Appendix J

Biological Assessment

U.S. Army Corps of Engineers
Memphis District

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT CORPS OF ENGINEERS
167 NORTH MAIN STREET B-202
MEMPHIS, TENNESSEE 38103-1894

Reply to
Attention of:

October 06, 2011

Regional Planning and
Environmental Division South

Mr. Charlie Scott
U.S. Fish and Wildlife Service
Missouri Ecological Services Field Office Supervisor
101 Park DeVille Drive, Suite A
Columbia, MO 65203-0057

Dear Mr. Scott:

The Memphis District, U.S. Army Corps of Engineers, is submitting the enclosed biological assessment on the potential effects of the St. Johns Bayou and New Madrid Floodway Project, Missouri, on federally threatened and endangered species. The biological assessment concludes that the project may affect, but is not likely to adversely affect the federally endangered interior least tern (*Sterna antillarum*), pallid sturgeon (*Scaphirhynchus albus*), or their critical habitats.

Pursuant to Section 7 of the Endangered Species Act, as amended, we are requesting your concurrence with this determination. If you have any questions concerning this submittal, please contact Mike Thron at (901) 544-0708 or e-mail at john.m.thron@usace.army.mil.

Sincerely,

Edward P. Lambert

Edward P. Lambert
Chief, Environmental Compliance Branch
Regional Planning and Environmental Division South

Enclosure

ENDANGERED SPECIES
BIOLOGICAL ASSESSMENT

INTRODUCTION

This Biological Assessment (BA) is submitted to the U.S. Fish and Wildlife Service (USFWS) by the U.S. Army Corps of Engineers (USACE) to evaluate the potential impacts to federally listed threatened and endangered species from the proposed construction of the St. Johns Bayou and New Madrid Floodway Flood Control Project, Missouri (Phase 1), in accordance with the Endangered Species Act of 1973, as amended. Correspondence from the USFWS dated December 13, 2010, stated that two federally listed species should be included in this assessment: the interior population of the least tern (*Sterna antillarum*) and pallid sturgeon (*Scaphirhynchus albus*). Additionally, the correspondence noted that the bald eagle (*Haliaeetus leucocephalus*) is known to occur within the project area and although it was removed from the endangered species list, it remains protected by the Bald and Golden Eagle Act and the Migratory Bird Treaty Act.

PROJECT DESCRIPTION

An environmental impact statement (EIS) is being prepared for the proposed project analyzing the authorized project alternatives and several avoid and minimization measures. The following is a description of the authorized project alternative. The authorized project as presented in this biological assessment describes the potential project that would have the greatest environmental impact to the ecological resources in the project area. Any avoid and minimization measures recommended in the EIS would decrease environmental impacts. Therefore, this BA encompasses the greatest potential impact to the resource, and revisions are not needed in the event of a selection of an avoid-and-minimize alternative detailed in the EIS.

St. Johns Bayou Basin

The authorized project alternative consists of channel enlargement and drainage improvements along the lower 4.5 miles of St. Johns Bayou, beginning at New Madrid, Missouri, continuing along the Birds Point New Madrid Setback Levee Ditch, and ending with 10.8 miles along St. James Ditch. Selective clearing and snagging has already been completed along a 4.3-mile reach of the Setback Levee Ditch beginning at it confluence with St. James Ditch. In addition, a 1,000 cubic feet per second (cfs) pumping station would be constructed a few hundred feet east of the existing gravity outlet at the lower end of St. Johns Bayou.

The lower 4.5 miles of St. Johns Bayou would be cleared and enlarged on both sides; bottom widths would be increased from approximately 80 feet to 200 feet. Approximately 2,485,000 cubic yards of material would be deposited along both banks creating a 220-foot wide embankment on each side**.** Following construction, the embankments would be allowed to re-vegetate naturally as part of a conservation easement.

The lower 8.1 miles of the Birds Point New Madrid Setback Levee Ditch would be enlarged from approximately 40 feet to 50 feet. The work would take place along the left descending bank and approximately 675,000 cubic yards of material would be placed in a 120-foot wide embankment located along the left descending bank. The area would be allowed to re-vegetate naturally as part of a conservation easement.

St. James Ditch would be enlarged along the left descending bank. The bottom width along the lower 3.5 miles would be enlarged from 35 feet to 45 feet. No changes to bottom width are anticipated along the remaining 7.8 miles of channel. However, top width along the left descending bank would be widened to an 80-foot average. Approximately 630,000 cubic yards of excavated material would be placed on a 100-foot wide embankment along the left descending bank. The area would be allowed to re-vegetate naturally as part of a conservation easement.

A 1,000 cfs pumping station would be constructed several hundred feet to the east of the existing gravity outlet structure on St. Johns Bayou. The pumping station would discharge interior impounded runoff over the levee during high Mississippi River stages. Pumping would commence when water in the sump area reached an elevation of 279.0 feet National Geodetic Vertical Datum (NGVD) and would continue until the sump elevation dropped to 277.0 feet NGVD. The gravity outlet structure gates would remain closed when river stages are greater than the sump elevation, thus preventing Mississippi River backwater flooding. The gates would remain open when the sump elevation is greater than the Mississippi River elevation, which would allow drainage through the St. Johns Bayou gravity outlet structure.

During waterfowl season (1 December to 31 January) the gates would be closed to impound interior runoff in the lower St. Johns Bayou Basin for the benefit of waterfowl. Impounded water would be managed to an elevation of 285.0 NGVD by gravity drainage or by turning on pumps in the event that impounded interior runoff elevations exceed an elevation of 285.0 feet NGVD.

New Madrid Floodway

The 1,500-foot levee gap at the lower end of the New Madrid Floodway between setback levee miles 35 and 37 would be closed with the construction of a levee and associated gated culverts. The closure levee would be constructed of approximately 233,000 cubic yards of material, have a crown elevation of 317.0 feet NGVD, top width of 16 feet, base width of approximately 302 feet, and have side slopes of 4.5:1. The footprint would be approximately 9 acres.

Four 10 by 10-foot gated box culverts would be constructed in Mud Ditch to maintain drainage in the New Madrid Floodway. The gates would be managed in a similar fashion as the existing St. Johns Bayou gravity outlet structure. The gates would be closed when the river elevation is higher than the sump elevation. Subsequently, the gates would be opened when the sump elevation is greater than the river elevation.

A 1,500 cfs pump station would be constructed in the New Madrid Floodway. Within the New Madrid Floodway, pumping would normally commence when the water in the sump reached 278.0 feet NGVD and would continue until sump elevation dropped to 275.0 feet NGVD. Should river stages drop during pumping to levels below the sump elevation, pumping operations would cease and the floodgates would be opened to allow for gravity drainage.

During waterfowl season (1 December to 31 January) the gates would be closed to impound interior runoff in the lower New Madrid Floodway for the benefit of waterfowl. Impounded water would be managed to an elevation of 284.4 NGVD. This would be accomplished by partially closing the gates to impede drainage through the structure. The pumping station would be used to maintain the elevation of 284.4 feet NGVD in the event that the Mississippi River elevation is greater than 284.4 feet NGVD.

Closing the levee gap at the lower end of the New Madrid Floodway would reduce the conveyance for flood water passage when the floodway is operated. To maintain the authorized 3-foot freeboard above the project design flood, a 14.1-mile section of the Setback Levee would require a grade raise to ensure flood protection in the St. Johns Bayou Basin at the authorized level of protection. Setback Levee grade raises range from 0.1 feet to three feet (average 1.28 feet) and would require 2.4 million cubic yards of material. Material would be obtained from adjacent borrow areas.

SPECIES ASSESSMENTS

INTERIOR LEAST TERN (*Sterna antillarum)*

Description

The interior population of the least tern, *Sterna antillarum*, was listed as a federally endangered species on 27 June 1985 (USFWS 1985). The recovery plan for the species was approved on 19 September 1990 (USFWS 1990), but no critical habitat has been designated. Least terns are the smallest of the American terns, measuring from 8.5 inches to 9.75 inches long and having a wingspan of approximately 20 inches. Least terns have a black-capped crown, white forehead, a black-tipped yellow bill, gray back and dorsal wings, white belly, and orange legs. The sexes are mostly identical. Juveniles tend to have a darker, mottled, brownish plumage and bill compared to adults, with a dark band behind the eye and a dark shoulder patch.

Taxonomic Status

Lesson first described the least tern species as *Sterna antillarum* in 1847. During the 1940s, this bird was classified as a subspecies of the European little tern (*Sterna albifrons*) (Burleigh and Lowery 1942). As a result of more recent studies on vocalizations, behavior, and limited morphology, Old and New World least/little terns are now considered separate species and the species name for the least tern was returned to *Sterna antillarum*. The American Ornithologists Union (AOU) currently recognizes the least tern under a previously published name *Sternula antillarum* (Banks et al. 2006) based on mitochondrial DNA and molecular phylogeny (Bridge et al. 2005). The USFWS however currently retains use of *Sterna antillarum* (pers. com. Lindsey Lewis). The AOU also recognizes three subspecies of least tern in North America; the California Least Tern, *S. a. browni*, the coastal least tern, *S. a. antillarum* and the inland least tern, *S. a. athalassos*. The three subspecies are virtually indistinguishable morphologically and are distinguished by the separation of their breeding ranges. Due to taxonomic difficulties, the USFWS is uncertain if the interior least tern qualifies as a separate subspecies. However, the Endangered Species Act allows for the listing of vertebrate subspecies as a discrete population.

Historical Range and Population Level

The interior least tern is a migratory, colonial shorebird that breeds and rears its young on islands along much of the Mississippi, Missouri, Arkansas, and Ohio River systems. Downing (1980) performed a partial survey on the lower Mississippi River in 1975 and estimated there were about 1,200 adult birds in the total interior population of the United States and 750 least terns from Cairo, IL to below Osceola, AR. At the time of the Federal listing in 1985, approximately 1,400 to 1,800 terns were believed to be remaining in the total United States population (USFWS 1985). In 1990, census data estimated approximately 5,000 interior least terns, with half of these occurring along the lower Mississippi River (USFWS 1990). Past census surveys concentrated on where terns had been found historically and did not seek possible new locations. Hardy (1957) was the first to attempt a census over the entire lower Mississippi River but was limited by time, money and equipment. Recent, more comprehensive surveys indicate the terns move to the first available sandy nesting sites in response to habitat changes. USACE and many state agencies have attempted to standardize survey techniques and data recording methods (Lott 2006). These coordinated surveys have shown a greater range and much larger population numbers than expected. The first coordinated range-wide survey for the interior least tern was conducted in 2005 with a count of 17,591 interior least terns with 62% being found on the lower Mississippi River (Lott 2006). Interior least terns are most abundant along the lower Mississippi River; and presently, more than 10,000 individuals are commonly observed there each year (Figure 1, USACE 1986-2010). Small boat surveys along the lower Mississippi River have documented between 28 colony locations in 1986 to as many as 107 in 2006 (USACE 1986 - 2010).

Least tern reproductive behavior corresponds to the Mississippi River hydrograph. Although high river elevations can take place during any time of the year, the river typically is at its highest stages during March and April and at its lowest stages in August and September. Least terns typically arrive on the Mississippi River nesting areas from late April through mid May and spend approximately 4 to 5 months at the breeding sites. Soon after arriving in the breeding area, least terns form colonies ranging from less than a dozen to several hundred birds. Courtship and nesting begin in late May and early June through late July. Reproduction takes place from late May through early August, dependent on specific yearly river stages. Courtship and breeding are followed by nest excavation and egg laying. The shallow nest scrapes are generally on the highest parts of the sandbars, the first parts to become exposed when river stages fall, and located a few yards apart or else widely scattered over the ground. Nest colonies can be from several hundred feet to nearly 3/4 mile long, depending upon the sand bar configuration.

Fall departure from colony sites varies according to the geographic location and the time of nesting. Generally, fall departure is no later than early September. Late season high river stages (*i.e.*, June floods), which periodically delay nesting into early August, prevent least tern migration until fledglings are mature enough to survive migration. Least terns of the Lower Mississippi River Valley migrate through and winter along the northern and eastern coast of South America, the eastern and western coasts of Central America and the Caribbean Islands, mixing with other least tern subspecies of North America. Exact wintering locations are largely undocumented (Whitman 1988).

Habitat and Reason for Decline

Interior least terns on the lower Mississippi River choose nest colony sites on large, isolated, mostly bare sandbars or on the upstream and high downstream sandy points of islands. A colony can cover from several hundred square feet to several acres. Almost all colony sites are on land that is separated from the riverbank during the breeding season. Terns do not use grassland or woodland habitat. On the older or larger sandbars, colonies are usually located several hundred yards away from large trees. The specific colony site is almost always on the highest part of the sandbar; the first part to become exposed as high spring river stages recede. Nest sites are well drained and usually set back from or high above the waterline. Individual nests are shallow depressions scraped out in the bare sand or gravel, usually next to a small piece of driftwood, among the debris wrack lines, or often within short, sparsely scattered vegetation (Smith and Renken 1991, USACE 1986-2010). On sandbars without driftwood, nests are in bare sand or gravel and often placed on the sand-ripple edges.

The primary reason cited in the literature for the decline in the least tern population is habitat loss. The loss is attributed to channelization, river stabilization structures, navigation structures, and dam construction for flood control, hydropower, and recreation (Hardy 1957, Downing 1980, USFWS 1985 and 1990, Smith and Stucky 1988, Whitman 1988). Increasing river development for industrial and recreational uses, in addition to increased irrigation water withdrawal from some rivers in the upper Midwest have caused a decline in available habitat. Least tern habitat may be available in those areas but it is often too short-lived to benefit the terns with a fully successful year class. However, in the Lower Mississippi River Valley, large sediment loads coupled with 40-ft. fluctuations in water level indicate that river conditions would allow for many sandbars to be made available to least terns as nesting habitat. USACE conducted a BA in 1999 evaluating effects on the interior least tern and its habitat due to channel improvement structures of the Mississippi River and Tributaries Project (USACE 1999a). The BA analyzed temporal and spatial relationships of sandbar habitat and usage according to the Low Water Reference Plane (LWRP), taking into account the slope of the river. Throughout many reaches of the lower Mississippi River, sandbars were shown to be dynamic in nature, including changes in size and elevation of some sandbars, degradation of other sandbars, and formation of new sandbars; however, little net change in total habitat area was observed. The BA found that the net effect of dike and revetment construction and related long term channel responses on total bare sandbar habitat for the interior least tern appears to have been comparatively small in the lower Mississippi River and that significant quantities of bare sandbar habitat remain present and would continue to remain present in the lower Mississippi River for the species. Much of the sandbar habitat utilized by least terns in the lower Mississippi River is associated within dike fields (USACE 1986-2010, USACE 1999a). Interagency meetings are held annually by the USACE to discuss proposed channel improvement work along the lower Mississippi River with various wildlife agencies and to incorporate habitat improvement features for the interior least tern into the USACE channel improvement program. Dike notches are a common feature placed within dike fields to increase aquatic habitat diversity and protect sandbars used by the interior least terns by isolating the colony with a back channel. The Recovery Plan goal for the lower Mississippi River was for a population between 2,200 and 2,500 adult least terns to remain stable for 10 years (USFWS 1990). Annual surveys conducted by USACE from 1985 to the present, have shown numbers exceeding 2,500 adult terns for more than twenty years in the lower Mississippi River with numbers exceeding 10,000 individuals in recent years (Figure 1).

Little is known about the interior least tern during its migration or on its winter range. Migration habitat characteristics have not been described in literature. However, it appears likely that least terns use habitat similar to that used for nesting, resting, and foraging during the regular breeding season. Significant habitat problems occurring in wintering areas and along migration routes could impact least tern populations (Whitman 1988).

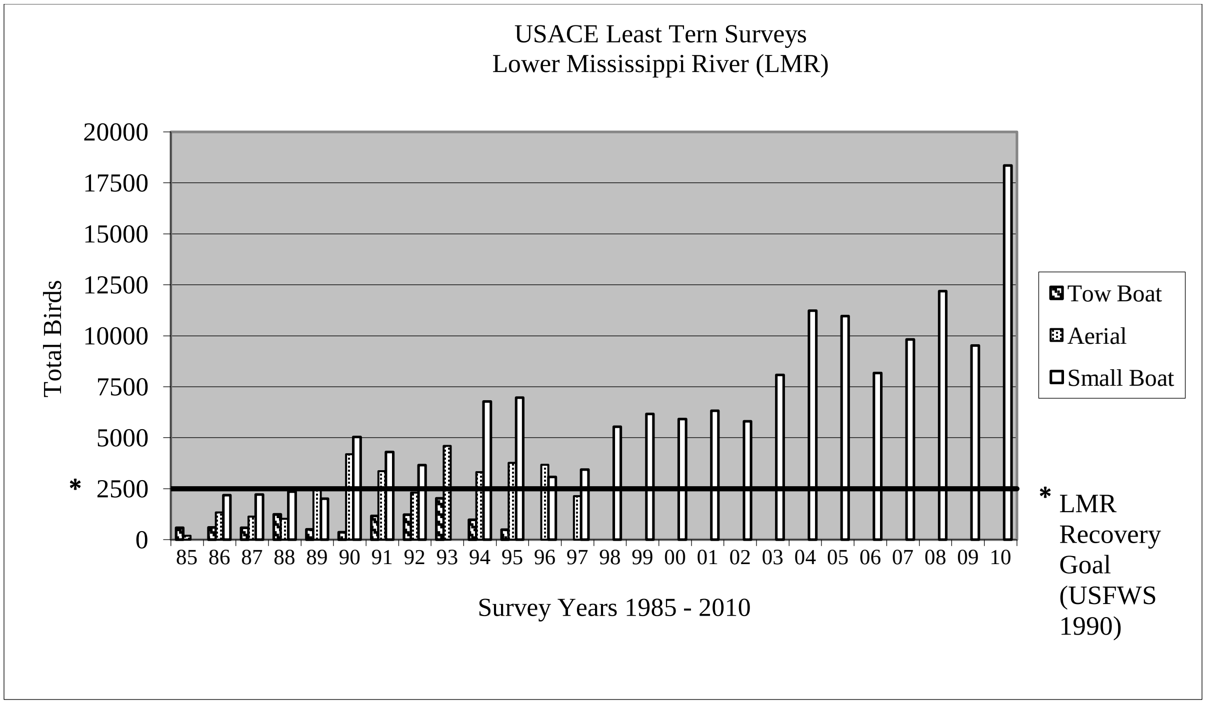

Figure 1. Interior least tern population data from U.S. Army Corps of Engineers surveys on the lower Mississippi River from 1985 to the present.

Food Habits

Least terns are almost exclusively piscivorous and plunge-dive to capture small fish near the surface of the water. Prey size seems to be more important than a preference for a particular species to the terns, feeding on fish up to approximately 3.5 inches in size (Moseley 1976, Whitman 1988, Smith and Renken 1990, USACE 1986-2010). Dominant prey species in the lower Mississippi River include shad (*Dorosoma spp.*), river carpsucker (*Carpiodes carpio*), *Notropis* minnows, white bass (*Morone chrysops*), largemouth bass (*Micropterus salmoides*), freshwater drum (*Aplodinotus grunniens*), and bluegill (*Lepomis macrochirus*) (Smith and Renken 1990, USACE 1986-2010). Observations of forage-sized bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) dropped on sandbars at colony locations have also increased in the past few years (USACE 2004–2010). Fishing occurs close to the colony locations. Most of the least tern colony locations in the lower Mississippi River are associated with dike fields, and least terns are commonly observed among these and surrounding habitats (USACE 1986-2010). Tibbs and Galat (1998) showed that both availability and taxa richness of forage sized fish were greater in the shallow areas between sandbars (*i.e.*, colony locations) and the contiguous river channel than in deep water. Other foraging habitats observed in the lower Mississippi River include natural and revetted riverbanks on the opposite side of the river from a colony, over current divergences (boils) in the main river channel, at the mouths of “outlets” of floodplain lakes and tributary streams, turbulent water around dikes, backwater chutes, and occasionally ponds and lakes near the river (Dugger 1997, USACE 1986-2010). On population surveys conducted by USACE, least terns were regularly observed fishing along the opposite revetted river bank, often 0.75 to 1 mile away, and distances up to 2.5 miles upstream and downstream from nesting colonies. The fishing area itself could be 0.75 miles in length (USACE 1986-2010). This contrasts with foraging distances on smaller rivers in Nebraska, where terns rarely ventured farther than 0.10 miles from their nesting colony (Faanes 1983).

Evaluation of Potential Impacts

Interior least terns do not typically nest within the project area. Record flooding in late April and early May 2011 resulted in operation of the Birds Point – New Madrid Floodway for the first time since the flood of 1937. Explosives were used to create an Inflow/Outflow Crevasse on the frontline levee near Big Oak Tree State Park resulting in a large quantity of sand being deposited in agricultural fields landside of the levee. Additionally, high river stages extended into the 2011 least tern breeding season and very few sandbars were exposed in the lower Mississippi River. A least tern colony of approximately 40 to 50 individuals was observed nesting in this sand deposit in late June 2011. As the river stages dropped and sandbars became exposed, the terns utilizing the sand deposit departed. By the middle of August 2011, vegetation had encroached onto the sand deposit, and all individuals had departed from that location. Coordination with the USFWS associated with this observed least tern colony was conducted during the Birds Point – New Madrid Floodway Repair Project, and it was determined that the proposed actions were not likely to adversely affect least terns. Since this time the majority of the sand deposit has been removed from the agricultural fields. Additionally, the land connection between this colony location and the forested Big Oak Tree State Park, increases the likelihood of predation by coyotes, owls, and other predators. Thus, future use of this location by least terns is extremely unlikely.

The closest regularly used colony location to the project area is associated with the Kentucky Point Dike Field a few miles downstream of New Madrid, Missouri (Figure 2). The proposed project would not impact sandbar habitat, thus no impacts to nesting habitat is expected.

The proposed project would reduce the duration and frequency of seasonal flooding in the project area. The impacts associated with the reduction in flood frequencies and durations have been assessed by a series of environmental models, including EnviroFish that quantifies fish spawning and rearing habitat. The proposed project is not likely to adversely affect least tern foraging because least terns forage on ubiquitous forage fish throughout the Lower Mississippi River, and there is ample remaining spawning and rearing habitat for these species.

Sheehan et al. (1998) sampled the tributaries within the proposed project area and found the most dominant taxon to be mosquitofish (*Gambusia affinis*), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), and gizzard shad (*Dorosoma cepedianum*). Killgore et al. (unpublished data) sampled St. Johns Basin, New Madrid Basin, and Mud Ditch to the confluence with the Mississippi River during 2007-2008. Over 4,000 individual fish representing 65 species were collected (Table 1). Similar to Sheehan et al. (1998), dominant taxa were mosquitofish, cyprinids, suckers, sunfish and shad. All of these species are found in various densities and habitats in the lower Mississippi River (Baker et al. 1991). The closest colony location is associated with the Kentucky Point Dike Field. The Kentucky Point Dikes are at various elevations ranging from 24 feet above the Low Water Reference Plane (LWRP) to 14 feet above the LWRP with several dike notches and both revetted and natural banks present throughout the dike field. This mosaic of habitats would undoubtedly provide spawning and rearing habitat for potential forage fish at intermediate river stages during appropriate times of the year. Dike field pools have been shown to contain similar larval fish compositions compared to other backwater habitats (*e.g.*, abandoned chutes and oxbow lakes) during slack-water conditions, consistently dominated by dense populations of shads, *Lepomis* spp. and inland silversides (Beckett and Pennington 1986). Additionally, Kentucky Point, located immediately across from New Madrid and adjacent to the closest least tern colony, is low in elevation and contains numerous abandoned channels and other fish spawning and rearing habitat (Figure 3). Other significant areas of batture land near the project area include Donaldson Point (Figure 3).

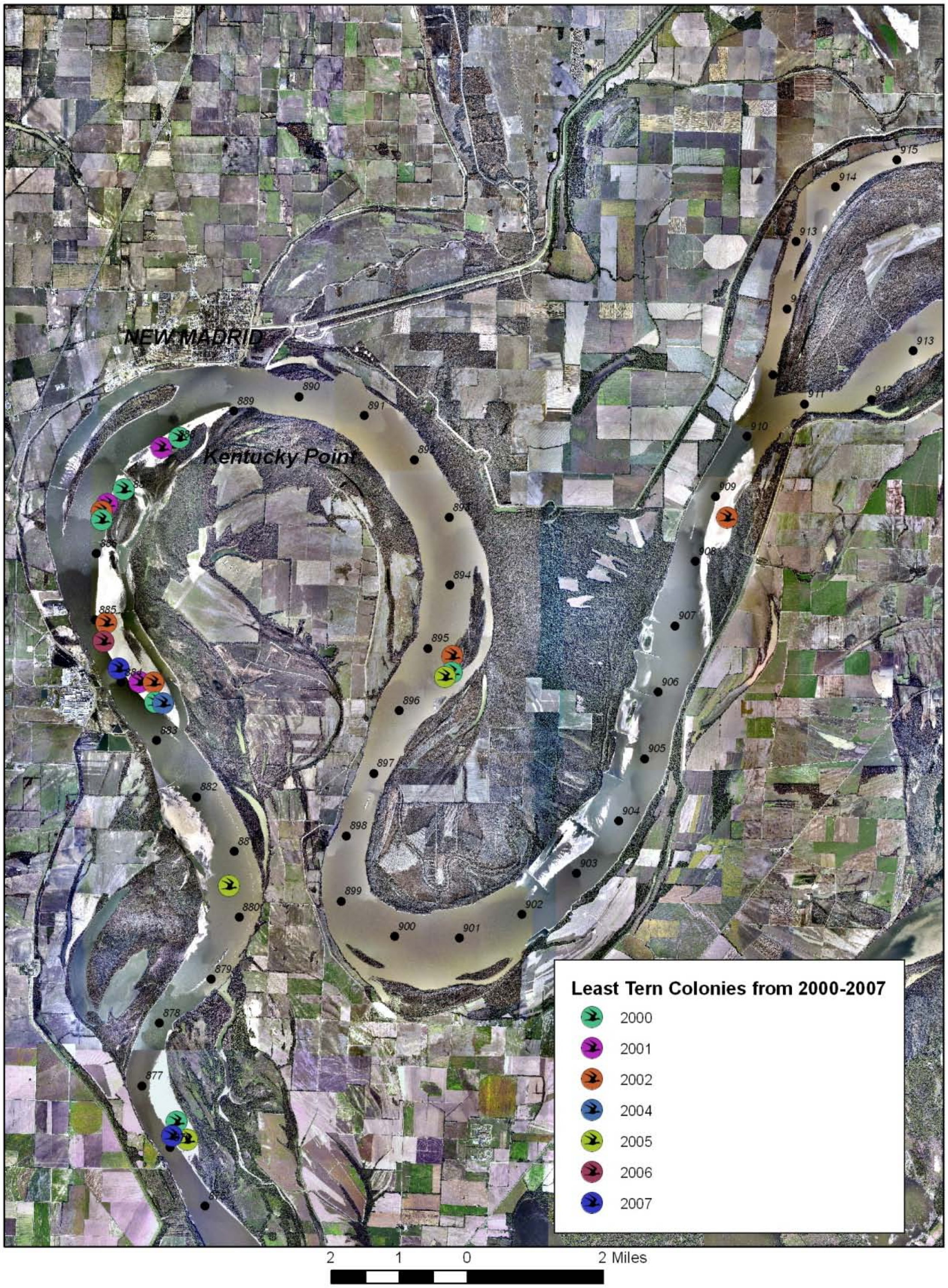

Figure 2. Locations of interior least tern colonies on the Mississippi River from USACE surveys conducted from 2000 to 2007 near New Madrid, Missouri, shown on a 2007 low-water aerial photograph.

Table 1. Fishes of the St. Johns/New Madrid project area collected in 2007-2008 by seines (n=18), hoopnets (n=32), electroshocking (n=4), and gill nets (n=6).	
Family and Species	Number
Lepisosteidae	
Spotted gar (*Lepisosteus oculatus*)	53
Shortnose gar (*L. platostomus*)	57
Longnose gar (*L. osseus*)	8
Clupeidae	
Skipjack herring (*Alosa chrysochloris*)	2
Gizzard shad (*Dorosoma cepedianum*)	137
Threadfin shad (*D. petenense*)	3
Hiodontidae	
Goldeye (*Hiodon alosoides*)	9
Esocidae	
Grass pickerel (*Esox americanus*)	7
Cyprinidae	
Grass carp (*Ctenopharyngodon idella*)	3
Red shiner (*Cyprinella lutrensis*)	5
Blacktail shiner (*C. venusta*)	442
Common carp (*Cyprinus carpio*)	21
Silver carp (*Hypophthalmichthys molitrix*)	76
Bighead carp (*H. nobilis*)	6
Ribbon shiner (*Lythrurus fumeus*)	193
Speckled chub (*Macrhybopsis aestivalis*)	1
Golden shiner (*Notemigonus crysoleucas*)	1
Emerald shiner (*Notropis atherinoides*)	114
Ghost shiner (*N. buchanani*)	20
Ironcolor shiner (*N. chalybaeus*)	195
Weed shiner (*N. texanus*)	18
Mimic shiner (*N. volucellus*)	16
Pugnose minnow (*Opsopoeodus emiliae*)	23
Bullhead minnow (*Pimephales vigilax*)	173
Bluntnose minnow (*P. notatus*)	107
Catostomidae	
River carpsucker (*Carpiodes carpio*)	42
Highfin carpsucker (*Carpiodes velifer*)	1
Smallmouth buffalo (*Ictiobus bubalus*)	307
Bigmouth buffalo (*I. cyprinellus*)	58
Black buffalo (*I. niger*)	41
Spotted sucker (*Minytrema melanops*)	
Ictaluridae	
Black bullhead (*Ameiurus melas*)	1
Yellow bullhead (*A. natalis*)	1
	7

Blue catfish (*Ictalurus furcatus*)	40
Channel catfish (*I. punctatus*)	102
Tadpole madtom (*Noturus gyrinus*)	10
Freckled madtom (*N. nocturnus)*	1
Flathead catfish (*Pylodictis olivaris*)	10
Aphredoderidae	
Pirate perch (*Aphredoderus sayanus*)	30
Cyprinodontidae	
Golden topminnow (*Fundulus chrysotus*)	54
Blackstripe topminnow (*F. notatus*)	37
Blackspotted topminnow (*Fundulus olivaceus*)	23
Poeciliidae	
Western mosquitofish (*Gambusia affinis*)	1168
Atherinidae	
Brook silverside (*Labidesthes sicculus*)	180
Percichthyidae	
White bass (*Morone chrysops*)	13
Striped bass (*M. saxatilis*)	1
Centrarchidae	
Green sunfish (*Lepomis cyanellus*)	47
Warmouth (*L. gulosus*)	16
Orangespotted sunfish (*L. humilis*)	90
Bluegill (*L. macrochirus*)	58
Longear sunfish (*L. megalotis*)	29
Redspotted sunfish (*L. miniatus*)	27
Spotted bass (*M. punctulatus*)	13
Largemouth bass (*M. salmoides)*	12
White crappie (*Pomoxis annularis*)	4
Black crappie (*P. nigromaculatus*)	
Elassomatidae	
Banded pygmy sunfish (*Elassoma zonatum*)	148
Percidae	
Mud darter (*Etheostoma asprigene*)	1
Bluntnose darter (*E. chlorosomum*)	12
Slough darter (*E. gracile*)	3
Harlequin darter (*E. histrio*)	2
Cypress darter (*E. proeliare*)	31
Saddleback darter (*Percina ouachitae*)	5
Dusky darter (*P. sciera*)	5
Sciaenidae	
Freshwater drum (*Aplodinotus grunniens*)	120
Total	4,341

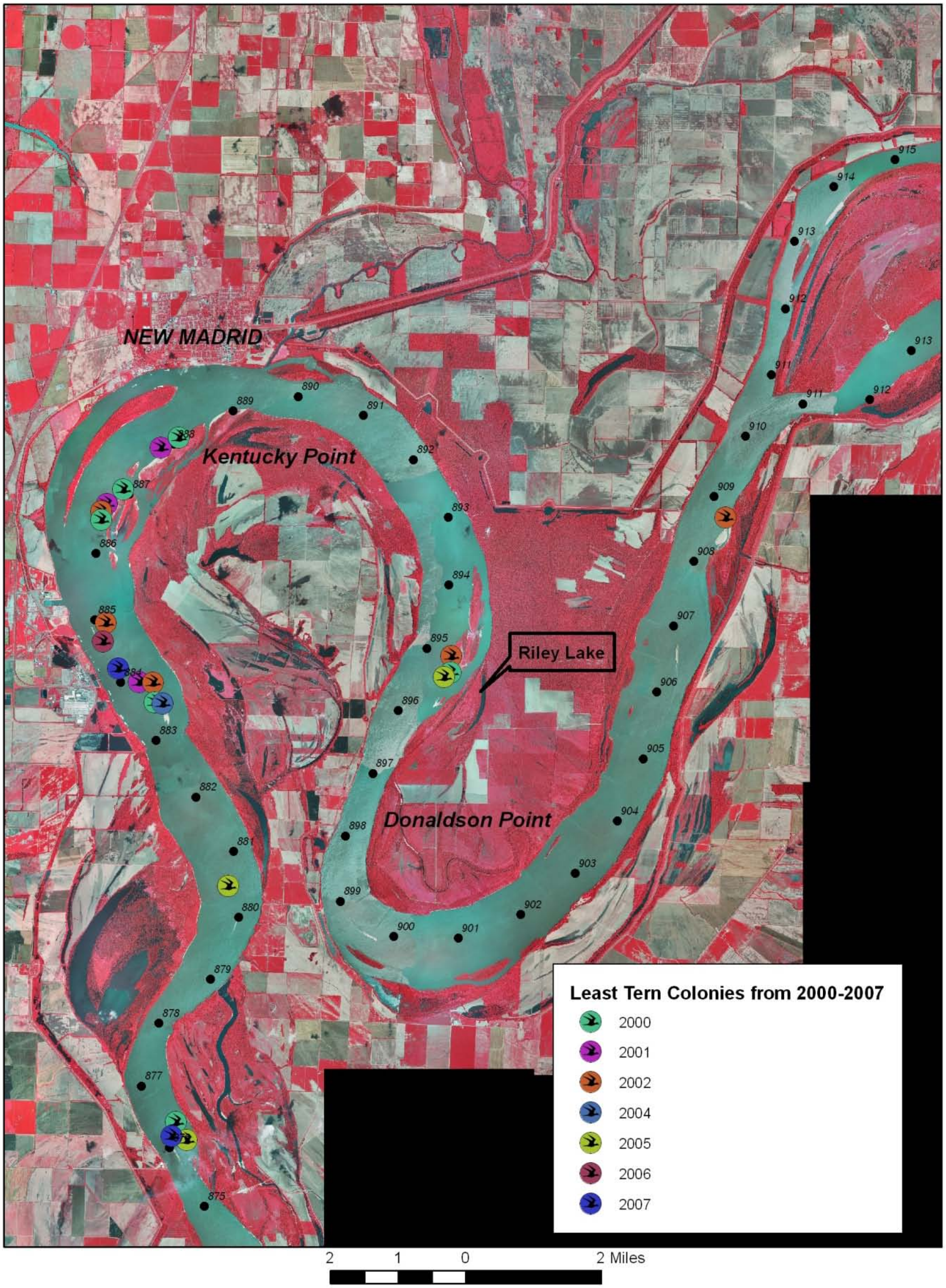

Figure 3. Interior least tern colonies in the vicinity of New Madrid, Missouri, shown on a 2009 high-water infrared aerial photograph.

Although no significant impacts to least tern foraging is expected as a result of the project, the proposed project would compensate for significant unavoidable impacts to fish spawning and rearing habitat. Since over 80% of the project area is devoted to agriculture production, the vast majority of impacts would be to agricultural lands. Agriculture fields provide sub-optimal habitat for fish when compared to bottomland hardwoods or floodplain lakes. However, flooded ag fields do provide good shorebird habitat. Moreover, several avoid and minimize measures are being developed that would reduce the overall impact of the project, including impacts to fish spawning and rearing habitat.

A range of compensatory mitigation measures were considered. They include but are not limited to wetland/bottomland hardwood restoration, restoration of hydrology to Big Oak Tree State Park, and restoring floodplain lake habitat. All of these measures would compensate for fish spawning and rearing habitat. However, mitigation measures that provide optimum fish habitat in foraging areas would directly benefit least terns. For example, the EIS is analyzing the restoration of Riley Lake, a floodplain lake that is located on Donaldson Point, immediately east of a least tern colony that was last observed in 2005 (see Figure 3). Attempts were made to drain the lake for agricultural purposes in the past. A preliminary mitigation measure being investigated is to construct a weir in the outlet channel to raise the lake to historic levels. Although this would provide optimum spawning and rearing habitat for fish, it would also likely be actively utilized by least terns while foraging. Mitigation measures that compensate for significant project impacts and would provide additional benefits to least terns would be investigated. This can include, but not be limited to, additional floodplain lake creation/restoration/rehabilitation, borrow pit construction, notching dike fields, reconnection/establishment of Mississippi River secondary channels, and other associated batture land compensatory mitigation measures.

PALLID STURGEON (*Scaphirhynchus albus)*

Much of the following information on pallid sturgeon was taken from the BA prepared for the Mississippi River Mainline Levees Enlargement and Seepage Control Project (USACE 1998b) by Dr. Jack Killgore and Dr. Jan Hoover, fishery biologists with the Engineer Research and Development Center, USACE.

Description

The pallid sturgeon was listed federally as an endangered species on 6 September 1990 (*Federal Register 55: 36647, USFWS 1994*), and a recovery plan was approved 7 November 1993 (USFWS 1993). Prior to this, it was listed as a threatened or endangered species by 9 of the 13 states in which it occurred (Kallemeyn 1983). It was also listed as threatened, later endangered, throughout its range by the Endangered Species Committee of the American Fisheries Society (Deacon et al. 1979, Williams et al. 1989). The USFWS conducted a 5-year review of this species' endangered status in 2007 and determined that no status change was needed at that time (USFWS 2007). Imperilment of this species is attributed to "destruction, modification, or curtailment of its habitat or range" and "other natural or manmade phenomena" (Williams et al. 1989). To date, no critical habitat has been designated for this species.

The pallid sturgeon is one of only three species of river sturgeons (*Scaphirhynchus* spp.), an ancient group of fishes that inhabit large, turbid rivers of the central United States. The recently described Alabama sturgeon (*Scaphirhynchus suttkusi*) is endemic to the Mobile Basin. The pallid sturgeon occurs sympatrically with the shovelnose sturgeon (*Scaphirhynchus platorynchus*) in parts of the Mississippi-Missouri River Basin (Lee 1980a, 1980b). However, the shovelnose sturgeon occurs over a wider geographic range than the pallid sturgeon, inhabiting the upper Mississippi River, Ohio River and tributaries, and formerly inhabiting the Rio Grande Basin from which the pallid sturgeon is unknown.

Taxonomic Status

Fishes characteristic of swift, turbid rivers with high temporal variation in discharge share several morphological features (Cross and Moss 1987). They are ventrally flattened and possess small eyes, hyper-developed cutaneous sense organs, and crowded, embedded scales. Sturgeon, however, are exceptional. They are large, elongate fishes with a pronounced rostrum (hard, forward-projecting snout), five rows of bony plates (one dorsal, two lateral, and two ventrolateral), a muscular extension of the body into the upper lobe of the tail fin, and an inferior protrusible mouth immediately posterior to four fleshy barbels (Robison and Buchanan 1988). River sturgeon differ from other sturgeons by lacking spiracles (small openings into the gill chamber anterior to the operculum) and by possessing a long filament on the upper lobe of the tail fin and a flat, spadelike rostrum. Both structures have hydrodynamic functions. The caudal filament probably provides sensory input allowing young sturgeon to stay aligned in current and avoid displacement by high velocities (Weisel 1978). The rostrum generates "lift" during swimming and "resistance" during station-holding (Aleev 1963).

The three species of river sturgeons are very similar in appearance and early biologists did not distinguish them from each other. Unusually pale river sturgeons were observed by commercial fisherman; and in 1905, these were recognized as a distinctive form (Forbes and Richardson 1905). Originally described as a new species belonging to a new genus (*Parascaphirhynchus albus*), the pallid sturgeon was later reevaluated taxonomically based on larger numbers of specimens and reassigned to the same genus as the shovelnose sturgeon (Bailey and Cross 1954).

Pallid sturgeon have been described as differing from shovelnose sturgeon by their conspicuously lighter coloration and in several morphomeristic characters (Bailey and Cross 1954, Robison and Buchanan 1988, Keenlyne, et al. 1994a). Pallid sturgeon often have a greater number of rays in the dorsal fin (37-42 versus 30-36) and anal fin (24-28 versus 18-23). Scales on the belly are often absent or reduced compared with those of shovelnose sturgeon. In pallid sturgeon, the bases of the barbels are often arranged in an arc with the outer barbels substantially (1.72-3.54 times) longer than the inner barbels. In shovelnose sturgeon the bases of the barbels are often aligned with the outer barbels only slightly (1.05-1.78 times) longer than the inner barbel.

Although pallid and shovelnose sturgeons are considered "readily separable...well-marked species" (Bailey and Cross 1954), physical differences between the two species can be difficult to determine due to geographic variation, allometric growth, and hybridization between pallid and shovelnose sturgeon (Kuhajda et al. 2007, Murphy et al. 2007). When morphomeristic measurements fail to separate the two species and their hybrids, genetic testing is another tool to identify pallid from shovelnose sturgeon and their hybrids. Genetic testing has been performed on populations of pallid sturgeon from the Missouri, middle Mississippi, and Atchafalaya Rivers but no comprehensive assessment has been performed range-wide, and specifically on the lower Mississippi River.

Due to the difficulty in separating the rare pallid sturgeon from the darker, more common, and commercially harvested shovelnose sturgeon, a Similarity of Appearance (SOA) rule was passed in 2010 (75 FR 53598-53606) making it illegal to harvest shovelnose sturgeon in areas where it occurs sympatrically with pallid sturgeon. The SOA was supported by higher mortality rates of pallid sturgeon where commercial fishing for shovelnose sturgeon was allowed (Columbo et al. 2007, Killgore et al. 2007b), and documented take of pallid sturgeon by commercial fishers (Bettoli et al. 2008). Recreational fishing for shovelnose sturgeon was not affected by this ruling.

Historic Range and Population Level

Pallid sturgeon are found throughout the Missouri River, the middle and lower Mississippi River, and in several larger tributaries including the Yellowstone, Platte, Kansas, St. Francis, Yazoo, Big Sunflower, and Atchafalaya Rivers (Lee et al. 1980a, Kallemeyn 1983, Ross and Brenneman 1991). Historically, pallid sturgeon populations were considered higher in the Missouri and Atchafalaya Rivers than in the Mississippi River (USFWS 1993, Etnier and Starnes 1993, Constant et al. 1997), but were "nowhere common" (Bailey and Cross 1954, Kallemeyn 1983). However, more recent sampling indicates significant pallid sturgeon populations exist in the lower Mississippi River (Killgore et al. 2007a).

Rarity of the pallid sturgeon is indicated by the paucity of records in the early scientific literature. The original taxonomic description was based on nine specimens collected near the mouth of the Illinois River (Forbes and Richardson 1905). In the next half-century, it was "definitively reported" only from the mouth of the Missouri River and the Mississippi River at Keokuk, Iowa. Re-description of the species was based on 17 specimens from 8 localities

(Bailey and Cross 1954). Occurrences in regional fish references are typically based on anecdote (Harland and Speaker 1951), sporadic occurrence (Cross and Collins 1975), or fewer than 5 voucher specimens (Cook 1959, Douglas 1974, Robison and Buchanan 1988, Ross and Brenneman 1991, Etnier and Starnes 1993).

Earlier collection records compiled for a 70-year period totaled only 250 observations (Kallemeyn 1983). Approximately 76 percent of those were from the Missouri River in Montana and the Dakotas, and most were from reservoirs constructed during the 1950's and 1960's. Only 13 specimens were confirmed from the lower Mississippi River prior to 1983. Since then, a relatively large population (over 100 specimens) has been documented in the Atchafalaya (Constant et al. 1997). More recent sampling efforts in the middle and lower Mississippi River indicate the presence of a significant population of pallid sturgeon with a substantial number of wild (non-hatchery origin) fish. Hatchery cultured pallid sturgeon have been released into the Missouri and Mississippi Rivers since 1994 and have been found inhabiting the middle and lower Mississippi River. Since 1997, more than 200 pallid sturgeon have been collected from more than 100 sites in the Mississippi River from its confluence with the Missouri River to New Orleans, Louisiana (Killgore et al. 2007a). When listed, there were only 28 recognized records of pallid sturgeon from the Mississippi River, with no recognized records from the Atchafalaya River (USFWS 2009).

Habitat and Reasons for Decline

Pallid sturgeon, like shovelnose sturgeon, inhabit comparatively large flowing rivers; but pallid sturgeon occur over a narrower range of conditions. They prefer greater turbidity (Bailey and Cross 1954, Lee 1980a; 1980b), finer substrates, and deeper, wider channels. They are more likely than shovelnose sturgeon to occur in sinuous reaches and near long-established islands and alluvial bars (Bramblett 1996). Pallid sturgeon typically inhabit thalwegs and channels of relatively low slope (Constant et al. 1997). Characteristic depths inhabited by pallid sturgeon vary among populations and with river morphometry, but fish typically avoid shallow waters. In the Atchafalaya River, pallid sturgeon inhabited depths of 23 to 69 feet (Constant et al. 1997). In the Middle Mississippi River, trawling studies indicated that young-of-year sturgeon (*Scaphirhynchus* spp.) may prefer low velocity habitats adjacent to the Main Channel (*e.g.*, dikes, side channels), whereas, larger sturgeon use a broader range of habitats (Phelps et al. 2010).

Rarity of the pallid sturgeon makes it difficult to document habitat-related declines in populations. However, declining populations and range reductions of paddlefish and shovelnose sturgeon suggest that populations of pallid sturgeon are similarly impacted (Kallemeyn 1983). Reduced numbers and possible extirpations are indicated in Kansas and in Missouri and are attributed to anthropogenic regulation of river flows (Cross and Moss 1987, Pflieger and Grace 1987). Dams block movements of pallid sturgeon, which may have home ranges greater than 185 miles; and populations become segregated and fragmented (Keenlyne et al. 1994, Bramblett

1996). Impoundments also create lentic environments, which are avoided by pallid sturgeon (Constant et al. 1997). Impoundments also reduce discharge, variation in discharge, erosion, turbidity, and presence of fine substrates, all of which are habitat factors to which the pallid sturgeon is specifically adapted (Bailey and Cross 1954, Cross and Moss 1987).

Reduced turbidity of water and a prevalence of coarse substrates are believed to reduce feeding efficiency of the pallid sturgeon. Population declines may be attributed to lowland rivers that have become more like upland rivers, resulting in possible competition with more adaptable, but biologically similar species (Pflieger and Grace 1987, Ruelle and Keenlyne 1994). Length-weight relationships for pallid sturgeon in the upper Missouri River suggest that fish of a given size were heavier prior to completion of reservoirs than after the reservoirs were established (Keenlyne and Maxwell 1993).

Water pollution may also have impacted pallid sturgeon populations. Long-lived, bottom-feeding fishes can bioaccumulate heavy metals and organic pesticides in their tissues. In the Missouri River, pallid sturgeon with high concentrations of mercury, cadmium, selenium, PCB's, DDT's, chlordane, and dieldrin are documented (Ruelle and Keenlyne 1993). These substances accumulate in multiple organ systems including the kidney, liver, and ovaries. High concentrations are associated with lower growth rates and decreased standing crops of fish. Several of these contaminants are concentrated in egg tissues and may impair successful reproduction.

Altered habitats reduce isolating mechanisms of sympatric species, and abundance of the two sturgeon species are disparate. Both factors reduce likelihood of intraspecific matings of pallid sturgeon and increase the likelihood of interspecific hybridization. Although some estimates of relative abundance of pallid to shovelnose sturgeon are as high as 1:5 (Etnier and Starnes 1993), most estimates are much lower, 1:20 to 1:400 (Kallemeyn 1983, Carlson et al. 1985). Killgore et al. (2007a) collected more than 6,200 sturgeon in the middle and lower Mississippi River with an average ratio of approximately 1 pallid for every 27 shovelnose sturgeon.

Recent studies have shown evidence of hybridization between pallid and shovelnose sturgeon in the lower and middle Mississippi River (Campton et al. 2000, Tranah et al. 2004, Schrey et al. 2007). Values for morphological and meristic characters of the hybrids are intermediate between those of shovelnose and pallid sturgeon. Hybrids also demonstrate intermediate growth rates and levels of piscivory when compared with those of the parent species. Historically, the documented percentage of sturgeon hybrids has varied considerably (Keenlyne et al. 1994b). More recent studies (Schrey at al. 2007) indicate these hybrids are not intermediate in all morphomeristic characters suggesting that they are not F1 hybrids (*i.e.,* first generation offspring of two different species).

Commercial fishing may also impact pallid sturgeon. Historically, river sturgeon were occasionally targeted by commercial fishermen and were frequently obtained as bycatch. Large specimens, including pallid sturgeon, were exploited for caviar, and smaller specimens, including shovelnose sturgeon, were discarded as nuisances (Carlander 1969, Moos 1978). Commercial fishing is believed to have contributed to declines of both species since the early 20th century (Colombo et al. 2007). To eliminate potential impacts to pallid sturgeon from commercial fishing, a Similarity of Appearance rule was passed in 2010 (75 FR 53598-53606) making it illegal to harvest shovelnose sturgeon in areas where it occurs sympatrically with pallid sturgeon. This rule eliminates the chance of any pallid sturgeon being mis-identified and harvested as a shovelnose sturgeon.

Life History

Pallid sturgeon are large, long-lived, and slow to mature. They attain sizes of 65 inches total length and 68 pounds, although adult sizes of 23 to 35 inches total length are probably typical (Carlander 1969, Lee 1980a, Kallemeyn 1983). The age of one individual (approximately 59 inches total length) and 37 pounds was estimated at 41 years. Pallid sturgeon probably attain greater ages than this (Keenlyne et al. 1992). Age of sexual maturity is 5 to 7 years for males and 9 to 12 years for females, but first spawning may not begin until age 15 to 17 years or later (Keenlyne and Jenkins 1993). Sex ratios may be skewed. Females outnumbered males 2:1 throughout the Missouri and Mississippi Rivers (Carlson et al. 1985), but 13 specimens collected in the middle Mississippi River consisted of 12 males and 1 undetermined individual (R. Sheehan, personal communication). Fecundity, however, is high. One very large female contained 170,000 eggs, approximately 11 percent of her body weight (Keenlyne et al. 1992).

Age and growth of pallid sturgeon in the middle and lower Mississippi River has been examined by Killgore et al. (2007b). Pallid sturgeon in the middle Mississippi River grew faster for a given age compared to populations in the lower Mississippi River. However, higher mortality rates and little to no recruitment of pallid sturgeon was found in the middle Mississippi River while in the lower Mississippi River mortality rates were low and recruitment was evident due to the presence of young sturgeon not of hatchery origin.

Pallid sturgeon spawning in the wild has never been observed (Kallemeyn 1983), but they are suspected to scatter their adhesive eggs over coarse gravel or rocky substrates in shallow areas of rivers like all other freshwater sturgeon (Wildhaber et al. 2007). Based on apparent reproductive conditions of adults, the spawning season is believed to be during spring, initiation dependent upon latitude and timing of proximate cues like spring runoff. It is presumed to take place during high water. Spawning probably begins in March in the lower Mississippi and Atchafalaya Rivers, late April or early May in the lower Missouri and middle Mississippi Rivers, and late May or early June in the upper Missouri River (Keenlyne and Jenkins 1993).

Only a few pallid sturgeon larvae have been collected in the wild, but advances in telemetry technology and techniques for collecting eggs, embryos, and larvae in the field have afforded researchers with many new insights into reproductive behavior (DeLonay et al. 2007; Hrabik et al. 2007; Simpkins and LaBay 2007). Radio tagged shovelnose sturgeon that showed gonadal development and physiological characteristics which indicated that they were ready to spawn, moved upstream, spawned, and moved downstream (DeLonay et al. 2007). Also, benthic sampling at the downstream ends of sand bars in the Mississippi River has captured pallid, shovelnose, and suspected hybrid sturgeon larvae (Hrabik et al. 2007). In the Missouri River, egg mats have been used to successfully collect sturgeon eggs from locations where reproductively mature shovelnose sturgeon were tracked using radio telemetry (Simpkins and LaBay 2007). In the middle Mississippi River, shovelnose sturgeon fecundity averages 29,573 eggs per female, and it was documented that age at maturity was 8 years for males and 9 years for females, spawning occurs every 2-3 years, and larvae grow rapidly up to 1.7mm/day (Tripp et al. 2009).

Growth during the first year is rapid. At one year of age, pallid sturgeon are approximately 11 inches total length and weigh just over 1 ounce. They grow an additional 4 inches per year during the following 3 years, and 1.2 to 2.4 inches per year after age 5 (Kallemeyn 1983). From approximately age 2 to 6, weight increases 2.1 to 8.8 ounces per year; in larger (>26.4 inches total length), older fish, weight increases more than 12.3 ounces per year (Keenlyne and Maxwell 1993). Several studies have estimated growth rates from pallid sturgeon captured in the wild (Carlander 1969; Kallemeyn 1983; Yerk and Baxter 2002; Killgore et al. 2007b). Growth rates of pallid sturgeon have been documented in hatcheries (Bollig 1998; USFWS 2007). The recapture of Passive Integrated Transponder (PIT)-tagged individuals is providing data for following growth of stocked fish in the wild (Peters and Parham 2008).

Pallid sturgeon, like shovelnose sturgeon, feed on aquatic insects, but unlike shovelnose sturgeon, also consume significant quantities of fishes (Carlson et al. 1985, Gerrity et al. 2005, Gerrity et al. 2006, Wanner 2007, Hoover et al. 2007). Also, as pallid sturgeon grow, fish become a progressively more important food item (Wanner 2007, Grohs 2008). One of the most common groups of fish prey for pallid sturgeon are river chubs belonging to the *Macrhybopsis* genus. These fish are bottom-oriented fishes occupying swift currents over sand and gravel substrates in medium to large, turbid rivers, which is very similar to habitat preferred by pallid sturgeon. Plant material is also frequently ingested but in small quantities.

Additional Data

General and project specific permits issued by the USACE recognize potential dredging-related risks to spawning pallid sturgeon. Dredging is prohibited during presumed "windows" of pallid sturgeon reproduction, 1 April through 30 June in Memphis, Vicksburg, and New Orleans districts.

Observations support previous studies demonstrating that pallid sturgeon occupy midchannels and deeper water more frequently than do shovelnose sturgeon, which are more likely to occur in shallower, near-shore waters (Moos 1978, Bramblett 1996, Constant et al. 1997). However, neither species of sturgeon are likely to occur in Mud Ditch, which empties into the Mississippi River, or upstream tributaries. Surveys conducted in the New Madrid Floodway during the summer and fall of 1997 and spring of 1998 (Sheehan et al. 1998) did not produce any adult or larval pallid sturgeon. Similarly, no sturgeon were collected in 2007-2008 (Killgore et al., unpublished data) in Mud Ditch, St. Johns Basin, and New Madrid Basin using gill nets, hoop nets, electroshocking, and seines (Table 1).

Evaluation of Potential Impact

Project-related impacts to the pallid sturgeon population in the lower Mississippi River are not anticipated for any habitats typically utilized by pallid sturgeon. Pallid sturgeon are a main channel species avoiding backwaters and small tributaries, although one pallid was recaptured in the Obion River (Killgore et al. 2007a). They inhabit deep thalwegs with hard-packed, sandy substrate, or channel border areas with steep shorelines near fast water, including dikes. Spawning occurs over gravel bars or possibly other hard substrates (*e.g.*, riprap stones) in fast-flowing waters. These habitats do not coincide with any locations in the project area. No sturgeon were collected in the New Madrid Floodway ditches or inundated land during surveys in the summer and fall of 1997 and spring of 1998 (Sheehan et al. 1998). As mentioned previously, during multiple sampling efforts from 2007-2008, shovelnose or pallid sturgeon were not collected in the lowermost reaches of Mud Ditch, which contains a direct connection to the Mississippi River, or in any other tributary in the St. Johns-New Madrid Basin. Despite the apparent absence of pallid sturgeon in the project area and lack of suitable spawning habitat, sturgeon could enter the mouth of Mud Ditch for feeding purposes. However, sturgeon are rarely documented in tributaries, and one of the primary forage items eaten by pallid sturgeon are river chubs belonging to the *Macrhybopsis* genus. Chubs are bottom-oriented fishes occupying swift currents over sand and gravel substrates in medium to large, turbid rivers similar to habitats preferred by pallid sturgeon (Pflieger 1997). Although an occasional *Macrhybopsis* may be found in the ditches within the project area (Table 1), these ditches are not suitable spawning habitat as they are mostly straight and sediment-laden, with little flow most of the year.

CONCLUSION

Based on currently available biological and ecological data, a review of published and unpublished literature and studies, communications with experts, and findings of recent USACE investigations, USACE has determined that the proposed actions may affect, but are not likely to adversely affect the federally endangered species of interior least tern and pallid sturgeon as well as sensitive species such as the bald eagle. Although no surveys were conducted specifically for bald eagle nests, multiple habitat assessments were conducted for the EIS and did not reveal any nests in the proposed construction footprint. If any active bald eagle nests are discovered in the proposed footprint prior to construction, avoidance measures and minimum work distances would be adhered to in accordance with the National Bald Eagle Management Guidelines.

LITERATURE CITED

Aleev, Y. G. 1963. Function of gross morphology in fishes. Academy of Sciences of the USSR, Moscow. Israeli Program for Scientific Translations, M. Raveh (translator) and H. Mills (editor), Keter Press, Jerusalem. 1773 pp.

Bailey, R. M. and B. Cross. 1954. River sturgeons of the American genus *Scaphirhynchus*: characters, distribution, and synonymy. Papers of the Michigan Academy of Science, Arts, and Letters 39:169-208.

Baker, J.A., J.K. Killgore, and R.L. Kasul. 1991. Aquatic habitats and fish communities in the Lower Mississippi River. Reviews in Aquatic Sciences 3:313-356.

Banks, R. C., C. Cicero, J. L. Dunn, A. W. Kratter, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising, and D. F. Stotz. 2006. Forty-seventh supplement to the American Ornithologists Union' Checklist of North American Birds. Auk 123:926-936.

Beckett, D.C. and C.H. Pennington. 1986. Water quality, macroinvertebrates, larval fishes, and fishes of the Lower Mississippi River: A synthesis. Technical Report E-86-12, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi.

Bettoli, P.W., M. Casto-Yerty, G.D. Scholten, and E.J. Heist. 2008. Bycatch of the endangered pallid sturgeon (*Scaphirhynchus albus*) in a commercial fishery for shovelnose sturgeon (*Scaphirhynchus platorynchus*). Journal of Applied Ichthyology (2008): 1-4.

Bollig, H. 1998. Fiscal year 1998 sturgeon activities and accomplishments. Gavins Point National Fish Hatchery, Yankton, South Dakota.

Bramblett, R. G. 1996. Habitats and movements of pallid and shovelnose sturgeon in the Yellowstone and Missouri Rivers, Montana and North Dakota. Ph.D. thesis, Montana State University, Bozeman, Montana. 210 pp.

Bridge, E. S., A. W. Jones and A. J. Baker. 2005. A phylogenetic framework for the terns (Sternini) inferred from mtDNA sequences: implications for taxonomy and plumage evolution. Molecular Phylogenetics and Evol. 35:459-469.

Burleigh, T.D. and G. H. Lowery, Jr. 1942. An Inland Race of *Sterna albifrons*. Museum of Zoology, Occasional Papers, No. 10:173-177, Louisiana State University.

Campton, D. E., A. L. Bass, F. A. Chapman, and B. W. Bowen. 2000. Genetic distinction of pallid, shovelnose, and Alabama sturgeon: emerging species and the US Endangered Species Act. Conservation Genetics 1:17-32.

Carlander, K. D. 1969. Handbook of Freshwater Fishery biology. Vol.1. Iowa State University Press, Ames. 752 pp.

Carlson, D. M. , W. L. Pflieger, L. Trial, and P. E. Haverland. 1985. Distribution, biology, and hybridization of *Scaphirhynchus albus* and *S. platorynchu*s in the Missouri and Mississippi Rivers. Environmental Biology of Fishes 14:51-59.

Colombo, R.E., J. E. Garvey, N. D. Jackson, R. Brooks, D. P. Herzog, R. A. Hrabik, and T. W. Spier. 2007. Harvest of Mississippi River sturgeon drives abundance and reproductive success: a harbinger of collapse? Journal of Applied Ichthyology 23:444-451.

Constant, G. C., W. E. Kelso, D. A. Rutherford, and C. F. Bryan. 1997. Habitat, movement, and reproductive status of pallid sturgeon (*Scaphirhunchus albus*) in the Mississippi and Atchafalaya Rivers. Report prepared for the U.S. Army Engineer New Orleans District. 78 pp.

Cook, F. A. 1959. Freshwater Fishes in Mississippi. Mississippi Game and Fish Commission, Jackson, Mississippi, 237 pp.

Cross, F. T. and J. T. Collins. 1975. Fishes in Kansas. University of Kansas Press, Lawrence, Kansas. 189 pp.

Cross, F. T. and R. E. Moss. 1987. Historic changes in fish communities and aquatic habitat in plains streams of Kansas. pp. 155-165, in Community and Evolutionary Ecology of North American Stream Fishes, W. J. Matthews and D. C. Heins (editors), University of Oklahoma Press, Norman, Oklahoma.

Deacon, J. E., E. G. Kobetich, J. D. Williams, S. Conteras, and others. 1979. Fishes of North America endangered, threatened or of special concern: 1979. Fisheries 4:29-44.

DeLonay, A. J., D. M. Papoulias, M. L. Wildhaber, M. L. Annis, J. L. Bryan, S. A. Griffith, S. H. Holan, and D. E. Tillitt. 2007. Use of behavioral and physiological indicators to evaluate *Scaphirhynchus* sturgeon spawning success. Journal of Applied Ichthyology 23:428-435.

Douglas, N. H. 1974. Freshwater Fishes of Louisiana. Claitor Publishing Company, Baton Rouge, Louisiana. 443 pp.

Downing, R. L. 1980. Survey of interior least tern nesting populations. American Birds 34:209- 211.

Dugger, K. M. 1997. The foraging ecology and reproductive success of least terns nesting on the lower Mississippi River. Ph. D. Dissertation. University of Missouri, Columbia. 137 pp.

Etnier, D. A. and W. C. Starnes. 1993. The Fishes of Tennessee. University of Tennessee, Knoxville, Tennessee. 681 pp.

Faanes, C. A. 1983. Aspects of nesting ecology of least terns and piping plovers in central Nebraska. Prairie Naturalist, 15,145-154.

Forbes, S. A. and R. E. Richardson. 1905. On a New Shovelnose Sturgeon from the Mississippi River. Bulletin III. State Laboratory of Natural History 7:37-44.

Gerrity, P. C., C. S. Guy, and W. M. Gardner. 2005. Habitat use, diet, and growth of hatchery-reared juvenile pallid sturgeon and indigenous shovelnose sturgeon in the Missouri River above Fort Peck Reservoir, Montana. Upper Basis Pallid Sturgeon, 2004 Annual Report, Helena, Montana.

Gerrity, P. C., C. S. Guy, and W. M. Gardner. 2006. Juvenile pallid sturgeon are piscivorous: a call for conserving native cyprinids. Transactions of the American Fisheries Society 135:604-609.

Grohs, K. L. 2008. Macroinvertebrate composition and patterns of prey use by juvenile pallid sturgeon (*Scaphirhynchus albus*) in the Missouri River, South Dakota and Nebraska. Masters Thesis. South Dakota State University.

Hardy, J. W. 1957. The Least Tern in the Mississippi Valley. Publication of the Museum, Michigan State University, East Lansing. Biology Series 1(1):1-60.

Harland, J. R. and E. B. Speaker. 1951. Iowa Fish and Fishing, Second Edition. Iowa State Conservation Commission, DesMoines, Iowa. 238 pp.

Hoover, J. J., S. G. George and K. J. Killgore. 2007. Diet of shovelnose sturgeon and pallid sturgeon in the free-flowing Mississippi River. Journal of Applied Ichthyology 23 (2007), 494-499.

Hrabik, R. A., D. P. Herzog, D. E. Ostendorf, and M. D. Petersen. 2007. Larvae provide first evidence of successful reproduction by pallid sturgeon, *Scaphirhynchus albus*, in the Mississippi River. Journal of Applied Ichthyology 23:436-443.

Kallemeyn. L. 1983. Status of the Pallid Sturgeon. Fisheries 8:3-9.

Keenlyne, K. D., E. M. Grossman, and L. G. Jenkins. 1992. Fecundity of the pallid sturgeon. Transactions of the American Fisheries Society 121:139-140.

Keenlyne, K. D. and L. G. Jenkins. 1993. Age at sexual maturity of the pallid sturgeon. Transactions of the American Fisheries Society 122:393-396.

Keenlyne, K. D. and S. J. Maxwell. 1993. Length conversions and length-weight relations for pallid sturgeon. North American Journal of Fisheries Management 13:395-397.

Keenlyne, K. D., C. J. Henry, A. Tews, and P. Clancy. 1994a. Morphometric comparisons of upper Missouri River sturgeons. Transactions of the American Fisheries Society 123:779-785.

Keenlyne, K. D., L. K. Graham, and B. C. Reed. 1994b. Hybridization between the pallid and shovelnose sturgeons. Proceedings of South Dakota Academy of Science 73:59-66.

Killgore, K. J., J. J. Hoover, S. G. George, B. R. Lewis, C. E. Murphy and W. E. Lancaster. 2007a. Distribution, relative abundance and movements of pallid sturgeon in the free-flowing Mississippi River. Journal of Applied Ichthyology 23 (2007), 476-483.

Killgore, K. J., J. J. Hoover, J. P. Kirk, S. G. George, B. R. Lewis and C. E. Murphy. 2007b. Age and growth of pallid sturgeon in the free-flowing Mississippi River. Journal of Applied Ichthyology 23 (2007), 452-456.

Kuhajda, B.R., R.L. Mayden, and R.M. Wood. 2007. Morphological comparisons of hatchery-reared specimens of Scaphirhynchus albus, S. platorynchus, and S. albus x S. platorynchus hybrids (Acipenseriformes: Acipenseridae). Journal of Applied Ichthyology 23 (2007), 324-347.

Lee, D. S. 1980a. *Scaphirhynchus albus* (Forbes and Richardson), Pallid Sturgeon. p. 43 in D. S. Lee, et al., Atlas of North American Freshwater Fishes, North Carolina State Museum of Natural History, Raleigh, North Carolina. 854 pp.

Lee, D. S. 1980b. *Scaphirhynchus platorynchus* (Rafinesque), Shovelnose Sturgeon. p. 44 in D. S. Lee, et al., Atlas of North American Freshwater Fishes, North Carolina State Museum of Natural History, Raleigh, North Carolina. 854 pp.

Liebelt, J. E. 1996. Lower Missouri River and Yellowstone River pallid sturgeon study, 1994-1995 report. Western Area Power Administration Grant Report No. BAO-709. 57 pp.

Lott, C.A. 2006. Distribution and Abundance of the Interior Population of the Least Tern (Sternula antillarum), 2005; A Review of the First Complete Range-Wide Survey in the Context of Historic and Ongoing Monitoring Efforts, ERDC/EL TR-06-13. U.S. Army Corps of Engineer Research and Development Center, Vicksburg, MS.

Moos, R. E. 1978. Movement and reproduction of shovelnose sturgeon *Scaphirhynchus platorynchus* (Rafinesque) in the Missouri River, South Dakota. Ph.D. Dissertation, University Of South Dakota, Vermillion. 213 pp.

Moseley, L. J. 1976. Behavior and Communication in the Least Tern (*Sterna albifrons*). Ph.D. Dissertation, University of North Carolina, Chapel Hill. 164pp.

Murphy, C. E., J. J. Hoover, S. G. George, and K. J. Killgore. 2007. Morphometric variation among river sturgeons (*Scaphirhynchus* spp.) of the Middle and Lower Mississippi River. Journal of Applied Ichthyology 23 (2007), 313-323.

Peters, E. J., and J. E. Parham. 2008. Ecology and management of sturgeon in the lower Platte River, Nebraska. Nebraska Game and Parks Commission, Nebraska Technical Series No. 18, Lincoln, Nebraska.

Pflieger, W. T. and T. B. Grace. 1987. Changes in the fish fauna of the Missouri River, 1940-1983. pp.166-177 *In* Community and Evolutionary Ecology of North American Stream Fishes, W. J. Matthews and D. C. Heins (editors), University of Oklahoma Press, Norman, Oklahoma.

Pflieger, W.T. 1997. The Fishes of Missouri. Missouri Dept. of Conservation, Jefferson City, MO, 372 pp.

Phelps, S. R. and F. W. Allendorf. 1983. Genetic identity of pallid and shovelnose sturgeon (*Scaphirhynchus albus* and *S. platorynchus*). Copeia 1983:696-700.

Phelps, Q.E., S. J. Tripp, J.E. Garvey, D. P. Herzog, D.E. Ostendorf, J.W. Riddings, J.W. Crites, and R.A. Hrabik. 2010. Habitat use during early life history infers recovery needs for shovelnose sturgeon and pallid sturgeon in the Middle Mississippi River. Transactions of the American Fisheries Society 139: 1060-1068.

Robinson, J. S. 1972. Population sampling of commercial fish in waters open to commercial fishing. Missouri Department of conservation, Project 4-3-R-7, Work Plan 21, Job 2, Jefferson City, Missouri, USA.

Robison, H. W. and T. M. Buchanan. 1988. Fishes of Arkansas. University of Arkansas, Fayetteville, Arkansas, 535 pp.

Ross, S. T. and W. M. Brenneman. 1991. Distribution of freshwater fishes in Mississippi. Mississippi Department of Wildlife, Fisheries and Parks, D-J Project F-69 Completion Report, Jackson, Mississippi, 548 pp.

Ruelle, R. and K. D. Keenlyne. 1993. Contaminants in Missouri River pallid sturgeon. Buelletin of Environment, Contamination, and Toxicology 50:898-906.

Ruelle, R. and K. D. Keenlyne. 1994. The suitability of shovelnose sturgeon as a surrogate for pallid sturgeon. Proceedings of South Dakota Academy of Science 73:67-81.

Sheehan, R. J., R. C. Heidinger, and P. S. Wills. 1998. St. Johns Basin and New Madrid Floodway Fisheries Survey: Final Report submitted to the U.S. Army Corps of Engineers, Memphis District by the Cooperative Fisheries Research Laboratory and Department of Zoology, Southern Illinois University at Carbondale, Illinois. 39 pp.

Schrey, A. W., B. L. Sloss, R. J. Sheehan, R. C. Heidinger, and E. J. Heist. 2007. Genetics discrimination of middle Mississippi River *Scaphirhynchus* sturgeon into pallid, shovelnose, and putative hybrids with multiple microsatellite loci. Conservation Genetics 8:683-693.

Simpkins, D. G., and S. R. LaBay. 2007. Site-specific assessment of spawning behavior and habitat use. Pages 217-255 *in* C. E. Korschgen, editor. Factors Affecting the Reproduction, Recruitment, Habitat, and Population Dynamics of Pallid Sturgeon and Shovelnose Sturgeon in the Missouri River. U.S. Geological Survey, Reston, Virginia.

Smith, J. W. and R. B. Renken. 1990. Improving the status of endangered species in Missouri: Least tern investigations. Final report, Jobs 1 and 2, Missouri Department of Conservation. Endangered Species Project No. SE-01-19.

Smith, J. W. and R. B. Renken. 1991. Least Tern Nesting Habitat in the Mississippi River Valley Adjacent to Missouri. Journal of Field Ornithology 62(4):497-504.

Smith, J. W. and N. P. Stuckey. 1988. Habitat management for interior least terns: problems and opportunities in inland waterways. Pages 134-149 *in* M.C. Landin, ed. Inland Waterways: Proceedings national workshop on the beneficial uses of dredged material. TRD-88-8.

Tibbs, J. E., and D. A. Galat. 1998. The influence of river stage on endangered least terns and their fish prey in the Mississippi River (USA). Regulated Rivers: Research & Management 00:0-00 (1998). 10 pp.

Tranah, G. J., D. E. Campton, and B. May. 2004. Genetic evidence for hybridization of pallid and shovelnose sturgeon. Journal of Heredity 95(6):474-480.

Tripp, S.J., Q.E. Phelps, R.E. Colombo, J.E. Garvey, B.M. Burr, D.P. Herzog, and R.A. Hrabik. 2009. Maturation and reproduction of shovelnose sturgeon in the middle Mississippi river. North American Journal of Fisheries Management 29: 730-738.

USACE. 1986. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Greeneville, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1987a. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Greeneville, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1987b. Recent Findings of Interior Least Terns in Historical Ranges on the Lower Mississippi River. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1988. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1989. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1990. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1991. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1992. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1993. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1994. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1997. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1998a. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 1998b. Mississippi River Mainline Levees Enlargement and Seepage Control, Supplement No. 1 to the Final Environmental Impact Statement, Mississippi River and Tributaries Project Mississippi River Levees and Channel Improvement. Prepared by the Memphis District, New Orleans District, and Vicksburg District, U.S. Army Corps of Engineers.

USACE. 1999a. Biological Assessment, interior population of the least tern (*Sterna antillarum*): Regulating Works Project, Upper Mississippi River (river miles 0-195) and Mississippi River and Tributaries Project, Channel Improvement Feature, Lower Mississippi River (river miles 0-954.5, AHP). U.S. Army Corps of Engineers, Mississippi Valley Division/Mississippi River Commission. Vicksburg, MS.

USACE. 1999b. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2000. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2001. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2002. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2003. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Vicksburg, Mississippi. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2004. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Baton Rouge, Lousiana. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2005. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Baton Rouge, Lousiana. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2006. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Baton Rouge, Lousiana. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2007. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Baton Rouge, Lousiana. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2008. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Baton Rouge, Lousiana. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2009. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Baton Rouge, Lousiana. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USACE. 2010. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Baton Rouge, Lousiana. U.S. Army Corps of Engineers, Memphis District, Memphis, TN. Unpublished agency report.

USFWS. 1985. Endangered and threatened wildlife and plants; interior population of the Least Tern to be endangered; final rule. Federal Register 50:21,784-21,792.

USFWS. 1990. Recovery Plan for the interior population of the Least Tern (*Sternula antillarum*). 90 pp.

USFWS. 1993. Pallid Sturgeon Recovery Plan. U.S. Fish and Wildlife Service, Bismark, North Dakota. 55 pp.

USFWS. 1994. The pallid sturgeon determined to be endangered. Federal Register 50:21784-21792.

USFWS. 2007. Pallid sturgeon (*Scaphirhynchus albus*) 5-year review summary and evaluation. U.S. Fish and Wildlife Service, Billings, Montana.

Wanner, G. A., D. A. Shuman, and D. W. Willis. 2007. Food habits of juvenile pallid sturgeon and adult shovelnose sturgeon in the Missouri River downstream of Fort Randall Dam, South Dakota. Journal of Freshwater Ecology 22:81-92.

Weisel, G. F. 1978. The integument and caudal filament of the shovelnose sturgeon, *Scaphirhynchus platorynchus*. American Midland Naturalist. 100:179-189.

Whitman, P. L. 1988. Biology and conservation of the endangered interior least tern: An alternative Review. U.S. Fish and Wildlife Service Biological Report 88(3). 22 pp.

Wildhaber, M. L., and coauthors. 2007. A conceptual life-history model for pallid and shovelnose sturgeon. U.S. Geological Survey, Circular 1315, Reston, Virginia.

Williams, J. E., J.E. Johnson, D. A. Hendrickson, S. Contereas-Balderas, and others. 1989. Fishes of North America endangered, threatened or of special concern: 1989. Fisheries 14:2-20.

Yerk, D. B., and M. W. Baxter. 2002. Lower Missouri and Yellowstone Rivers pallid sturgeon study 2001 annual report. Montana Fish, Wildlife and Parks, Fort Peck, Montana.