A SURVEY OF LOCK AND DAM #1 ON THE LOWER OSAGE RIVER, MISSOURI

Photo credit: USFWS, 2002

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Introduction

Scientific literature supports the notion that habitat loss is the greatest threat to our native wildlife. An estimated 47% of endangered or threatened species are affected by aquatic habitat alterations (Wilcove et al. 1998). This includes dams on large rivers, which have long been known to create barriers to movement of migratory fish species such as salmonids and sturgeon (Jager et al. 2001; Raymond 1979). Additionally, other structures such as low-head dams and many road crossings on tributary rivers and streams also have adverse effects on fish populations. Studies on the Fox River, in northeast Illinois, have shown that the lowhead dams there have adversely affected the aquatic communities throughout the drainage (Santucci et al. 2005). Gillette et al. (2005) also documented differences in upstream and downstream fish assemblages caused by a series of small low-head dams on the Neosho River in Kansas. Due to their unique life history strategy involving a brief period of parasitism with host fish many native mussel species, among the most threatened of all taxa (Wilcove et al. 1998), are also highly susceptible to the effects of aquatic passage barriers. Additionally, these structures not only influence the morphology of the stream beds where Unionid mussels aggregate, but may also create a distributional barrier to the host fish (Watters 1996). Fragmentation of river basins has restricted movements of fish, degraded habitat and water quality and thereby degraded the associated biotic communities (Wilcove et al. 1998, McIninch and Garman 2000; Santucci et al. 2005; Grady et al. 2011).

Imperiled sturgeon species, such as the federally endangered pallid sturgeon (*Scaphirhynchus albus*), require large, turbid and free-flowing riverine habitat with rocky or sandy substrate (Gilbraith et al. 1988). Pallid sturgeon are benthic fish that inhabit areas of swifter water than does the related but smaller shovelnose sturgeon (*S. platorynchus*) (Pflieger 1997; Carlson et al. 1985). Similar to other large bodied riverine species, pallid sturgeon and shovelnose sturgeon are migratory species, often moving hundreds of river miles to spawn (Bramblett and White 2001). Historical records indicate that pallid sturgeon were found throughout the Missouri and Mississippi River drainages from Montana to Louisiana. These records also describe widespread use of larger tributaries like the Yellowstone, Platte, lower St. Francis, Big Sunflower and the Atchafalaya rivers (Bailey and Cross 1954; Constant et al. 1997). Habitat loss over the past century and river fragmentation is believed to have strongly influenced the decline of pallid sturgeon. The 2003 Amendment to the U.S. Fish and

Wildlife Service (USFWS) Biological Opinion stated that the primary cause of decline for pallid sturgeon was "…destruction and alteration of big-river ecological functions and habitat that were once provided by the Missouri and Mississippi Rivers. The physical and chemical elements of channel morphology, flow regime, water temperature, sediment transport, turbidity and nutrient inputs that once functioned within big river ecosystem[s] have been dramatically altered by construction of mainstem and tributary dams, construction of navigation projects (*e.g*., channelization) and subsequent isolation of the floodplain through flood control projects." Tributaries may provide critical habitat and play a key role in the recovery of pallid sturgeon. In response to the 2000 Missouri River Biological Opinion, the Army Corps of Engineers (COE) has developed monitoring and restoration projects to avoid jeopardizing pallid sturgeon populations. As part of their Implementation Plan, the COE is working with the USFWS and state natural resource agencies to execute a Pallid Sturgeon Population Assessment Program (PSPAP) program.

As a compliment to the PSPAP occurring on the Missouri River, sampling of tributaries on the lower Missouri River has recently documented the presence of pallid sturgeon utilizing confluences and tributaries proper. Two hatchery stocked pallid sturgeon were captured in 2008 and one in 2009 from the delta complex of the Niobrara River (Wanner et al. 2010). In addition, Missouri Department of Conservation reported having caught one hatchery stocked pallid sturgeon in 2007 and four hatchery stocked pallid sturgeon in 2009 below the Johnson County Weir on the Kansas River (Niswonger et al. 2010). Finally, between 2003 and 2010, Columbia Fish and Wildlife Conservation Office (Columbia FWCO) captured 37 pallid sturgeon, 138 lake sturgeon (state endangered) (*Acipenser fulvescens*), and 2,500 shovelnose sturgeon at the confluence with the Osage River. These captures indicate that larger tributaries, though highly altered, may still be important habitat in the life histories of sturgeon throughout the Missouri River basin.

In addition to endangered fish species, the Osage River supports fragile mussel beds that are home to nearly 40 species, including two federally listed; pink mucket (*Lampsilis abrupta*) and scaleshell (*Leptodea leptodon*), one federally proposed; spectaclecase (*Cumberlandia monodonta*), two state endangered; elephant ear (*Elliptio crassidens*) and ebonyshell (*Fusconaia ebena*), as well as several species of conservation concern; black sandshell (*Ligumia recta*), hickorynut (*Obovaria olivaria*) and rock pocketbook (*Arcidens confragosus*) (A. Roberts, USFWS, personal communtication). These Unionid mussels have a complex mode of reproduction, which includes a brief, obligatory parasitic stage on a specific host fish. Male mussels release sperm directly into the water and females living downstream siphon the sperm into the gill chamber, where eggs are fertilized and develop into larvae (glochidia). Once glochidia are expelled by the female, they must quickly attach to the gills or the fins of an appropriate fish host to complete development. Following proper host fish infestation, glochidia transform into juvenile mussels and drop from the host. Suitable habitat must exist at the site for survival (USFWS 2006).

The pink mucket (*Lampsilis abrupta)* population in the lower Osage River is one of the most significant remaining throughout its range. It is the largest known population west of the Mississippi, and is considered essential to the recovery of this species (USFWS 2006). A large mussel bed with aggregations of pink mucket and the aforementioned mussel species has been documented in a side channel by the USFWS immediately upstream of Lock and Dam 1. In addition to providing essential habitat for an endangered mussel species, the cobble-gravel substrate and low flow within the side channel may provide a suitable spawning substrate and conditions for lithophilic fish species (those that lay eggs on a rock, cobble or gravel substrate), such as sturgeon.

Methods

Study Location and History

The Osage River is the largest tributary of the Missouri River in the state of Missouri. The Osage River originates in eastern Kansas and empties into the Missouri River at river kilometer (km) 209 (river mile 130), approximately 19 km below Jefferson City, Missouri (Figure 1). It flows easterly through the state for over 480 km traversing the formerly grass-dominated prairie faunal region and forested mountain faunal region (Pflieger 1997). The Osage River has been highly altered for navigation, hydroelectric power and recreation. Two reservoirs have been formed by large hydroelectric dams on the Osage River. Harry S. Truman Lake, the upper reservoir, is impounded by Truman Dam, which is managed by U. S. Army Corps of Engineers (ACOE); the Lake of the Ozarks is the lower reservoir and is impounded by Bagnell Dam and managed by Ameren UE. Bagnell Dam is a bottom draw reservoir which produces rapidly fluctuating cool, clear discharges altering flow regimes in the system until its confluence with the

Missouri River nearly 130 km downstream. The river's channel is meandering with mostly coarse sand and gravel substrates and water levels are extremely variable, resulting in a series of pools, shallow shoals, sandbars and islands.

Alterations to the lower Osage River began in 1871 by ACOE and included dredging of shoals, cutting overhead brush, removing snags and construction of wing dams and training walls. However, these methods proved inadequate and too costly to provide for reliable maintenance of a navigation channel for steamboat traffic; as a result, demand for slackwater navigation developed (Pollock 1999). Construction of Lock and Dam #1, at river km 19.5 (river mile 12.1), began in 1895 under considerable pressure from Congress and commercial navigation interests.

Lock and Dam #1 (L&D#1) is a concrete, steel and timber structure 260 meters (m) wide and 3 m high, with a navigational lock on the left descending bank 12 m wide and 67 m long. Steam power was used to manipulate gates on both the dam and the lock. A high water navigational passageway was included in the design. With intensive pressure to complete the project, a test of the lock chamber in 1906 resulted in the failure of the center section of the dam. Although the lock was functional, repairs to the dam were not completed until 1914. Upon completion and with the aid of wing dams and training structures, a 32 km long and one meter deep channel formed and served as a navigation channel above the L&D (Pollock 1999).

Over time, maintenance and operational costs outweighed the economic benefit to the region. The completion of Bagnell Dam in 1931 ended the last vestiges of long distance Osage River navigation; L&D#1 ceased all operations in 1951 and the property was sold to a private interest in 1960 (Pollock 1999). The L&D#1 has not been maintained and its structural condition may now be compromised with visibly crumbling concrete, exposed steel rebar and decaying timber cribbing. Undercutting of the dam adjacent to the lock wall is apparent with the formation of a whirlpool immediately upstream of the dam at certain flows. Furthermore, debris in the upper portion of the lock chamber has created a turbulent plunge (Appendix A). Not only does this hydraulic jump create a barrier to fish, but it also presents a significant hazard to public safety as seen in 2009, when a 41 year-old man entered the lock structure of L&D#1 on a jet ski, capsized in the turbulence and drowned (KRCG news 2009).

Study Objectives

Previously, a study found pallid sturgeon exhibiting spawning behavior in the Yellowstone River, an altered tributary to the Missouri River similar to the Osage River (Bramblett and White 2001). Because the Osage River may have also been an historical spawning location for pallid sturgeon, sampling occurred during peak spawning migrations on the Missouri River (April – May) in both 2010 and 2011 (Delonay et al. 2009). The presence of pallid sturgeon in the lower reach of the Osage River could indicate that this tributary is important to the species. Our survey work began in 2010 to document the presence of pallid sturgeon in the lower Osage River below L&D#1, as well as the extent to which all sturgeon species utilized this reach of river. Additionally, sampling at this location could help to document a portion of the faunal stream assemblage and determine the presence of known host fish species for the imperiled mussel populations in the lower Osage River. Use of the Osage River by pallid sturgeon and other fish hosts for mussels would provide insight to the value of this habitat for these species and aid in determining whether the construction of fish passage or complete removal of L&D#1 is warranted and may ultimately contribute to successful recovery of these critically imperiled species.

2010 Effort

In 2010, the intent of the scope of work was to determine if pallid sturgeon were utilizing the Osage River above the confluence with the Missouri River; *i.e.*, a presence/absence design. Sampling was conducted between river km 8.8 and 19.5 (river mile 5.5 and 12.1). Trotlines baited with nightcrawlers were deployed mid-April through mid-May to target sturgeon species. Ten lines per day were deployed with a heavy grappling hook-style anchor upstream and back-anchored with a cement weight tied to a buoy. Hooks on 35 cm tuna leader were attached to the mainline using ganion clips. Twenty to forty 3/0 circle hooks were attached per 61 m (205 ft) of mainline. A target deployment of 400 hooks was attempted each day. Trotlines were fished overnight with a minimum soak time of 12 hours and a maximum of 24 hours. Sampling locations were non-randomly selected by the crew leader in an effort to target pallid sturgeon. Trotlines were set Monday through Thursday to avoid conflicts with recreational anglers Friday through Sunday. Trotlines were reset at pallid sturgeon capture locations. Species and length were recorded for all captured fish. Pallid sturgeon were checked for hatchery markings (coded wire tags (CWT) and elastomeres) and passive integrated transponder (PIT) tags. Photographs were taken for pallid sturgeon and shovelnose x pallid sturgeon hybrids. After 27 April 2010, blood was drawn from pallid sturgeon captures and processed by US Geological Survey, Columbia Environmental Research Center for reproductive status using hormone assays.

2011 Effort

The scope of work in 2011 was modified after 2010 surveys detected the presence of pallid sturgeon in the lower Osage River. Sampling was conducted between river km 15 to 19 (river mile 9.9 to 12.1), with emphasis on samples in the tailwaters of L&D#1. Additional metrics were incorporated into the scope of work to include latitude and longitude (decimal degrees), water temperature (˚C) and depth (m). Depth was recorded at the beginning, mid-point and end of each trotline. Habitat parameters, including turbidity (NTU), water velocity (m/sec) taken at 80% of total depth (bottom) and 20% of total depth (top), and substrate descriptions, were taken each time a pallid sturgeon was captured. Turbidities were measured using Hach 2100P turbidimeter, flows were measured with a Marsh-McBirney Flomate meter and substrate was collected using a Hesse Sampler. When necessary, these habitat measurements were taken at the midpoint of the trotline. Fork length (mm) and weight (g) were collected for all sturgeon species and total length (mm) was recorded for all other species. Morphometric and meristic measurements were taken from “unmarked” pallid sturgeon using Sheehan’s Character Index (CI), a guide for species field identification (Sheehan et al. 1999). Sturgeon were deemed hybrid (shovelnose sturgeon x pallid sturgeon) when scores ranged from -0.45 to +0.51 on Sheehan’s CI scale. Passive integrated transponder tags were implanted under the dorsal fin of pallid, hybrid and lake sturgeons. Because some stocked pallid sturgeon have expelled or lost hatchery markings, fin clips were collected from pallid sturgeon and suspected hybrids to be analyzed for genetic purity or hatchery year class identification and digital images were taken for documentation. Blood was not taken from pallid sturgeon in 2011; however, pallid sturgeon larger than 750 mm and heavier than one kilogram were analyzed for broodstock potential or telemetry research using ultrasound endoscopy.

Additionally, from 25 – 27 April 2011, trotlines were deployed above L&D#1 in an effort to determine if sturgeon are able to pass over or through L&D#1 and access habitats available upstream of the structure. Nearly 10 kilometers, from river km 19.5 to 29.0 (river mile 12.1 to 17.9), were sampled in a targeted effort to capture sturgeon, collected in accordance with the scope of work defined for sampling below L&D#1.

Analyses

Because lines varied slightly in the number of hooks deployed, due to variability in number of hooks set or hooks that were lost and could not be retrieved, catches were standardized as 40 hooks per line. Mean catch per unit effort (CPUE) was calculated as number of fish per 40 hook line.

Stock densities were calculated to assess pallid and shovelnose sturgeon population structure. Proportional Stock Density (PSD) is the proportion of fish of quality size in a stock. Relative Stock Density (RSD) is the proportion of fish of a selected size group in a stock and, in general, indicates health of fish populations relative to reproductive potential and age of fish (Shuman et al. 2006). Relative condition (K_n), a general measure of a fish's plumpness, is an accepted measure of local and regional summaries of condition (Murphy and Willis 1992). Relative condition of pallid sturgeon was calculated using $K_n = (W / W')$, where W is weight of the individual and W' is the length-specific mean weight predicted by the weight-length equation calculated for that population. Shuman et al. (2011) provided a weight-length regression [$\log_{10} W = -5.9435 + 3.1708 * \log_{10} FL$ ($r^2 = 0.98$)] for over 2,000 pallid sturgeon captured throughout the Missouri River basin.

Relative weight (W_r) is commonly used as a condition index (Anderson and Neuman 1996). Relative weight was calculated as: $W_r = W/W_s$ X 100, where W is the actual weight and W_s is the length-specific standard weight for that species (Wege and Anderson 1978). A standard weight (W_s) equation ($\log_{10} Ws = -6.287 + 3.330 \log_{10} FL$) was developed for shovelnose sturgeon by Quist et al. (1998).

To determine if size structure differed from the mainstem Missouri River, length frequencies of 1,499 shovelnose sturgeon captured within 10 miles upstream and downstream of the confluence on trotlines during April and May 2003 – 2009 were compared (Figure 2). A Student's t-test was conducted to compare size structure of shovelnose sturgeon captured at L&D#1 in 2011 and the mainstem Missouri River from years 2003 – 2009. Kolmogorov-Smirnov goodness-of-fit test was used to test the quality of the distribution.

Potential reproductive status of shovelnose sturgeon was also evaluated using length/weight ratios and comparing with ratios of known gravid shovelnose sturgeon provided by J. Buckler, University of Missouri, personal communication.

Exploratory Sampling

Complementary to Columbia FWCO's sampling efforts, the U.S. Geological Survey (USGS) Columbia Environmental Research Center also conducted an underwater sonar survey on 20 April 2011 below L&D#1 using dual frequency identification sonar (DIDSON). DIDSON is an advanced sonar technology that uses sound waves to produce underwater imagery of fish and their habitat in deep or turbid water where light cannot penetrate. High-resolution images are collected at high speed by the DIDSON camera and can be played back to create moving images useful for identifying fish and observing their behavior. The DIDSON was deployed over trotlines which had been set at least 12 hours prior in an attempt to observe captured fish behavior, identify species and estimate size. After the trotlines were pulled, the results were verbally discussed between biologists.

Results

In 2010, 5,480 hooks were deployed for 14 hook nights, which captured 964 fish representing 23 species (Starostka 2010) (Appendix B). Three hatchery stock pallid sturgeon and one pallid x shovelnose sturgeon hybrid were captured within 500 m of the dam. Two of the three pallid sturgeon captured were analyzed for reproductive status. One of the pallid sturgeon was determined to be an immature female. Hormone assays of the other pallid sturgeon indicated that it was either a first-time maturing stage III (yellow-egged) or a non-reproductive, between-cycle stage III female (Starostka 2010). In addition to pallid sturgeon, 30 lake sturgeon and 638 shovelnose sturgeon were also captured. Other species of note captured during 2010 include two American eel (*Anguilla rostrata*), a facultative catadromous species born in salt water.

In 2011, 4,517 hooks were deployed below L&D#1 for 12 hook nights, which captured 635 fish representing 19 species (Appendix B). Water temperatures ranged from 14.0°C to 16.4°C and flows varied widely, ranging from 70 cms (2,460 cfs) to 1,014 cms (35,800 cfs). Trotlines were set in a range of depths from 1.3 m to 8.1 m. Overall mean CPUE was 5.52 fish per 40 hook night. Captures include 11 field-identified pallid sturgeon (Appendix C), as well as 16 lake sturgeon and 389 shovelnose sturgeon.

All pallid sturgeon captured below L&D#1 in 2011 were captured in the tailwater, at river km 19 (river mile 12.1) (Figure 2). Pallid sturgeon were captured in turbidities ranging from 12 NTU to 82 NTU over gravel and sand substrate. Bottom water velocities at pallid sturgeon capture locations ranged from 0.04 m/s to 1.08 m/s and top water velocities ranged from 0.1m/s to 1.07 m/s. Qualitatively, pallid sturgeon captures appeared to correspond with rises in the hydrograph (Figure 3).

Pallid sturgeon captured in 2011 ranged in length from 502 mm to 913 mm and weighed from 390 g to 2,910 g. Three of the pallid sturgeon captured bore hatchery markings. One pallid sturgeon had a CWT, located dorsally at the posterior end of the head. Another pallid sturgeon had a horizontal yellow elastomere marking, located ventrally on the right side of the rostrum and a PIT tag at the base of the dorsal fin. The third hatchery marked fish had both a coded wire tag and a vertical pink elastomere, also on the right side of the rostrum (Appendix C). Genetic analysis of the eight unmarked pallid sturgeon, performed by USFWS Northeast Fishery Center Conservation Genetics Lab, confirmed the field identification of four pallid sturgeon. Because these fish did not match any of the parental lineages on file, these are presumed wild. Two of the eight unmarked pallid sturgeon were deemed pallid sturgeon x shovelnose sturgeon hybrids. Genetic confirmation of two pallid sturgeon are still pending (Table 1; Appendix C). Notably, eight of the 11 (72 %) field-identified pallid sturgeon captured at L&D#1 were unmarked. For comparison, pallid sturgeon captures from the Missouri River (± 10 miles from Osage River confluence) during April and May 2003 – 2009 were queried. During that timeframe, 36 pallid sturgeon were captured on trotlines from the mainstem Missouri River. Of those, 36 % (N = 13), were unmarked and genetic results confirmed two unknown origin pallid sturgeon (presumed wild), five hatchery origin pallid sturgeon and one shovelnose x pallid sturgeon hybrid.

Two of the unmarked pallid sturgeon captured at L&D#1 were larger than 750 mm and were evaluated as potential broodstock for the artificial propagation program. Field endoscopy by USGS indicated that one was a non-reproductive female and the other a non-reproductive male. The largest fish captured at L&D#1 was of hatchery origin and was also evaluated for reproductive status and potential use as a telemetry subject. Endoscopy indicated that this was also a non-reproductive female. Because this was a non-reproductive fish and telemetry supplies were limited, it was not implanted with a telemetry tag (Appendix C).

Three pallid sturgeon were within the stock length category and had relative condition scores of 0.90, 0.91 and 0.95. Four pallid sturgeon and two hybrid sturgeon captured at L&D#1 fell within the quality length category and had condition scores (K_n) ranging between 0.83 and 0.98. Two year classes (1992 and 2003) of stocked pallid sturgeon were recaptured at L&D#1 in 2011. Of the two recaptured 2003 year class hatchery stocked pallid sturgeon, length and K_n scores were greater than or equal to mean scores of pallid sturgeon captured from 2009 in the mainstem Missouri River (N = 8; $\bar{x}$ length = 620 mm, 2*se* = 85; $\bar{x}$ K_n = 0.91, 2*se* = ±0.193). One pallid sturgeon was of preferred size and had a condition score of 0.93 (Table 1). Proportional stock densities for pallid sturgeon = 72 and RSD were S = 27, Q = 63 and P = 9 (Table 2).

Shovelnose sturgeon were captured throughout the sampling area in 2011 (N = 389). Shovelnose sturgeon ranged in length from 441 mm to 739 mm and weights from 290 g to 1,260 g. Forty shovelnose sturgeon were in the quality length category with a mean relative weight (W_r) = 92. Most shovelnose sturgeon, n = 310, were within the preferred length category and had a W_r = 81. Thirty-nine shovelnose were in the memorable length category and had a W_r = 78. Proportional stock densities of shovelnose sturgeon were 100 and RSD were Q = 10, P = 80 and M = 10 (Table 3). Of note were 15 recaptured shovelnose sturgeon bearing Floy® tags from other studies.

According to Steffensen and Hamil (2008) and Pflieger (1997), shovelnose sturgeon reach 210 mm in their first year, 315 mm, 409 mm, 485 mm, 541 mm and 600 mm in each of the subsequent years. Based on these length-at-age analyses, shovelnose sturgeon captured in the Osage River are greater than 4 years of age. Due to the limited data available from 2010 and given that the portion of the Osage River below L&D#1 is an open system, we assumed that sturgeon captured in the Osage River were not residents but were originating from the Missouri River. Overall size distributions were significantly different between L&D#1 ($\bar{x}$ = 578, *sd* = 51.7) and the Missouri mainstem ($\bar{x}$ = 586, *sd* = 62.3); $t(1886) = -2.60$, $p = 0.009$. Kolmogorov-Smirnov goodness-of-fit test was significant $p < 0.002$, indicating that the distributions were not equal (Figure 4).

Fork length/weight ratios ranged from 0.55 to 1.57, $\bar{x}$ = 0.90 (*se* ± 0.01). Based on a range scores from 0.396 – 0.785, $\bar{x}$ = 0.535 (*se* ± 0.016) for known gravid shovelnose sturgeon (J. Buckler, personal communication), most shovelnose sturgeon in the Osage River do not appear to be reproductive females (Figure 5).

Sampling efforts above L&D#1 resulted in 1,188 hooks fished over three hook nights and 107 fish captured (Appendix B). Mean CPUE above the dam was 3.512 fish per 40 hook line. Daily comparisons of CPUE were 2.20, 5.40 and 2.94 fish per 40 hook line above L&D#1 and 7.67, 5.57 and 6.74 fish per 40 hook line below the dam, respectively. One hatchery stocked pallid sturgeon was captured above L&D#1 at river mile 16.7. This pallid sturgeon measured 444 mm and weighed 250 g and bore a yellow elastomer tag on the left side of the rostrum and a lateral scute mark on the third right scute (Appendix C). Hatchery records suggest that this fish was stocked in 2007 in the South Dakota portion of the Missouri River at river mile 845, meaning that this fish passed through Gavin's Point Dam, downstream to the mouth of the Osage River, and up the Osage River past L&D#1 for a total journey of 1,178 km (732 miles). The pallid sturgeon captured above L&D#1 was captured in a turbidity of 27 NTU over gravel substrate. The bottom water velocity was 0.47 and the top water velocity was 1.07 m/s. Also of interest were 16 shovelnose sturgeon and 3 lake sturgeon. One of the shovelnose sturgeon was originally captured by Columbia FWCO crews and tagged with a Floy® tag on the Missouri River in 2007.

Exploratory Sampling

The USGS DIDSON crew was successful at identifying parts of the trotline, watching hooked fish behavior and identifying fish to the family level (*i.e.* sturgeon). These results were not quantified. DIDSON imagery revealed multiple sturgeon in the vicinity downstream of L&D#1. DIDSON surveys in the lock structure, did not detect sturgeon or any other fish species.

Discussion

The confluence of the Osage River with the Missouri River has been a consistently successful location to capture sturgeon species. Between 2003 and 2010, Columbia FWCO has captured 37 pallid sturgeon, 2,500 shovelnose sturgeon and 138 lake sturgeon at the confluence. Results of telemetry efforts by USGS also indicate the significance of the Osage River, and its confluence, to pallid sturgeon (Davenport et al. 2011). Between 2008 and 2010, eleven adult telemetered pallid sturgeon were identified 69 times in the Osage River and the confluence area. Tracking efforts have detected some of these sturgeon moving up the Osage River as far as L&D#1; however, no telemetered pallid sturgeon have been identified above the structure (Davenport et al. 2011). The inability to detect telemetered sturgeon above the structure during high water, when the dam sill is overtopped, suggests that L&D#1 is likely a formidable barrier under most flow conditions.

Compounded with telemetry data extending from 2008, two consecutive years of pallid sturgeon captures at the base of L&D#1 indicate the potential importance of the Osage River for this species. However, during April and May of 2011, gravid pallid sturgeon were not detected nor were spawning aggregations apparent in the lower Osage River. The unusually high number of wild, hybrid and unmarked pallid sturgeon utilizing the Osage River may indicate the importance of the tributary for food, refugia or historical spawning areas by wild pallid sturgeon. A systematic sampling design spanning a greater spatial and temporal framework, coupled with continued telemetry studies, are necessary to determine if the Osage River is being utilized by gravid pallid sturgeon.

While incremental relative stock density length categories are more applicable to managed sport fisheries, these are also useful to describe size classes of sturgeon. No sub-stock or trophy sized pallid sturgeon were captured in the lower Osage River at L&D#1. Sub-stock pallid sturgeon were stocked on 26 April 2010 in the Missouri River within 25 river miles of the Osage River confluence. Perhaps these young fish are not yet able to recognize environmental cues from this tributary due to their origin in hatchery raceways or are not able to adjust to the variable flows in the Osage River. The lack of representation by these length classes may also be a reflection of the narrow timeframe in which sampling occurred for this study. No trophy sized pallid sturgeon have been captured by Columbia FWCO in the lower 250 miles of the Missouri River since pallid sturgeon monitoring efforts began in 2003. This size class has likely been extirpated from the lower Missouri River due to overharvest and habitat loss and stocked fish have not been at large long enough to attain this size.

According to Shuman et al. (2011), a K_n of 1 is ideal for relative condition; however, based on the scores of more than 2,000 pallid sturgeon from the Missouri River, K_n scores between the mid 0.80's and 0.90's is typical. It has been observed that stocked pallid sturgeon have a high K_n in the early stages after release (Sub-stock range), decreased K_n values as the fish transitions to maturity (Stock and Quality ranges) then increasing as the fish becomes mature (Preferred, Memorable, Trophy ranges) (Shuman et al. 2011). Comparisons of the mean lengths between the 2003 year class captured on the Osage River and on the mainstem, indicate that the two fish captured on the Osage River have adjusted well since stocking and appear to be successfully foraging, growing in size and adapting to river conditions. Condition scores of the two 2003 year class pallid sturgeon are typical and can be considered healthy. Conversely, weights of these fish are lower than the mean weights of pallid sturgeon from the mainstem Missouri (Herman et al. 2010). Based on the large standard error associated with this measurement, the mean weight comparison is likely being influenced by an outlier. Unfortunately, because unmarked pallid sturgeon were of unknown age or year class, comparisons were not made to mainstem Missouri River stocked pallid sturgeon.

Comparison of length frequency histograms indicate that, like the pallid sturgeon, smaller, young shovelnose sturgeon (i.e. Sub-stock and Stock length categories) and very large shovelnose sturgeon are not utilizing the Osage River during April and May. While this result is statistically significant; it is unknown as to the biological significance. This result may be a reflection of comparing one sample year to seven years of data from the mainstem Missouri River. If shovelnose sturgeon are spawning in the lower Osage River, flows would likely discharge larvae into the Missouri River based on drift models in Braaten et al. (2008). Likewise, alterations to the confluence area (*i.e.*, high wing dike) may currently prevent larvae drifting down the Missouri River from finding refugia in the Osage River. Water flows passing the confluence may also prove too swift for small sturgeon, thereby preventing access to the lower Osage River. Gear bias for larger fish is a consideration; however, sturgeon less than one year old have been captured on trotlines by Columbia FWCO. Alternatively, although primary food sources for adult shovelnose sturgeon include aquatic insect larvae and nymphs (Rapp et al. 2011), young sturgeon may exhibit dietary preference for specific taxa or species. Seasonality of invertebrates, variable flows and gravel substrates may affect the presence of preferred dietary benthic invertebrates in the lower Osage River, providing yet another explanation for absence of Sub-stock and Stock length classes. Few trophy sized shovelnose sturgeon may remain in the lower Missouri River due to overharvest or habitat alterations (Herman et al. 2010). Until 2010, shovelnose sturgeon were legally harvested in the lower Missouri River drainage for caviar which is a likely explanation for the lack of this length class in the lower Osage River. The significance of these finding can only be defined by continuing a systematic sampling design spanning a greater spatial and temporal framework on the lower Osage River.

Mean relative weight and RSD values for shovelnose sturgeon in the Osage River were similar to mean W_r and RSD values of shovelnose sturgeon from the Missouri River in 2009 (Herman et al. 2010). These values suggest that shovelnose sturgeon populations in both rivers are healthy and that prey abundance is not limiting for size classes Quality and greater in either river.

Shovelnose sturgeon spawn at temperatures ranging from 17 °C to 21 °C (Keenlyne 1997). Temperatures in the Osage River ranged from 14 °C to 16 °C during sampling efforts in 2011, just below this threshold. To determine if gravid shovelnose sturgeon were staging or aggregating in the area below the dam, length/weight ratios were compared to known ratios of gravid shovelnose sturgeon. The mean length/weight ratio of shovelnose sturgeon captured at L&D#1 in 2011 was higher than the mean score for gravid shovelnose sturgeon provided by Buckler (personal communication), suggesting that, as a whole, gravid female shovelnose sturgeon were not abundant. However, approximately 30% of shovelnose sturgeon fell within the range of gravid shovelnose sturgeon (Figure 5). Though length/weight ratios for these fish were within the range of gravid fish, all scores (ranging from 0.553 to 0.785) were above the mean for gravid shovelnose ($\bar{x}$ = 0.540) provided by Buckler. From mid-April through mid-May, shovelnose sturgeon utilizing the Osage River did not visually appear to reproductive; however, additional sampling in water temperatures from 17 ˚C to 21 ˚C is warranted.

The capture of the hatchery stocked pallid sturgeon and the recapture of the shovelnose sturgeon above L&D#1 implies that, at times, the structure is passable by sturgeon. Curiously, the pallid sturgeon captured above the dam was found in habitat qualitatively similar to the habitat near the Niobrara River confluence where it was reportedly stocked, *i.e.* a clear, cold and shallow river with natural gravel substrate. Perhaps this is an indication of natal imprinting or site fidelity and habitat preference of young sturgeon based on stocking location. Additional research, beyond the scope of this study, would be needed to address this hypothesis but may provide essential information for the stocking and recovery of pallid sturgeon.

Relatively low catch rates above L&D#1 suggests that, at least at certain water levels or flows, this structure is indeed a barrier to most fishes utilizing the lower Osage River. Anecdotally, one trotline did not anchor in the fast flow and gravel substrate and drifted across the sill of the dam. Approximately half the hooks were below the structure and half above. While it is difficult to determine the time at which the trotline became immobilized or the exact location of capture, it is interesting to note that six fish were removed from the portion of the line on the downstream side of the structure as compared to one fish captured above. The six fish captured below the dam were not included in any analyses.

Inability of fishes to openly access areas upstream of L&D#1 and decreased numbers of fish above the barrier may also impact mussel populations known to inhabit this section of the Osage River. Because Unionid mussels have a unique life history phase of parasitizing gills of native fishes, restricted fish movements at critical mussel spawning times may negatively impact these species. Additionally, Watters (1996) suggests that lowhead dams may also contribute to the decline of Unionid mussel species by restricting and isolating populations. Mussels are sedentary animals, some moving less than a meter in a lifetime, and are dependent upon fish to disperse their glochidia upstream and downstream. Variable daily flows at L&D#1 may create impassible conditions thereby preventing host fish from passing over the dam at crucial spawning times and may also restrict host fish from accessing key mussel habitat.

Exploratory Sampling

Confirmation of our ability to determine presence of fish, family identification of fish and some behaviors were successful with DIDSON camera technology. Camera operators were able to access areas of L&D#1 not accessible to sampling gear and observed fish, including sturgeon among the cribbing and debris. Inside the lock structure, no fish were observed. Anecdotally, what appeared to be "potholes" were observed on the floor of the lock chamber, which may warrant further investigation into the integrity of the structure. Additionally, the use of DIDSON technology may be limited to times of low flows, either low water or when the Missouri River is high and causes water to back up to L&D#1. Otherwise, turbulence causes interference, or noise, on the sonar image and may camouflage the presence of fish in the area. Wind and water turbulence also present challenges for the boat operator to hold the camera in place during recording. Observations of large numbers of sturgeon aggregating below the dam suggest that the dam may be a significant barrier for all sturgeon species (E. Pherigo, USGS, personal communication). Seasonal use of DIDSON, side-scan and down-scan technologies would be beneficial to determine habitat use of fish in the footings of the dam. This technology may also be useful to structural engineers to map debris fields or to detect movement of debris, noting degradation to provide some assessment of structure stability in relation to L&D#1.

Species of note

In 2010, two American eel were captured on the Osage River. Both of these fish were captured at the mouth of the Maries River at river km 16 (river mile 9.9). Another American eel was captured at the confluence with the Missouri River in early April 2011. Until recently, only two American eel had been captured by Columbia FWCO in the lower 130 miles of the Missouri River between 2003 and 2009. American eels have a unique life history as a facultative catadromous species. American eels spawn in the Sargasso Sea near Bermuda and spend the first few years of life drifting in ocean currents and inhabiting coastal marine and estuarine habitats. Upon reaching a sexually immature adult stage, many American eel disperse to freshwater streams and rivers while others may remain in marine or estuarine habitats (USFWS 2010) until reaching sexual maturity. Like many other species, American eels no longer have access to much of their historical habitat because of dams and modifications to rivers throughout their range.

The Osage River is recognized for its recreational fishing opportunities. During spring spawning migrations, the Osage River is a hotspot for paddlefish snagging and striped bass fishing. An encounter with a landowner on the Osage River led to another interesting discovery about the importance of this river. While fishing for striped bass, this landowner caught a hybrid striped bass approximately 585 mm in total length. Upon filleting, a VEMCO telemetry tag was discovered in the body cavity with identifying serial numbers. The fish was tagged by Southern Illinois University Carbondale (SIUC) researchers as part of a fish passage project on the Mississippi River. The fish was initially captured and tagged 1 November 2010 at Alton, IL, approximately 10 miles upstream of the confluence with the Missouri River. After being at-large for 150 days, the fish had moved 140 miles and had grown approximately 50 mm. Researchers at SIUC indicated that this was the third telemetered hybrid bass captured on the Osage River, with one being captured at the base of Bagnell Dam. The fusiform body shape and swimming habits of the Morone species may aid them in passage over or through L&D#1 in a wider range of flow conditions than for the ventrally flattened, benthic sturgeon.

Management Recommendation

The Osage River is an important tributary to the Missouri River not only for the federally endangered pallid sturgeon, but for many native fishes and mussels. A collective effort to systematically evaluate and monitor aquatic organisms over all spatial and temporal variables in the Osage River is imperative to understand its role in the life histories of the species that inhabit it and the degree to which L&D#1 is a barrier to fish movement. Currently, our knowledge of fishes utilizing the Osage River is based on springtime snapshot sampling. For a more complete assessment of the fisheries assemblage and the importance of the Osage River for these fishes, a rigorous year-round sampling design is warranted. From our data and anecdotal reports, we know that L&D#1 is passable at certain water levels and flows. However, to fully understand the conditions under which this structure can be overcome, we suggest implementing a long-term fish passage study. Advancements in technology would allow for expanded use of DIDSON cameras, side-scan and down-scan sonar, passive tracking arrays and radio and acoustic telemetry equipment, which would add valuable information to fish movement data at L&D#1.

We also recommend that, based on the visible decay of L&D#1, a full structural inspection and analysis be performed. Defining the extent of the deterioration and its current structural state is paramount for determining the likelihood of a catastrophic failure. Construction of L&D#1 began more than 115 years ago, with operations ceasing more than 60 years ago. On average, lowhead dam life expectancy is approximately 50 years (RAW/TU 2000). Comparatively, the Gates Mills Dam, in Ohio, was also constructed in 1906 and catastrophically failed after a heavy rainfall event in February 2011 (WEWS News 2011). In the event of a catastrophic failure of L&D#1, grade control would be lost and the upstream mussel bed and associated habitat for the endangered pink mucket may be destroyed. In the ensuing collapse, concrete, rebar, and other dam debris would be flushed downstream negatively impacting additional habitat and creating safety hazards.

Based on available literature about the importance of tributaries to native riverine fishes and documentation of dams as barriers to aquatic organisms, a logical conclusion would be recommend either the removal or stabilization and creation of fish passage through L&D#1. Access to potential spawning, rearing and foraging habitat is increasingly important for native aquatic species. Creating passage at this dam would make nearly 130 km (80 river miles) of this tributary accessible to fish and would likely benefit the imperiled mussel populations in the Osage River. The ability to protect and preserve aquatic species in the Osage River can only be achieved through a scientific, long-term monitoring program and continued working partnerships within and among government agencies, universities and private industries.

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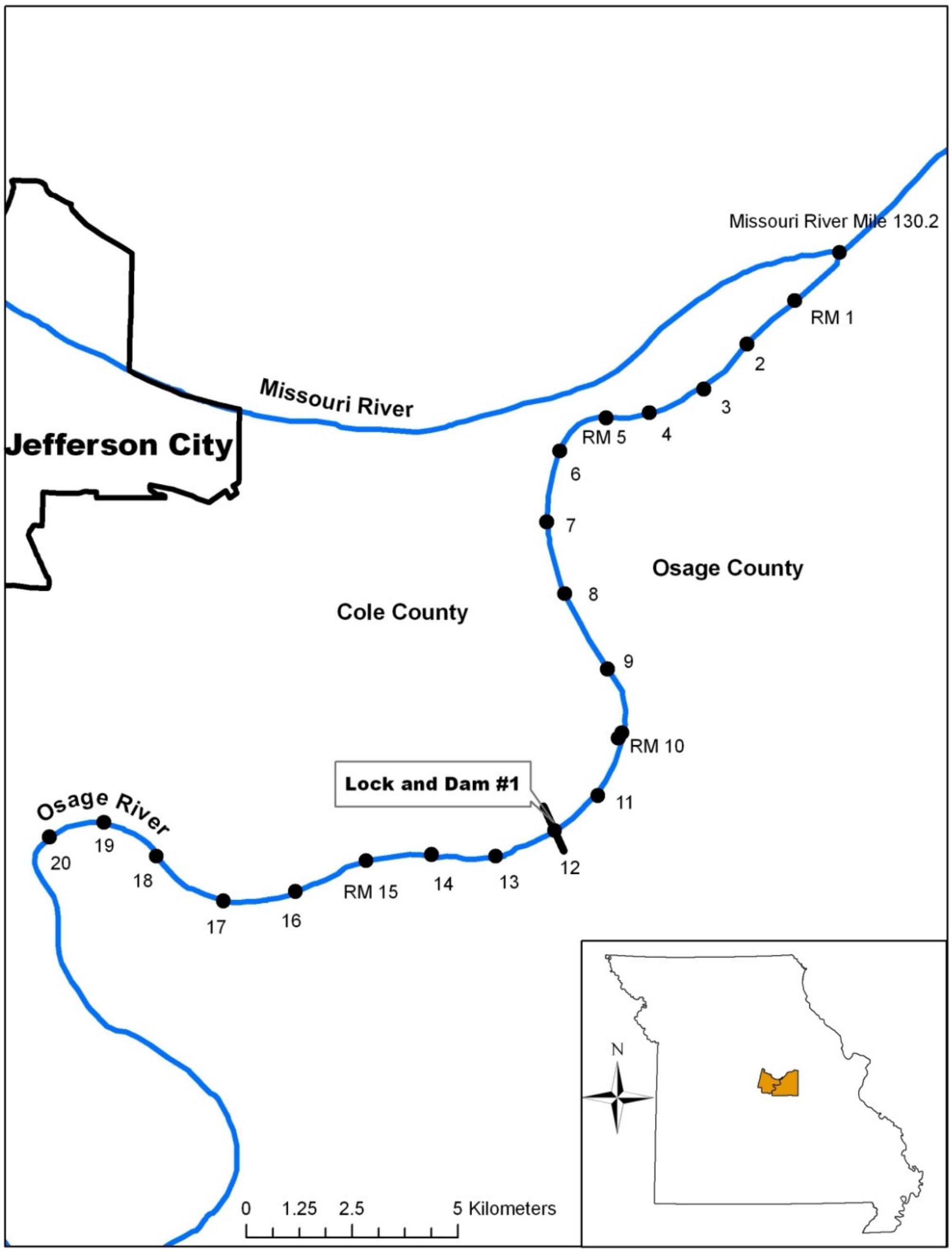


Figure 1. Map of sample area on lower Osage River.

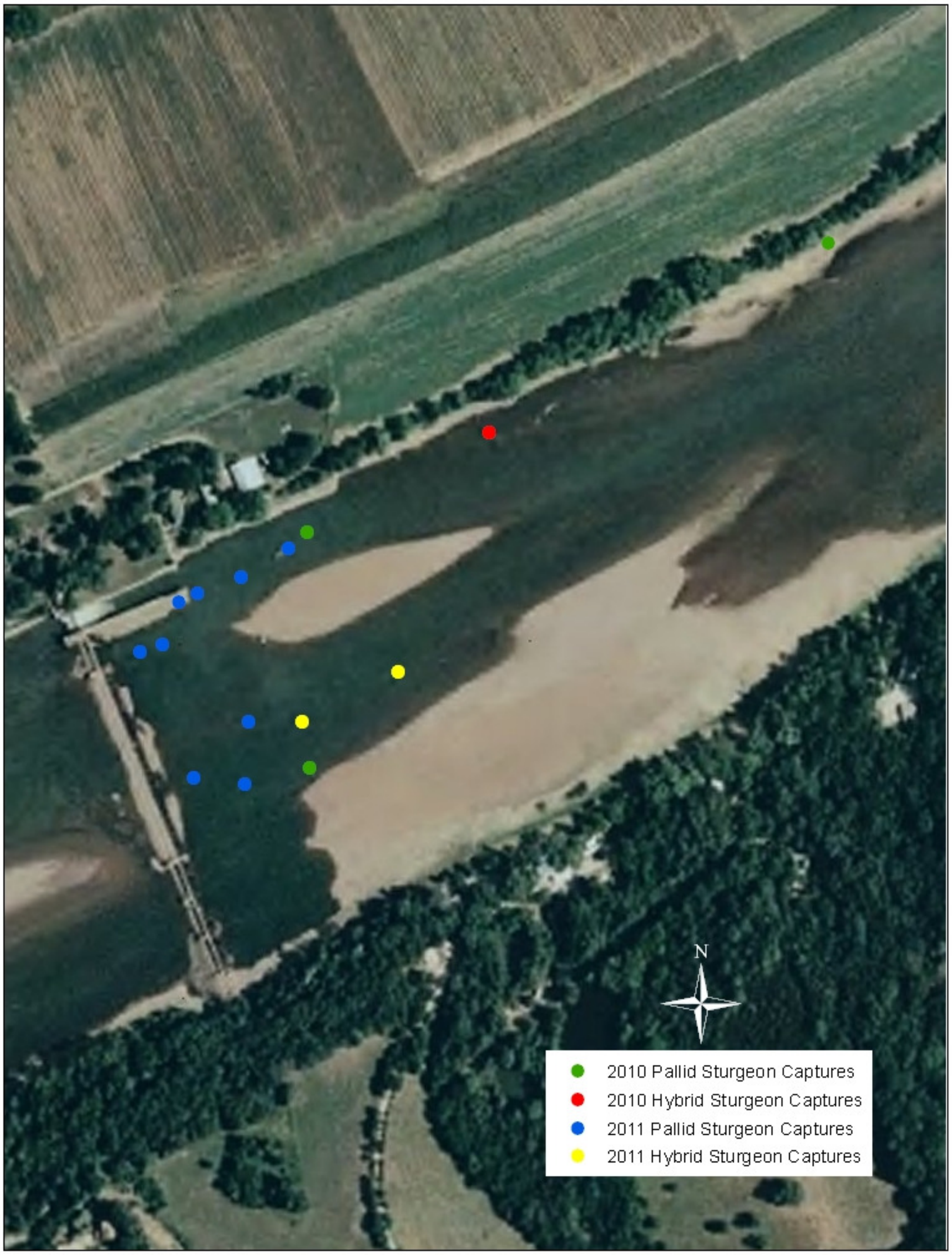


Figure 2. Locations of pallid sturgeon and hybrid sturgeon captured below L&D#1 in 2010 and 2011. Satellite imagery, from 2006, shows L&D#1 at low water for ease of identifying proximal location of fish to structure elements.

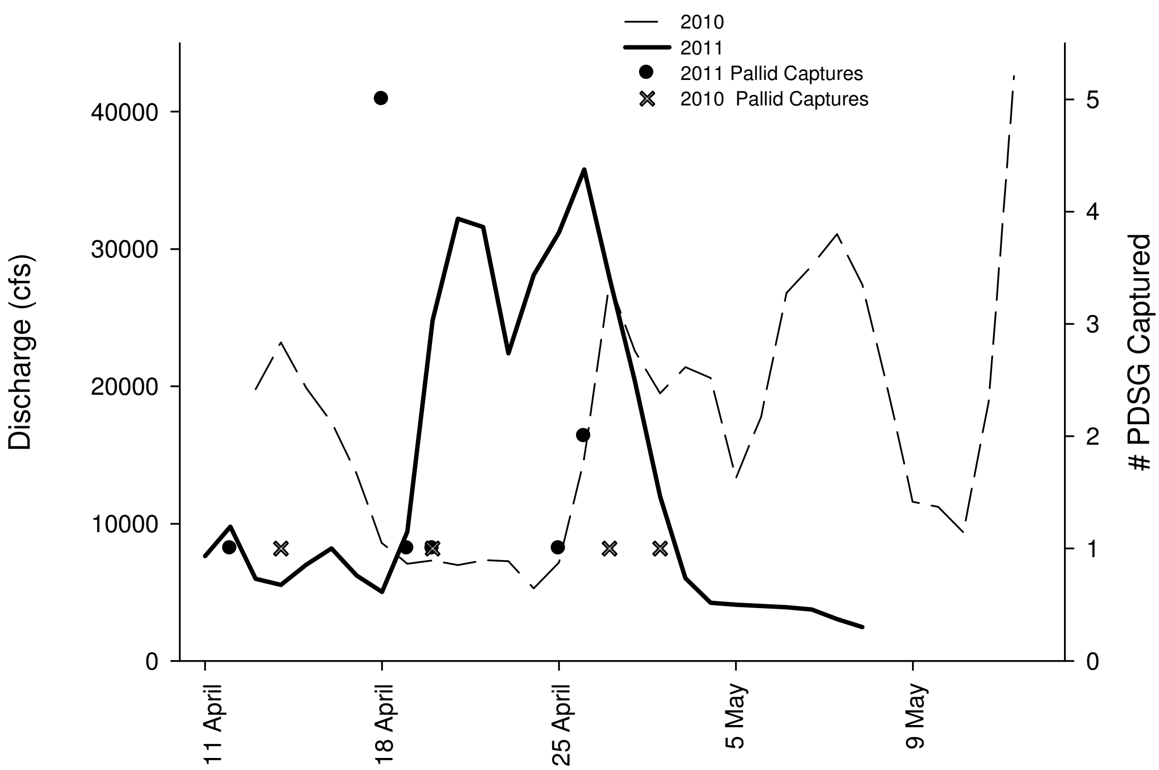


Figure 3. Hydrograph of Osage River from USGS gauge 06926510, river mile 34.5, below St. Thomas, MO. Pallid sturgeon captures from 2010 and 2011 have been overlayed.

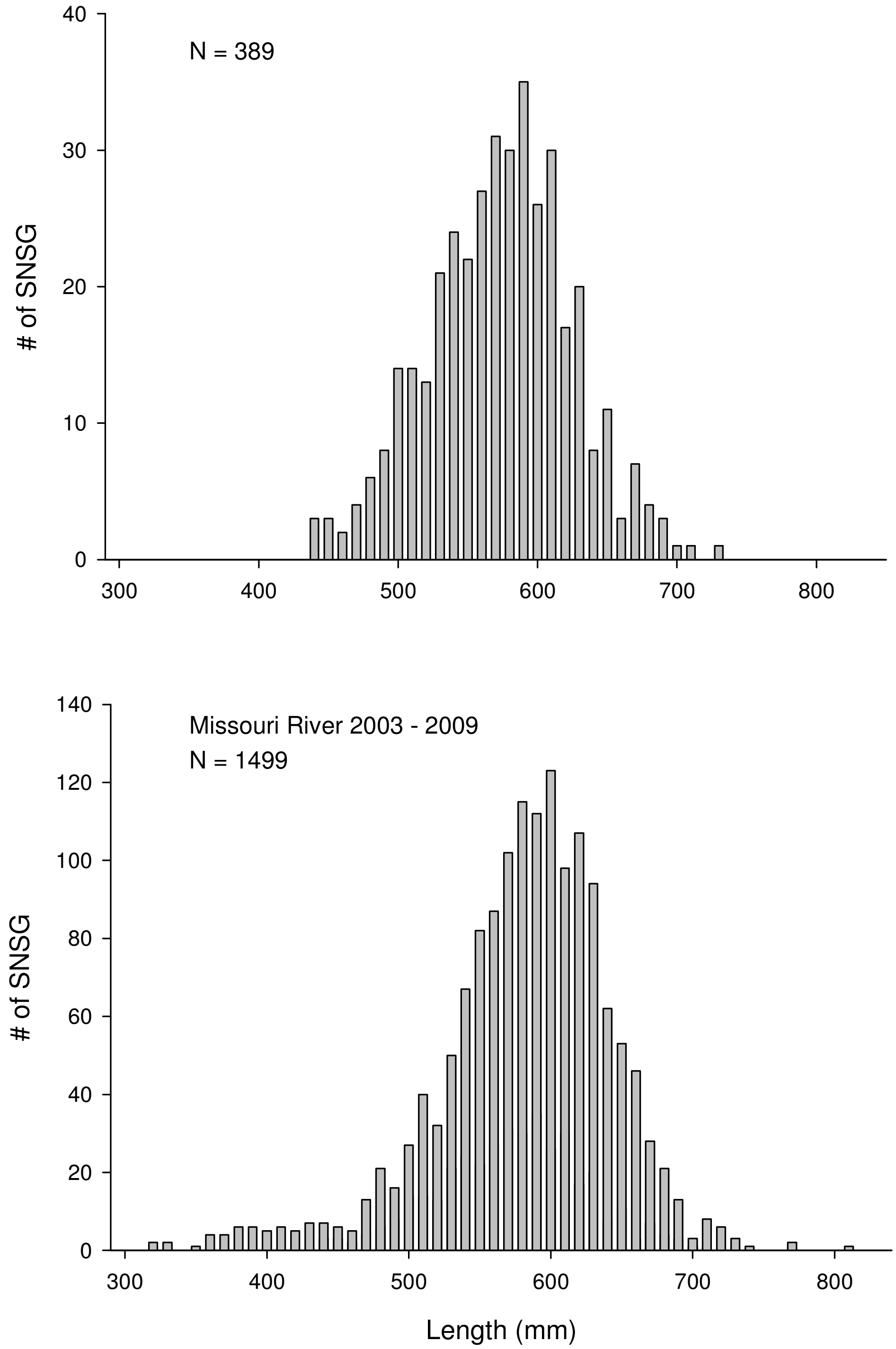


Figure 4. Length frequency histograms for shovelnose captured on the Osage River and the mainstem Missouri River. Size distributions of shovelnose sturgeon were significantly different ($p = 0.009$) between the lower Osage River and mainstem Missouri River.

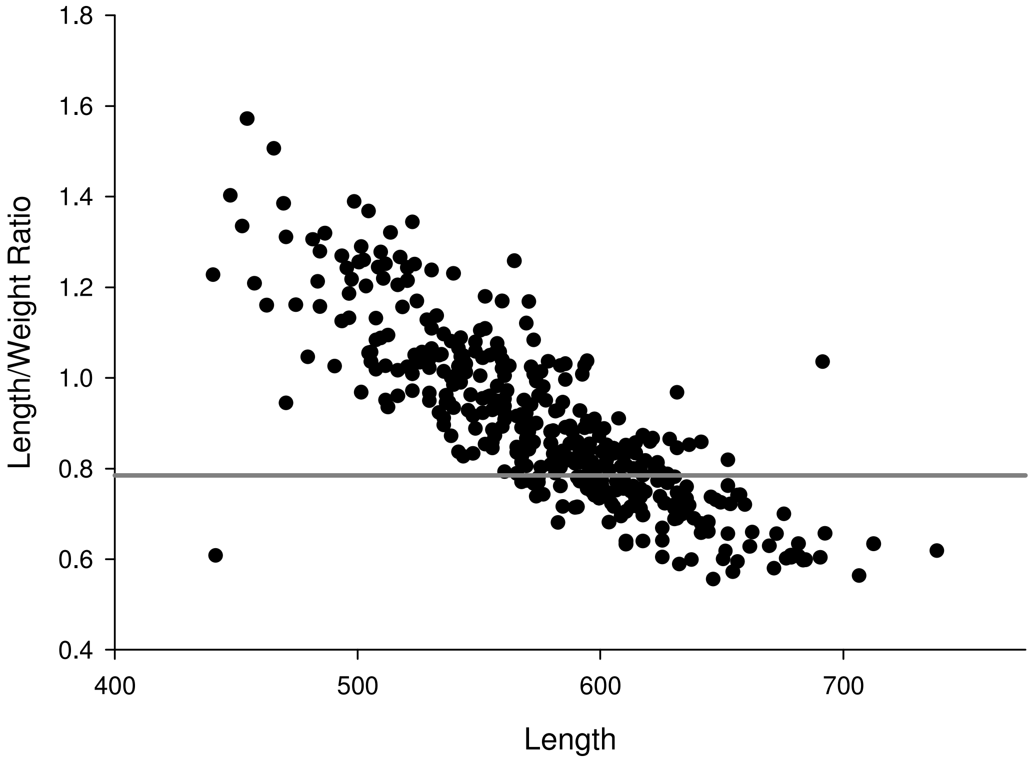


Figure 5. Fork length (mm)/weight (g) ratios of shovelnose sturgeon captured at L&D#1 on the Osage River. Length/weight ratios for known gravid female shovelnose sturgeon ranged from 0.396 to 0.785 (mean = 0.535, se ±0.016). Upper range of gravid female shovelnose ratios denoted by grey line. Fork length/weight ratios of shovelnose captured from Osage River ranged from 0.553 to 1.569 (mean = 0.900, se ±0.010).

Table 1. Relative condition (K_n) and length categories for pallid sturgeon captured in the Osage River below Lock & Dam #1. Hatchery marked fish denoted by “H”.

Date	PIT	Fork Length (mm)	Weight (g)	Length Category[a]	K_n[b]	Genetic Confirmation[c]
12 Apr 2011	460D423053	913	2910	P	0.93	H
18 Apr 2011	486E367332	599	740	S	0.95	W
18 Apr 2011	4866472105	720	1220	Q	0.86	W
18 Apr 2011	4423776909	632	910	Q	0.98	H
18 Apr 2011	48686A4A57	695	1180	Q	0.93	X
18 Apr 2011	486869721F	727	1250	Q	0.85	X
19 Apr 2011	47235F1F0A	790	1690	Q	0.87	?
20 Apr 2011	486E530D30	694	1050	Q	0.83	W
25 Apr 2011	4A49253076	502	390	S	0.90	W
26 Apr 2011	4A491B5D34	626	820	S	0.91	H
26 Apr 2011	4868446E65	812	1780	Q	0.84	?

a = Pallid sturgeon fork length categories (sub-stock (SS), <330 mm; stock (S), 330 mm; quality (Q), 630 mm; preferred (P), 840 mm; memorable (M), 1,040 mm; and trophy (T), 1,270 mm) (Quist et al. 1998).
b = Relative condition (K_n) was calculated for all pallid sturgeon using the formula K_n = (W/W’), where W is the weight of the individual and W’ is the length-specific mean weight for a fish in the population. Weight-length regression [$\log_{10}$W’ = -6.2561+3.2932 $\log_{10}$FL (r^2 = 0.98)] provided by Shuman et al. (2011).
c = Genetic determination codes: H = hatchery; W = confirmed pallid sturgeon, presumed wild; X = pallid sturgeon x shovelnose sturgeon hybrid; ? = genetic results pending.

Table 2. Proportional stock density (PSD)[a] = 72. Incremental relative stock density (RSD)[b] by a length category for shovelnose sturgeon in Osage River in 2011. Length categories determined using methods proposed by Quist (1998).

Length category	N	RSD
Sub-stock (0-149 mm)	0	.
Sub-stock (150-249 mm)	0	.
Stock	3	27
Quality	7	63
Preferred	1	9
Memorable	0	.
Trophy	0	.

[a] PSD = (# of fish ≥ Q / # fish ≥S) * 100
[b] RSD = (# of fish of a specified length class / # of fish ≥ minimum stock length fish) * 100.

Table 3. Incremental relative stock density (RSD)[a] and mean relative weight (Wr) by a length category for shovelnose sturgeon in Osage River in 2011. Length categories[b] determined using methods proposed by Quist (1998).

Length category	N	RSD	Wr (+/- 2SE)
Sub-stock (0-149 mm)	0	.	.
Sub-stock (150-249 mm)	0	.	.
Stock	0	.	.
Quality	40	10	92 (3.76)
Preferred	310	80	81 (1.30)
Memorable	39	10	78 (3.68)
Trophy	0	.	0
Overall Wr	.	.	82 (1.164)

[a] RSD = (# of fish of a specified length class / # of fish ≥ minimum stock length fish) * 100.
[b] Length categories based on the percentage of the largest known shovelnose sturgeon: Sub-stock FL < 250 mm (20 %), Stock FL =250-379 mm (20 – 36 %), Quality FL = 380 – 509 mm (36 – 45 %), Preferred FL = 510 - 639 mm (45 – 59 %), Memorable FL = 640 – 809 mm (59 – 74 %), Trophy FL > 810 mm (>74 %).

Appendix A. Photos of L&D#1 at various times, flows and water levels.

Photo credit: USFWS, 2002

Aerial view of L&D#1 looking north, lock structure at center of photo.

Photo credit: USFWS, 2002

Aerial view of lock structure (center), sill and pillar of L&D#1.

Photo credit: USFWS, 2002

Aerial view looking upstream at lock chamber.

Photo credit: Andy Roberts, USFWS, 2006

Lock chamber plunge pool and turbulence.

Photo credit: Andy Roberts, USFWS, 2006

Upstream side of L&D#1 looking north at top of lock chamber.

Photo credit: Bill Turner, Missouri Department of Conservation, 2005

Whirlpool formed by undercutting of structure, upstream side of dam adjacent to lock wall.

Photo credit: Bill Turner, Missouri Department of Conservation, 2005

Downstream flow from undercutting, adjacent to lock wall.

Photo credit: Andy Roberts, USFWS, 2006

Upstream view of dam sill and pillars.

Photo credit: Andy Roberts, USFWS, 2006

Upstream view of pillar degradation.

Photo credit: Bill Turner, Missouri Department of Conservation, 2005

Downstream dam sill and pillar of L&D#1.

Photo credit: Bill Turner, Missouri Department of Conservation, 2005

Structural decay of L&D#1 dam sill and pillar.

Photo credit: Bill Turner, Missouri Department of Conservation, 2005

L&D#1 dam wall construction and pillar.

Photo credit: Bill Turner, Missouri Department of Conservation, 2005

Timber, steel and rock cribbing along downstream face of L&D#1.

Photo credit: Bill Turner, Missouri Department of Conservation, 2005

Timber, steel and rock cribbing along lock wall (looking upstream, lock wall on right).

Appendix B. Species captured in lower Osage River in 2010 and 2011.

Common name	Scientific name	Totals 2011 Below	Totals 2011 Above	Totals 2010
American Eel	*Anguilla rostrata*			2
Black buffalo	*Ictiobus niger*			2
Black bullhead	*Ameiurus melas*	1		
Blue catfish	*Ictalurus furcatus*	49	11	24
Bluegill	*Lepomis macrochirus*	3		1
Common carp	*Cyprinus carpio*	1		2
Channel catfish	*Ictalurus punctatus*	77	50	59
Chestnut lamprey	*Ichthyomyzon castaneus*	1		
Flathead catfish	*Pylodictus olivaris*	4	6	2
Freshwater drum	*Aplodinotus grunniens*	31	9	45
Goldeye	*Hiodon alosoides*	1		4
Golden Redhorse	*Moxostoma erythrurum*		5	22
Lake sturgeon	*Acipenser fulvescens*	16	3	30
Pallid sturgeon	*Scaphirhynchus albus*	11	1	3
Rock bass	*Ambloplites rupestris*	1		
River redhorse	*Moxostoma carinatum*	5		15
Sauger	*Sander canadensis*			1
Striped bass x White bass	*Morone saxatilis x M. chrysops*	3		3
Striped bass	*Morone saxatilis*	1		
Shorthead redhorse	*Moxostoma macrolepidotum*	33	9	85
Shortnose gar	*Lepisosteus platostomus*			9
Smallmouth buffalo	*Ictiobus bubalus*	7		8
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	389	11	638
Shovelnose sturgeon x pallid sturgeon	*Scaphirhynchus platorynchus x Scaphirhynchus albus*			1
Spotted bass	*Micropterus punctulatus*		1	2
White bass	*Morone chrysops*		1	1
Stonecat	*Noturus flavus*	1		5
	Totals	**635**	**107**	**964**

Appendix C. Pallid sturgeon captures from lower Osage River 2011.

12 April 2011

PIT tag #: 460D423053 Length: 913 mm Weight: 2,910 g

This fish contained a coded wire tag indicating that it was of hatchery origin and was likely spawned in 1992 and stocked in the Missouri River in 1994 or 1997. A new PIT tag was injected at the base of the dorsal fin. This fish also had a lump or scar tissue ventrally, mid-way between the pectoral and pelvic fins. A tissue sample to determine parental lineage was taken. Based on size and weight, USGS was contacted for endoscopy and evaluation for telemetry. Endoscopy identified this as a non-reproductive female but with fat deposits around gonads. Due to limited telemetry supplies, this fish was not implanted and was released at Mari-Osa Access, river mile 10.1.

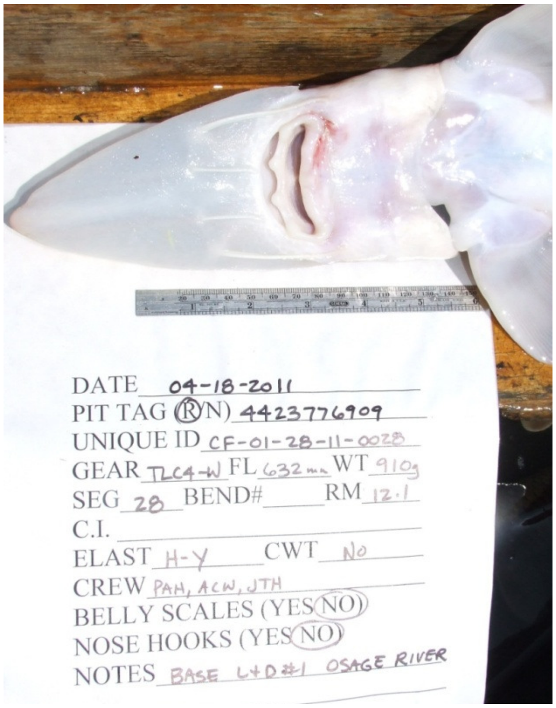
18 April 2011

PIT tag #: 486E367332
Length: 599 mm
Weight: 890 g

This fish had no obvious hatchery markings. A CI value = -1.295, gave this a species field-identification of pallid sturgeon. Genetic analysis confirms that this is a pallid sturgeon, and is presumed wild. Fish was injected with new PIT tag and released at capture location.

PIT tag #: 4866472105
Length: 720 mm
Weight: 1,220 g

This fish had no obvious hatchery markings. A CI value = -1.323, gave this a species field-identification of pallid sturgeon. Genetic analysis confirms that this is a pallid sturgeon, and is presumed wild. Fish was injected with new PIT tag and released at capture location.

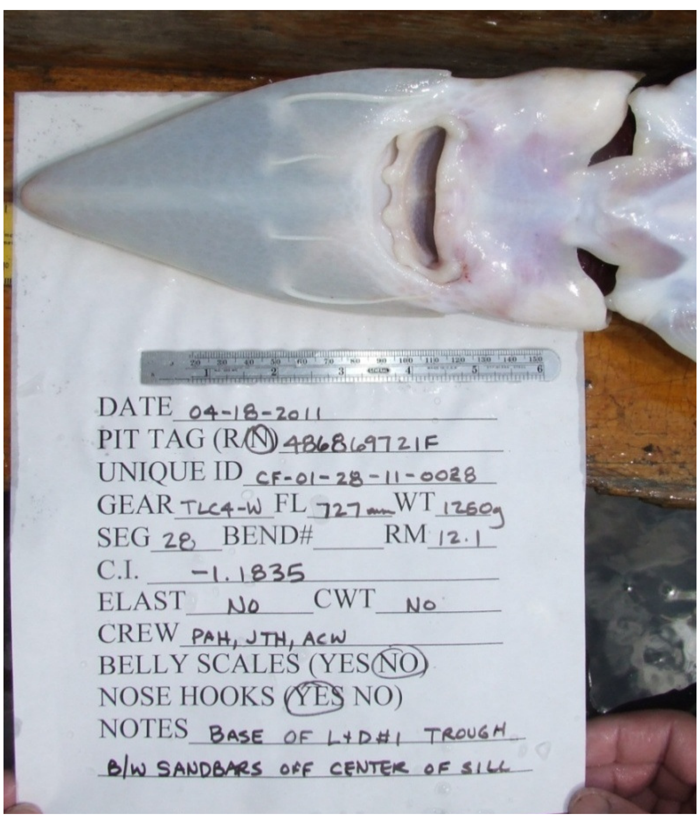


PIT tag #: 4423776909
Length: 632 mm
Weight: 910 g

This fish contained a PIT tag and horizontal yellow elastomer on the right side of the ventral rostrum. This fish was spawned at Neosho National Fish Hatchery on 24 June 2003 and stocked at Bellevue, IA 30 July 2004. The fish was 229 mm and 45 g at stocking. At stocking this fish also had a horizontal yellow elastomer on the left side of the rostrum, this was not evident upon recapture.

PIT tag #: 48686A4A57
Length: 695 mm
Weight: 1,180 g

This fish was recaptured with a PIT tag. Records indicate that it was originally captured 2 September 2010 at river mile 127.8 on the Missouri River. At that time, the fish bore no other markings, a PIT tag was injected and a genetic tissue sample was taken. A CI value of -0.8997 was calculated giving a species field-identification of pallid sturgeon. Genetic analysis indicates that this is a pallid sturgeon x shovelnose sturgeon hybrid.



PIT tag #: 486869721F
Length: 727 mm
Weight: 1,250 g

This fish had no obvious hatchery markings. A CI value = -1.184, was calculated giving a species field-identification of pallid sturgeon. Genetic analysis indicates that this is a pallid sturgeon x shovelnose sturgeon hybrid. Fish was injected with new PIT tag and released at capture location.

19 April 2011

PIT tag #: 47235F1F0A Length: 790 mm Weight: 1,690 g

This fish was recaptured with a PIT tag. Fish was originally captured by USGS in 2008. Based on size and weight, USGS was contacted for endoscopy and evaluation for broodstock or telemetry. Endoscopy identified this as a non-reproductive male but with fat deposits around gonads. Due to limited telemetry supplies, this fish was not implanted and was released at point of capture, river mile 12.1. A CI value of -0.4773 was calculated, indicating that this is a pallid sturgeon, however scores are not strong. Records from USGS indicate that this is a wild pallid sturgeon, however a second tissue sample was collected for repeated confirmation. Genetic results are still pending.

20 April 2011

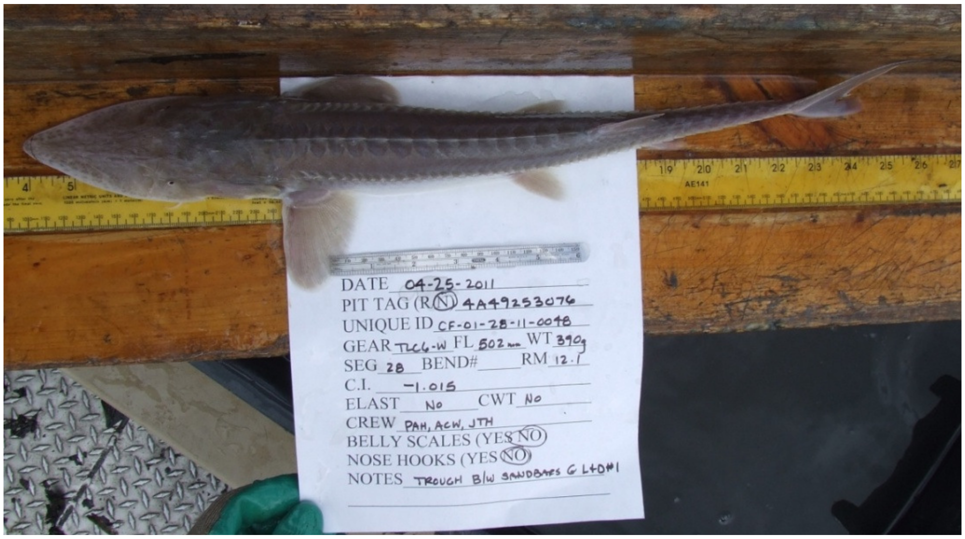
PIT tag #: 4868E530D30
Length: 694 mm
Weight: 1,040 g

This fish had no obvious hatchery markings. A CI value = -1.653, gave this a species field-identification of pallid sturgeon. Genetic analysis confirms that this is a pallid sturgeon, and is presumed wild. Fish was injected with new PIT tag and released at capture location, river mile 12.1.

25 April 2011

PIT tag #: 4A49253076 Length: 502 mm Weight: 390 g

This fish had no obvious hatchery markings. A CI value = -1.015, gave this a species field-identification of pallid sturgeon. Genetic analysis confirms that this is a pallid sturgeon, and is presumed wild. Fish was injected with new PIT tag and released at capture location, river mile 12.1.



26 April 2011

PIT tag #: 4A491B5D34 Length: 626 mm Weight: 820 g

This fish contained a coded wire tag and vertical pink elastomer on the right side of the ventral rostrum. This fish was spawned at Garrison Dam National Fish Hatchery in June 2003 and was stocked in November or December 2003 in the Missouri River. Fish was injected with new PIT tag and released at capture location, river mile 12.1.

PIT tag #: 4868446E65 Length: 812 mm Weight: 1,780 g

This fish was recaptured with a PIT tag and evidence of fresh tissue sample clip from caudal fin. Fish was originally captured by Columbia FWCO on 4 April 2011 at river mile 130.2 (Osage River confluence). Based on size and weight at time of original capture, USGS was contacted for endoscopy and evaluation for broodstock. Endoscopy identified this as a non-reproductive female and was released at Bonnot's Mill Access, river mile 2.0. After processing upon recapture, fish was released at capture location, river mile 12.1. Genetic results are still pending.

PIT tag #: 44215D6A4E
Length: 444 mm
Weight: 250 g

This fish was captured above L&D#1 at river mile 16.7. This fish had a vertical yellow elastomer on the left side of the ventral rostrum and the 3rd right scute was removed. This fish was spawned at Gavins Point Dam National Fish Hatchery on 20 June 2006 and was stocked 9 May 2007 at Standing Bear Bridge, South Dakota at river mile 845. This fish passed through Gavins Point Dam and L&D#1 over 730 river miles. Fish was injected with new PIT tag and released at capture location.