5.0 Pallid Sturgeon (*Scaphirynchus albus*)

5.1 Status of the Species

This section presents the biological or ecological information relevant to formulating the biological opinion. Appropriate information on the species' life history, its habitat and distribution, and other data on factors necessary to its survival, is included to provide background for analysis in later sections. This analysis documents the effects of past human and natural activities or events that have led to the current range-wide status of the species. Portions of this information are also presented in listing documents, the recovery plan (USFWS 1993), the Final Biological Opinion for the Operation and Maintenance of the 9-Foot Navigation Channel on the Upper Mississippi River System (USFWS 2000), and the Biological Assessment of the Upper Mississippi River-Illinois Waterway System Navigation Study (USACE 2004).

5.1.1 Species/critical habitat description

The pallid sturgeon (*Scaphirynchus albus*) was listed as an endangered species on September 6, 1990 (55 FR 36641) pursuant to the Endangered Species Act of 1973 (16USC 1531 et seq.) as amended. No critical habitat is designated for this species. The pallid sturgeon was originally described as a species by Forbes and Richardson in 1905. The pallid sturgeon is native to the Missouri and Mississippi Rivers and is adapted to the pre-development habitat conditions that existed in these large rivers. These conditions can generally be described as large, free-flowing, warmwater, turbid habitats with a diverse assemblage of physical attributes that were in a constant state of change (USFWS 1993). Floodplains, backwaters, chutes, sloughs, islands, sandbars and main channel waters formed the large-river ecosystem that provided the macrohabitat requirements for all life stages of pallid sturgeon and other native large-river fish. Today, these habitats and much of the once functioning ecosystem has been changed by human developments.

5.1.2 Life history

The type specimens for identification were collected at or near Grafton, Illinois, on the lower Illinois and Mississippi Rivers (Forbes and Richardson 1905). The species is described as having a flattened, shovel-shaped snout; long, slender, and completely armored caudal peduncle; and lacks a spiracle (Smith 1979). The mouth is toothless, protrusible, and ventrally positioned under the snout, as with other sturgeon. Pallid sturgeon are similar in appearance to the more common and darker shovelnose sturgeon (*S. platyrhynchus*). Pflieger (1975) reported the principal features distinguishing pallid sturgeon from shovelnose sturgeon as the paucity of dermal ossifications on the belly, 24 or more anal fin rays and 37 or more dorsal fin rays. Sexual maturity for males is estimated to be 7 to 9 years, with 2 to 3 year intervals lapsing between spawning events. Females are estimated to reach sexual maturity in 15 to 20 years, with 3 to 10 year intervals between spawning events (Keenlyne and Jenkins 1993). The length of time between spawning events depends partially on the quality and quantity of food available in their natural habitat (Keenlyne and Jenkins 1993). The fecundity of a given female may vary greatly by individual, with most spawning only a few times during a normal life span (Duffy et al. 1996). Spawning appears to be a function of floodflows (increased discharge and velocity) that generate spawning migrations, temperature and interaction with other pallid sturgeon (Steve Krentz, USFWS, pers. comm. 2003). The influence of turbidity and conductivity is unknown

(Steve Krentz, USFWS, pers. comm. 2003). Pallid sturgeon have adhesive eggs, therefore, spawning is thought to occur over hard substrates of gravel or cobble accompanied by moderate flow. At hatching, young pallid sturgeon begin a migration period that may continue for up to 13 days (Kynard et al. 1998). Suitable habitat and forage food must be available after yolk-sac absorption during the initial stages of larvae development. Larval pallid sturgeon have been collected in the Lower Missouri River, Middle Mississippi River and Lower Mississippi River which indicates that limited reproduction is occurring in the wild. In April and May 2001, the Missouri Department of Conservation (MoDOC) collected 40 larval sturgeon utilizing the Missouri benthic trawl (Hrabik 2002). In spring of 2003, the MoDOC collected an estimated 50 larval sturgeon in the MMR (Dave Herzog, MoDOC, pers. comm. 2004). It is unclear at this time how many of these larval sturgeon are pallid sturgeon or hybrids. From April to September 2002, the CMFRO collected 11 YOY sturgeon in Lisbon Bottoms on the Lower Missouri River. Five of these fish were identified as shovelnose sturgeon and six still need to be identified (Grady and Mauldin 2002). A total of eight larval sturgeon (4 in 2002 and 2 in 2003) have been collected in the Lower Missouri River as part of a larval fish sandbar habitat study being conducted by the University of Missouri (Kerry Reeves, Univ. of Missouri, pers. comm. 2003.). Two individuals have been identified to species, one pallid sturgeon and one shovelnose sturgeon, while the remainder awaits positive identification.

Pallid sturgeon feed on benthic macroinvertebrates and drifting invertebrates during early life stages (juveniles) (Modde and Schmulbach 1977, Carlson et al. 1985). However, older juvenile and adult pallid sturgeon are more piscivorous than the shovelnose sturgeon and switch to a diet composed of a greater proportion of fish as they mature.

5.1.3 Population dynamics

A comparison of pallid sturgeon and shovelnose sturgeon catch records provides an indication of the relative population sizes of pallid sturgeon compared to shovelnose sturgeon. At the time of their original description, pallid sturgeon composed 1 in 500 (0.20%) river sturgeon captured in the Mississippi River at Grafton, Illinois (Forbes and Richardson 1905). However, it is not known whether this apparent rarity of pallid sturgeon compared to other sturgeon was indicative throughout the range or only in this part of the Mississippi River. Historical records would indicate that pallid sturgeon were never abundant in the Mississippi River above the mouth of the Missouri River. Carlson et al. (1985) captured 4,355 river sturgeon on the Missouri and Mississippi Rivers. Eleven (0.25 percent) of these were pallid sturgeon.

Upper Missouri River - Duffy et al. (1996) reported that mark and recapture data estimated 50 to 100 adult pallid sturgeon remain in the Missouri River above Fort Peck Dam in Montana (Recovery - priority management area #1[RPMA #1]) and between 200 and 300 adult pallid sturgeon remain between Garrison Dam in North Dakota and Fort Peck Dam, which also includes the Yellowstone River (RPMA#2). More recently, the Upper Basin Recovery Work Group estimated that fewer than the original estimated number of pallid sturgeon still remain, leaving approximately 30 – 50 adult pallid sturgeon in RPMA#1 and between 89 and 236 adult pallid sturgeon in RPMA#2 (Kapuscinski 2003).

The pallid sturgeon sub-population in this river reach is aging and declining in status. The population is estimated at 151 individuals with 95 percent confidence intervals of 89 to 236 individuals (Kapuscinski 2003). This is down from an estimated 166 individuals in 2002 and

178 individuals in 2001. Kapuscinski (2003) estimates that this population of wild pallid sturgeon will be extinct by 2018 based on trend data collected for the period 1991-2003. The Service has interpreted Kapuscinski's conclusion of extinction to mean that this sub-population would be extirpated by 2018.

It should be noted that Kapusinski (2003) compensated for certain assumptions that are necessary for a valid outcome from the original method used to estimate population size (Schnable mark-recapture). Certain assumptions for a valid outcome in the original analysis, which were found to be incorrect, leave insufficient data to inform the present analysis. These include the rate at which tags are shed and the uniformity of effort expended to collect fish. These assumptions result in an overestimation and underestimation, respectively. An additional assumption concerning the rate of mortality during the study period was also found to be incorrect. The original analysis assumed no mortality during the study period. Kapusinski (2003) provided an estimate of natural mortality (10 percent) and subtracted known marked individuals that died during the study. Incorporating these into the analysis to address the mortality assumption resulted in a slightly lower abundance estimate than the estimate obtained from the original analysis.

Krentz (2000) reported capturing 23 pallid sturgeon in 2000 in RPMA#2 at the confluence of the Yellowstone and Missouri Rivers. These fish were primarily collected to obtain broodstock for propagation efforts. Catch rates were calculated for the period from 1998 to 2000. The catch-per-unit-effort (CPUE) for pallid sturgeon was 0.62/hour drifting in 1998, 0.41/hour drifting in 1999 and 1.66/hour drifting in 2000. The CPUE for pallid sturgeon was 1.16/hour drifting in 2001 and 0.80/hour drifting in 2002 (Krentz et al. 2002). However, Krentz (2000) stated that caution should be used in utilizing this information for any analysis of relative abundance as the sampling was not random and productive habitats were targeted.

Yerk and Baxter (2001) reported capturing 17 adult pallid sturgeon in RPMA#2 during 2000. Eight of the adults were untagged fish. They reported that the smallest individual captured was likely a pallid/shovelnose sturgeon hybrid based on its character index value (346.1). Fifteen of these adults were captured in April at the confluence of the Missouri and Yellowstone Rivers. Yerk and Baxter (2001) also reported recapture of three hatchery reared pallid sturgeon.

Kapuscinski and Baxter (2003) summarized the second year results of a 5 year study to investigate pallid sturgeon recovery efforts in RPMA #2. During 2002, they captured 15 adult pallid sturgeon; however, only 3 of these adults were untagged individuals. They noted that the recapture rate (80 percent) was very high compared to previous years (53 percent in 2000 and 2001). Eleven of the 15 adult pallid sturgeon were captured during spring at the confluence of the Missouri and Yellowstone Rivers. The CPUE for pallid sturgeon averaged 0.18 per net drifted and 1.37 per drift hour. This compares to the CPUE of 0.50 per net drifted for 2001 (Yerk and Baxter 2000) and 1.67 per drift hour reported by Krentz (2000). In addition, they captured a total of 6 hatchery reared pallid sturgeon. They reported a catch rate for hatchery reared pallid sturgeon captured in drifted trammel nets of 0.1165/hr compared to 16.19/hr for shovelnose sturgeon (Kapuscinski and Baxter 2003).

<u>Middle Missouri River</u> – Sport anglers have reported up to five pallid sturgeon catches per year on the Missouri River between the headwaters of Oahe Reservoir in North Dakota and Garrison Dam; however, no catches have been reported since 2002. Occasional catches were reported

from the riverine reach above Gavins Point Dam to the Fort Randall Dam, suggesting that perhaps as many as 25 to 50 fish remain in each of these areas. No catches of adults have been reported since 1992. A small population also existed between Oahe Dam and the Big Bend Dam on the Missouri River in South Dakota with perhaps 50 to 100 fish remaining in the upper few miles of the riverine section above the headwaters of Lake Sharpe; however, no catches have been reported since 2001 (Steve Krentz, USFWS, pers. comm. 2003).

<u>Lower Missouri River</u> - Recent records of the pallid sturgeon in the Lower Missouri River from Gavins Point Dam (river mile 811.1) to the mouth of the Platte River (river mile 595.5) are rare. According to the Service's pallid sturgeon database a total of 20 pallid sturgeon have been reported in this reach. Eight of these fish were reported for the unchannelized reach from Gavins Point Dam to Ponca, Nebraska (river mile 753.0). Thirteen of these records were reported prior to 1990. Seven pallid sturgeon have been reported since listing of the species in 1990. The Nebraska Game and Parks Commission has been conducting a study of the ecology of the Missouri River since 1998 by conducting sampling in various sections of the Missouri River including the unchannelized river below Gavins Point Dam and in the channelized river adjacent to Nebraska. In 2000, sturgeon were sampled with a modified benthic trawl. The CPUE averaged 1.54 shovelnose sturgeon in the spring and 0.24 in the summer (Mestl 2001). No pallid sturgeon were collected during this sampling effort. Additional benthic trawl sampling was conducted as part of mitigation site monitoring. This resulted in the collection of 16 shovelnose sturgeon at various locations and one pallid sturgeon which was collected at Goose Island (Mestl 2001). No data were provided concerning the pallid sturgeon in order to note whether this was a wild origin or hatchery reared fish.

During a Mississippi Interstate Cooperative Resources Agencies (MICRA) study from 1996 to 2000 (Grady et al. 2001), 21 pallid sturgeon were collected in the Lower Missouri River and Middle Mississippi River. Of the 9 pallid sturgeon collected in the Lower Missouri River, 7 were presumed to be of wild origin, while 2 were hatchery stocked fish. Of the 12 pallid sturgeon collected in the Middle Mississippi River, 1 was considered a wild origin fish and 11 were considered hatchery stocked fish (Table 6 in Grady et al. 2001). The ratio of wild pallid sturgeon to all river sturgeon collected dropped from 1 in 398 (0.25 percent) collected by Carlson et al. (1985) to 1 in 647 (0.15 percent) (Grady et al. 2001). The contribution of hatchery reared fish is evident as wild and hatchery raised pallid sturgeon accounted for 1 in 247 (0.41 percent) of all river sturgeon (Grady et al. 2001).

In 2001, the Service's Columbia Missouri Fishery Resources Office (CMFRO) began work on the Lower Missouri River Pallid Sturgeon Monitoring and Population Assessment Project. Sampling occurred in 6 reaches along 170 river miles and resulted in collection of 4,110 fish from 11 families with 77 trawl hauls and 12 net nights (Doyle et al. 2002). No pallid or hybrid sturgeon were collected, however, 198 shovelnose sturgeon and 2 lake sturgeon were collected. Fourteen YOY sturgeon were collected. While 4 of these have been identified as shovelnose sturgeon, 10 have not yet been identified to species (Doyle et al. 2002). In 2002, the CMFRO sampled 6 reaches along 200 river miles. Among the 27,903 fish collected were 12 pallid sturgeon, 12 pallid/shovelnose hybrids, 3,044 shovelnose sturgeon and 28 lake sturgeon (Doyle and Starostka 2003). Five of the pallid sturgeon were classified as juveniles. While four of these fish were from recent stocking of hatchery reared fish, one was presumed to be wild (Doyle and Starostka 2003). According to Doyle and Starostka (2003) pallid sturgeon continue to decline at a rapid rate. Within the 200 river miles they sampled, the ratio of pallid sturgeon compared to all river sturgeon decreased from 1:311 (0.32%) in the 1996-2000 MICRA study to 1:387 (0.26%) in 2002. It should be noted, however, that the sampling effort in 2002 does not reflect the same sampling effort or gear utilized during the MICRA study which was completed over a period of five years.

From January 2000 through March 2001, the CMFRO collected information on seasonal fish abundance and species composition in the area of the Highway 19 bridge replacement at Hermann, Missouri. They collected over 3000 fish including 3 pallid sturgeon, 14 hybrids and 1990 shovelnose sturgeon (Milligan 2002).

Middle Mississippi River (Upper Mississippi River miles 196.0 to 0.0) - In May 2002 the Corps' St. Louis District initiated a three year Pallid Sturgeon Habitat and Population Demographics study in the Middle Mississippi River (MMR). The study is being carried out by staff from the Corps' Waterways Experiment Station, the Missouri Department of Conservation (MoDOC), and SIUC. By May 2003, a total of 41 pallid sturgeon and 3,636 shovelnose sturgeon had been collected from throughout the MMR (USACE 2003a). The ratio of pallid sturgeon compared to shovelnose sturgeon (1:89) is much higher than in other parts of the pallid sturgeon's range. As of March 2004, a total of 58 pallid sturgeon have been collected in the MMR as part of this study (Jack Killgore, USACE, pers. comm. 2004). It is conservatively estimated that approximately 60 percent of these pallid sturgeon are MoDOC hatchery reared fish released in 1994 and 1997 (Dave Herzog, MoDOC, pers. comm. 2003). It is also possible that the higher of pallid sturgeon to shovelnose sturgeon may be a result of declining numbers of shovelnose sturgeon due to commercial harvest of sturgeon flesh and roe (Dave Herzog, MoDOC, pers. comm. 2003). In 2003, the Illinois Department of Natural Resources (IDNR) collected 9 pallid sturgeon while sampling for shovelnose sturgeon in the Chain of Rocks area (river miles 189.0 to 185.0) of the MMR (Rob Maher, IDNR, pers. comm. 2003), possibly indicating this is a staging area for sturgeon spawning. This is further substantiated by the recent collection of 7 pallid sturgeon in the Chain of Rocks area by SIUC and IDNR. This includes one female thought to have black eggs (Jim Garvey, SIUC, pers. comm. 2004).

Lower Mississippi River and Atchafalaya River - During sampling in 2001, Hartfield et al. (2002) collected 383 shovelnose sturgeon (58 – 725 mm), 11 pallid sturgeon (203-785 mm) and 3 intermediates. In 2003 trawling efforts resulted in the collection of 78 shovelnose sturgeon, 5 pallid sturgeon and one intermediate near Vicksburg, Mississippi (Hartfield et al. 2004). In late 2000 and early 2001, biologists collected a total of 83 pallid sturgeon and 109 hybrid sturgeon during sampling at the Old River Control Structure at the junction of the Mississippi and Atchafalaya Rivers in Louisiana (Reed 2002). A new 4-year pallid sturgeon study was initiated in 2001 which has thus far resulted in collection of 74 sturgeon. Of these, 11 were pallid sturgeon and 20 were classified as hybrids (Reed 2002).

Since 1997, the Corps of Engineers, Waterways Experiment Station has been collecting pallid sturgeon in the Lower Mississippi River, with a formal study being initiated in 2000 (Killgore 2004). A total of 2,590 shovelnose sturgeon and 115 pallid sturgeon have been collected to date. This yields a pallid sturgeon to shovelnose sturgeon ratio of 1:23 (Killgore 2004) which is a much higher ratio of pallid sturgeon than what occurs in the rest of the range of the species.

5.1.4 Status and distribution

The pallid sturgeon was listed because a review of the literature showed a sharp decline in pallid sturgeon observations over the range of the species and especially so in the Missouri River from Gavins Point Dam to the headwaters. In the 1960's, 500 observations were made (i.e., an average of 50 per year); in the 1970's, 209 observations (i.e. an average of 21 per year); and in the 1980's, 65 observations (i.e., an average of about 7 per year) over the entire 5,725 kilometers (3,550 miles) of range (50 CFR Part 17). The Final Rule went on to indicate that the decline of the species appeared to correspond with expanded commercial harvest while, during the same time, recruitment began to fail. The decline, however, also followed the extensive developments of the 1950's and 1960's of the Missouri and Mississippi rivers. Kallemeyn (1983), and Gilbraith et al. (1988) attributed the decline, either directly or indirectly, to habitat modification. Modification of the pallid sturgeon's habitat by human activities has blocked fish movement, destroyed or altered spawning areas, reduced food sources or ability to obtain food, altered water temperatures, reduced turbidity, and changed the hydrograph of the river system. Overfishing, pollution, and hybridization that occur due to habitat alterations also have probably contributed to the species population decline (USFWS 1993).

The historic distribution of pallid sturgeon as described by Bailey and Cross (1954) primarily included the Missouri River, the Mississippi River from the mouth of the Missouri River to the Gulf of Mexico and the lower reaches of the Platte, Kansas and Yellowstone Rivers. Records also indicated pallid sturgeon were present in the Mississippi River at Grafton, Illinois, (Forbes and Richardson 1905) and as far north as Keokuk, Iowa (Bailey and Cross 1954, Coker 1930). Today, the distribution includes the Missouri River, Middle and Lower Mississippi River, the Atchafalaya River and the lower reaches of the Yellowstone, Platte, Kansas, St Francis and Big Sunflower Rivers (Constant et al. 1997). Of the total range of approximately 3,515 river miles, 28 percent is impounded, 21 percent has been affected by upstream impoundments (altered hydrograph, temperature and sediment budget) and 51 percent is channelized (Keenlyne 1989). The amount of impounded river miles fluctuates from year to year depending on the amount of inflow into Upper Missouri River reservoirs (i.e., drought or flood conditions) and the Corps of Engineers' operations. The channelized river miles of the Lower Missouri River and Middle Mississippi River are also affected by operation and maintenance of upstream impoundments, especially affecting sediment transport. The altered hydrograph and temperature effects are attenuated as the Missouri River progresses downstream (Robb Jacobson, USGS, pers. comm. 2003) and enters the Mississippi River. The result is a highly fragmented range of habitats with varying suitability for pallid sturgeon.

Due to intensive study effort in recent years, catch records have increased indicating pallid sturgeon remain scarce but are widely distributed throughout their range (Figure 5-1).

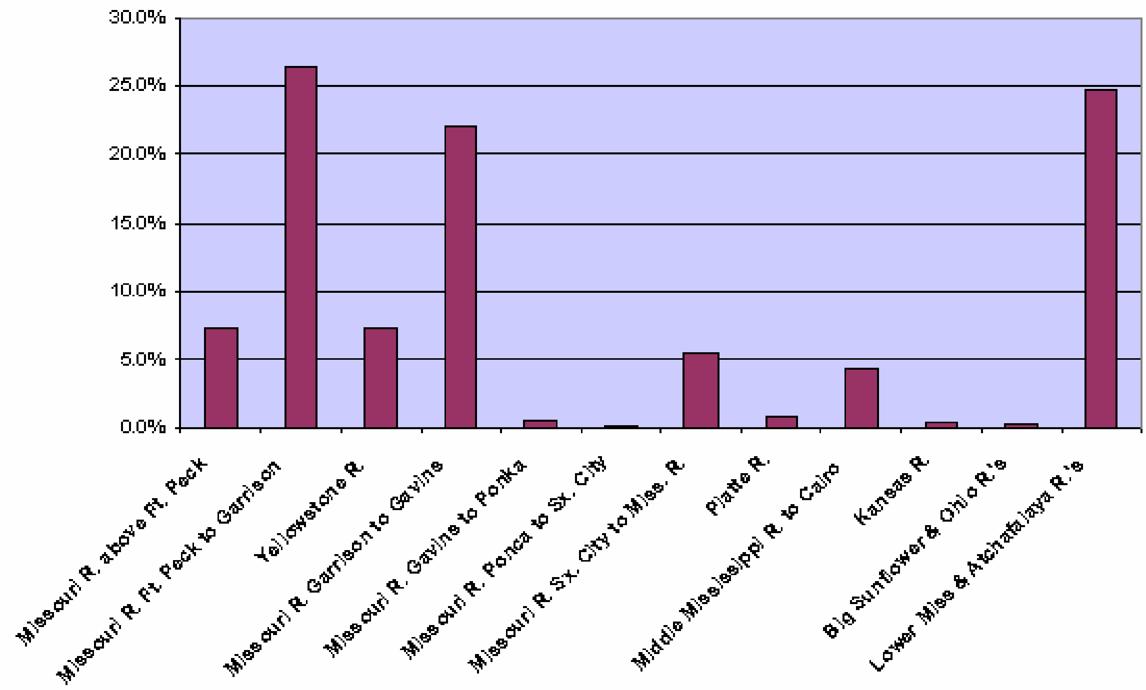

Figure 5-1. Rangewide Distribution of Pallid Sturgeon Catch Records

As noted with the above information, pallid sturgeon are widely distributed throughout their range and occur in small numbers relative to the closely related shovelnose sturgeon (see Table 5-1). Increasingly, the total numbers of pallid sturgeon collected during sampling reflect higher numbers of released hatchery reared fish and hybrids than wild fish. The collection of larval and juvenile pallid sturgeon is becoming more common due to increased effort and gear efficiency. However, the low numbers of these age classes suggests to most sturgeon researchers that pallid sturgeon reproduction is a rare event and recruitment from reproduction has not been documented. It should be noted that the numbers of larval and juvenile pallid sturgeon collected may also be an artifact of sampling gear bias and/or a variable level of effort aimed at these size classes.

As is shown in Table 5-1, data that are collected and reported throughout the range of the pallid sturgeon is inconsistent and difficult to compare between reaches. The Service concludes from the data represented in Table 5-1 and discussed in the text above that there is a continuous and ongoing decline in the population of adult pallid sturgeon in the Upper Missouri River reaches. Additionally, for both the Lower Missouri River alone, as well as the Lower Missouri River and the Middle Mississippi River combined, there appears to be a shift in the relative abundance of pallid sturgeon to shovelnose and other river sturgeon. Data from Grady et al. (2001) and MoDOC indicate that shovelnose sturgeon populations are either stable or declining, respectively. This indicates to the Service that there is a true reduction in the abundance of pallid sturgeon to reflect a lower ratio of pallid sturgeon compared to other sturgeon species.

Table 5-1. Estimates of adult pallid sturgeon and ratio of pallid sturgeon to other sturgeon from the literature and reports.

Upper Missouri River	Middle Missouri River	Lower Missouri River	Middle Mississippi River	Lower Missouri River/Middle Mississippi River Combined	Lower Mississippi River
200-300 Duffy et al. 1996	25-50 (GPD to FRD)	1:311 (0.32%) Grady et al. 2001	1:89 (1.1%)[1] USACE 2003	1:398 (0.25%)[2] Carlson et al. 1985	1:23 (4.3%) Killgore 2004
178 Year 2001 Kapusinski 2003		1:387 (0.26%) Doyle and Starostka 2003		1:647 (0.15%) Grady et al. 2001 1996-2000 Cumulative	
166 Year 2002 Kapusinski 2003					
151 (89-236) (95% Confidence) Year 2003 Kapusinski 2003					

[1] Ratio on Middle Mississippi River is to shovelnose sturgeon only
[2] Ratio is to all river sturgeon (shovelnose, lake, pallid, hybrid)

To summarize, since issuance of the 2000 Biological Opinion (USFWS 2000a), additional pallid sturgeon research and survey work has been initiated. This includes additional collection of small numbers of pallid sturgeon larvae and juveniles. However, evidence of recruitment of wild origin pallid sturgeon is lacking. The species is largely being maintained through artificial propagation programs, particularly in the Upper Missouri River where the sub-population below Fort Peck Dam is predicted to be extirpated by 2018. An exception to this is the Lower Mississippi River, where the species status is largely unknown with the exception of recent collections in several locations. Hybridization with the closely related shovelnose sturgeon in the Lower Missouri River and Mississippi remains a concern (Keenlyne et al, 1994).

Pallid sturgeon are threatened by many factors, including habitat loss and degradation, hybridization, commercial fishing, and contaminants/pollutants. These threats to the species appear to be increasing rather than decreasing and continue to adversely affect the pallid sturgeon.

New threats

Additional threats to the species further compound the species status. Entrainment due to dredging operations and commercial navigation traffic represents an unknown, but perhaps significant, threat to the species through direct mortality. The presence of exotic Asian carp has increased dramatically in the Missouri and Mississippi Rivers. These species compete with native river fish for food and habitat and may present a significant long-term threat to the pallid sturgeon.

5.2 Environmental Baseline

This section is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat, and ecosystem within the action area. Factors affecting the species include those described previously under *Status and Distribution*, *Reasons for Decline*, and *New Threats.* In accordance with 50 CFR §402.02, the action area includes all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. The Corps' Biological Assessment defined the project area as the Upper Mississippi River and Illinois Waterway. The Upper Mississippi River extends from the confluence of the Ohio River to Upper St. Anthony Falls in Minneapolis-St. Paul, Minnesota. The Illinois Waterway extends from its confluence with the Mississippi River at Grafton, Illinois to T.J. O'Brien Lock in Chicago, Illinois. However, beyond this project area, portions of the Lower Missouri River and the Lower Mississippi River will experience indirect effects as a result of the proposed action. These indirect effects will occur in the form of increased navigation traffic as a result of navigation improvements and improved habitat quality and biological productivity as a result of ecosystem restoration (e.g., improved water quality, improved habitat quality). Therefore, the action area for purposes of this analysis includes the Upper Mississippi River, Illinois Waterway, Lower Missouri River and Lower Mississippi River.

The past and present impacts of construction, operation and maintenance of the 9-Foot Channel Project were analyzed in the 2000 Biological Opinion (USFWS 2000a). The 2000 Biological Opinion highlighted the importance of the Middle Mississippi River to the pallid sturgeon and provides baseline information for this biological opinion for the Navigation Study. Therefore, the environmental baseline in the 2000 Biological Opinion is incorporated by reference. Environmental baseline information from the 2000 Biological Opinion is included to the extent that it will add clarity and context to this biological opinion. Otherwise the environmental baseline is based on surveys, studies, and other information obtained since 2000. In addition, the following information is also updated in the environmental baseline: 1) State, local and private actions already affecting the species or that will occur contemporaneously with this consultation; 2) unrelated Federal actions affecting pallid sturgeon that have completed formal or informal consultations; and 3) Federal and other actions within the action area that may benefit pallid sturgeon.

5.2.1 Status of the pallid sturgeon within the action area

The current status of pallid sturgeon in the action area remains largely unknown, but available information suggests to the Service that there may be a reduction in the abundance of wild pallid sturgeon, as reflected in generally lower ratios of pallid sturgeon to other sturgeon species. As reported in the rangewide status section on pallid sturgeon, during a MICRA study from 1996 to

2000 (Grady et al. 2001), 21 pallid sturgeon were collected in the Lower Missouri River and Middle Mississippi River. Of the 9 pallid sturgeon collected in the Lower Missouri River, 7 were presumed to be of wild origin, while 2 were hatchery stocked fish. Of the 12 pallid sturgeon collected in the Middle Mississippi River, 1 was considered a wild origin fish and 11 were considered hatchery stocked fish. The ratio of wild pallid sturgeon to all river sturgeon collected dropped from 1 in 398 (0.24 percent) collected by Carlson et al. (1985) to 1 in 647 (0.15 percent) (Grady et al. 2001). The contribution of hatchery reared fish is evident as wild and hatchery raised pallid sturgeon accounted for 1 in 247 (0.41 percent) of all river sturgeon (Grady et al. 2001). Doyle and Starostka (2003) reported the ratio of wild pallid sturgeon to all river sturgeon collected in combined 2002 samples was 1:387 (0.26 percent). Data collected from 1996-2000 within the same reaches showed a ratio of 1:311 (0.32 percent) (Grady et al. 2001). On the other hand, within the Middle Mississippi River and the Lower Mississippi River, the ratio of pallid sturgeon to shovelnose sturgeon is reported at 1:89 (1.12 percent) and 1:23 (4.34 percent), respectively (USACE 2003a, Killgore 2004).

There are a number of factors that could influence wild pallid sturgeon abundance and the different ratios of pallid sturgeon compared to other sturgeon in the catch: 1) increased harvest pressure on shovelnose sturgeon, 2) a prevalence of stocked pallid sturgeon in the catch, and/or 3) a greater rate of decline in pallid sturgeon populations. Data on declining shovelnose sturgeon populations in the Middle Mississippi River supports increased harvest pressure as being a factor. The MoDOC (Hrabik 2002) reports that catch per unit effort of shovelnose sturgeon during winter sampling using gill nets showed a dramatic decline from 1997 to 2002. From other studies, however, shovelnose sturgeon populations in the Lower Missouri River and Middle Mississippi River show no apparent excessive exploitation as would be evidenced by reduced numbers of large reproductive fish (Grady et al. 2001, Doyle and Starostka 2003). Commercial sturgeon harvest has been closed in Louisiana and Mississippi for a number of years. In the last few years the state of Arkansas closed commercial sturgeon fishing in the Mississippi River, while it is still allowed in Illinois, Missouri, Kentucky, and Tennessee.

It is also believed that capture of hatchery released pallid sturgeon is playing a major role in influencing the overall ratio of pallid sturgeon to other sturgeon. Based on the presence of coded wire tags, it is conservatively estimated that approximately 60 percent of the pallid sturgeon recently collected in the Middle Mississippi River are hatchery reared fish released in 1994 and 1997 by the MoDOC (Dave Herzog, MoDOC, pers. comm. 2003). It is unclear what factors may be influencing the relatively higher percentage of pallid sturgeon compared to shovelnose sturgeon in the Lower Mississippi River.

Within the action area there is some evidence of reproduction with the occasional capture of larval stages and juveniles. However, the population structure remains unknown. Opportunities for collection of larval and juvenile pallid sturgeon are increasing with gear improvements and targeted sampling, but the low numbers of these age classes suggest to most sturgeon researchers that pallid sturgeon reproduction is a rare event and that recruitment to reproductive age classes is not occurring. However, it should be noted that the numbers of larval and juvenile pallid sturgeon collected may also be an artifact of sampling gear bias and/or a variable level of effort aimed at these size classes.

As noted above, relative abundance estimates of pallid to other sturgeon have ranged from 0.24 to 4.34 percent. Recent data from Grady et al. (2001) and Herzog (2002) in the action area indicate that shovelnose sturgeon populations are either stable or declining, respectively. This, along with increased capture of hatchery-raised fish implies that wild pallid sturgeon numbers may also be stable to declining.

5.2.2 Factors affecting the pallid sturgeon environment in the action area

Habitat loss

Lower Missouri River - In the Lower Missouri River from Gavins Pt. Dam downstream approximately 76.1 miles to Sioux City, Iowa, suitable physical habitat conditions exist; however, dam operations affect current/velocity, turbidity, water depth, substrate, temperature and the hydrograph. From Sioux City downstream approximately 139.5 miles to the mouth of the Platte River, the physical habitat conditions are substantially reduced and the hydrograph is significantly altered. From the mouth of the Platte River, downstream approximately 595.5 miles to the Mississippi River, the physical habitat conditions improve and the alterations to the hydrograph are attenuated due to the influences of tributary inflow. The transport and suspension of sediment for turbidity and habitat development and sustainability is also significantly impaired.

Since 2000, bank stabilization and maintenance continues through out this river reach. The Corps has been implementing certain habitat development aspects of the 2000 Biological Opinion for Missouri River Operations (USFWS 2000b). These include land acquisition (1,100 acres) from Gavins Point Dam to Sioux City, Iowa, to benefit piping plovers, least terns, and pallid sturgeon. During 2001 through 2003, the Corps made modifications to the navigation project that resulted in the creation of 1,365 acres of shallow water habitat. Projects included: excavation of over 400 notches in dikes; construction of reverse dikes/notches at Marion and Plowboy Bends; side channel construction at Overton Bottoms, Tobacco Island and California Bend; buried dike excavation and notching at Overton Bottoms; chevron construction and dike lowering near Nebraska City; and modification of dike maintenance at selected locations from Sioux City to the mouth to encourage aquatic habitat development.

According to the 2000 Biological Opinion for Missouri River Operations, approximately 77,000 acres (105 acres/mile) of shallow water, slow velocity habitat occurred in the predevelopment river below Sioux City, Iowa. It was estimated that approximately 2-5 percent or 2.1-5.25 acres/mile of the historical acreage remains between Sioux City and the Grand River confluence in the developed river. Since issuance of the 2000 Biological Opinion for Missouri River Operations, the Corps conducted new modeling studies which estimate that approximately 18.0 acres/mile of shallow water habitat currently occurs below the Grand River in the Lower Missouri River (6,017 total acres). The 2000 Biological Opinion for Missouri River Operations RPA specified that 20-30 acres of shallow water habitat should be created in the Lower Missouri River. As such, an estimated 8,000 to 14,000 additional acres of shallow water habitat must be established.

Middle Mississippi River - The MMR historically had a meandering pattern and shifted its course over the years, leaving oxbows lakes and backwaters (Theiling 1999). The undeveloped river was shallow and characterized by a series of runs, pools and channel crossings that provided a diversity of depth (Theiling 1999). In 1824, the MMR surface area totaled 109 mi^2 (87.2% riverbed, 12.8% islands) (Simons et al. 1974). In 1796, Collot (1826) surveyed the river and mapped 55 side channels. His historical account describes a very dynamic system with the capability to create and maintain a diversity of habitat types. In describing the great potential for change in the system, Collot (1826) wrote:

> *"The Mississippi River has not only the inconvenience of being of an immense extent, of winding in a thousand different directions, and of being intercepted by numberless islands; its current is likewise extremely unequal, sometimes gentle, sometimes rapid; at other times motionless; which circumstances will prevent, as long as both sides remain uninhabited, the possibility of obtaining just data with respect to distances. But an insurmountable obstacle will always be found in the instability of the bed of this river, which changes every year; here a sharp point becomes a bay; there an island disappears altogether. Further on, new islands are formed, sandbanks change their spots and directions, and are replaced by channels; the sinuosities of the river are no longer the same; here where it once made a bend it now takes a right direction, and there the straight line becomes a curve; here ravages and disorders cannot be arrested or mastered by the hand of man, and it would be extreme folly to undertake to describe them, or to pretend to give a faithful chart of this vast extent of waters, as we have done for the course of the Ohio, since it would not only be useless but dangerous."*

Today, the natural meandering processes of the MMR have been altered through channelization. Wingdams, revetments, closing structures and bendway weirs have fixed the channel in place, disrupting the dynamic processes that create and maintain pallid sturgeon habitat. Physical habitat in the MMR is becoming homogeneous. With construction of the nine-foot channel navigation project, the river bank top width has been reduced, side channels, islands and ephemeral sand bars have been lost, and the physical process of channel meandering has been arrested. Stabilization of the river has led to extensive levee development isolating most of the floodplain. Sediment transport and availability for habitat development have been significantly impaired as a result of Corps' actions on both the Upper Mississippi River and the Missouri River. The result has been the loss of aquatic habitat diversity over time. This process is on-going.

<u>Lower Mississippi River</u> – The 954.0 river miles of the Lower Mississippi River represents approximately 25 percent of the historic range of the pallid sturgeon. This area represents perhaps the best remaining habitat available for pallid sturgeon. Although the Lower Mississippi River has been altered with channel regulating works (e.g., dikes, revetments) to promote river navigation, aquatic habitat diversity remains. This includes side channel/island complexes and backwaters. The river is much wider than the Lower Missouri River and the Middle Mississippi River. Unlike the Middle Mississippi River, levees tend to be set back, allowing more access to floodplain habitats which improves foraging conditions for pallid sturgeon through production of small fish and aquatic invertebrates.

However, the amount of aquatic habitat lost as a result of channel regulation in the Lower Mississippi River has not been assessed. The Lower Mississippi River Conservation Committee has developed a Lower Mississippi River Aquatic Resource Management Plan. One objective of this plan is to identify, define, describe and delineate habitats in the Lower Mississippi River. To that end, the Lower Mississippi River Resource Assessment was authorized in the Water Resources Development Act of 2000. To date, funding has not been appropriated to complete the assessment.

As of 2000 approximately 80% of the floodplain of the Middle Mississippi River had been isolated from the main channel due to levee construction. This number continues to increase as additional levee projects are constructed. Since 2000, the Ste. Genevieve 500 year levee project has been completed. Although this levee was constructed to protect the historic town, it was largely constructed along the bank of the Middle Mississippi River and provides additional flood protection for large amounts of agricultural land. The Festus/Crystal City Small Flood Control Project is currently under construction. This 100 year flood protection project is designed to protect the cities, including a wastewater treatment facility, from backwater flooding from the Mississippi River. In addition, the Corps has recently approved the Design Deficiency Study for the Bois Brule Levee and Drainage District in Missouri. This project will correct design deficiencies to ensure a 50 year level of flood project for this largely agricultural area. However, given recent adjustments in flow frequencies, the level of protection will actually be much greater than the 50 year level.

Throughout the action area, isolated backwaters, side channels and wetlands have been degraded due to incompatible agricultural practices, poor stormwater management and sedimentation. Destruction and isolation of these important floodplain features has reduced riverine productivity (Theiling et al. 2000) by decreasing energy inputs (organic matter, carbon) into the main channel and precluding seasonal flood pulses (Junk et al. 1989, Ward and Stanford 1995, Ward et al. 1999), thus reducing habitat quality for main channel fisheries. Isolation of wetlands reduces their habitat value to riverine fish, which make seasonal movements to backwaters and floodplains (USACE 1999b). Levees also contribute to increased flood heights and increased water level variability because floodwaters are confined in a smaller cross-sectional area (Belt 1975, Chen and Simons 1986, Bellrose et al. 1983). As a result, flood control projects in the action area have affected the production of forage food organisms for pallid sturgeon (macroinvertebrates and fish) and may have isolated pallid sturgeon from important rearing/feeding areas and/or seasonal refugia.

Hybridization

The rate of hybridization between pallid sturgeon and shovelnose sturgeon may be increasing in the action area. Studies in the Middle Mississippi River suggest a relatively high incidence of hybridization between shovelnose sturgeon and pallid sturgeon (Sheehan 1997a, 1997b, 1998). Sheehan et al. (1997b) and Carlson and Pflieger (1981) noted a 3:2 ratio of hybrid sturgeon to pallid sturgeon. Sheehan et al. (1997b) speculated that if this is representative of the sturgeon populations in the Middle Mississippi River, hybridization may pose a significant threat to pallid sturgeon as the species continues to cross with shovelnose sturgeon. Keenlyne et al. (1994) reported that hybridization may be occurring in half of the river reaches within the range of pallid sturgeon and that hybrids may represent a high proportion of remaining sturgeon stocks.

During the MICRA study from 1996 to 2000, seven pallid/shovelnose sturgeon hybrids were collected in the Middle Mississippi River and 15 were collected in the Lower Missouri River. The rate of hybridization increased from 1 in 365 (0.27 percent) river sturgeons in the late 1970's (Carlson et al. 1985) to 1 in 235 (0.42 percent) in the 1990's (Grady et al. 2001).

Surveys conducted as part of the Highway 19 bridge replacement project near Hermann, Missouri, resulted in collection of 3 pallid sturgeon, 14 hybrids and 1,990 shovelnose sturgeon (0.70 percent hybrids) (Milligan 2002). In addition, as part of the Lower Missouri River Pallid

Sturgeon Monitoring and Population Assessment Project, CMFRO collected 12 pallid sturgeon, 12 hybrids and 3022 shovelnose sturgeon (0.39 percent hybrids) (Doyle and Starostka 2003).

In the Lower Mississippi River, Hartfield, et al. (2002) collected 11 pallid sturgeon, 3 intermediates and 383 shovelnose sturgeon (0.76 percent intermediate). Hartfield (2002) later reported collection of 9 pallid sturgeon, 615 shovelnose sturgeon and 6 intermediates that were more similar to shovelnose sturgeon (2.0 percent intermediate).

Commercial Fishing

It has previously been reported that mortality of pallid sturgeon occurs as a result of illegal and incidental harvest from both sport and commercial fishing activities. Herzog (2002) reports that the commercial fishers observed over the years are non-discriminate in their take of sturgeon (including pallid sturgeon). Recently, the MoDOC has documented incidental/illegal harvest of pallid sturgeon as a result of commercial sturgeon fishing (Craig Gemming, MoDOC, pers. comm. 2003). The value of native sturgeon roe has increased dramatically in recent years due to the collapse of the Russian caviar industry. As the commercial harvest of shovelnose sturgeon roe increases, there will be an increased by-catch of pallid sturgeon incidental to this harvest. This has the potential to further depress pallid sturgeon populations. For example, Williamson (2002) recently summarized reports from various states for the harvest of shovelnose sturgeon (flesh and eggs). In Illinois, the harvest of shovelnose sturgeon roe has increased from 47 pounds reported in 1990 to 8,197 pounds in 2001. The commercial shovelnose sturgeon catch (flesh and roe) in Missouri increased from 12,183 pounds in 1999 to 65,128 pounds in 2001 for the Mississippi River and from 7,472 pounds in 1999 to 12,370 pounds in 2001 for the Missouri River. The increase harvest pressure of shovelnose sturgeon has also created concern for the population status of this species. Herzog (2002) reports that the catch per unit effort for Middle Mississippi River shovelnose sturgeon collections declined from 527 fish (25 net nights) in 1997 to 30 fish (20 net nights) in 2002. The high was 1,052 fish (54 net nights) in 1998. As a result, the MoDOC has proposed regulation changes to further protect sturgeon populations and the Iowa Department of Natural Resources has closed commercial sturgeon fishing in the Missouri River (Steve Krentz, USFWS, pers. comm. 2003). Commercial sturgeon harvest has been closed in Louisiana and Mississippi for a number of years. In the last few years the state of Arkansas closed commercial sturgeon fishing in the Mississippi River, while it is still allowed in Illinois, Tennessee, Kentucky, and Missouri.

Contaminants

Environmental contaminants may play a role in the decline of pallid sturgeon, citing fish consumption health advisories from Kansas City to the mouth of the Mississippi, representing 45 percent of the pallid sturgeon's total range (USFWS 2000b). In addition, PCBs, cadmium (Cd), mercury (Hg), and selenium (Se) were detected at elevated but below lethal levels in tissues of three pallid sturgeon tissues from the Missouri River in North Dakota and Nebraska. Detectable levels of chlordane, DDE, DDT and dieldrin were also reported (Ruelle and Keenlyne 1994). The 2000 Biological Opinion for Missouri River Operations also hypothesized that the "prolonged egg maturation cycle of pallid sturgeon, combined with a bioaccumulation of certain contaminants in eggs, could make contaminants a likely agent adversely affecting eggs and embryo, development or survival of fry, thereby reducing reproductive success." Environmental contaminants, although suspected to have a role in sturgeon dynamics, have only recently begun to be more fully examined in relation to sturgeon reproduction and health in both the MMR and Missouri River and more information is needed.

Coffey et al. (2000) conducted a preliminary contaminant investigation on fish collected from a chlordane consumption advisory site (contaminants known to be present) in the MMR and from a reference site without advisories (contaminants not known to be present). Results indicate that wild shovelnose collected from the consumption advisory site exhibited enlarged livers, often an indicator of contaminant exposure. These affected fish were also determined to have among the highest tissue concentrations of organochlorine compounds and metabolites. Some results were a bit contradictory, with one fish having high residue levels and no health anomalies, and some results were observed in fish from both contaminated and reference areas. However, sample sizes in this study were small. These preliminary data suggest that the role of environmental contaminants on sturgeon dynamics needs to be further evaluated.

Coffey et al. (2001) also conducted a risk assessment for MMR pallid sturgeon. Using conservative assumptions in most parts of the assessment, they determined that water and sediment may carry biologically important concentrations of contaminants, at levels reducing the food base and increasing exposure and bioaccumulation in pallid tissues. Most notable were the eight heavy metals found in sediments that have been detected in fish tissue, including in sturgeon, above adverse effect thresholds (As, Cd, Cu, Pb, Hg and Se). This is also the case for DDD, DDE, chlordane and dieldrin.

Papoulias et al. (draft preliminary results, 2003) sampled adult shovelnose sturgeon monthly in the Lower Missouri River between May 2001 and June 2002. Investigations noted an unusually high incidence of sturgeon with characteristic gonadal anomalies consistent with abnormal hermaphroditism (AH). AH in an animal is characterized by possessing both male and female gonads or abnormal gonads exhibiting both male and female characteristics within the same organ (ovo-testes). Papoulias and Tillitt (2004) noted observing the incidence of intersex as high as 13% among male shovelnose sturgeon. It is unknown whether this condition occurs in pallid sturgeon. Papoulias and Tillitt (2004) state that factors that may cause hermaphroditism in sturgeon and the consequences on reproduction are unknown. Senescence, genetic abnormalities, hybridization, radiation, chemicals, diet, temperature and environmental disturbance have all been implicated in the literature. Papoulias et al. (2003) found that “gonadal abnormalities may indicate the potential for reproductive impairment in this species and others and should be investigated.”

Commercial Navigation Traffic

Previously mentioned under new threats, commercial navigation traffic within the action area is a private enterprise, however, it is also a direct effect of the Corps’ operation and maintenance of the navigation system. The effect of towboat propellers on fish populations is a concern associated with commercial navigation traffic. As part of the Restructured Mississippi and Illinois River Navigation Feasibility Study, the Corps has conducted several studies to determine the impacts of navigation traffic on fisheries resources. Of particular concern has been the entrainment of fish larvae; however, the Corps has also conducted studies to evaluate entrainment of juvenile and adult fish. Although some of these studies were initiated prior to the 2000 Biological Opinion (USFWS 2000a), much of the data/information regarding entrainment and baseline traffic effects has only recently become available. Therefore, the following information will serve to update the baseline analysis contained within the 2000 Biological Opinion.

Larval Sturgeon - Cada (1990) reported that fish eggs and larvae that pass through water currents induced by a propeller may come in contact with the blade and can experience stresses from pressure changes and shear forces. Killgore et al. (2001) evaluated mortality of icthyoplankton entrained through a scale model of a towboat propeller. Fish species tested included larval shovelnose sturgeon, larval lake sturgeon, the larvae and eggs of paddlefish, larval blue sucker and juvenile common carp. Fish were subjected to treatments at various shear stress levels ranging from 634 to 4,743 dynes/cm^2 (1 dyne = the force that would give a free mass of 1 g an acceleration of 1 cm/s^2) (Killgore et al. 2001). They found mortality to be a linear function of shear stress for all species and life stages. Larger larvae (e.g., shovelnose sturgeon) experienced lower mortality, while smaller larvae (e.g., lake sturgeon, blue suckers) experienced higher mortality (>75 percent). All larval species experienced delayed mortality, particularly at higher stress levels; however, common carp juveniles and paddlefish eggs did not experience delayed mortality (Killgore et al. 2001).

Shear stress from propeller jet velocities can exceed 5,000 dynes/cm^2. Killgore et al. (2001) concluded that shear stress due to towboat traffic is probably a primary force contributing to the mortality of icthyoplankton entrained during vessel passage, but the magnitude of mortality is dependent on individual size of icthyoplankton. The extent of mortality would be a function of the amount of tow traffic in a given river system, towboat speed and traffic levels during the time of year when larvae are most susceptible to shear stress (e.g., early developmental phase) (Killgore et al. 2001).

In order to estimate the impacts of commercial navigation traffic on fish populations due to larval fish entrainment, the Corps conducted complex modeling studies utilizing a model called NavLEM. The following briefly explains this process:

The year 2000 traffic was utilized as the baseline condition (e.g., without project) for this analysis. The results indicate that 4.8 million sturgeon larvae were entrained and killed by commercial navigation traffic in the open river for the Year 2000 (Bartell and Nair 2003). These estimated numbers of entrained and killed larvae are difficult to evaluate directly given that natural rates of larval fish mortality are high (Bartell and Nair 2003) and fish typically produce large numbers of eggs and larvae (USACE 2004b). To put this in perspective, the 4.8 million sturgeon larvae are estimated to represent approximately 0.81 percent of the sturgeon larvae produced in the open river during the year 2000 spawning season (Bartell and Nair 2003). However, this percentage is only an approximation and assumes larvae are evenly distributed across the river (Bartell and Nair 2003).

The model estimates that in the baseline condition for the Middle Mississippi River, 2,962 sturgeon equivalent adult fish were lost due to commercial navigation traffic (USACE 2004b, Bartell and Nair 2003). Utilizing the ratio of pallid sturgeon to shovelnose sturgeon of 1:84, this would equate to approximately 35 pallid sturgeon being lost in the Middle Mississippi River in the baseline condition. Further, the model estimates that 59 sturgeon recruits were lost due to commercial navigation in the Middle Mississippi River (Bartell and Nair 2003). This equates to approximately 2 pallid sturgeon recruits being lost every 3 years in the baseline condition.

It should be noted that there is a great deal of uncertainty associated with modeling and estimating larval fish mortality. These uncertainties are explained in detail in Appendix ENV-E of the Navigation Feasibility Report. The actual numbers of pallid sturgeon lost in any given year would be a function of many factors, including: overall sturgeon larvae abundance, distribution of larvae in the navigation channel (vertically and horizontally), navigation traffic levels during the larval drift period and navigation channel depth.

Juvenile/Adult Sturgeon - Guetreter et al. (2003) developed a method to estimate mortality rates of adult fish caused by entrainment through the propellers of commercial towboats operating in river channels. They estimated entrainment mortality rates of adult fishes in Pool 26 of the Upper Mississippi River and Alton Pool of the Illinois River where fish kills attributed to entrainment were observed. Their estimates of entrainment mortality rates were 0.53 fish/km of towboat travel (80 percent confidence interval, 0.00 – 1.33 fish/km) for shovelnose sturgeon. They concluded that their approach applies more broadly to commercial vessels operating in confined channels, including other large rivers and intracoastal waterways.

During discussions with the Corps as they developed their Biological Assessment, the Corps expressed concerns that the entrainment mortality rates reported by Guetreter et al. (2003) overestimate mortality to shovelnose sturgeon due to towboats. Their main concerns were associated with the sampling design that resulted in filtering only a small fraction of the propwash from towboats and which was not designed to account for rare events. In addition, the Corps expressed concern that the mortality rate was based on collection of one dead shovelnose sturgeon during ambient sampling and not during trawling behind a moving towboat.

Despite a wide disparity in estimating the mortality of shovelnose sturgeon, and subsequently pallid sturgeon, attributed to commercial navigation traffic. However, the best information available indicates sturgeon are entrained by towboats. This results not only in instantaneous mortality, but delayed mortality and injuries resulting in harm. In addition, although data for other species may indicate the capability to move away from towboats, this may not be the case with sturgeon. Informal and unpublished observations by USGS indicate that shovelnose sturgeon exhibit a 3-dimensional flight response, scattering in all directions, including straight upward (Steve Gutreuter, USGS, pers. comm. 2004). Such behavior may make them more susceptible to towboat entrainment than other species of fish.

Despite the difficulties, some analysis of baseline traffic mortality is warranted in order to better understand the impacts of commercial navigation traffic on pallid sturgeon. To determine the extent of shovelnose sturgeon mortality attributed to towboats, two data points are required. The first data point is the mortality rate expressed a fish/km of towboat travel. For this analysis, we have utilized the mortality rate for skipjack herring reported by Killgore et al. (2003) of 0.01 fish/km. It is recognized that this mortality rate may either underestimate or overestimate the mortality rate of shovelnose sturgeon. The mortality rate likely underestimates the mortality of all fish caused by towboat entrainment since some of the mortality attributed as being net induced by Killgore et al. (2003) likely occurred as a result of entrainment. On the other hand, the mortality rate likely overestimates the mortality rate for shovelnose sturgeon since skipjack herring are pelagic and likely more susceptible to entrainment than sturgeon or benthic fish.

To further refine the mortality estimate, consideration was given to the number of shovelnose sturgeon collected as a percentage of the overall number of fish collected in the study by Killgore et al. (2003) which is 0.02%. Therefore, the mortality rate estimate for shovelnose sturgeon is calculated as: 0.01 mortality of fish/km X 0.0002 shovelnose sturgeon/km = 0.000002 shovelnose sturgeon/km of towboat travel. It should be noted that Dettmers et al. (2001) found that shovelnose sturgeon comprised approximately 5% of the fish population in the navigation channel of Pool 26. However, they did not collect any shovelnose sturgeon in the navigation channel of the Alton Pool of the Illinois River. The disparity in the numbers of shovelnose sturgeon collected in the two studies adds further uncertainty to calculating sturgeon entrainment due to towboats.

The second data point required for this analysis is the km of towboat travel for the MMR. This information can be obtained by multiplying the baseline navigation traffic information for the MMR by the length (km) of river traveled. Table 5-2 provides baseline traffic information as provided by the Corps for the Open River and Pool 27. The baseline or future without project condition is based on the "Future Without Project – TCM Least Favorable Scenario" (USFWS 2004b). This allows a more conservative (for the species) estimate of the effects of the proposed action.

Table 5-2: Baseline Traffic – Annual (Future Without Project)

YEAR	OPEN RIVER	POOL 27
2000	10,185	8,075
2010	9,778	7,699
2020	9,796	7,654
2030	9,957	7,680
2040	10,259	7,842
2050	9,818	7,309

Table 5-3 provides the baseline km of towboat travel based on multiplying the number of towboats by the length of river (e.g., 296.06 km for the Open River and 27.35 km for Pool 27) (per Tom Keevin, USACE, St. Louis District and Steve Bartell, Cadmus Group, Inc., Maryville, TN).

Table 5-3: Baseline KM of Tow Travel (Annual)

YEAR	OPEN RIVER	POOL 27	TOTAL KM
2000	3,015,371	220,851	3,236,222
2010	2,894,875	219,568	3,105,442
2020	2,900,204	209,337	3,109,541
2030	2,947,869	210,048	3,157,917
2040	3,037,280	214,479	3,251,758
2050	2,906,717	199,901	3,106,618

An estimate of the number of shovelnose sturgeon killed by towboat entrainment can be calculated by multiplying the mortality rate estimate (0.000002 fish/km) and the km of towboat travel estimates. From this information, an estimate of the number of pallid sturgeon killed can be determined based on the ratio of pallid sturgeon to shovelnose sturgeon in the Middle Mississippi River. This ratio varies depending on the number of sturgeon collected during ongoing sampling. For purposes of this analysis and consistency with the Corps' Biological Assessment (USACE 2004a), the ratio utilized is 1:84 (e.g., 1 pallid sturgeon for every 84 shovelnose sturgeon. This ratio is based on the results of ongoing sampling in the Middle Mississippi River. Table 5-4 represents the baseline traffic mortality estimates for shovelnose sturgeon and pallid sturgeon. Overall, under existing conditions, it is estimated that 1 pallid sturgeon is killed every 10 years.

Table 5-4: Baseline and Incremental Increase in Traffic Mortality Estimates (Annual)

YEAR	BASELINE SHOVELNOSE STURGEON	BASELINE PALLID STURGEON
2000	6.5	0.1
2010	6.2	0.1
2020	6.2	0.1
2030	6.3	0.1
2040	6.5	0.1
2050	6.2	0.1

Of necessity, certain assumptions are utilized in these calculations. These include: 1) Sturgeon abundance in the Middle Mississippi River is the same as in Pool 26 and the Alton Pool of the Illinois River; 2) Sturgeon entrainment by towboats is a relatively rare event, but does occur; 3) In the Middle Mississippi River, sturgeon are equally susceptible to entrainment as pelagic fish, such as skipjack herring or gizzard shad; and 4) Although pallid sturgeon are rare compared to shovelnose sturgeon, they are equally susceptible to towboat entrainment. Similar to larval fish, the actual numbers of juvenile/adult pallid sturgeon entrained in any given year would be a function of many factors, including: overall sturgeon abundance, distribution of sturgeon within the navigation channel (both vertically and horizontally), navigation traffic levels, sturgeon abundance in the navigation channel during different seasons and navigation channel depth. In addition, although the rate is not measurable, many sturgeon likely suffer delayed mortality as a result injuries sustained during entrainment. Also many fish sustain non-fatal injuries, however, these may affect overall fish health and reproductive capability, resulting in harm.

In addition to the effects of point-to-point tow traffic, fleeting and terminal facilities are necessary at specific points on the river system to transfer commodities, and to provide fuel and service to towboats. Numerous fleeting and terminal facilities are located in the action area. Within the species range, these facilities are most numerous in the St. Louis Harbor, but are also widely distributed along the river system to take advantage of rail and highway transportation modes. Fleeting areas are typically constructed within main channel border habitats. Towboats maneuvering within fleeting areas cause resuspension of sediments. In addition, fleeting areas and terminals often require periodic dredging, which disturbs bottom sediments. Most often, these sediments are disposed in the open water downstream. As a result of these activities, fleeting operations likely affect macroinvertebrate production on a local scale. In addition, contaminated sediments may be resuspended and transferred downstream.

Towboats maneuver and reconfigure barges in both authorized fleeting areas and unregulated areas. The use of unregulated areas is referred to as casual mooring and has involved tying of to larger bankline trees with braided steel cable, resulting in girdling and eventual toppling. Harbor boats and towboats maneuvering in near-shore areas contribute to bankline erosion as well as bottom sediment resuspension noted previously. Since pallid sturgeon exhibit a preference for main channel border habitats (Sheehan et al. 1998, 2002), this may result in entrainment of juvenile and adult sturgeon, thus resulting in some degree of mortality.

Commercial Sand and Gravel Dredging

In 1998, the Corps' Waterways Experiment Station published a Technical Note that summarizes existing literature regarding potential impacts to aquatic organisms caused by entrainment during dredging and dredged material disposal operations (Reine and Clarke 1998). Entrainment in this case is defined as the direct uptake of aquatic organisms by the suction field generated at the draghead or cutterhead (Reine and Clarke 1998). Armstrong et al. (1982) reported entrainment rates that ranged from 0.001 to 0.135 fish/cy for both pipeline and hopper dredging activities. They found that both small and large fish were entrained in similar proportions, and, therefore, concluded that large fish did not actively avoid the dredge any more than small fish. Armstrong et al. (1982) reported an initial mortality rate of 37.6 percent. Larson and Moehl (1990) reported entrainment rates ranging from <0.001 to 0.341 fish/cy during a 4-year study at the mouth of the Columbia River in Oregon. The majority of fish entrained were demersal with a few pelagic species also being collected (Larson and Moehl 1990).

Buell (1992) monitored entrainment by the hydraulic dredge *R.W. Lofgren* during dredging operations in the Columbia River. Buell reported an entrainment rate of 0.015 fish/cy for white sturgeon (*Acipenser transmontanus*). Substantial numbers of juvenile white sturgeon (300 to 500 mm) were entrained, which was largely attributed to dredging in an area referred to as the local "sturgeon hole". However, the overall entrainment rate reported by Buell (1992) is comparable to rates reported for other species of fish. To date, no studies have been completed in the Missouri or Mississippi Rivers to evaluate possible fish entrainment due to commercial sand and gravel dredging or navigation channel maintenance. The Corps has previously stated that entrainment of pallid sturgeon due to navigation channel maintenance dredging could not be ruled out (USACE 1999a).

Invasive Species

Since issuance of the 2000 Biological Opinion, Asian carp populations have greatly increased in the Missouri River and Mississippi River systems. Bighead carp and silver carp have become the most abundant large fish in portions of the Lower Missouri River (Duane Chapman, USGS, pers. comm. 2003). The abundance of these fish, coupled with their ability to consume massive quantities of phytoplankton and zooplankton, presents a great risk to the productivity of the Missouri River and Mississippi River aquatic food web. Bighead and silver carp have the potential to consume and retain large quantities of energy from lower trophic levels of the river's food web. This could occur to such a degree that pallid sturgeon and most other native fishes will be negatively impacted. In addition, pallid sturgeon larvae may be preyed upon by bighead and silver carp while they are part of the ichthyoplankton.

<u>Bighead carp</u> - Bighead carp are known to school and occupy the upper to middle layers of the water column. They prefer large rivers and depend on velocity, a spring rise in the hydrograph

and temperature regimes to spawn (Lin 1991). Five ontogenic shifts in feeding ecology of bighead carp were summarized by Lazareva et al. (1977) in fish less than 1 year of age. These included feeding on phytoplankton, then shifting to protococcaeceans, diatoms, bluegreen algae and *Rotaria* eggs, and finally to feeding on zooplankton exclusively. Bighead carp have a large suction volume, fast growth rates and voracious appetites enabling them to decimate concentrations of zooplankton quickly. Preliminary data from the Missouri River indicates that bighead carp can also feed on detritus, which gives them an alternate food source in periods when zooplankton concentrations are low (Duane Chapman, USGS, pers. comm. 2003).

Laird and Page (1996) state that bighead carp have the potential to deplete zooplankton populations that could negatively impact the food availability for many larval fish, adult filter feeding fish and native mussels to a significant degree. Most species of fish in the Missouri and Mississippi Rivers have a larval stage in which the fish are part of the plankton, and thus can be vulnerable to Asian carp predation. Bighead carp host a number of disease causing agents, including 2 bacteria, 1 fungus, 22 protozoa, 6 trematoda, 3 cestoda and 3 copepoda species (Jennings 1988). The impact of these agents on native fish has not been assessed.

Silver carp - Silver carp are known to school and occupy the upper to middle layers of the water column. Similar to bighead carp, silver carp feeding ecology shifts as the fish ages. As adults, they feed primarily on phytoplankton with zooplankton as a secondary food source. Due to a modified gill structure, the fish filters food items at a ratio of 248:1. Silver carp also feed on organic detritus and associated bacteria, indicating opportunistic feeding behavior. In large numbers, the silver carp has the potential to cause enormous damage to native species because it feeds on plankton required by larval fish and native mussels (Laird and Page 1996) and has the potential to compete with adult native fish that rely on plankton for food (Pflieger 1997). Intraspecific feeding competition between silver carp and endemic fishes in backwater habitats, lakes, pools, etc., appears to be the greatest threat. Silver carp may also displace native river fish from spawning habitats.

Grass carp - Grass carp are herbivorous and depend on floodplain habitats for successful recruitment. In most rivers where grass carp reproduce successfully, floodplains provide a large volume of still, shallow, warm water containing vegetative cover. There are few macrophytes in the Missouri or Mississippi Rivers. However, ongoing efforts to reconnect the floodplain in these river systems, while essential to native species, will also likely benefit grass carp.

Other invasive aquatic species - There are other aquatic invasive species in the Great Lakes and Illinois River that may eventually move into the Mississippi and Missouri Rivers and which may prove to be detrimental to pallid sturgeon. These include the ruffe and round goby.

Additional Federal Project/Programs, State, Local and Private Actions

Implementation of the O&M Biological Opinion Reasonable and Prudent Alternative

In April 2000, the Service issued a jeopardy Biological Opinion (USFWS 2000a) for pallid sturgeon to the Corps of Engineers for continued operation and maintenance of the nine-foot channel navigation project on the Upper Mississippi River. The impacts of continued operation and maintenance of the nine-foot channel project on the pallid sturgeon are described in detail in the 2000 Biological Opinion are incorporated here by reference. The Corps accepted the

Reasonable and Prudent Alternative (RPA) and is in the process of implementing it. The RPA called for: 1) conducting a pallid sturgeon habitat study in the Middle Mississippi River; 2) development of a pallid sturgeon conservation and restoration plan, which would include monitoring of both pallid sturgeon populations and habitat; 3) implementation of a long-term aquatic habitat restoration program to restore habitat quantity, quality and diversity; and 4) implementation of short-term aquatic habitat restoration measures (e.g., pilot projects). Although the pallid sturgeon conservation and restoration plan is still under development, to date the Corps has completed a number of pilot projects that have improved habitat conditions on a local scale. These projects include rehabilitation of Santa Fe Chute side channel, placement of woody debris piles in various locations, incorporation of woody debris into dikes during maintenance, dike notching, and construction of a chevron dike to facilitate development of a sand bar island and associated aquatic habitat. The Corps has indicated a commitment to continue to implement the RPA as described, including the long-term aquatic habitat restoration program. Thus, overall habitat conditions on the MMR should stabilize and improve over time.

Emergency Wetland Reserve Program and Wetland Reserve Program

The Service and states are working with the Natural Resources Conservation Service and the Farm Services Agency to protect and restore flood-created habitats and floodplain wetlands through the Emergency Wetland Reserve Program and the Wetland Reserve Program. These programs provide incentive payments to landowners for conservation easements (perpetual and 30-year). As of 2002, approximately 25,462 acres of floodplain lands along the Lower Missouri River have been enrolled in the program. Along the Middle Mississippi River, approximately 21,000 acres of floodplain lands in Illinois have been enrolled. The majority of the floodplain lands enrolled in these programs continues to be isolated from the river system due to levees. However, those lands that are connected to the river system, provide habitat for fish spawning and invertebrate production and also provide nutrients for the river system.

National Wildlife Refuge Projects

<u>Big Muddy National Fish and Wildlife Refuge</u> - The Big Muddy National Fish and Wildlife Refuge is authorized to acquire up to 60,000 acres (24,300 ha) of the Missouri River floodplain between Kansas City and St. Louis. To date, the Service has acquired 8,139 in 10 units and manages an additional 1,301 acres (527 ha) of Corps' mitigation lands. Acquisition of additional refuge lands is contingent on adequate funding and willing sellers, and may take 20 to 50 years to complete. The Corps has already initiated habitat restoration (reforestation through plant succession and planting, chutes, wet prairies, etc.). Adjacent to Jameson Island in central Missouri, the Service and the Corps have modified channel training structures to increase shallow-water and sandbar habitat. The Corps and the Service are also working to maintain a navigation grade control structure at a chute created at Lisbon Bottoms during the 1993 and 1995 floods. The Corps has modified repairs to a revetment to allow continued flow through the chute. Habitat improvements have already shown positive biological results as documented in the fish use of those areas. A wide variety of fish species, including several of special concern and the pallid sturgeon, have been documented in and around those habitats. Taking full advantage of the restoration opportunities of the Refuge is expected to take many years. The long-term benefits of those areas should be evaluated to better refine potential restoration work.

Desoto National Wildlife Refuge - Desoto National Wildlife Refuge (NWR) also manages the nearby Boyer Chute NWR near Blair, Nebraska. The refuge is a joint Federal and local conservation partnership to restore a portion of Missouri River habitat that flows through the 2.5-mi (4 km) chute paralleling the river. Currently, the refuge covers approximately 2,000 ac (810 ha). The Refuge is currently working with the Corps to construct new aquatic habitats on the refuge.

Middle Mississippi River National Wildlife Refuge - The Middle Mississippi River NWR was established following the flood of 1993 and is managed as part of the Mark Twain NWR Complex. To date approximately 4,200 acres of floodprone lands have been acquired. This includes the recent acceptance of Beaver Island as a result of a donation from a partnership with Ducks Unlimited and the American Land Conservancy. The primary management goal of the refuge is to restore habitats that have been lost or degraded as a result of modifications to the floodplain and river. The Service is currently working with the Corps to implement habitat restoration projects, including sidechannel and off-channel aquatic habitat restoration for the benefit of pallid sturgeon.

Restoration stocking - In response to obvious declines in pallid sturgeon numbers and the notable lack of recruitment, MoDOC began an augmentation effort by releasing fingerlings raised at Blind Pony State Fish Hatchery. Through this effort, approximately 7,000 fingerlings were released in the Missouri and Mississippi Rivers in 1994 and an additional 3,000 fingerlings were released in 1997 (Graham 1997, 1999). Since 2000, approximately 16,600 hatchery raised pallid sturgeon have been released in the Lower Missouri River. No additional hatchery reared pallid sturgeon have been released in the Middle Mississippi River or Lower Mississippi River since 1997. However, this year pallid sturgeon were collected in the Lower Mississippi River and several of these fish have been spawned at Natchitoches National Fish Hatchery (Steve Krentz, USFWS, pers. comm. 2004).

The outcome of stocking as a tool to avoid extinction and to recover pallid sturgeon will not be known for some time. To be successful, stocked pallid sturgeon must mature to spawn in suitable habitat, recruit to the population, then spawn again.

5.2.3. Summary

As noted previously, the current status of pallid sturgeon in the action area remains largely unknown. Within the action area there is some evidence of reproduction with the occasional capture of larval stages and juveniles, but an accurate estimate of age structure in the action area is not possible at this time. As noted above, relative abundance estimates of pallid to other sturgeon have ranged from 0.24 to 4.34 percent. Recent data from Grady et al. (2001) and Herzog (2002) in the action area indicate that shovelnose sturgeon populations are either stable or declining, respectively. This, along with increased capture of hatchery-raised fish implies that wild pallid sturgeon numbers may also be stable to declining.

5.3 Effects of the Action

This section includes an analysis of the direct and indirect effects of the proposed action on the species and/or its critical habitat and its interrelated and interdependent activities.

The Upper Mississippi River-Illinois Waterway System Navigation Study proposes to implement both navigation improvement and ecosystem restoration actions. The navigation improvement program also contains a mitigation component for unavoidable adverse impacts to natural resources of the UMRS.

This Tier I biological opinion for the pallid sturgeon evaluates the effects of these actions from a programmatic scale. Site-specific impacts will be evaluated during the Tier II planning process for specific projects and Tier II biological opinions provided to the U.S. Army Corps of Engineers for those projects that are likely to adversely affect pallid sturgeon.

The proposed action (project) is the implementation of the recommended plan contained in the Draft Integrated Feasibility Report and Programmatic EIS for the Upper Mississippi River-Illinois Waterway System Navigation Feasibility Study (USACE 2004). If enacted as recommended, the project will include Federal policy changes, interagency coordinating mechanism or institutional arrangement modifications, changes in operation of existing facilities, manipulation of landcover types to change habitat features, and a suite of construction activities for navigation feature improvement, navigation structure modification, and ecosystem restoration.

Conservation measures to minimize harm to listed species which are proposed by the action agency are also considered part of the proposed project and their implementation is required under the terms of the consultation. The Corps did not include Conservation Measures in their March 2004 Biological Assessment:

Short term impacts to pallid sturgeon at all life stages in the action area during construction activity are expected to be outweighed by the long term benefits of proposed ecosystem restoration measures. Improved aquatic habitat diversity and structural diversity would be expected to benefit the species. The long-term effects of the program on pallid sturgeon will be positive, although it is difficult at this point to determine the full extent of positive impacts. This uncertainty occurs for several reasons. Firstly, the full scope of the program and its implementation has yet to be determined. Although the types of projects to be constructed in the Middle Mississippi River are generally known, the full scope or scale of these projects remains uncertain and will be dependent upon funding levels, prioritization and the results of implementation of the adaptive management framework. Secondly, one of the major ecosystem needs for the Middle Mississippi River is floodplain restoration, including restored floodplain connectivity. However, much of the floodplain in the MMR is in private ownership, therefore, restoration in these areas will largely require cost-share partners and will require willing sellers. Even in the best situations, restoration of connectivity will be challenging. Given these limitations, it is not certain that large scale floodplain restoration will be achievable, at least not in the near term.

5.3.1 Direct effects

5.3.1.1 Navigation improvements

The range of the pallid sturgeon does not overlap with any of the proposed site-specific construction measures proposed. Therefore, this construction is not likely to adversely affect pallid sturgeon.

Commercial Navigation Traffic

Commercial navigation traffic within the action area is a private enterprise, however, it is also a direct effect of the Corps' operation and maintenance of the navigation system. With implementation of the proposed action, navigation traffic is expected to increase in the action area. The effect of towboat propellers on fish populations is a concern associated with commercial navigation traffic. As part of the Navigation Feasibility Study, the Corps has conducted several studies to determine the impacts of navigation traffic on fisheries resources. Of particular concern has been the entrainment of fish larvae, however, the Corps has also conducted studies to evaluate entrainment of juvenile and adult fish.

Larval sturgeon - Cada (1990) reported that fish eggs and larvae that pass through water currents induced by a propeller may come in contact with the blade and can experience stresses from pressure changes and shear forces. Killgore et al. (2001) evaluated mortality of icthyoplankton entrained through a scale model of a towboat propeller. Fish species tested included larval shovelnose sturgeon, larval lake sturgeon, the larvae and eggs of paddlefish, larval blue sucker and juvenile common carp. Fish were subjected to treatments at various shear stress levels ranging from 634 to 4,743 dynes/cm^2 (1 dyne = the force that would give a free mass of 1 g an acceleration of 1 cm/s^2) (Killgore et al. 2001). They found mortality to be a linear function of shear stress for all species and life stages. Larger larvae (e.g., shovelnose sturgeon) experienced lower mortality, while smaller larvae (e.g., lake sturgeon and blue suckers) experienced higher mortality (>75 percent). All larval species experienced delayed mortality, particularly at higher stress levels, however, common carp juveniles and paddlefish eggs did not experience delayed mortality (Killgore et al. 2001).

Shear stress from propeller jet velocities can exceed 5,000 dynes/cm^2. Killgore et al. (2001) concluded that shear stress due to towboat traffic is probably a primary force contributing to the mortality of icthyoplankton entrained during vessel passage, but the magnitude of mortality is dependent on individual size of icthyoplankton. The extent of mortality would be a function of the amount of tow traffic in a given river system, towboat speed and traffic levels during the time of year when larvae are most susceptible to shear stress (e.g., early developmental phase) (Killgore et al. 2001).

In order to estimate the impacts of commercial navigation traffic on fish populations due to larval fish entrainment, the Corps conducted complex modeling studies utilizing a model called NavLEM. The Service requested the Corps to determine if the results of this modeling effort could be utilized to determine the annual mortality of adult shovelnose sturgeon that could be attributed to increased navigation traffic. This information could then be used to estimate the number of equivalent pallid sturgeon adults lost as a result of increased navigation traffic. The BA (USACE 2004a), pages 73-76, explains the methodology and results of this analysis.

A summary of the Corps' modeling results for annualized adults lost for the open river reach (excluding Pool 27) for shovelnose sturgeon and pallid sturgeon are as follows: The pallid sturgeon equivalent adults lost is based on the ratio of pallid sturgeon to shovelnose sturgeon of 1 to 84 for the Middle Mississippi River and are presented in parentheses. The numbers reflect the equal allocation of the total number of lost adults across the 50 year planning period. Equivalent adults lost do not occur until the year 2026 as traffic increases are not expected until 2020 in this analysis. The 2020 entrainment impacts show up initially in 2026 following 5 years to reach adulthood. The results of this analysis show that for the years 2026-2035, 2036-2045, and 2046-2050 there are separate, temporally overlapping projections with associated minimum, average and maximum values.

Utilizing the ratio of pallid sturgeon to shovelnose sturgeon for the Middle Mississippi River of 1 to 84, the data from this analysis indicates a conservative estimate of 3 to 4 equivalent adult pallid sturgeon may be lost due to increased navigation traffic during the 50 year planning period. The data for Pools 16-27 was excluded from this estimation as pallid sturgeon are not known to occur in Pools 16-26. Pool 27 is a relatively short reach of the Middle Mississippi River (27.35 km) and the number of pallid sturgeon lost in this reach is expected to be a relatively minor increment that should be captured in the estimate of 3 to 4 fish for the Middle Mississippi River. The additional mortality of pallid sturgeon larvae is not expected to occur until 2020 and beyond when navigation traffic is predicted to increase.

It should be noted that there is a great deal of uncertainty associated with modeling and estimating larval fish mortality. These uncertainties are explained in detail in Appendix ENV-E of the Navigation Feasibility Report (USACE 2004b). The actual numbers of pallid sturgeon lost in any given year would be a function of many factors, including: overall sturgeon larvae abundance, distribution of larvae in the navigation channel (vertically and horizontally), navigation traffic levels during the larval drift period and navigation channel depth.

<u>Juvenile/Adult sturgeon</u> - Guetreter et al. (2003) developed a method to estimate mortality rates of adult fish caused by entrainment through the propellers of commercial towboats operating in river channels. They estimated entrainment mortality rates of adult fishes in Pool 26 of the Upper Mississippi River and Alton Pool of the Illinois River where fish kills attributed to entrainment were observed. Their estimates of entrainment mortality rates were 0.53 fish/km of towboat travel (80 percent confidence interval, 0.00 – 1.33 fish/km) for shovelnose sturgeon. They concluded that their approach applies more broadly to commercial vessels operating in confined channels, including other large rivers and intracoastal waterways.

During discussions with the Corps as they developed their Biological Assessment, the Corps expressed concerns that the entrainment mortality rates reported by Guetreter et al. (2003) overestimate mortality to shovelnose sturgeon due to towboats. Their main concerns were associated with the sampling design that resulted in filtering only a small fraction of the propwash from towboats and which was not designed to account for rare events. In addition, the Corps expressed concern that the mortality rate was based on collection of one dead shovelnose sturgeon during ambient sampling and not during trawling behind a moving towboat.

Based on the several studies referenced above, there could be a wide disparity in estimating the mortality of juvenile/adult shovelnose sturgeon, and subsequently pallid sturgeon, attributed to commercial navigation traffic. However, the best information available indicates sturgeon are entrained by towboats. This results not only in instantaneous mortality, but delayed mortality and injuries resulting in harm. In addition, although data for other species may indicate the capability to move away from towboats, this may not be the case with sturgeon. Informal and

unpublished observations by USGS indicate that shovelnose sturgeon exhibit a 3-dimensional flight response, scattering in all directions, including straight upward (Steve Gutreuter, USGS, pers. comm. 2004). Such behavior may make them more susceptible to towboat entrainment than other species of fish.
Despite the difficulties, some analysis of incremental increases in traffic mortality is warranted in order to better understand the impacts of commercial navigation traffic on pallid sturgeon. To determine the extent of shovelnose sturgeon, and subsequently pallid sturgeon, mortality attributed to towboats, two data points are required. The first data point is the mortality rate expressed as fish/km of towboat travel. For this analysis, we have utilized the mortality rate for skipjack herring reported by Killgore et al. (2003) of 0.01 fish/km. It is recognized that this mortality rate may either underestimate or overestimate the mortality rate of shovelnose sturgeon. The mortality rate likely underestimates the mortality of all fish caused by towboat entrainment since some of the mortality attributed as being net induced by Killgore et al. (2003) likely occurred as a result of entrainment. On the other hand, the mortality rate likely overestimates the mortality rate for shovelnose sturgeon since skipjack herring are pelagic and are likely more susceptible to entrainment than sturgeon or benthic fish.

To further refine the mortality estimate, consideration was given to the number of shovelnose sturgeon collected as a percentage of the overall number of fish collected in the study by Killgore et al. (2003) which is 0.02% (includes both Mississippi River and Illinois River samples). Therefore, the mortality rate estimate for shovelnose sturgeon is calculated as: 0.01 mortality of fish/km X 0.0002 shovelnose sturgeon/km = 0.000002 shovelnose sturgeon/km of towboat travel. It should be noted that Dettmers et al. (2001) found that shovelnose sturgeon comprised approximately 5% of the fish population in the navigation channel of Pool 26. However, they did not collect any shovelnose sturgeon in the navigation channel of the Alton Pool of the Illinois River. The disparity in the numbers of shovelnose sturgeon collected in the two studies adds further uncertainty to calculating sturgeon entrainment due to towboats.

The second data point required for this analysis is the incremental increase in km of towboat travel for the MMR. This information can be obtained by multiplying the incremental increase in navigation traffic information for the MMR by the length (km) of river traveled. Table 5-5 provides incremental increase in traffic information as provided by the Corps for the Open River and Pool 27. The future with project condition is based on the "Future With Project – TCM Most Favorable Scenario" (USACE 2004b). This allows a more conservative estimate (for the species) of the effects of the proposed action.

Table 5-5: Incremental Traffic Increases – Annual (Future With Project – Future Without Project)

YEAR	OPEN RIVER	POOL 27
2000	0	0
2010	1,652	1,503
2020	2,949	2,675
2030	4,762	4,381
2040	6,502	6,006
2050	6,927	6,427

Table 5-6 - provides the incremental increase in km of towboat travel based on multiplying the number of towboats by the length of river (e.g., 296.06 km for the Open River and 27.35 km for Pool 27) (per Tom Keevin, USACE, St. Louis District and Steve Bartell, Cadmus Group, Inc., Maryville, TN).

Table 5-6: Incremental Increase KM of Tow Travel (Annual)

YEAR	OPEN RIVER	POOL 27	TOTAL KM
2000	0	0	0
2010	489,091	41,107	530,198
2020	873,081	73,161	946,242
2030	1,409,837	119,820	1,529,658
2040	1,924,982	164,264	2,089,246
2050	2,050,808	175,778	2,226,586

An estimate of the number of shovelnose sturgeon killed by towboat entrainment can be calculated by multiplying the mortality rate estimate (0.000002 fish/km) and the km of towboat travel estimates. From this information, an estimate of the number of pallid sturgeon killed can be determined based on the ratio of pallid sturgeon to shovelnose sturgeon in the Middle Mississippi River. This ratio varies depending on the number of sturgeon collected during ongoing sampling. For purposes of this analysis and consistency with the Corps' Biological Assessment (USACE 2004a), the ratio utilized is 1:84 (e.g., 1 pallid sturgeon for every 84 shovelnose sturgeon. This ratio is based on the results of ongoing sampling in the Middle Mississippi River. Table 5-7 represents the incremental traffic increase mortality estimates for shovelnose sturgeon and pallid sturgeon. Overall, under future with project conditions, it is estimated that an additional 1-2 pallid sturgeon will be killed over the 50 year project life.

Table 5-7: Incremental Increase in Traffic Mortality Estimates (Annual)

YEAR	SHOVELNOSE STURGEON	PALLID STURGEON
2000	6.5	0.1
2010	6.2	0.1
2020	6.2	0.1
2030	6.3	0.1
2040	6.5	0.1
2050	6.2	0.1

Of necessity, certain assumptions are utilized in these calculations. These include: 1) sturgeon abundance in the Middle Mississippi River is the same as in Pool 26 and the Alton Pool of the Illinois River, 2) sturgeon entrainment by towboats is a relatively rare event, but does occur, 3) in the Middle Mississippi River, sturgeon are equally susceptible to entrainment as pelagic fish, such as skipjack herring or gizzard shad, and 4) although pallid sturgeon are rare compared to shovelnose sturgeon, they are equally susceptible to towboat entrainment. Similar to larval fish, the actual numbers of juvenile/adult pallid sturgeon entrained in any given year would be a function of many factors, including: overall sturgeon abundance, distribution of sturgeon within the navigation channel (both vertically and horizontally), navigation traffic levels, sturgeon abundance in the navigation channel during different seasons and navigation channel depth. In addition, although the rate is not measurable, many sturgeon likely suffer delayed mortality as a result injuries sustained during entrainment. Also many fish sustain non-fatal injuries, however, these may affect overall fish health and reproductive capability, resulting in harm.

During informal consultation, velocity changes resulting from passing towboats was identified as possibly adversely affecting pallid sturgeon. Increased commercial navigation traffic might cause fish displacement from low velocity habitats during cold water periods. If displacement occurs and fish continue to drift for long periods of time, survival is unlikely (USACE 2004b). Physical model studies conducted by the Corps indicate that velocities under ambient conditions in the vicinity of wingdams exceed displacement velocities for fish. With the exception of an area immediately behind the wingdam and close to the shoreline, all ambient velocities exceeded 0.10 m/sec and ranged from 0.10 to .50 m/sec (USACE 2004b). The results also indicate that under existing conditions, barge traffic increases velocities in the vicinity of wingdams beyond pallid sturgeon critical swimming speeds at low temperatures (e.g., 0.15 m/s at 10 $^{\circ}$C, Adams et al. 2003). The magnitude of this change in velocity is dependent upon the distance of the towboat from the wingdam and whether the towboat is upbound or downbound.

During cold temperatures, pallid sturgeon are likely seeking low velocity refugia that occur in association with wingdams. As navigation induced velocity changes are persistent in the Middle Mississippi River under baseline conditions and ambient velocities often exceed displacement velocities, it is likely that pallid sturgeon actively avoid areas subject to extreme velocity changes due to navigation traffic. Therefore based on the best information available at this time, we concur with the Corps' assessment that incremental increases in navigation traffic would have little additional effect.

5.3.1.2 Mitigation

Mitigation planning for the impacts associated with incremental increases in navigation traffic falls into four major biological areas – fisheries, submersed aquatic plants, bank erosion, and backwater-side channel sedimentation (USACE 2004a). Despite discussion in the Corps' Biological Assessment, only fisheries and bank erosion mitigation is being applied to the Middle Mississippi River (USACE 2004b). The activities being proposed for mitigation has the potential to both adversely and beneficially affect pallid sturgeon. However, the proposed mitigation strategy is based on staged implementation depending upon staged implementation of navigation study alternatives. In addition, the proposed mitigation will be implemented within the adaptive management framework. As a result, there is a high degree of uncertainty as to whether the effects of the proposed mitigation on pallid sturgeon will be realized.

According to the Corps' Biological Assessment (USACE 2004a), fishery mitigation measures include large woody debris anchors, backwater improvements, dike alterations and fish passage. All of the mitigation measures are designed to improve the fishery of the Mississippi River (USACE 2004b). Short-term adverse impacts to pallid sturgeon could occur depending upon location and timing of construction. This could include physical displacement and short-term decreases in forage food abundance due to construction.

However, in the long-term the effects of these measures on pallid sturgeon would be beneficial. Large woody debris anchors provide important structure for the attachment of invertebrates (Nilsen and Larimore 1973) and provide habitat for fish (Lehtinen 1997, Ward and Stanford

1995, Benke et al. 1985), both of which are important food resources for pallid sturgeon. Backwaters provide both important winter and nursery habitat for fish (Scaeffer and Nickum 1986, Bodensteiner and Lewis 1992) and are important for invertebrate production (Neuswagner et al. 1982). Large introductions of woody debris can have a major impact on channel morphology by creating local scour and deposition patterns, including initiating formation of islands and mid-channel bars (Ward and Stanford 1995). Improving side channels and backwaters would increase zooplankton, macroinvertebrate and fish production, thus improving the forage base for pallid sturgeon. Modification of wing dams/dikes would increase habitat diversity that may provide improved foraging habitat, larval/juvenile rearing habitat and seasonal refugia for pallid sturgeon.

Bank erosion mitigation measures include such structural measures as offshore revetments, bank protection and vegetative/bioengineered protection. Bank erosion measures could have further long-term adverse impacts to pallid sturgeon by further reducing channel meandering and the input of sediment and nutrients into the main channel. However, these effects would be difficult to quantify given that much of the MMR is already revetted and channel meandering has been arrested by existing channel regulating works structures.

Use of off-bankline revetments or incorporating woody debris into protection measures would be beneficial to pallid sturgeon by providing important riverine habitat for fish species and macroinvertebrates that serve as prey for pallid sturgeon. Bankline revetments are known to provide habitat for a rich abundance of invertebrates (Beckett et al. 1983, Payne et al. 1989) and fish (Farabee 1986). In addition, commercial fisherman capture shovelnose sturgeon on rock revetments during the spawning season, suggesting the possibility that these areas could potentially be used by pallid sturgeon for spawning (USACE 2004a, Jack Killgore, USACE, pers. comm. 2004).

5.3.1.3 Ecosystem restoration

Descriptions of proposed ecosystem restoration measures are summarized in *Project Description* preceding, and the Biological Assessment (USACE 2004)

Island Building

The recommended plan includes 91 island building projects throughout the UMRS. These projects have an estimated footprint impact of 30 acres each, with a total estimated area of influence of about 91,000 acres, or about 1,000 acres per project (USACE 2004a).

Depending upon the location and timing of island building and the methods utilized for construction, short term adverse effects are likely for pallid sturgeon. For example, larval pallid sturgeon have been collected at the downstream tips of islands. Building islands near these locations during life stages when pallid sturgeon utilize this habitat type may result in either mortality or displacement of larval/juvenile fish. Obtaining material for island creation from these areas may also result in mortality as young fish may be entrained or physical displacement may occur. Dredging and disposal to build islands will result in short term changes to local zooplankton, macroinvertebrate and small fish populations which may also be detrimental by reducing young pallid sturgeon prey. While pallid sturgeon evolved in highly turbid river environments, large local increases in turbidity may also impact young pallid sturgeon foraging capability and success.

However, long-term positive benefits to pallid sturgeon are anticipated as a result of island building. Island habitats provide bathymetric diversity and create rearing habitats for larval and juvenile pallid sturgeon. In addition, with island establishment, side channels are also created which provide additional aquatic habitat diversity that may also provide larval/juvenile rearing habitat and provide seasonal refugia and forage food production areas.

Fish passage

Fish passage structures that may impact pallid sturgeon have been proposed at Melvin Price Locks and Dam and at Kaskaskia Lock and Dam. As discussed in the Corps' Biological Assessment, short-term adverse impacts may occur due to construction impacts (e.g., localized increases in turbidity) and potential elimination of habitat utilized by pallid sturgeon. These adverse effects are anticipated to be insignificant.

The long-term effects of these fish passage structures may be more significant, but are potentially beneficial. Historic records indicate pallid sturgeon were collected in the Mississippi River as far north as Keokuk, Iowa (Bailey and Cross 1954, Coker 1930). While pallid sturgeon have been collected in the tailwaters of Melvin Price Locks and Dam, it is extremely uncertain as to whether this species would move into Pool 26 if fish passage was provided.

There are no historic records of pallid sturgeon in the Kaskaskia River. However, pallid sturgeon commonly occur at the mouth of the Kaskaskia River and recently, have also been located in the tailwaters of Kaskaskia Lock and Dam. Providing fish passage at this location may provide the opportunity for pallid sturgeon to migrate into the Kaskaskia River for spawning. Alternatively, Kaskaskia Lock and Dam may be preventing spawning runs for the shovelnose sturgeon, thus possibly contributing to hybridization between the two species due to spawning habitat overlap. Fish passage at Kaskaskia Lock and Dam may provide increased spawning habitat for shovelnose sturgeon, reducing the amount of overlap between the species in the main channel of the Mississippi River.

Floodplain Restoration

The recommended plan calls for 16 projects below Pool 13, each with a footprint of about 5,000 acres, totaling about 80,000 acres. Short-term adverse effects to pallid sturgeon may occur depending upon techniques utilized for floodplain restoration. For example, if material is dredged from the river and disposed in floodplain areas to create ridge habitat for reforestation, such activities could have short-term adverse effects. Dredging material may result in mortality through entrainment or physical displacement of pallid sturgeon. Dredging results in short-term changes to local zooplankton, macroinvertebrate and small fish populations which may be detrimental by reducing young pallid sturgeon prey. While pallid sturgeon evolved in highly turbid river environments, large local increases in turbidity may also impact young pallid sturgeon foraging capability and success.

The long-term beneficial effects of the floodplain restoration measure on pallid sturgeon is unknown. While the importance of the seasonal flood pulse and river connection is mentioned in the Corps' BA, there is no discussion of floodplain connectivity as part of restoration in the southern reaches. Without connectivity, flow of nutrients to the river produced by the above referenced activities will be greatly inhibited. Fish will have limited access to floodplain habitats, thus floodplain spawners which produce forage fish will not benefit from the restored habitats.

Water Level Management and Dam Point Control

The recommended plan includes implementing water level management in 12 pools. The area of influence for a 2-foot drawdown is approximately 2,350 acres in each pool. The recommended plan also includes changing control points in Pools 25 and 16. The direct area of influence would total approximately 6,000 acres. The indirect area of influence is much larger and not easily defined. For example, fish may come from great distances to exploit flooded terrestrial areas, or energy transported from the floodplain to the river may be processed many miles away. The change in flood regimes can also directly and indirectly affect floodplain plant communities (USACE 2004a).

Water level management of backwater projects varies greatly in scope from large-scale projects using permanent management levees and fixed pumps affecting thousands of acres, to small backwaters isolated with temporary berms and drawn down with portable pumps affecting less than 100 acres. Under The recommended plan, seven backwater water level management projects, totaling 7,000 acres of influence are proposed (USACE 2004a).

The effects of water level management in the Pools and Dam Point Control on pallid sturgeon will be beneficial but are difficult to quantify. Improved aquatic plant production throughout the UMR-IWW should improve water quality in the river system. In addition, increased aquatic plant, macroinvertebrate and fish production should facilitate the transfer of energy throughout the system. Pallid sturgeon should realize some of these benefits even though the species occurs outside the area of direct impact.

Similarly, the impacts of water level management in backwaters are difficult to quantify, but overall would be generally beneficial by improving nutrient input/cycling and improving forage food production for pallid sturgeon. Some short term adverse effects could occur as a result of construction. This could result in large localized increases in turbidity and locally reduced prey items. Restricting flow into contiguous backwaters for long periods could have long term adverse impacts by preventing the flow of nutrients and prey items into the main channel for utilization by pallid sturgeon.

Backwater Restoration

The recommended plan includes 208 backwater restoration projects with a 20 acre footprint each. The result would be 124,800 acres of influence, or approximately 600 aces per project (USACE 2004a).

Backwater restoration projects may have short term adverse effects to pallid sturgeon. However, depending upon the location of the project, these effects should be minimal as pallid sturgeon are not known to directly utilize backwater habitats, particularly disconnected backwaters located in the floodplain. Large localized increases in turbidity may impact pallid sturgeon ability to successfully forage. In addition, there may be localized decreases in zooplankton, macroinvertebrates and small forage fish during and immediately after construction. Construction of closing dams or restricting flow into currently connected backwaters would have a long-term adverse impact to pallids sturgeon by precluding the use of this habitat.

Over the long-term, pallid sturgeon are expected to benefit from backwater restoration projects. Improved productivity in these habitats will increase pallid sturgeon forage base and improve nutrient inputs into the main channel. In addition, projects that connect backwaters to the main channel and provide deep water habitat may provide seasonal refugia depending upon the degree of connectivity.

Side Channel Restoration

Side channels serve as important nursery areas and as refugia from the swift currents and harsh environments of the thalweg (Environmental Sci. and Eng. 1982, Fremling et al. 1989). Recent evidence suggests that side channels may be important rearing areas for larval pallid sturgeon. In 1999, one confirmed and two probable larval pallid sturgeon were collected from a large sandbar complex at the lower end of Lisbon Chute, a reconnected side channel of the Missouri River (Jim Milligan and Joanne Grady, USFWS, pers. comm. 2000). More recently, MoDOC have collected larval pallid sturgeon in the Middle Mississippi River at downstream island tips (Hrabik 2002). This habitat type is associated with side channel/island complexes. In addition, adult pallid sturgeon have been captured in MMR side channels (Mike Peterson, MoDOC, pers. comm. 1999, Dave Herzog, MoDOC, pers. comm. 2003). Furthermore, side channels are an integral component of the habitat complexity of the UMR ecosystem, particularly the MMR. These areas not only provide nursery areas and refugia for fish, but serve an important role in the cycling of nutrients and in the production of food organisms for many species.

In its natural state, an alluvial river divides itself into two or more channels by the processes of either erosion or deposition. Side channels which are obliterated by deposition are replaced by new side channels caused by floods and/or river migrations. In the MMR, the river is no longer free to migrate and produce new side channels (Simons et al. 1974) due to channel training structures (e.g., wingdams, revetments, closing structures). Side channels in the MMR have been closed off and others have sedimented in (Simons et al. 1975, Theiling 1999). The loss of side channels is well documented. In 1797 there were 55 side channels (Collot 1826), 35 in 1860 (Simons et al. 1974), 27 in 1968 (Simons et al. 1974), and only 25 today (USACE 1999a). Many of the remaining side channels are not natural but were created as a result of wingdam/dike field construction. Many of those that remain are degraded and much smaller than in the past (Theiling et al. 2000) and function more as backwater habitat since they are disconnected from the main channel during large portions of the year. For example, within six study reaches analyzed, Theiling et al. (2000) noted that approximately 918 acres of secondary channel habitat was lost during the period 1950 to 1994 due to closing structures and resulting sediment accumulation and terrestrial encroachment. Of this amount, approximately 275 acres were lost from 1975 to 1994. In the absence of further human-induced changes in hydrology or geomorphology of the MMR, most of the remaining side channels may disappear (Theiling 1999). Side channels provide seasonal refugia, larval and juvenile rearing habitat and forage food production for pallid sturgeon. For this reason, the 2000 Biological Opinion RPA identified restoration of side channels as a high priority measure to preclude jeopardy to the species.

The recommended plan includes 147 side channel restoration projects with a footprint impact of approximately 100 acres per project. The total area of influence is estimated to be approximately 14,700 acres (USACE 2004a).

Side channel restoration may have short-term adverse effects to pallid sturgeon depending upon the location and timing of construction and the methods utilized. As larval pallid sturgeon utilize the downstream tips of islands, construction activities that impact these areas may displace larval/juvenile fish or result in direct mortality. Similarly, construction activities that impact deep water habitat in side channels during winter may displace adult pallid sturgeon. Large local increases in turbidity may also impact young pallid sturgeon foraging capability and success.

However, the long-term positive benefits of side channel restoration for pallid sturgeon should be extremely significant. Restoration of these habitats should create additional downstream island tip habitat and bathymetric diversity that will provide larval/juvenile rearing habitat. Improving depth and accessibility in sidechannels will provide additional seasonal refugia for pallid sturgeon. In addition, side channel restoration will increase zooplankton, macroinvertebrate and fish production, thus increasing pallid sturgeon prey base and providing for nutrient inputs into the main channel.

Wing Dam and Dike Alteration

The effect of channel training structures in reducing channel width and surface area, and thereby habitat diversity, was most apparent within a few years of construction. However, although occurring at a slower rate, the effects are ongoing. For example, in evaluating side channel sedimentation and land cover change in the MMR, Theiling et al. (1999) found that main channel habitat decreased by 1667 acres in the six study reaches during the period 1950 to 1994. Of this amount, approximately 412 acres were lost from 1975 to 1994. In addition, dikes and revetments have not only narrowed the river channel, but deepened it as well (Chen and Simons 1986, Nielson et al. 1984). Simons et al. (1974) gave the following example of riverbed degradation in a 14-mile reach of the MMR due to channel constriction:

> *By 1966 the river had been contracted to an average width of 1800 feet. The riverbed had lowered about 8 feet between 1889 and 1966. In July 1967, the Corps of Engineers selected this 14-mile reach as a test reach to develop design criteria on obtaining and maintaining a dependable 9-foot deep navigation channel [Degenhardt 1973]. Between 1967 and 1969, this test reach narrowed from 1800 feet to 1200 feet in width. In 1971, the riverbed was resurveyed. The contraction from 1800 feet to 1200 feet had resulted in a 3-foot lowering of the riverbed [Degenhardt 1973]. In 1971 the low water riverbed in the 14-mile reach between mile 140 and 154 was on the average 11 feet lower than in 1889."*

Channel training structures have also altered the natural hydrograph of the MMR by contributing to higher water surface elevations at lower discharges than in the past and to a downward trend in annual minimum stages (Simons et al. 1974, Wlosinski 1999). Wlosinski (1999) found water-surface elevations have decreased at the same low discharge of 60,000 cfs during the period from 1880 to present. The downward shift of annual minimum stages can be partially attributed to the degradation of the low-water channel by wingdams (Simons et al. 1974). River stages fluctuate as much as 15 m annually, effectively dewatering some secondary channels during low stages (Fremling et al. 1989).

Notching dikes, lowering their profile, or altering their angle to the channel are some actions that can be used to increase habitat diversity through the creation of new scour holes, sandbars, and flow refugia. When wing dike alteration is done on the dike field level, or in association with new structure placements, new side channels, islands and off-channel areas can be created. The recommended plan includes 64 wing dam/dike alteration projects (five structures per project) for a total of approximately 640 acres of influence. [excerpt from USACE 2004a]

Wing dam and dike fields are utilized by pallid sturgeon. Deep scour holes that develop in association with wing dams provide seasonal refugia, particularly during winter. Pallid sturgeon also utilize the sand bar habitat that accretes between wingdams. Although their preference for this habitat is poorly understood, at a minimum it is believed these areas provide important foraging habitat. Although the 2000 Biological Opinion RPA identified modification of channel training structures as a medium priority for pallid sturgeon, wing dam/dike alterations is critical to improving habitat diversity in the MMR for a wide range of species.

Depending upon the time of year and location of construction, these projects may have short-term adverse effects for pallid sturgeon. Activities that impact existing deepwater habitat may result in displacement of pallid sturgeon. Projects that impact existing sand bar habitat may disrupt foraging habitat. However, these adverse effects are expected to occur at a local, individual dike scale. By completing restoration/enhancement projects at the scale of the dike field, long-term beneficial effects for pallid sturgeon should result by the creation of additional side channels, sand bars and scour holes. Such activities are likely to create additional larval/juvenile rearing habitat and seasonal refugia and improve forage food production. Construction of closing dams, additional revetment construction and restricting flow into contiguous backwaters may have long-term adverse effects to pallid sturgeon by reducing accessibility to important habitats like side channels and reducing forage food and nutrient inputs into the main channel.

Island Protection and Shoreline Protection

The effects of island/shoreline protection projects on pallid sturgeon are mixed. The use of revetments (in conjunction with wing dams) has largely arrested the natural meandering capability of the river, thus reducing habitat diversity. Many islands in the Middle Mississippi River have been lost, mostly due to sediment accretion in side channels. Therefore, the protection of the remaining islands will provide long-term benefits to pallid sturgeon to the extent the project protects the sidechannel and downstream island tip habitat that is important for pallid sturgeon. Long-term adverse impacts could occur as a result of constructing closing dams or additional levees. These projects could restrict access of pallid sturgeon to important habitat for larval/juvenile rearing and seasonal refugia and also impact the input of pallid sturgeon forage food and nutrients into the main channel.

Shoreline protection measures could have further long-term adverse impacts to pallid sturgeon by further reducing channel meandering and the input of sediment and nutrients into the main channel. However, these effects would be difficult to quantify given that much of the Middle Mississippi River is already revetted and channel meandering arrested.

Use of off-bankline revetments or incorporating woody debris into protection measures would be beneficial to pallid sturgeon by providing important riverine habitat for fish species and macroinvertebrates that serve as prey for pallid sturgeon. Bankline revetments are known to provide habitat for a rich abundance of invertebrates (Beckett et al. 1983, Payne et al. 1989) and fish (Farabee 1986). In addition, commercial fisherman capture shovelnose sturgeon on rock revetments during the spawning season, suggesting the possibility that these areas could potentially be used by pallid sturgeon for spawning (USACE 2004a, Jack Killgore, USACE, pers. comm. 2004).

Topographic diversity

Topographic diversity projects may have both short-term adverse effects and long-term beneficial effects to pallid sturgeon depending on location and timing of construction. Obtaining dredge material from the main channel or other areas may result in entrainment of pallid sturgeon, possibly leading to mortality. However, obtaining dredge material from either main channel border or side channel habitats could create additional bathymetric diversity, including deep holes, which would be beneficial to pallid sturgeon.

Forest Management

Although a terrestrial activity, some management actions proposed to implement this ecosystem measure could impact the aquatic environment (e.g., shore pipe, boosters to reach dredged material placement sites, use small dredges to expand placement options) and could adversely affect pallid sturgeon depending upon timing and location of dredging and depending upon where dredge material is obtained. Dredging for material could result in entrainment and mortality of pallid sturgeon or displacement from larval/juvenile rearing habitats. However, additional bathymetric diversity could be created which would be a beneficial effect.

In addition, several management actions are proposed that could have long-term positive effects for pallid sturgeon. These actions generally involve floodplain reconnection and include: notching levees, setback levees, and removal of levees. Such actions would improve production of zooplankton, macroinvertebrates and fish that provide forage for pallid sturgeon. Nutrient inputs into the main channel would also be improved.

5.3.1.4. Summary

Many of the ecosystem measures proposed in the recommend plan were included in the 2000 Biological Opinion (USFWS 2000a) Reasonable and Prudent Alternative as actions necessary for the pallid sturgeon. This includes island building (e.g., restore gravel bars, restore sand bars), side channel restoration, floodplain restoration (e.g., restore floodplain connectivity, restore the riparian corridor, restore woody debris) and wing dam/dike alteration (e.g., modify training structures). The benefits of such ecosystem measures are described in recent literature on river/floodplain ecology. (Beamesderfer and Farr 1997, Benke et al. 1985, Petts et al. 1989, Ward and Stanford 1995).

5.4 Cumulative Effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation under section 7 of the Act. The Service is unaware of any additional state, tribal, local or private actions that are reasonably certain to occur in the action area producing cumulative effects beyond those ongoing effects already considered in the Environmental Baseline.

5.5 Conclusion

After reviewing the current status of pallid sturgeon, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the Corps' proposed implementation of the alternatives for navigation improvements and ecosystem restoration is not likely to jeopardize the continued existence of the pallid sturgeon. No critical habitat has been designated for this species, therefore, none will be affected.

As discussed in the 2000 BO (USFWS 2000), and section 5.2 preceding, the MMR is important to the survival and recovery of the pallid sturgeon. The range of the pallid sturgeon does not overlap with any of the proposed site-specific construction measures proposed. Therefore, this construction is not likely to adversely affect pallid sturgeon, and projected traffic increases associated with the recommended plan are estimated to increase pallid sturgeon mortality by only 1-2 fish over the entire project life. Ecosystem restoration measures will only affect a few individuals on a temporary localized basis during project construction, and will, over the project life, contribute to restoration of features beneficial to pallid sturgeon. Therefore, we do not anticipate any negative effects to the MMR population, and consequently, no reductions in reproduction, numbers or distribution of the rangewide population of pallid sturgeon.

5.6 Incidental Take Statement

5.6.1 Introduction

Section 7 of the Act and Federal regulation under Section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the Corps so that they become binding conditions of any action directly implemented by the Corps or any contract, grant, or permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require the contractor, grantee or permit applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the contract, grant document or permit, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(I)(3)]

5.6.2 Extent of take anticipated

The amount or extent of incidental take for pallid sturgeon can be quantified for certain aspects of the proposed action and cannot be quantified for other aspects. Based on the assumptions and estimates provided in the preceding *Effects of the Action* section, the Service anticipates that 4 juvenile/adult and 2 equivalent adult pallid sturgeon will be incidentally taken as a result of increased navigation traffic associated with navigation improvements during the 50 year planning period. This incidental take is expected to be in the form of killing.

The Corps proposed ecosystem restoration program will involve dredging and disposal of material in habitat utilized by pallid sturgeon. As such, pallid sturgeon may be killed by entrainment due to dredging or by disposal of material in occupied habitat. The Service anticipates that no more than 1 juvenile/adult and 20 larval pallid sturgeon per year will be killed as a result of these actions.

Incidental take of pallid sturgeon as a result of other aspects of the proposed action will be difficult to detect for the following reasons: pallid sturgeon are widely distributed in the action area; pallid sturgeon are rare and occupy habitats where detection is difficult; finding dead or impaired specimens is unlikely; and losses may be masked by seasonal fluctuations in numbers or other causes that makes detection difficult. Non-quantifiable incidental take is expected to be in the form of killing, harm and harassment. This incidental take is explained further below for each component of the proposed action.

Commercial Navigation Traffic - Not all pallid sturgeon entrained by towboat propellers are killed instantaneously. Some individuals will suffer delayed mortality. Others will suffer non-fatal injuries that may affect reproductive fitness/capability and/or long-term survival, thus causing harm.

Project Mitigation - Implementation of project mitigation measures will result in physical displacement of individual pallid sturgeon and short-term decreases in forage food abundance which is harassment.

Fleeting - Towboats are utilized to maneuver barges into and out of fleeting areas. Increased towboat activity will result in additional pallid sturgeon being killed or injured through towboat propeller entrainment. In addition, habitat modification associated with constructing fleeting areas, movement of barges into/out of fleeting areas and maintenance dredging will result in physical displacement of pallid sturgeon or decreases in forage food abundance which is harassment.

Ecosystem Restoration Program - Habitat restoration will result in habitat modification that will physically displace pallid sturgeon. Short-term decreases in forage food abundance will occur. These effects result in harm and harassment of pallid sturgeon.

Since the level of incidental take of pallid sturgeon for these aspects of the proposed action cannot be adequately determined, incidental take will be anticipated by: (1) loss or modification of larval/juvenile pallid sturgeon rearing habitat (downstream island tips and/or sandbars with current disrupting features); and (2) loss or adverse modification of connected side channel/backwater habitats which provide seasonal refugia and serve as forage food production areas.

Loss of larval/juvenile rearing habitat

The individual components of the Corps proposed action that are most likely to result in incidental take of larval/juvenile pallid sturgeon rearing habitat are island building and wing dam/dike alteration. According to the Corps' Biological Assessment (USACE 2004a), 91 island building projects are proposed with a total of 91,000 acres of influence. Conservatively, it is estimated that approximately 1/3 (30) of these projects would be constructed in the Middle Mississippi River with an estimated area of influence of 30,000 acres. It is anticipated that no more than 10% of these projects would adversely impact pallid sturgeon larval/juvenile rearing habitat for a total of 3,000 acres of impact. Similarly, the Corps' has proposed 64 wing dam/dike alteration projects with a 640 acres area of influence. It is estimated that approximately ¾ of these projects would be implemented in the Middle Mississippi River with an estimated area of influence of 480 acres. It is estimated that no more that 10% of these projects would adversely impact pallid sturgeon larval/juvenile rearing habitat for a total of 48 acres of impact. These calculations are based on the assumption that the entire area of influence would be adversely impacted. This assumption is made in order to provide the most conservative estimate (for the species) of anticipated impacts.

Loss or adverse modification of connected side channel/backwater habitat

The individual components of the Corps proposed action that are most likely to result in incidental take of pallid sturgeon seasonal refugia and forage food production areas are side channel and backwater restoration. According to the Corps' Biological Assessment, 147 side channel restoration projects are proposed with a total of 14,700 aces of influence. Conservatively, it is estimated that approximately ½ of these projects would be constructed in the Middle Mississippi River with an estimated area of influence of 7,400 acres of influence. It is anticipated that no more than 25% of these projects would adversely affect pallid sturgeon seasonal refugia and forage food production by isolating these habitats from the main channel, for a total of 1,850 acres of impact. Similarly, the Corps' has proposed 208 backwater restoration projects with a total of 124,800 acres of influence. It is estimated that approximately ¼ of these projects would be constructed in the Middle Mississippi River with an estimated 31,200 acres of influence. It is anticipated that no more 10% of these projects would aversely affect pallid sturgeon seasonal refugia and forage food production by isolating these habitats from the main channel, for a total of 3,120 acres of impact. These calculations are based on the assumption that the entire area of influence would be adversely impacted. This assumption is made in order to provide the most conservative estimate (for the species) of anticipated impacts.

5.6.3 Effect of the take

In the accompanying biological opinion, the Service determined that this level of expected take is not likely to result in jeopardy to the species, or destruction or adverse modification of critical habitat.

5.6.4 Reasonable and prudent measures

To ensure that the anticipated level of incidental take is commensurate with the take that occurs per the proposed action, the Corps of Engineers (Corps) and the Service is implementing a tiered programmatic consultation approach. This approach utilizes a tiered consultation framework with the subject consultation resulting in this Tier I biological opinion. All subsequent projects will be Tier II consultations with Tier II biological opinions issued as appropriate (i.e., whenever the proposed project will result in unavoidable adverse effects to threatened and endangered species).

As individual projects are proposed under the recommended plan, the Corps shall provide, for any action that may affect Indiana bats, project-specific information to the Service that (1) describes the proposed action and the specific area to be affected, (2) identifies the species that may be affected, (3) describes the manner in which the proposed action may affect listed species, and the anticipated effects, (4) specifies whether the anticipated effects from the proposed project are similar to those anticipated in the programmatic BO, (5) estimates a cumulative total of take that has occurred thus far under the tier I BO, and (6) describes any additional effects, if any, not considered in the tier I consultation. If it is determined that the proposed project may affect the pallid sturgeon, the Corps will provide this information in a tier II BA to document anticipated effects of the subject action.

The Service will review the information provided by the Corps for each proposed project. If it is determined during this review that a proposed project is not likely to adversely affect listed species, the Service will complete its documentation with a standard concurrence letter and specifies that the Service concurs that the proposed project is not likely to adversely affect listed species or designated critical habitat.. If it is determined that the action is likely to adversely affect listed species or designated critical habitat and these effects are commensurate with those contemplated in the programmatic BO, then the Service will complete a tier II BO with a project-specific incidental take statement within the annual allotted programmatic incidental take, and project specific Reasonable and Prudent Measures and Terms and Conditions, if appropriate..

The Service believes the following reasonable and prudent measures are necessary and minimize impacts of incidental take of pallid sturgeon:

1. As referenced in the Corps' Biological Assessment (USACE 2004a), the Corps shall implement additional towboat propeller entrainment studies to further evaluate the scope of impacts additional tow traffic will have on juvenile/adult pallid sturgeon. These studies will utilize the methodology developed by Killgore et al. (2003) or other methods as deemed appropriate. This RPM addresses incidental take associated with incremental increases in navigation traffic.

2. The Corps shall implement studies to more fully determine larval sturgeon densities in the Middle Mississippi River. The information obtained in these studies can then be used to further refine estimated larval pallid sturgeon mortality and measurement of equivalent adults lost. This RPM addresses incidental take associated with incremental increases in navigation traffic.

3. The Corps shall develop a fleeting plan for the Middle Mississippi River. This fleeting plan shall identify important pallid sturgeon habitat areas that should be placed "off-limits" to fleeting, identify areas that are suitable for fleeting and having no or minimal impacts on pallid sturgeon and identify other measures that should be taken to minimize the impacts of fleeting on pallid sturgeon.

4. Pre-project fisheries surveys and physical habitat surveys will be completed for each project, as appropriate, to assess the sites current value for pallid sturgeon. The need for pre-project monitoring may be determined on a site specific basis, in consultation with the Service, as not all projects will impact pallid sturgeon. This RPM addresses incidental take associated with navigation project mitigation and the ecosystem restoration program.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which carry out the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. The Corps shall develop a study plan for additional towboat entrainment studies in the Middle Mississippi River. This plan of study shall be developed in coordination with the Service and other fisheries sampling experts from the states, universities and/or the USGS, as appropriate. The plan of study shall be completed no later than the end of fiscal year 2010.

2. Additional towboat entrainment studies as described in the plan of study developed in Term and Condition #1 shall be completed by no later than the end of fiscal year 2015. Annual monitoring reports and a final report on towboat entrainment studies shall be provided to the Service.

3. The Corps shall develop a study plan for collecting larval sturgeon densities in the Middle Mississippi River. This plan of study shall be developed in coordination with the Service and other fisheries sampling experts from the states, universities and/or USGS, as appropriate. The plan of study shall be completed no later than the end of fiscal year 2010.

4. The Corps will revise larval sturgeon entrainment estimates for the Middle Mississippi River based on the data collected in the larval sturgeon density study. These revised estimates will be completed no later than fiscal year 2017.

5. In coordination with the U.S. Fish and Wildlife Service and other appropriate federal and state natural resource agencies, initiate development of the Systemic Barge Fleeting Plan for the Upper Mississippi River System in Funding Year One of the Upper Mississippi River - Illinois Waterway System Navigation Capacity Improvement Project. Information from the

plan will assist in locating future actions to avoid and minimize effects to pallid sturgeon. The fleeting plan should be completed within three years of initiation and identify (1) important pallid sturgeon habitat areas that should be avoided; (2) areas that are suitable for fleeting and have no or minimal impacts on pallid sturgeon; and (3) other measures to avoid/minimize the impacts on pallid sturgeon.

Requirements for Monitoring and Reporting of Incidental Take of Pallid Sturgeon

Federal agencies have a continuing duty to monitor the impacts of incidental take resulting from their activities [50 CFR 402.14(i)(3)]. In doing so, the Federal agency must report the progress of the action and its impact on the species to the Service as specified below.

1. Supply the Service with an annual report, due by January 31 of each following year, that summarizes the progress of studies, surveys, and plans prepared in support of the preceding reasonable and prudent measures.

2. The larval sturgeon densities plan of study developed in Term and Condition #3 shall be completed by no later than the end of fiscal year 2015. Annual monitoring reports and a final report shall be provided to the Service.

3. Site specific monitoring plans will be developed and implemented during and following construction of project mitigation features and ecosystem restoration projects in order to further evaluate incidental take of pallid sturgeon. This RPM addresses incidental take associated with navigation project mitigation and the ecosystem restoration program.

4. All dead pallid sturgeon encountered during sampling and monitoring activities will be preserved on ice and provided to the University of Alabama per the Service's cooperative agreement. Blood and tissue samples will be provided to Southern Illinois University at Carbondale for genetics analysis. The Fish and Wildlife Service Ecological Services Field Offices in Rock Island and Marion, Illinois will be notified of any dead pallid sturgeon.

Closing

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. The anticipated amount of incidental take for pallid sturgeon is described above. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Corps must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

Conservation Recommendations

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help carry out recovery plans, or to develop information.

1. Since sturgeon show a preference for other habitats besides the main channel, providing more diverse habitats in the Middle Mississippi River should redistribute those fish out of the main channel, making them less susceptible to towboat entrainment. Therefore, we recommend accelerated habitat restoration in the MMR in order to minimize effects to pallid sturgeon.

2. In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

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REINITIATION NOTICE – CLOSING STATEMENT

This concludes formal consultation on the actions outlined in the recommended plan provided in the Draft Integrated Feasibility Report and Programmatic EIS for the Upper Mississippi River-Illinois Waterway System Navigation Feasibility Study, 29 April 2004, and contained in the Corps' Biological Assessment, dated April 2004. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.