences of Pallid Sturgeon in the Elkhorn River. Nebraska Game and Parks Commission records report angler catches of two Pallid Sturgeon; one each in 1999 and 2002 (National Research Council 2005). The 2002 record is reported to have occurred three miles upstream of Snyder, Nebraska, effectively extending the contemporary range of Pallid Sturgeon in this river (Figure 3). Additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

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). In 1952 six juvenile specimens (294-415 mm, 11.6-16.3 in) were collected below this dam during a period of record flooding (Bailey and Cross 1954). 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 support 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) (Chillicothe News in litt., 2009; 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 18th century as the French began to settle along the Mississippi River (Cowdrey 1977). These early 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 and funded 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 the United States 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). Following the flood of 1927, the Flood Control Act of 1928 included provisions for strengthening and raising existing levees and included floodways and spillways (Cowdrey 1977); examples of the latter being the Birds Point-New Madrid floodway, the Old River Control Complex, the Morganza floodway, and the Bonnet Carré spillway (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 and Ohio rivers. The earliest lock and dam structures were constructed in 1867 near Keokuk, 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, tributary alterations, channel cut-offs, 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 (5 Rmi) 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. A single historical Pallid Sturgeon observation in the upper Mississippi River near Keokuk, Iowa (Coker 1929) was considered as "dubious" and likely to represent "stragglers" (Bailey and Cross 1954). Recent sampling, however, has documented the movement of several Pallid Sturgeon through the lowermost locks and dams from the middle Mississippi River into the pools of the upper Mississippi River (Herzog in litt., 2009; Herzog

2010). 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 of the contemporary river is approximately 1,541 Rkm (958 Rmi) in length.

Between 1929 and 1942, bendway cutoffs shortened the LMR by 245 Rkm (152 Rmi) over a 809 km (503 mi) 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 began 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). Despite extensive alteration, the lower Mississippi River retains significant amounts of in-channel complexity and floodplain connectivity thought to be important to Pallid Sturgeon.

MISSISSIPPI RIVER TRIBUTARIES

As previously stated, data post-listing indicate that main-stem tributaries and tributary confluences may be used more frequently 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 may be important to the Pallid Sturgeon during certain times of the year or perhaps during certain life stages.

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). While movement into the Kaskaskia River by Pallid Sturgeon has not been documented, movement into this river may be impeded by 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.

Ohio River

The Ohio River (Figure 5) is the largest tributary to the Mississippi River system within the range of Pallid Sturgeon. While Pallid Sturgeon have been collected from the Mississippi River near the Ohio River confluence, there are no recent reports of Pallid Sturgeon and no confirmed records of presence in this system. It is possible Pallid Sturgeon could occur in this river up to the Olmstead Lock and Dam (Figure 5), but additional data are needed to determine if this tributary serves any role for the recovery of Pallid Sturgeon.

Obion River

A single Pallid Sturgeon has been documented in the Obion River (Figure 5). This fish was originally tagged in the Mississippi River near Osceola, Arkansas and was subsequently recaptured in the Obion River near Bogota, Tennessee (Killgore et al. 2007b). 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.

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-reared Pallid Sturgeon were documented in the lower Saint Francis River (Graham in litt., 1994) downstream from the W. G. Huxtable Pumping Plant (Figure 5). Subsequently, a tagged female Pallid Sturgeon was found to have entered the Saint Francis River in 2013. This fish remained in the river April 14-17. (Lewis in litt., 2013). 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.

Arkansas River

The Arkansas River (Figure 5) confluences with the Mississippi River near Rkm 933 (Rmi 580). Pallid Sturgeon currently can access the lower 64 Rkm (40 Rmi) from the confluence with the Mississippi River upstream to the Wilbur D. Mills Dam. To date, three Pallid Sturgeon have been documented entering this lower reach during 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.

Red River

The Red River (Figure 5) was a tributary to the Mississippi River during the 19th and early 20th centuries. However, anthropogenic alterations in the 1960s connected the Red River with the Atchafalaya River when the Old River Control Complex was completed. While historical Pallid Sturgeon presence data are lacking, contemporary observations have documented a limited number of Pallid Sturgeon in the lower Red River; specifically the reaches downstream from Lock and Dam 3 (Slack et al. 2012). 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.

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 to 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 U.S. Army Corps of Engineers constructed the Old River Control Complex 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. With 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.

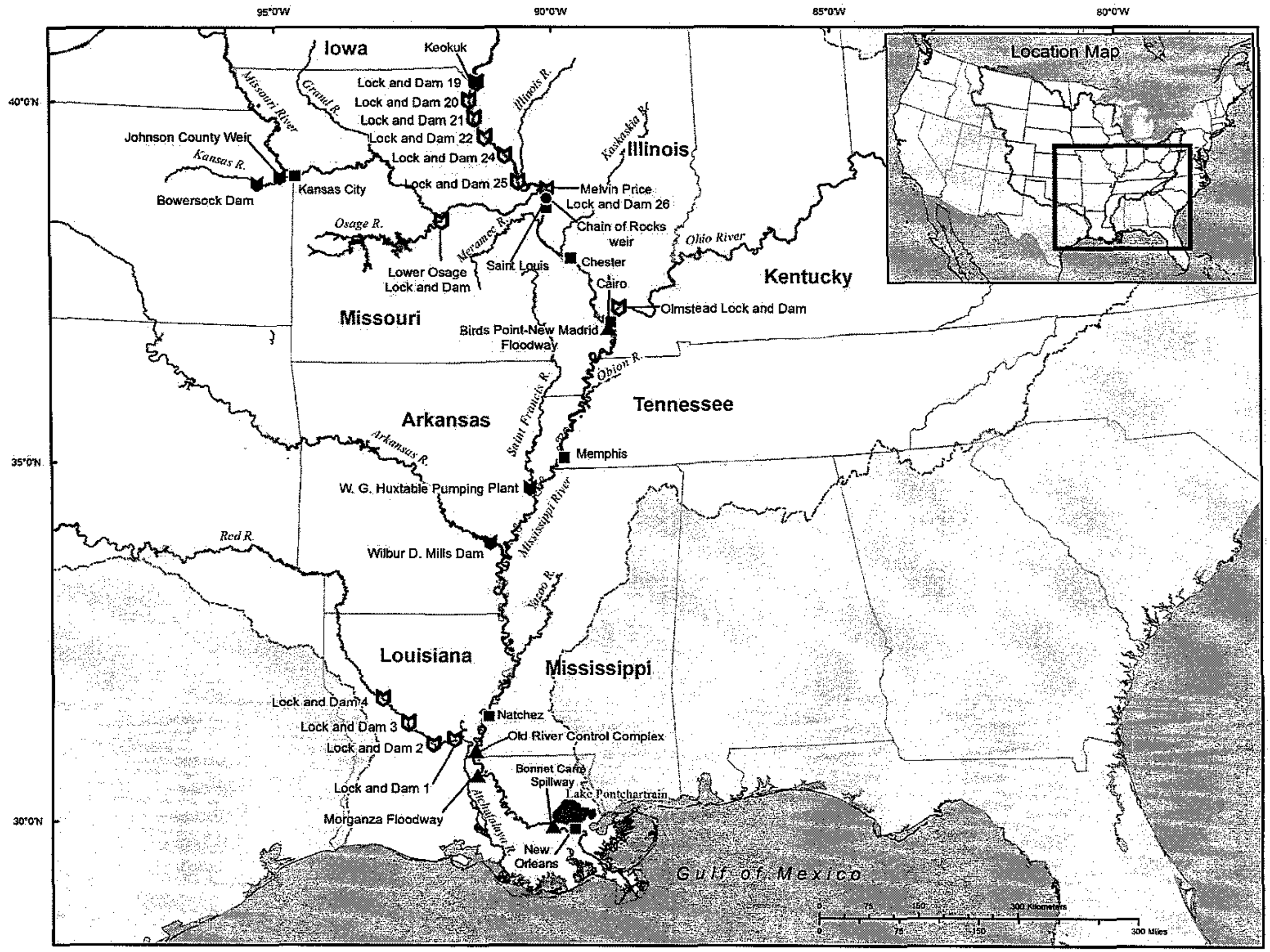

Figure 5 Map of prominent structures in the Mississippi River Basin.

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 released in the Mississippi River below Natchez, Mississippi (2 specimens), and above Memphis, Tennessee (1 specimen) have been captured in the Atchafalaya River; confirming 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) produced 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. River channelization, and bank stabilization within the Missouri River basin 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, Platte, and Kansas rivers have experienced similar affects due to dams and water resource development, as well as bank stabilization efforts within their respective watersheds. Other issues that have influenced habitat formation and maintenance are associated with maintaining navigation channels on portions of the Missouri River and 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, the effects from 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

Much of the available information 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 /Pollution: 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 1994; 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 normal 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. 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 Tetrachlorodibenzo-p-dioxin 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, dichloro-diphenyl-trichloroethane, and dieldrin) at concentrations of concern (Ruelle and Keenlyne 1993; Ruelle and Henry 1994). 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).

Because more information is needed to evaluate the exposure and effects of environmental contaminants to Pallid Sturgeon, a basin-wide contaminants review for Pallid Sturgeon was initiated in 2008. To date, this investigation has identified pesticides, metals, organochlorines, hormonally active agents, and nutrients as contaminants of concern throughout the species' range. 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: Little is known about Pallid Sturgeon tolerances of low dissolved oxygen concentrations and limits have not been quantified for all life stages. However, data from other sturgeon species are insightful. In general, sturgeon are not as tolerant of hypoxic conditions (very low dissolved oxygen levels) 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 organisms within 10-12 days post hatch (Kallemeyn 1983; Kynard et al. 2007). This benthic life history strategy can result in sturgeon encountering hypoxic. 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. Measurements on the lower Missouri River from 2006-2009 showed that large rises in the river during spring and summer may result in dissolved oxygen levels falling to < 2 mg/l and remaining below 5 mg/l for several days (Blevins 2011). Dissolved oxygen levels of 3 mg/l and water temperatures of 22-26 °C (71.6-78.8 °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.

Temperature: The Pallid Sturgeon is ectothermic, that is its body temperature is dependent on water temperatures. As a result, water temperatures influence nearly every aspect of the Pallid Sturgeon's life history requirements. As described previously, water temperatures affect rates of sexual maturity, spawning migrations, gonad development, rates of embryonic development, larval drift distances, and habitat quality (Keenlyne 1995; Kynard et al. 2002; U.S. Geological Survey 2007; Braaten et al. 2008; DeLonay et al. 2009; Webb in litt., 2011).

Anthropogenic changes within the range of Pallid Sturgeon that have substantially affected historical water temperatures are bottom release dams. The water in deep reservoirs thermally stratifies resulting in a colder and denser water layer at depth. When this cold water is released, it substantially cools the riverine environments downstream. As an example, average and maximum water temperatures immediately downstream of Fort Peck Dam can be reduced by as much as 6° C (10.8° F) and 10.4° C (18°F), respectively (Fuller and Braaten 2012). While the magnitude of these effects decrease with increased distance from the dam, these cooling effects still influence 290 Rkm (180 Rmi) of the Missouri River downstream. Even at this distance, the average and maximum temperatures are still 1° C (1.8° F) cooler than Missouri River reaches above Fort Peck Reservoir (Fuller and Braaten 2012).

Thus, the altered temperature profiles of riverine habitats downstream from large bottom-release dams influence nearly every aspect of the life-history requirements and habitats of Pallid Sturgeon. While the magnitude of effects from altered temperature profiles vary by dam, they may be the most problematic in the inter-reservoir reservoir reaches of the impounded Missouri River.

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 impact Pallid Sturgeon during many life phases and localized and/or regionally poor or degraded water quality should be viewed as a threat to the species. However, additional data are needed to quantify and qualify the magnitude of these threats in some river reaches.

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, towboat propellers, 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.

Towboat propellers: Empirically derived propeller entrainment data for Pallid Sturgeon are lacking. However, available propeller entrainment data for Shovelnose Sturgeon collected in the Mississippi River upstream of Lock and Dam 26 (Figure 5), indicates it occurs and can be lethal (Killgore et al. 2011; Miranda and Killgore 2013) with mortality estimates being as high as 0.53 Shovelnose Sturgeon per 1 Rkm (0.6 Rmi) of towboat travel (Gutreuter et al. 2003). Because barge operation occurs in waters occupied by Pallid Sturgeon and propeller entrainment induced mortality has been documented for Shovelnose Sturgeon, it is reasonable to conclude that towboat propellers can entrain and harm Pallid Sturgeon. However, comparable studies have not been conducted in waters commonly occupied by Pallid Sturgeon, thus, the magnitude of this threat is difficult to assess and additional research is needed.

Dredge Operations: The U.S. Army Corps of Engineers 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 collected in the middle Mississippi River near the Chain of Rocks weir (Figure 5) indicate that Shovelnose Sturgeon can be entrained and this entrainment is relatively lethal (Ecological Specialists, Inc. 2010). However, the risk of dredge entrainment is likely to vary by dredge design (i.e., mechanical or hydraulic) and swimming capabilities (Hoover et al. 2011). 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 Lower Yellowstone Irrigation Project's Intake Diversion Dam on the Yellowstone River (Figure 4) 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 Carré spillway (Reed in litt., 2008; USFWS 2009a).

Subsequently, in 2011, the Bonnet Carré spillway was opened again to alleviate flooding. Following closure, 20 Pallid Sturgeon were collected behind the spillway (U.S. Army Corps of Engineers 2012) 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. One interesting observation in 2011 was the collection of a tagged Pallid Sturgeon from behind the Bonnet Carré spillway that was previously collected behind the spillway and released into the Mississippi River in 2008 (U.S. Army Corps of Engineers 2012). Additionally, the Birds Point–New Madrid and the Morganza Floodways (Figure 5) were also opened in 2011. While subsequent sampling did not document Pallid Sturgeon within either floodway, 26 Shovelnose Sturgeon were reported as entrained in the Birds Point–New Madrid Floodway and no sturgeon were reported in the Morganza Floodway (U.S. Army Corps of Engineers 2012). 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 towboat propellers, 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. "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 (Intergovernmental Panel on Climate Change 2007). The term "climate change" 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 (Intergovernmental Panel on Climate Change 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) (Intergovernmental Panel on Climate Change 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 identify that the trend in global climate patterns is one of warming; average temperatures in the United

States are at least 1.1°C (2°F) higher than they were 50 years ago (Intergovernmental Panel on Climate Change 2007; U.S. Global Change Research Program 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 (Intergovernmental Panel on Climate Change 2007). These changes to the water cycle are anticipated to affect water use (U.S. Global Change Research Program 2009), which may alter existing reservoir operations. Broadly, these potential effects to Pallid Sturgeon could be altered spawning behavior (i.e., movement and timing), reduced survival of early life stages and young-of-year, and reduced late-season habitat suitability due to reduced flows and presumably warmer temperatures. Another predicted outcome is increased or prolonged periods of drought (Intergovernmental Panel on Climate Change 2007; U.S. Global Change Research Program 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 Intergovernmental Panel on Climate Change (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 (U.S. Global Change Research Program 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 overall water quality.

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 Endangered Species 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 disease outbreaks, but they may also simply exist in a carrier state. Fish pathogens 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 include Viral Hemorrhagic Septicemia Virus and the Missouri River sturgeon iridovirus.

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, Viral Hemorrhagic Septicemia Virus 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 Viral Hemorrhagic Septicemia Virus 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 Missouri River sturgeon iridovirus 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 confirmed 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 exposes naturally-spawned Pallid Sturgeon to predation which 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. Though Braaten and Fuller (2002, 2003) examined 759 stomachs from 7 piscivore (fish eating) fishes in Montana, they found no evidence of predation on sturgeon. Other studies have, however, documented *Scaphirhynchus* sturgeon as food items. Hogberg and Pegg (2013) found sturgeon in the stomachs of Flathead Catfish (*Pylodictis olivaris*) studied in the lower Missouri River. 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 incidental harvest of Pallid Sturgeon during commercial Shovelnose Sturgeon harvest has been documented in several States where Pallid and Shovelnose sturgeon are sympatric. This resulted in a Federal rule treating Shovelnose Sturgeon as threatened under the Endangered Species 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, River and Harbors Act of 1899, Federal Power Act, National Environmental Policy Act, and the Fish and Wildlife Coordination Act .

The Clean Water Act (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 Clean Water Act 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 Clean Water Act as it relates to pollutant discharge and water quality standards.

In addition to regulating pollutant discharges, the Clean Water Act also allows the U.S. Environmental Protection Agency 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 Clean Water Act requires the U.S. Environmental Protection Agency to provide reasonable assurances that aquatic organisms are protected from impingement or entrainment. In 2004, the agency issued regulations (69 FR 41575-41624) to minimize entrainment and impingement mortality associated with cooling water intakes at power production facilities. However, these regulations were suspended in 2007 (72 FR 37107-37109). In 2011, the public comment period was reopened 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 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 Clean Water Act. 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 and other Federal agencies, including resource agencies, in licensing and relicensing power projects. The Federal Energy Regulatory Commission 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 (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 this act would include considerations of Pallid Sturgeon and their habitats in project planning. However, while this act provides for disclosure of environmental impacts, it does not require minimization. Thus, the degree to which this act offers protection to the Pallid Sturgeon is variable and based upon voluntary adoption of conservation measures. Compliance with this act 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 (16 U.S.C. §§661-667e as amended) requires that Federal agencies funding, sponsoring, or permitting activities give consideration and coordination of wildlife conservation with respect to water resources development programs. Under the Fish and Wildlife Coordination Act, 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 Fish and Wildlife Coordination Act, Pallid Sturgeon and their habitats are given due consideration in water development activities. However, while the Fish and Wildlife Coordination Act may result in implementation of conservation measures (i.e., screening of water diversion structures) on new water projects, this act 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 (Government Accountability Office 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.

- Hybridization was identified as a threat to the species when it was listed (55 FR36641-36647) and is discussed further under Factor E below. At the time, the prevailing hypothesis relates hybridization with habitat alterations 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 is 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

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 (Krentz in litt. 2010). Additional research is necessary to fully evaluate the extent and magnitude of these effects.

Gas and Oil Pipelines: The federal authority for pipeline safety is the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration. This agency reports that there were 2.3 million miles of pipelines in the United States carrying natural gas and hazardous liquids (primarily petroleum, refined petroleum products, and other chemicals). Many pipelines cross rivers within the range of Pallid Sturgeon; some of which are buried under the river bed.

While not directly within the historical range of Pallid Sturgeon, the 2011 rupture of the Silvertip Pipeline crossing under the Yellowstone River serves as a reminder that accidental releases of hazardous materials can occur. Depending on the timing, magnitude, and the material leaked, a ruptured pipeline could pose a threat to Pallid Sturgeon.

Summary of Impacts from Energy Development

Increased demand for energy resources has led to an increased interest in new technology for development and exploration. 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.

The conveyance of oil and gas through pipelines could result in localized negative effects should a rupture occur resulting in the substances being transported spilling into waters occupied by Pallid Sturgeon. The U.S. Department of Transportation's Office of Pipeline Safety is responsible for regulating the safety of design, construction, testing, operation, maintenance, and emergency response of domestic oil and natural gas pipeline facilities. Additionally, there are state offices responsible for managing, permitting, and inspecting pipelines.

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.

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 introgressive 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, a few have postulated that hybridization played a role in past 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 sturgeon species and it can lead to the creation of new species (Arnold 1992). However, regardless of whether similar events might have led to new sturgeon species in the past, the Endangered Species Act instructs us to address threats to the integrity of listed species. While the mode and rate of *Scaphirhynchus* hybridization is difficult to assess, understanding the evolutionary relationship between Shovelnose and Pallid sturgeon is important to better be able to assess potential threats that hybridization may impose on Pallid Sturgeon recovery.
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 relative threat to Pallid Sturgeon recovery will require statistically testing the hypothesis of hybridization against alternatives. Since hybridization is 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), extent, and frequency or rate of occurrence of hybridization. Once these processes are elucidated, simulation/modeling exercises can address the actual risks associated with *Scaphirhynchus* 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 Carp (*Cyprinus carpio*), Grass Carp (*Ctenopharyngodon idella*), Silver Carp (*Hypophthalmichthys molitrix*), Bighead Carp (*Hypophthalmichthys nobilis*) and Black Carp (*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; similarly the range of the zebra mussel continues to expand (Kolar et al. 2005).

According to the American Fisheries Society (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 in the Mississippi River 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 a reduced foraging effectiveness 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 to Pallid Sturgeon described previously.

MISSOURI RIVER

Within the Missouri River basin, where channelization and 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 utilizing the PSCAP 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 PSCAP, a basin-wide Pallid Sturgeon population monitoring program has been established to track changes 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 Bureau of Reclamation 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 (*Macrhybopsis gelida*) 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 or installing a large "curtain" around the intakes such that they draw down and release 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 U.S. Army Corps of Engineers the authority to assist the Bureau of Reclamation 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. Release of hatchery-reared Pallid Sturgeon produced as part of the PSCAP was initiated in 1994 and has occurred annually since 2002 in this reach. Available data indicate the PSCAP has lessened the likelihood of local extirpation, but long-term population viability currently remains uncertain (Steffensen 2012). 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 and US Fish and Wildlife Service 2012). Based on current and anticipated commitments, habitat restoration in this reach will continue, effectively increasing the quantity and quality of potential sturgeon habitats.

The Platte River is an important tributary to the Missouri River in this reach. The largest anthropogenic factor affecting habitat in the lower Platte River is upstream water withdrawals. The National Research Council (2005) identified that periods of drought could negatively affect habitats in the lower Platte River. During July 2012, a fish kill incident was reported in the lower Platter River following a period of prolonged drought. One dead hatchery-reared Pallid Sturgeon was confirmed (Nebraska in litt., 2012). 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.

UPPER MISSISSIPPI RIVER

While few Pallid Sturgeon have been documented in the Upper Mississippi River, the U.S. Army Corps of Engineers has continued to evaluate fish passage through the locks and dams. In addition, the fish community and habitat diversity is being address through U.S. Army Corps of Engineers elements of the Upper Mississippi River Restoration-Environmental Management Program. These elements include the Habitat Rehabilitation and Enhancement Projects and Long Term Resource Monitoring (U.S. Army Corp of Engineers in litt., 2013). Habitat enhancement projects include dike modifications, construction of chevron dikes, side channel enhancement, island construction, and reconnection of the river to the floodplain. Furthermore, since 1943 the Upper Mississippi River Conservation Committee (see http://www.umrcc.org/) has partnered with agencies and others to further cooperative conservation efforts for fish and habitat within the Upper Mississippi River.

MIDDLE MISSISSIPPI RIVER

The U.S. Army Corps of Engineers 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. The Middle Mississippi National Wildlife Refuge has resulted in improved floodplain connectivity along 96 km (60 mi) of the Mississippi River downstream from St. Louis, Missouri. 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 U.S. Army Corps of Engineers established the Lower Mississippi River Environmental Program 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 U.S. Army Corps of Engineers Mississippi Valley Division, initiated informal consultation with the USFWS under section 7(a)(1) of the Endangered Species Act to use Lower Mississippi River Environmental Program designs and additional measures to conserve and manage listed species associated with the lower Mississippi River navigation channel. Annual meetings with the U.S. Army Corps of Engineers, 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 (a Federal and State agency partnership) to identify and initiate secondary channel restoration opportunities within the leveed floodplain. Under its Mississippi River Conservation Initiative, this group has identified approximately 220 priority restoration opportunities in the Lower Mississippi River. Over the past decade, more than 64 km (40 mi) of secondary channel habitats have been rehabilitated helping to restore hundreds of acres of seasonally flooded habitats and over 200 dike notches have been constructed to maintain and/or 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 U.S. Army Corps of Engineers' Engineer Research and Development Center has been conducting distribution and abundance studies on Pallid Sturgeon for more than 10 years. This center has evaluated susceptibility of sturgeon to entrainment through dredging and diversion structures, identified engineering modifications to minimize entrainment potential, assessing the benefits of dike notching, sturgeon utilization of in-river engineered structures, seasonal and spatial distribution of young-of-year sturgeon, and young-of-year sturgeon diets. 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, middle and lower Mississippi, and Atchafalaya rivers, and in portions of major tributaries like the Yellowstone and Platte 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 6) identified in the recovery strategy described above are defined as:

> The Great Plains Management Unit (GPMU) (Figures 6 and 7) 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 6 and 8) 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 6 and 9) 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 6 and 10) 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.

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

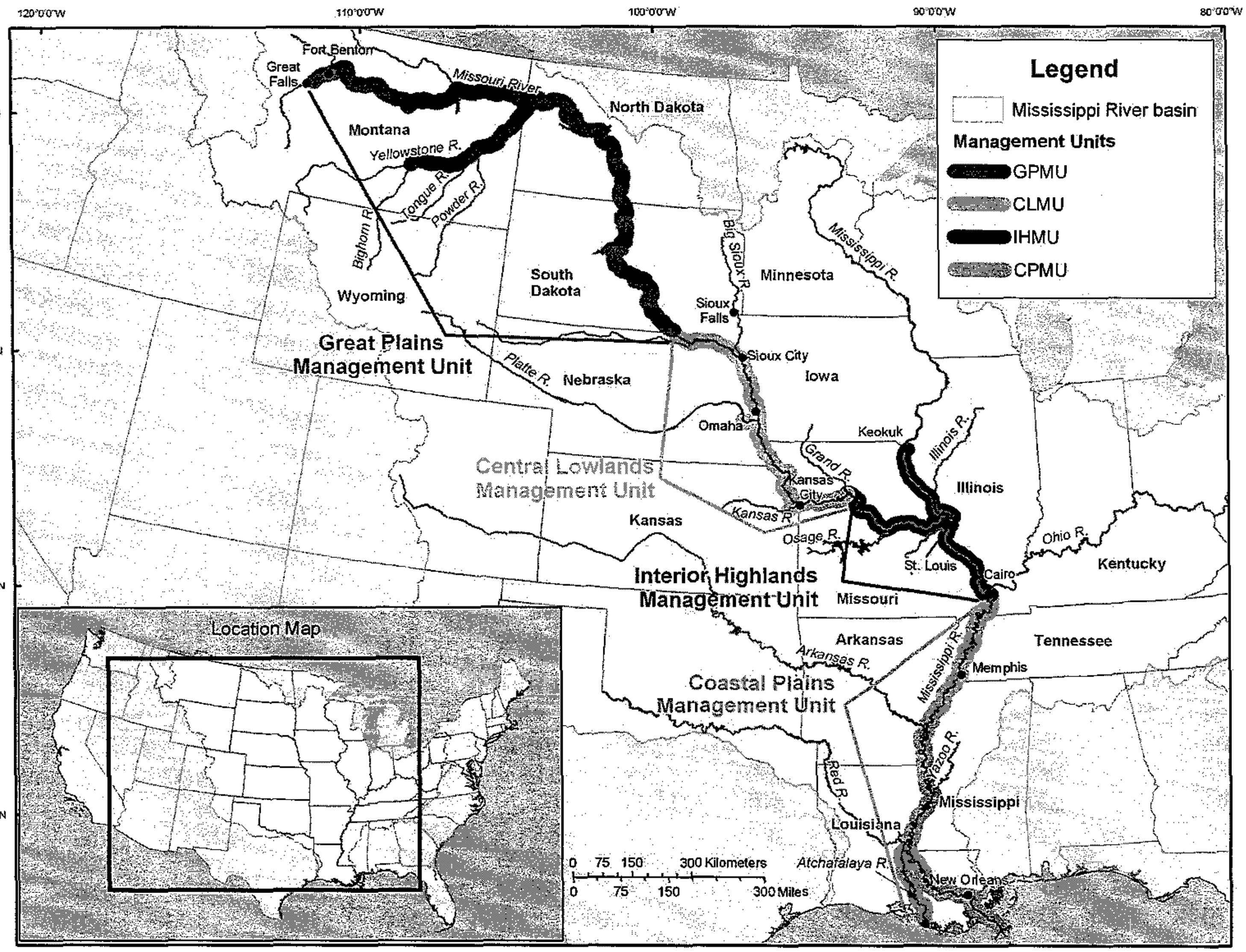

Figure 6 Map depicting Pallid Sturgeon management units.

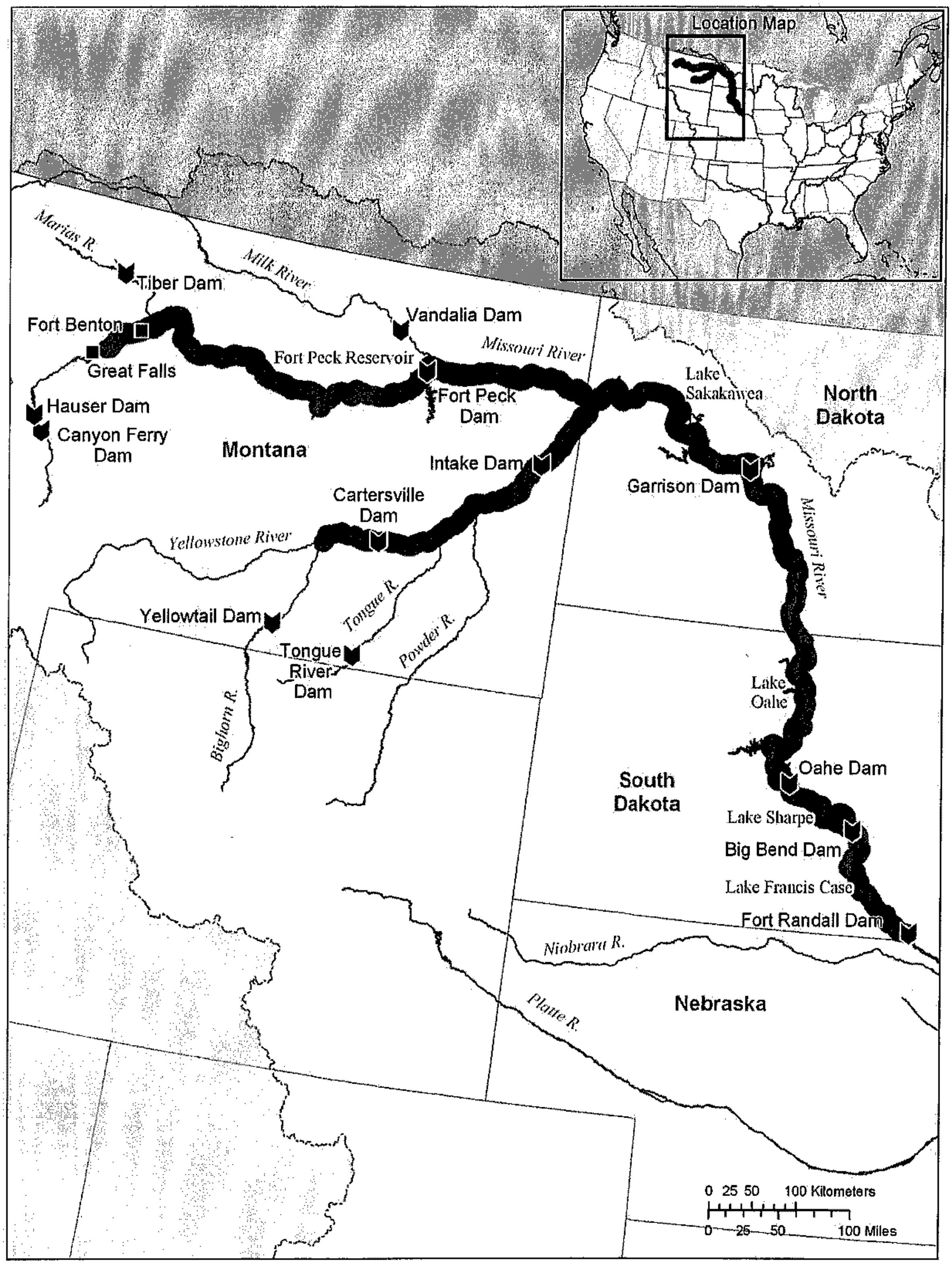

Figure 7 Map depicting the Great Plains Management Unit.

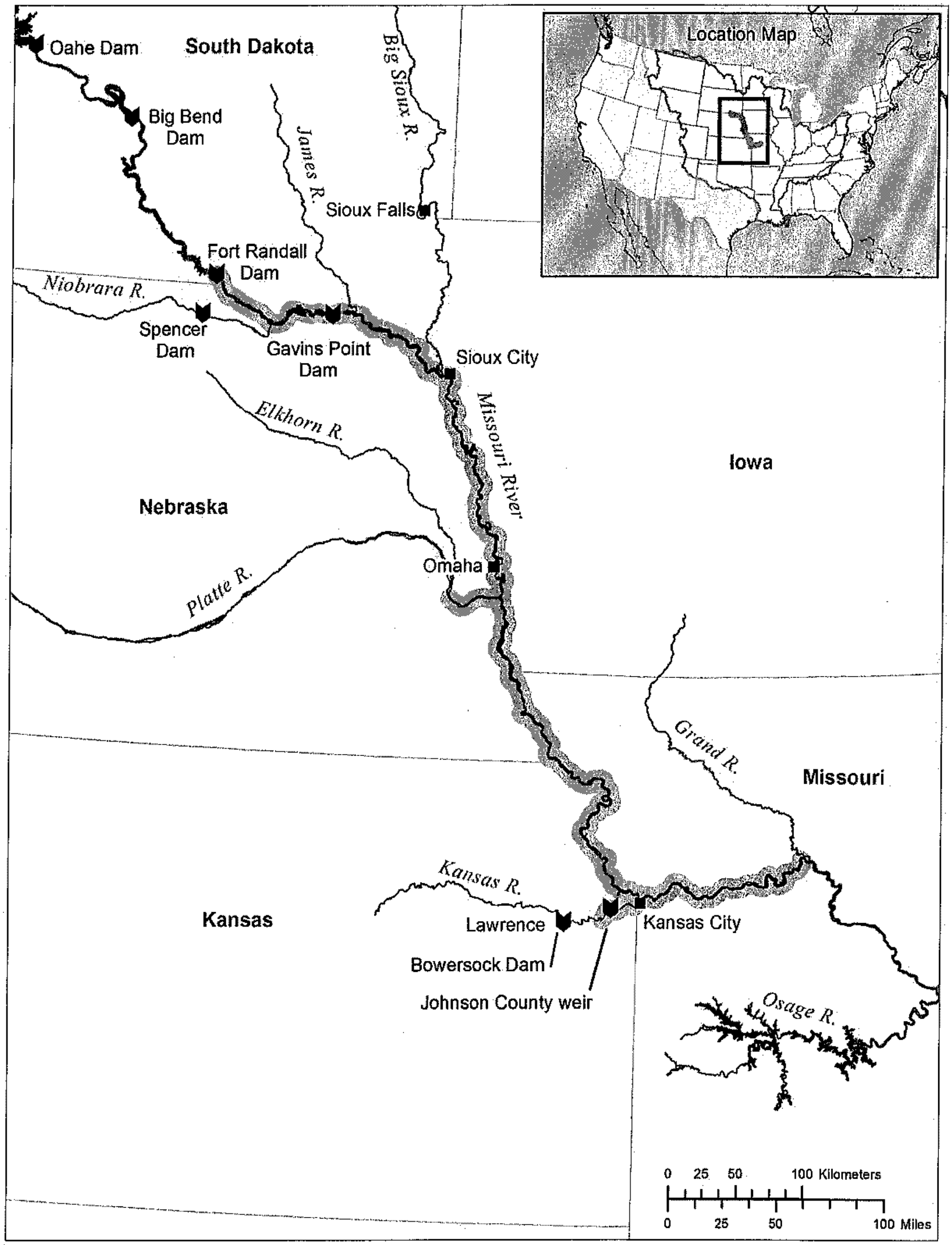

Figure 8 Map depicting the Central Lowlands Management Unit.

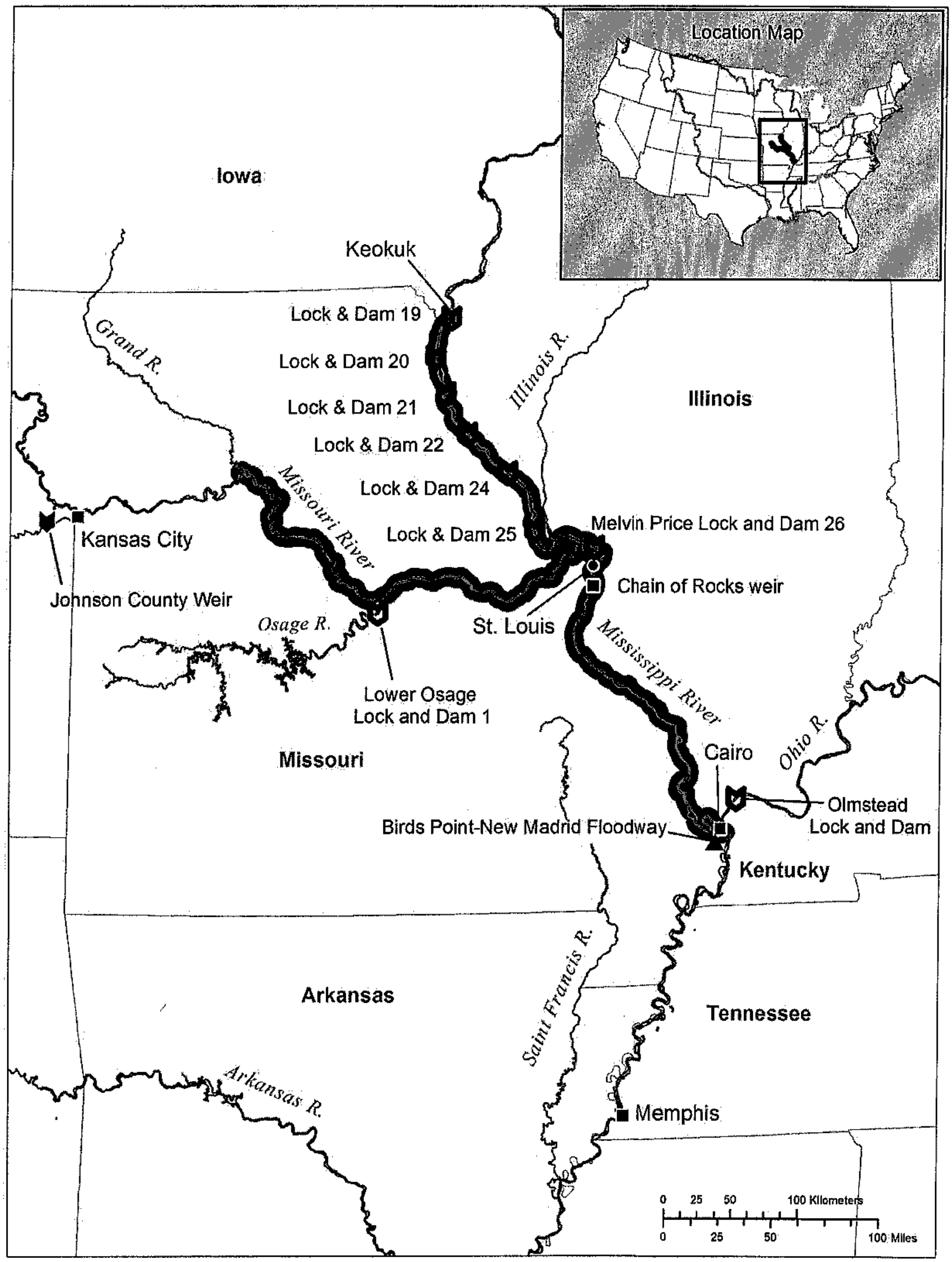

Figure 9 Map depicting the Interior Highlands Management Unit.

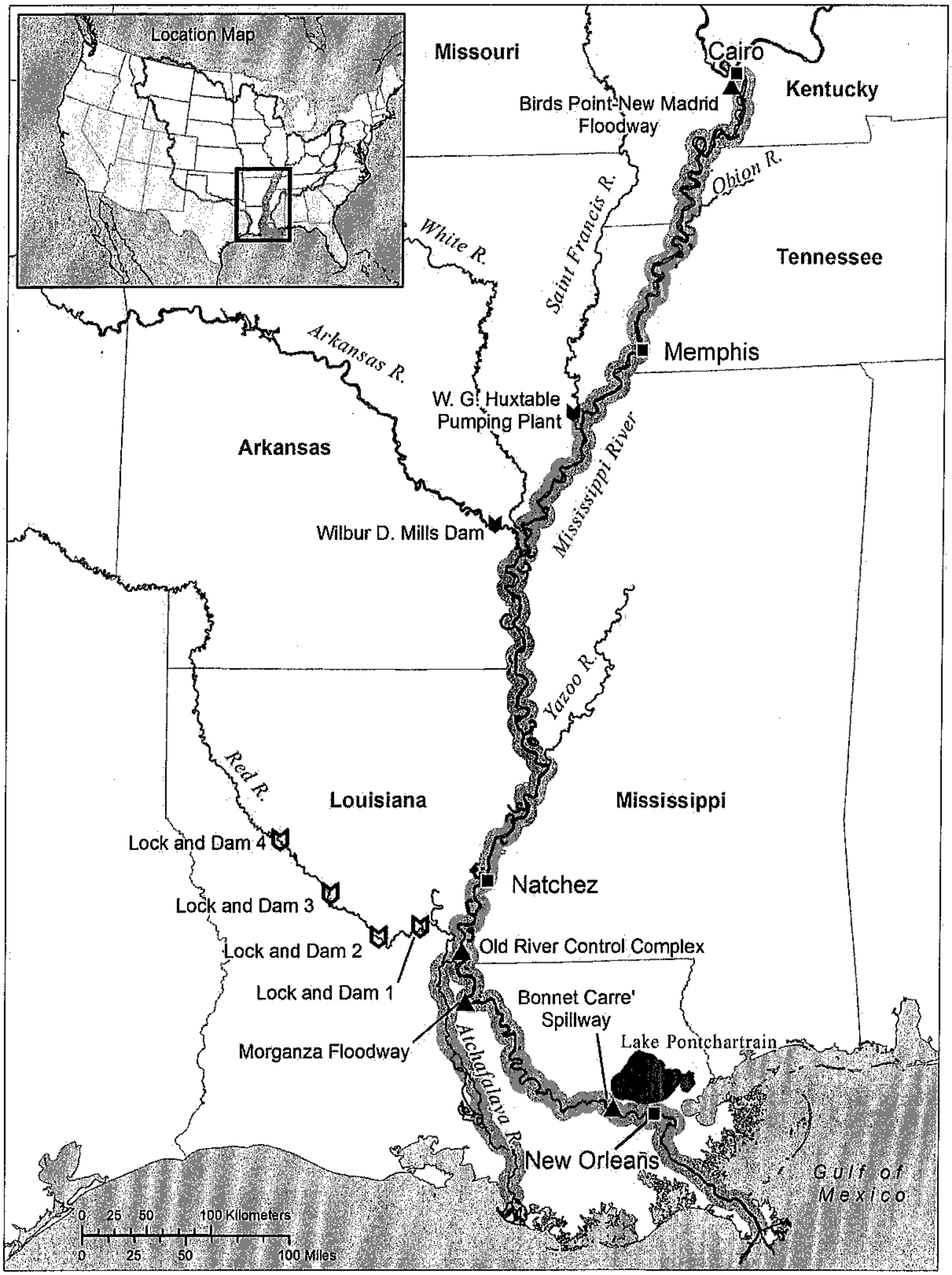

Figure 10 Map depicting the Coastal Plains Management Unit.

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 a spawning population that results in sufficient recruitment of naturally-produced Pallid Sturgeon into the adult population at levels necessary to maintain a genetically diverse wild adult population in the absence of artificial population augmentation. Metrics suggested to define a minimally sufficient population would include 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 juvenile Pallid Sturgeon (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 ($N_e \geq 500$), conserve localized adaptions, and preserve rare alleles.

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 OUTLINE/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 or exceed the latest national recommended water quality criteria (e.g., U.S. Environmental Protection Agency 2009);

(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 adequate mechanisms are in place 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 or when the underlying threat has been addressed such that regulatory mechanisms are no longer needed. For example, overutilization must be addressed for either downlisting or delisting to occur. Under the current protections afforded by the Endangered Species 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 within the other management units (USFWS 2007). Concerns over limited recruitment (i.e., potential for local extirpation) resulted in the establishment of the PSCAP. While artificial propagation and stocking measures are helping to maintain the species, successful natural spawning and recruitment is necessary for recovery. To evaluate when this has been achieved, reliable population trend estimates will be needed.

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 juvenile

Pallid Sturgeon (age 2+) can provide inferences into potential adult recruitment levels. Thus, documenting presence or absence of wild juvenile 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 juvenile Pallid Sturgeon 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 DPSs in the future. Section 3 of the Endangered Species 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 Endangered Species 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

Dams greatly reduced the river's ability to satisfy the life history requirements of Pallid Sturgeon by: 1) blocking movements to spawning and feeding areas; 2) affecting historical genetic exchange among reaches, (i.e., affecting emigration and immigration); 3) decreasing turbidity levels by trapping sediment in reservoirs; 4) reducing distances available for larvae to drift; 5) altering water temperatures; 6) altering conditions and flows in spawning areas; 7) altering flows and temperatures associated with spawning movements; and 8) possibly reducing food sources by lowering productivity (Hesse et al. 1989; Keenlyne 1989; USFWS 2000a; Bowen et al. 2003).

Modifying current dam operations to restore a more natural hydrograph can facilitate meeting the species' life history requirements to promote species recovery. Modifying dam releases (increasing or decreasing), at the appropriate time, may improve spawning cues over baseline conditions and lowered discharges in the summer may reduce larval drift rates in truncated reaches. Additionally, lower pool elevations in some key reservoirs, (i.e., 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 and temperature (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 fully understand the effects main-stem Missouri River and tributary 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, floodplain access, 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 and/or reduce larval development times (i.e., reduce drift rates and/or increase water temperatures) for larval Pallid Sturgeon.
   (a) If necessary, modify releases from Fort Peck Dam to increase retention times and/or reduce larval development times (i.e., reduce drift rates and/or increase water temperatures) for 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.

(6) Evaluate flow-release scenarios from Yellowstone River tributary dams (Yellowtail Dam and Tongue River Reservoir) to improve habitat conditions and drift rates for larval Pallid Sturgeon.
   (a) If necessary, modify flows from Yellowstone River tributary dams to improve habitat conditions and drift rates for larval Pallid Sturgeon in the Yellowstone River.

CLMU

(1) Evaluate spillway releases and/or flow-release scenarios from Missouri River dams (Fort Randall and Gavins Point dams) to improve habitat conditions in downstream reaches.
   (a) If necessary, implement spillway releases and/or alter flows 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: relocating the 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, modifying flows from the dam, or removing Gavins Point Dam).
   (a) If feasible and necessary, implement method of increasing sediment transport downstream from Gavins Point Dam.

(4) Modify flows from Gavins Point Dam to facilitate successful migration, spawning, and survival of pallid sturgeon upstream of the Platte River confluence.
   (a) If feasible and necessary, implement flow modifications re-create elements of the hydrograph necessary for the appropriate and successful migration and spawning of pallid sturgeon above the Platte River.

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 careful analysis is 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.
  - (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.
  - (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.
  - (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.
    (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.
    (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, Atchafalaya River.
    (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. As an example, the practice of modifying dikes has been implemented at various locations within the Missouri and Mississippi rivers as means to create habitat and restore riverine function. However, evaluation of these practices suggests that the intended benefits may not be fully manifesting themselves (Ridenour et al. 2009: Schloesser et al. 2012). Thus, it is essential to evaluate existing efforts to create 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 juvenile 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 effects 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. Over allocation of water resources can affect instream habitats by reducing the hydrograph or extreme flow depletions can render river reaches as uninhabitable for portions of the year. Understanding existing water allocations and projected withdrawal patterns is essential to evaluating the magnitude of effects associated with depletions and implementing flow protection strategies necessary to meet the life history needs of Pallid Sturgeon. Additionally, 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 Bureau of Reclamation 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.

CLMU, IHMU, CPMU

(1) Assess potential for entrainment losses associated with commercial navigation/towboat entrainment.
    (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 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 U.S. Army Corps of Engineers 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 regulates interstate transmission of electricity as well as licensing hydropower projects. As part of the licensing process, Federal Energy Regulatory Commission 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 INVASIVE SPECIES/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. The results of these investigations should be used to implement eradication or control efforts consistent with Pallid Sturgeon recovery.

GPMU, CLMU, IHMU, CPMU

(1) Where applicable, assess the effects of invasive or aquatic nuisance species to increase the understanding of these organisms and the magnitude of their status as a threat to Pallid Sturgeon.
    (a) If necessary, implement control measures to minimize adverse effects resulting from of invasive or aquatic nuisance species.

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) 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) Improve methods to better distinguish larvae and juvenile Pallid Sturgeon from larvae and juvenile 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 juveniles 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) Diet information;
    (a) Obtain appropriate diet information
    (b) Quantify diets and describe trophic linkages.
    (c) 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 primarily conducted through the Pallid Sturgeon Population Assessment Program and are focused on detecting changes in Pallid Sturgeon and other species' population trends in response to habitat restoration practices. Data from these efforts have been useful in evaluating success of some recovery tasks like stocking, survival, distribution, and population growth; however, geographic expansion of 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 the "Biological procedures and protocols for researchers and managers handling Pallid Sturgeon" range-wide.
(4) Develop a range-wide standardized database to integrate monitoring, propagation, stocking, and genetic data to meet reporting requirements that measure progress toward recovery.

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 standardization among genetic labs work with Pallid Sturgeon.
(3) Implement range-wide standardized analysis and reporting requirements for all genetic data.

(4) Integrate archival catalogs of genetic samples and genetic results with standardized monitoring and stocking databases.
(5) Continue to assess relationship and justification of management units.
(6) 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 a policy on DPSs 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) If conservation status assessment indicates a change is appropriate which will meaningfully advance conservation or significantly limit unnecessary regulation, identify and list appropriate DPS(s), 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) If conservation status assessment indicates a change is appropriate which will meaningfully advance conservation or significantly limit unnecessary regulation, 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). All 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 placement 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.

(2) Ensure that hatchery stocking and propagation records are incorporated into integrated a range-wide species recovery database.

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 management and monitoring strategy as progress is gained toward full recovery of this species.

(a) Develop and implement a post downlisting or delisting range-wide monitoring plan.

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 this recovery plan (2014-2047).

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. Accurate cost estimates were not practicable to derive for some recovery tasks due to the complex nature of the action (i.e., availability of willing sellers of private property rights, changes in existing laws, etc.). Additionally, some of the costs of identified tasks may be wholly or partially funded under existing State or Federal programs intended to fulfill the requirements of existing laws or regulations outside of the Endangered Species Act, but ultimately may provide benefits to Pallid Sturgeon. As such, these costs are difficult to estimate and not included in the calculation of the costs estimates for downlisting and delisting.

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	2014 -2018	2019 -2024	2025 -2030	2031 -2040	2040 -2047	
				REGION	DIVISION							
1	1.1.1	Determine effects of dams on limiting recruitment and survival of Pallid Sturgeon	3	6	FR, ES	BOR, COE, STATES	300	600				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	FR, ES, RF	BOR, COE, STATES	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	FR, ES	COE, BOR,	6,000	6,000	3,000			
1	1.1.4	Provide and protect instream flows	5+	3,4,6	FR, 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	FR, ES	COE, BOR, EPA, NRCS, FERC, STATES	27,000	18,000	17,000			
1	1.1.6	Provide protection for important habitat forming processes	5+	3,4,6	FR, 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 invasive species/ Aquatic Nuisance Species	3+	3, 4, 6	FR, ES	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	150	150				
1	2.2.1	Evaluate sexual maturity and spawning life history parameters	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	750	750				
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	750	750				
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	750	750				

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	2014 - 2018	2019 - 2024	2025 - 2030	2031 - 2040	2040 - 2047	
				REGION	DIVISION							
1	3.1	Monitor Pallid Sturgeon population	5+	3,4,6	FR	COE, BOR, USGS, STATES	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, STATES	200	200	200	200	200	
3	3.3	Assess population for consideration of DPSs	5+	3,4,6	FR,ES	USFWS		20				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		100	100			Data analysis. Data collection costs absorbed under existing programs
1	4.1	Conservation propagation and stocking program	5+	3,6	FR	COE, BOR, STATES	925	1025	550			
1	4.2	Evaluate success of propagation and stocking program	5+	3,4,6	FR	COE, BOR, STATES	75	75	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	150	150				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	100		

*detailed description available in Recovery Outline/Narrative section.

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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.)

APPENDIX B: Summary of Public Comments

On March 15, 2013, we published a notice in the Federal Register soliciting public comments on our release of a draft revised recovery plan for the endangered Pallid Sturgeon (51 FR 16526).

The new revised recovery plan constitutes the first revision of the recovery plan since 1993. The revised recovery plan documents the current understanding of the species' life history requirements, identifies probable threats that were not originally recognized, includes revised recovery criteria, and based on improved understanding of the species, describes those actions believed necessary to eventually delist the species.

In our announcement, we request assistance in the recovery plan revision effort by providing the public with the opportunity to review the revised plan and solicited any additional information related to Pallid Sturgeon that was not already included in the draft revision. Specifically, we requested any new information, analyses, or reports that summarize and interpret: population status and threats, demographic or population trends; genetics and competition; dispersal and habitat use; habitat condition or amount; and adequacy of existing regulatory mechanisms, management, and conservation planning.

Concurrent with the public comment period, we solicited independent peer review of the document from four individuals prominent in the field of sturgeon biology, ecology, and/or large river ecosystems.

The 60-day public comment period closed on May 14, 2013 and we are grateful for the contributions from those who provided information during this review and comment period. This input ultimately improved the information contained within this revision to our 1993 Pallid Sturgeon Recovery Plan.

Peer-review and public comments ranged from minor editorial suggestions to providing new information. As appropriate, we have incorporated all applicable comments into the text of this revised recovery plan. All comment letters are on file at the Montana Fish and Wildlife Conservation Office, 2900 4th Ave. North, Suite 301, Billings, Montana 59101.

List of Commenters:

PEER REVIEWERS:

Dr. Craig Paukert
Missouri Cooperative Fish
and Wildlife Research Unit
University of Missouri
302 Anheuser-Busch Nat Res
Bldg.,
Columbia, MO 65211

Dr. Mark Pegg
School of Natural Resources
University of Nebraska
402 Hardin Hall
Lincoln, NE 68583

Dr. Kenneth J. Sulak
U.S. Geological Survey
Southeast Ecological Science
Center
7920 NW 71st St.
Gainesville, FL 32653

ADDITIONAL COMMENTERS:

Montana Fish Wildlife and Parks

Missouri Department of Conservation

National Park Service,
Biological Resource Management Division

Nebraska Game and Parks Commission

South Dakota Dept. of Game, Fish, and Parks

U.S. Army Corps of Engineers,
Mississippi Valley Division

Following are those substantive comments that were not addressed in the final Pallid Sturgeon Recovery Plan, along with our response to each comment. Comments are arranged into the following categories – general information, downlisting/delisting criteria, and recovery tasks.

GENERAL INFORMATION

Comment 1: One reviewer questioned how we can conclude the Pallid Sturgeon population is stable when very large sections of the range have no population estimates?

Response 1: In this context, a stable population is one that is in a relatively steady-state either artificially or naturally. A stable designation, however, is not meant to imply that the population is viable, self-sustaining, or recovered. Our conclusion that the Pallid Sturgeon population is stable is based on a variety of factors including, but not limited to:

1) The success of the Pallid Sturgeon Conservation Augmentation Program (PSCAP). As a result of the PSCAP, multiple year-classes have been established and current survival estimates suggest that long-term persistence of the species is anticipated to occur in those reaches where localized extirpation appeared imminent prior to implementation of the PSCAP.

2) Long-term sampling data in many portions of the range with relatively consistent catch-per-unit-effort data;

3) Population abundance estimates, where available; and

4) Implementation of the Similarity of Appearance Rule to reduce or eliminate harvest of Pallid Sturgeon in association with commercial shovelnose sturgeon harvest.

Comment 2: One commenter suggested the section describing the diets of Pallid Sturgeon should mention the importance of native large-river minnow species.

Response 2: We acknowledge that limited data suggest that native turbid-adapted cyprinid species have been documented as a food item for Pallid Sturgeon and several species of these minnows have declined coincident with Pallid Sturgeon. However, while it has been documented that Pallid Sturgeon consume native large-river minnow species, where they are relatively abundant, their overall importance to Pallid Sturgeon is difficult to ascertain. Future research will attempt to examine species relationships and dependencies.

Comment 3: One reviewer questioned whether the Kansas River was ever historically occupied by Pallid Sturgeon and one commenter indicated support for increased emphasis on the potential importance of tributaries to the recovery of Pallid Sturgeon.

Response 3: Information gained following the original version of this plan warrants further investigation into the potential roles tributary rivers play in overall Pallid Sturgeon recovery. One explanation of the low observations of Pallid Sturgeon in tributaries, post-listing, could be attributable to low sampling efforts, low population sizes, or both. Currently, increased sampling and monitoring efforts across the species' range have resulted in more tributary observations including those in the Kansas River. Additionally, in portions of the range, hatchery-reared Pallid Sturgeon account for many of the observations in tributaries. Thus, more information is needed to fully assess the role of certain tributaries in Pallid Sturgeon recovery.

Comment 4: One reviewer noted that fundamental empirical knowledge of how many Pallid Sturgeon exist for major portions of the species' range are lacking (i.e., between Gavins Point Dam and St. Louis, Missouri and the Mississippi River downstream of the Ohio River confluence). Additionally, it was noted that no population segment currently exceeds either the 500 or 5000 minimum adequate population size explained within the plan. Finally, it was suggested that Pallid Sturgeon in the northern most reaches of its range should be considered as critically endangered, since abundance estimates do not approach the lower threshold of 500 individuals in the effective breeding population.

Response 4: We summarized the available information related to abundance estimates in the Present Distribution and Abundance section within the draft version of this plan. Based on additional information received during the comment period on the draft version of this plan, this section was updated in the final version.

The recommendation for considering population segments as critically endangered as compared to endangered may be the result of terminology used by different groups. While the International Union for Conservation of Nature distinguishes between critically endangered and endangered species by defining a critically endangered species as one being at an extremely high risk of extinction in the wild and an endangered species as one being at a very high risk of extinction in the wild, the Endangered Species Act does not. Under the Endangered Species Act, an endangered species is one defined as "...any species which is in danger of extinction throughout all or a significant portion of its range...", thus, in accordance with Federal law we use the latter definition for Pallid Sturgeon.

Comment 5: Several commenters discussed proposed hydrokinetic installations in the Mississippi River. The comments ranged from concerns over what effects these structures may have on Pallid Sturgeon and how they would be monitored to providing references for research efforts that may offer insight into the probable effects from these structures.

Response 5: Between the completion of the first draft and final draft revision to this plan, the large numbers of preliminary permits issued for exploration of hydrokinetic power in the Mississippi River were withdrawn by the permit holders. Thus, the section on hydrokinetic power was removed from the energy development discussion in the final version of this plan. However, if future permit applications suggest this potential threat may re-emerge, it will be reconsidered in the context of species recovery planning.

Comment 6: One reviewer indicated that not enough attention has been given to looming problems due to global warming and climate change.

Response 6: We agree that there are many uncertainties associated with the possible effects from climate change. Given these uncertainties, it is difficult to predict what future conditions might be and how those conditions may affect currently recommended practices. However, recovery plans can and should be updated, as needed, to ensure that both new and changing threats are acknowledged, described, and suitable recovery tasks are identified.

Comment 7: One commenter suggested adding additional language to the Water Quantity section under Factor D: Inadequacy of Existing Regulatory Mechanisms to clarify various nuances related to water rights held by Montana Fish Wildlife and Parks, and water reservations held by County Conservation Districts and municipalities.

Response 7: The intent of this section within the plan is not to provide a thorough account of the nuances associated with instream flow reservations, nor to discuss the nuances of water rights and reservations, but rather to provide a very simple illustrations to the reader such that they may better understand the relationship between junior and senior water rights under western water law. Our recommendations to resolve the concerns identified above are discussed in the Recovery Outline/Narrative under section 1.1.4.

Comment 8: One reviewer indicated that important placenames or landmarks used in the text and important in delineating the extent of listed reaches are not shown in some figures (e.g., Figure 2 and 3).

Response 8: Due to the scale of the maps used in various figures (e.g., Figure 2 and 3) some prominent landmarks were not labeled in order to prevent overcrowding of feature labels. We chose instead to highlight the contemporary range of the species within the map (bold and red line) to visually illustrate the reaches being described within the text.

Comment 9: One commenter expressed concern over the Platte River Recovery Implementation Program's ability to improve and maintain habitat for species, including Pallid Sturgeon and described a fish kill on the Lower Platte River during the late summer of 2012 which included two confirmed Pallid Sturgeon. The commenter attributed this fish kill to water withdrawal and low flows during a prolonged drought and concluded that flows are not always sufficient to maintain Pallid Sturgeon in the Platte River. Additional information provided included modeling efforts at the University of Nebraska suggesting river discharge and the daily variability in discharge were the biggest factors leading to the occurrence of Pallid Sturgeon in the lower Platte River and that maintenance of adequate flows and a natural hydrograph are vital to the management of the Platte River to aid Pallid Sturgeon recovery.

Response 9: The Platte River Recovery Implementation Program was developed to offset the adverse effects to federally listed species resulting from federal water-related activities in the Platte River basin above the Loup River confluence (i.e., central Platte River). One of the goals of the Platte River Recovery Implementation Program is to test the assumption that, by managing flows for federally listed species in the central Platte River, benefits would accrue to Pallid Sturgeon habitat located downstream in the lower Platte River. Members of the Platte River Recovery Implementation Program have committed to provide 130,000-150,000 acre feet of managed flows for central Platte River species by the end of calendar year 2019. As a partner in the Platte River Recovery Implementation Program, we are committed to ensuring defined benefits for all federally listed species in the Platte River basin including the Pallid Sturgeon in the lower Platte River.

We acknowledge the commenter was correct when they stated that a fish kill on the lower Platte River during the summer of 2012 resulted in the confirmed death of at least two Pallid Sturgeon and many Shovelnose Sturgeon. This fish kill was likely the result of high temperatures and low flows, which led to unfavorable conditions for fish. We will work with Platte River Recovery Implementation Program partners and water users in the lower Platte River basin to minimize the death of additional Pallid Sturgeon by avoiding low flow conditions.

Comment 10: One reviewer noted the terms "sub-adult" and "juvenile"were used in the draft plan, but never defined and recommended it might be useful to define the terms "juvenile" and "sub-adult" to distinguish these from one another, and from adults.

Response10: In the draft version of this plan, we used sub-adult and juvenile synonymously. In the final version of this plan we use the term juvenile in reference to all fish that are not considered embryos or larvae, and those that have not reached sexual maturity.

DOWNLISTING/DELISTING CRITERIA

Comment 11: One commenter recognized the current difficulties with identifying small Pallid Sturgeon and expressed concerns that identifying natural recruitment based on young-of-year or juvenile Pallid Sturgeon as a recovery criteria may not be realistic.

Response 11: As described in this plan under the General Description heading, Pallid Sturgeon are similar in appearance to Shovelnose Sturgeon and taxonomic (i.e., morphomerisitic) characters and ratios can vary with age of the fish (allometric growth), making identification of juvenile fish difficult. This lack of uniform applicability of morphometric indices also may be attributable to greater morphological differences documented between the upper Missouri River Pallid Sturgeon and Pallid Sturgeon inhabiting the middle and lower Mississippi and Atchafalaya rivers. Another confounding factor is genetic introgression between Shovelnose and Pallid sturgeon. Genetic analysis confirms introgressive hybridization between Pallid and Shovelnose sturgeon occurs and likely has been occurring for several generations, perhaps as many as 60 years, however; it is poorly understood how this may affect identification accuracy based on taxonomic (i.e., morphomerisitic) characters. To better resolve these issues, we have funded a comprehensive study within the lower Mississippi River to independently compare genomic species identification with identification based on taxonomic (i.e., morphomerisitic) characters to better evaluate concordance among these two methods. Until these results are completed, we consider that a combination of genetic and taxonomic (i.e., morphomerisitic) characters is more reliable than taxonomic character identification alone.

Comment 12: Several reviewers and commenters discussed the current goal of 5,000 adults per management. In general the nature of these comments were:

1) One reviewer sought clarity on if this was achievable or measurable and if we would use confidence intervals in determining whether the goal was met.

2) One reviewer indicated that the goal was reasonable.

3) One commenter sought clarity on how the adult population size would be determined and defined three possible analytical approaches.

4) One commenter expressed concern about this goal and the carrying capacity of currently available habitat.

Response 12: As part of the recovery planning process, we are required to provide objective and measurable recovery criteria. In this plan (see Adult Population Targets section), we defined a minimum target of 5,000 adult fish in each management. This target was determined by using the minimum effective breeding population size to derive an initial minimum target for each management unit. However, we also recognize that this target should be considered interim until empirically-derived Pallid Sturgeon specific data are developed, evaluated, and incorporated into an appropriate population viability analysis to derive management unit or, if designated, DPS specific minimum viable adult population estimates. Thus, the delisting and downlisting targets defined in this plan can and should be updated and modified in subsequent plan revisions, as appropriate, in an adaptive fashion based on available data and analyses.

Finally, at present, there is not a universal standard approach to deriving reliable population estimates for Pallid Sturgeon. We are, however, required to review and consider the best commercially and scientifically available data when making listing-related decisions. As such, we will consider the validity of the methods used based on the data available, the variability in the data (i.e., confidence intervals surrounding a population point estimate), assumptions made, and appropriateness of methodology employed as population estimates are developed.

Through the above process, we anticipate that future management unit specific, or, if designated, DPS specific minimum viable adult population targets, would account for and consider carrying capacity of available suitable habitats during the estimation development.

Comment 13: Two reviewers and several commenters raised questions or concerns about the use of stock density indices as a measure of recruitment. In general, the nature of these comments or questions were to seek clarity on:

1) How does an incremental-RSD equate to a specific number of adult pallid sturgeon?

2) The application of Shuman et al. (2006) to calculate stock density estimates range-wide and the applicability of these to all management units due to latitudinal gradients in growth and morphology.

3) Stock density indices and Catch-per-unit-effort are useful tools to assess population structure and recruitment, but how do they fit into the recovery criteria?

Response 13: We specified incremental-RSD values for stock to quality sized fish (as described by Shuman et al. (2006)) being 50-85 over each 5-year sampling period as a means to monitor and assess if adequate recruitment was occurring within each management unit. Thus, the incremental-RSD values specified are not intended to be directly related to a specific number of adults. However, with the application of appropriate survival rate information, inferences in predicted future adult trends maybe possible to derive.

We have concluded that the application of Shuman et al. (2006) to calculate stock density estimates are appropriate because relative stock density indices are a valid method to quantify length frequency data. The length categories utilized in stock density development are derived from and based upon percentages of the world-record length of the species in question (Willis et al. 1993). The values described in Shuman et al. (2006) were derived as a percentage of the largest fish on record. Therefore, the stock density length categories are expected to be appropriate across the range of the species. Additionally, in developing this interim target, we considered reach-specific variability across the Pallid Sturgeon's range and identified the interim target incremental-RSD of stock to quality-sized naturally produced fish as a range from 50-85, rather than a set value, to account for range-wide variability.

Finally, we also recognize that the utility of the incremental-RSD index relies on the ability to accurately discern small Pallid Sturgeon from Shovelnose Sturgeon which seems to become increasingly harder to do in the lower reaches of the species' range and can require genetic testing. Thus, we included other variables that are not solely dependent on identification of the smaller-sized Pallid Sturgeon (i.e., catch-per-unit-effort data indicative of a stable or increasing population and survival rates of naturally produced fish (age 2+) equal to or exceeding those of the adults). These indices, used in conjunction with incremental-RSD of stock to quality-sized naturally produced fish being 50-85, should provide sufficient confidence when evaluating if the downlisting or delisting criteria have been met.

Comment 14: One commenter suggested the stated Pallid Sturgeon generation time (20-30 years) is too short.

Response 14: The definition we used for generation length is defined as the average age of parents of individuals in a cohort of offspring. Generation length (IUCN 2010) offers insights into the turnover rate of breeding individuals in a population, and is considered greater than the age at first breeding and less than the age of the oldest breeding individual. Additionally, based on the IUCN guidelines (2010) we agree with their assertion that in the context of this plan that it is appropriate to extrapolate generation length from closely related well-known taxa (Shovelnose Sturgeon in the case of this plan) and to apply it to lesser-known and potentially threatened taxa.

Given the limited data on management-unit-specific age structure for this species, we estimated the generation length for each species as age at first reproduction + 1/natural mortality rate as defined by the IUCN (2010). We assumed a stable age structure with an earliest age of maturity, averaged over both sexes, of 10 for Pallid Sturgeon (Keelyne & Jenkins 1993) and 5 for shovelnose sturgeon (Keenlyne 1997). The annual mortality rate for both species was assumed to be 5% for adults after reaching sexual maturity (Bratten et al. 2009, Keenlyne 1997). The estimate for Pallid Sturgeon and Shovelnose Sturgeon, using primarily upper basin information, generated a generation length time of 22 and 12, respectively. The range provided is given to reflect variance across the species' range (i.e., anticipated shorter generation lengths and possible earlier maturity in the lower portions of the species' range).

Comment 15: One commenter agreed that the potential application of the DPS policy could provide a mechanism to reconsider reach-specific listing status for the Pallid Sturgeon while keeping full Endangered Species Act protection for identified DPSs that have not yet experienced recovery. However, they expressed concerns that the criteria used to designate a DPS (i.e., discreteness and significance) may be biased towards listing rather than downlisting.

Response 15: We appreciate the expression of support for our inclusion of the Distinct Population Segment Overview section in this plan. We recognize that the DPS policy provides flexibility under the Endangered Species Act and that there may be current data gaps that will need to be filled in order to make an adequate determination under the DPS policy.

RECOVERY TASKS

Comment 16: Several reviewers commented on the lack of recovery task prioritization.

Response 16: Identified recovery tasks are assigned numerical priorities to highlight the relative contribution they may make towards species' recovery. The following ranking schema is utilized in Part III: Implementation Schedule in this plan.

The priority numbers found in column 1 of the implementation 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.

Through this process we have identified a general prioritization of recovery actions.

Comment 17: One reviewer questioned the availability of data to support the plan's recommendation to provide fish passage, while another commenter agreed that fish passage was an important concept for assisting with Pallid Sturgeon Recovery.

Response 17: Numerous lines of evidence indicate that increasing habitat connectivity can provide benefits and facilitate recovery. Newly hatched Pallid Sturgeon larvae are predominantly pelagic, drifting in the currents for 11 to 13 days and dispersing 245 to 530 km (152 to 329 mi), depending on water column velocity and temperature. Within portions of the species' range, requisite drift distances are lacking due to fragmentation (e.g., Intake Dam on the Yellowstone and Fort Peck Dam on the Missouri). Thus, providing access to spawning areas upstream of some barriers can increase the available drift distances. Additionally, historical and current data indicate suitable habitats exist upstream of several known barriers. These are some examples of the data leading us to conclude, that for some barriers providing fish passage is a reasonable recovery tasks which, if implemented, will help to address the threats of habitat loss, alteration, and degradation within the historical range of the species. Where possible, we tried to identify and highlight areas where fish passage efforts may assist overall recovery by increasing access to tributary habitats.

Comment 18: One commenter questioned the need to provide fish passage at the Wilbur D. Mills Dam constructed to block the old Arkansas River channel and indicated that restoring fish passage at this site would be challenging.

Response 18: At this time, we have not concluded whether Pallid Sturgeon passage at the Wilbur D. Mills Dam is necessary or essential for recovery of Pallid Sturgeon. In both the draft and final version of this plan, we recognized this barrier on a large tributary to the Mississippi River as a possible recovery option. However, we have not recommended doing anything at this structure at the present time. We believe this issue (the need to provide passage of Pallid Sturgeon at the Wilbur D. Mills Dam) should be further evaluated. If data were to indicate that providing passage would further conservation of the species and is deemed necessary for recovery, then we would recommend that passage be restored at this site.

Comment 19: One commenter indicated they were unaware of any published studies documenting Pallid Sturgeon utilizing woody debris, or that woody debris is essential to their forage base.

Response 19: While direct data defining linkages between Pallid Sturgeon and/or their common forage base directly using woody debris may be unavailable, it should not be simply discounted. Natural riverine processes, prior to anthropogenic alteration, included bank erosion that recruited large woody debris into the riverine environment. The important ecological role of woody debris in river environments is well documented in numerous publications (e.g., Fishcenich and Morrow 1999; Boyer et al. 2003; Archer 2009) some of which include: contributing organic matter, providing substrate for invertebrates, generating hiding cover and velocity breaks for fishes, as well as affecting river channel morphology, sediment deposition, hydraulic characteristics, and increased habitat diversity.

Given that historical snag removal efforts were effective at removing woody debris from extensive portions of Missouri and Mississippi rivers and bank stabilization activities have limited natural erosion process that would allow woody debris recruitment, we have identified the need to develop programs or efforts that can help restore woody debris to these rivers as a means of restoring riverine function or creating habitats. This recommendation then focuses more on ecosystem restoration to benefit the species; a fundamental purpose defined within the Endangered Species Act. The three studies cited in the above paragraph include:

Archer, M. W. 2009. Retention, movement, and the biotic response to large woody debris in the channelized Missouri River. Master's thesis. University of Nebraska, Lincoln.

Boyer, K. L., D. R. Berg, and S. V. Gregory. 2003. Riparian management for wood in rivers. Pages 407-420 in S. V. Gregory, K. L. Boyer, and A. M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland.

Fischenich, C., and J. Morrow, Jr. 1999. "Streambank Habitat Enhancement with Large Woody Debris," EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR- 13), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Comment 20: One reviewer and two commenters expressed concerns related to the Pallid Sturgeon Conservation Augmentation Program. The concerns ranged from stocking taking up resources that could be used to implement other recovery tasks, the need to begin shifting emphasis from the propagation program to monitoring of introduced, hatchery-reared pallid sturgeon (i.e., dispersal of hatchery progeny into the Mississippi River, effects on genetic diversity and fitness, and general behavior as they mature), and risks of introducing or amplifying pathogens into the river systems through hatchery-reared fish.

Response 20: From a recovery planning perspective, priority is given to those actions that must be taken to prevent extinction, local extirpation, or populations declining to an irreversible level. In the context of this plan, the use of artificial propagation is identified as a method to prevent localized extirpation. Where appropriate, we prioritized efforts in developing and implementing the Pallid Sturgeon Conservation Augmentation Program. The focus of this program is to preserve the remaining wild genetic diversity before it is lost due to recruitment failure and localized extirpation, as well as to bolster population numbers within reaches where conservation augmentation is deemed necessary. These efforts have been successful at preventing local extirpation and capturing genetic diversity; essentially providing additional time to implement other necessary aspects of the recovery program.

Additionally, in this plan we discuss the use of artificial propagation, where deemed necessary, in the Recovery Outline/Narrative. Specifically, we identified the need to annually review, update if necessary, and implement range-wide stocking and propagation plans using the most recent information, as well as using the best available information to evaluate effectiveness of hatchery products within each management unit, and to determine when stocking is no longer warranted. We will continue to work closely with our partners and seek input and guidance from the Pallid Sturgeon recovery team and basin working groups to help ensure the range-wide stocking and augmentation plan is governing stocking efforts appropriately.

Comment 21: One reviewer commented on the development of a population viability analysis (Task 3.4) cautioning that there must be fundamental empirical pallid Sturgeon population data in place from a multi-year mark-recapture research effort. Additionally, this reviewer identified other data deficiencies for developing a population viability analysis, including; population size, population structure (modes and valleys), and mortality rate.

Response 21: We generally agree that there are prerequisite data that must be acquired before a population viability analysis should be attempted. As such, we ranked the recovery tasks to reflect this. For example, in the implementation schedule, the items under Task 3.1 Monitor Pallid Sturgeon Population, e.g., developing and implement a range-wide Pallid Sturgeon monitoring program that will provide adequate data to evaluate progress toward downlisting and delisting criteria, are identified as priority 1. Whereas task 3.4 Conduct a Population Viability Analysis is ranked as a priority 2 item.

Comment 22: One reviewer and two commenters highlighted what they see as apparent deficiencies in fundamental knowledge and suggested an outline of priority needs as follows:

1) Develop the fundamental knowledge of population abundance and structure for each major reach occupied by the species over its range (i.e., a range-wide population assessment),

2) Finding bottlenecks to recruitment,

3) Identify spawning grounds, and

4) Identify important habitats used by key life history stages.

Response 22: We agree and believe our prioritization list provided in the Implementation Schedule aligns with and addresses the general concern identified. It should also be noted that many of the specific items mentioned are included in ongoing research activities (i.e., developing population estimates, survival rate estimation, studying spawning movements and locations, etc.).

Comment 23: One commenter questioned why some recovery tasks under Section 1.1.1 use the word "evaluate" and inferred from this that potential implementation of restoration efforts is not a focus of near-term conservation efforts. The commenter ultimately recommended increased emphasis on implementation over evaluation to address issues related to dams that are well understood and documented.

Response 23: As part of the recovery planning process, we identify limiting biology or life history requirements, the recognized and probable threats to the species relative to the identified listing factors, and delineate reasonable measures believed necessary to assure sustainable recovery. Through this process, we have identified that dams are one of the primary anthropogenic landscape-level alterations associated with Listing Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range. To help address the threat from dams, we have outlined a series of reasonable potential actions to facilitate achieving a self-sustaining population of Pallid Sturgeon within each management unit such that downlisting and eventual delisting can be realized.

For example, looking at the recommendation under the Recovery Outline/Narrative under section 1.1.1 (2), we recommend evaluating spillway releases from Fort Peck Dam to improve flow, turbidity, and temperature conditions downstream, specifically to benefit Pallid Sturgeon in terms of promoting species recovery, and further identify actively implementing this activity if it proves feasible and useful in facilitating recovery of the species. However, the exact magnitude, duration, and timing of spillway releases necessary to improve flow, turbidity, and temperature conditions specifically necessary for Pallid Sturgeon recovery are unknown. Thus, we conclude that this action should be evaluated such that necessary prescribed flows can be developed and subsequently implement if feasible.

Comment 24: One commenter recommended inclusion of language in the plan that emphasizes the importance of Pallid Sturgeon recovery in all historically occupied river reaches that currently are considered suitable Pallid Sturgeon habitat, or can be restored to such levels through habitat restoration and that the success criterion for the fish passage project at Intake Dam on the Yellowstone River be based on Pallid sturgeon measures (e.g., passage, spawning, and recruitment).

Response 24: When this plan was developed, there was a strong emphasis from the Upper Basin Pallid Sturgeon Workgroup to seek and implement fish passage and entrainment protection measures at Intake Dam and sufficient data are available to warrant this management action. Thus, this plan identifies the need to restore fish passage at Intake Dam as mentioned above. However, this plan does not define the exact mechanism through which fish passage and entrainment protection would be achieved. Those specifics are being developed in coordination and cooperation with recovery partners and are subject to various processes (i.e., National Environmental Policy Act).

We are committed to working with partners to help ensure defined benefits for this federally listed species in the Missouri and Mississippi River basins are met, but want to reiterate that the goal of this species recovery program is to sufficiently address the threats to Pallid Sturgeon such that the species no longer fits the definition of threatened or endangered.

Comment 25: One commenter questioned if levee setbacks have been implemented within the range of the Pallid Sturgeon and acknowledge that the concept of increasing floodplain connectivity can improve aquatic habitat conditions. However, this commenter indicated that this type of restoration would have limited applicability because of cost and that benefits would be very reach specific. This commenter concluded that there is no published evidence to support the contention that Pallid Sturgeon require floodplain connectivity because they are main-channel inhabitants and the majority of the food items observed in the digestive tract of Pallid Sturgeon, at least in the Lower Mississippi River, originate in main-channel environments.

Response 25: We agree that increasing floddplain connectivity can improve aquatic habitat conditions and, ultimately, improving the ecosystem upon which Pallid Sturgeon depend. We also recognize that restoring this connectivity will have varying degrees of benefit which may be largely dependent upon levee proximity to the existing channel, the degree of localized channelization, and existing riparian habitat features. The Recovery Task category this is listed under is Create Physical Habitat and Restore Riverine Function which specifically relates to protecting, enhancing, and restoring habitat diversity and connectivity. It is anticipated that site specific planning and evaluation will be required to implement the various components associated with this task. Finally, while data documenting Pallid Sturgeon usage of the inundated floodplain is currently unpublished, Nebraska Game and Parks Commission has documented Pallid Sturgeon usage of floodplain habitats associated with the Missouri River flooding in 2011 (Justin Haas in litt., 2013; Kirk Steffensen, personal communication).