2015 Annual Report

Biological Opinion on the Operation of the Missouri River Mainstem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System

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Interior least tern (*Sterna antillarum athalassos*) on a sandbar at Deer Island, August 2015

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U.S. Fish and Wildlife Service

2015 Annual Report
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List of Acronyms and Abbreviations

Acronym/Abbreviation	**Phrase**
ACT	Agency Coordination Team
ADCP	acoustic Doppler current profiler
AdH	adaptive hydraulics
AM	Adaptive Management
ASA	Assistant Secretary of the Army
BA	Biological Assessment
BiOp	Biological Opinion on the Operation of the Missouri River Mainstem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System dated November 30, 2000, and amended December 16, 2003
BOR	Bureau of Reclamation
BRT	Biological Review Team
BSNP	Bank Stabilization and Navigation Project
CEM	conceptual ecological model
cfs	cubic feet per second
CPUE	catch per unit effort
CORE	Cooperating for Recovery Team
Corps	U.S. Army Corps of Engineers
CR	Conservation Recommendations
CSRP	Comprehensive Sturgeon Research Project
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESH	emergent sandbar habitat
FONSI	Finding of No Significant Impact
FWCA	Fish and Wildlife Coordination Act
GIS	Geographic Information System
HAMP	Habitat Assessment and Monitoring Program
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HTC	Hydroscience and Training Center, Colorado State University
IDNR	Iowa Department of Natural Resources
IRC	Interception and Rearing Complex
ISAP	Independent Science Advisory Panel
ISP	Integrated Science Program
KDWP	Kansas Department of Wildlife and Parks
LCLSMS	Lewis and Clark Lake Sediment Management Study
LETE	interior least tern
LMOR	lower Missouri River
LWD	Large Woody Debris
MAF	million acre-feet
MDC	Missouri Department of Conservation
M&E	monitoring and evaluation
MinBPop	minimum breeding population
mm	millimeter(s)
MNRR	Missouri National Recreational River
MOT02	Micromesh Otter Trawl (2mm mesh size)
MP/EIS	Management Plan/Environmental Impact Statement
MRERP	Missouri River Ecosystem Restoration Plan
MRRIC	Missouri River Recovery Implementation Committee
MRRP	Missouri River Recovery Program
m/s	meters per second
msl	mean sea level
N_e	population size

NAS	National Academy of Sciences
NEPA	National Environmental Policy Act
NGP	Northern Great Plains
NGPC	Nebraska Game and Parks Commission
NPWRC	Northern Prairie Wildlife Research Center
NLCD	National Land Cover Data
NWHC	National Wildlife Health Center
NWI	National Wetlands Inventory
NWK	U.S. Army Corps of Engineers, Kansas City District
NWO	U.S. Army Corps of Engineers, Omaha District
O&M	Operations and Maintenance
OT04	Otter Trawl (4mm mesh size)
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
PEIS	Programmatic Environmental Impact Statement
PIPL	piping plover
PIR	Project Implementation Report
PSPAP	Pallid Sturgeon Population Assessment Project
POT02	Push Trawl (2mm mesh size)
RM(s)	River Miles(s)
ROD	Record of Decision`
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measure
RPMAs	Recovery Priority Management Areas
SDGFP	South Dakota Game, Fish and Parks
SDSU	South Dakota State University
SWH	Shallow Water Habitat
T&E	threatened and endangered
TP	total phosphorus
TPDMS	Tern and Plover Data Management System
TPMP	Tern and Plover Monitoring Program
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USGS-CERC	USGS-Columbia Environmental Research Center
WRDA	Water Resources Development Act
WRRDA	Water Resources Reform Development Act
YOY	young-of-year

EXECUTIVE SUMMARY

This Annual Report summarizes the U.S. Army Corps of Engineers (Corps) 2015 implementation efforts for the Missouri River Recovery Program (MRRP) as part of the reporting requirements of the 1990 *Missouri River Bank Stabilization and Navigation Fish and Wildlife Mitigation Project Reaffirmation Report* and in response to the *Biological Opinion on the Operation of the Missouri River Mainstem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project* (BSNP), *and the Operation of the Kansas River Reservoir System* which was released in 2000 and further amended in 2003 (USFWS 2000;2003 [BiOp]). The 2003 Amended BiOp determined that the operations of the Missouri and Kansas Reservoir Systems, as well as the operation and maintenance of the BSNP would jeopardize the continued existence of the federally listed endangered pallid sturgeon (*Scaphirhynchus albus*). However, it determined that implementation of the actions included in the Corps' Biological Assessment (BA) would avoid jeopardizing the survival and recovery of the interior least tern (*Sterna antillarum athalassos*) and threatened piping plover (*Charadrius melodus*). This report describes activities and progress in implementation of the elements of the Reasonable and Prudent Alternatives (RPAs), Reasonable and Prudent Measures (RPMs) and Conservation Recommendations (CRs) outlined by the U.S. Fish and Wildlife Service (USFWS) in the BiOp. This report generally covers the activities of the calendar year of 2015; however, Fiscal Year (FY; 1 October 2014 to 30 September 2015) is sometimes referenced due to budgetary cycles.

The Missouri River Recovery Management Plan/Environmental Impact Statement (MP/EIS) is being developed and will evaluate the effectiveness of current MRRP actions. This effort will lead to management recommendations which effectively meet objectives related to jeopardy avoidance for the three listed species. As part of the MP/EIS process, the most up-to-date scientific information is being used to conduct a comprehensive Effects Analysis. The Effects Analysis was substantially completed during 2015 and publication is expected in 2016, following technical review. Currently, the draft MP/EIS is scheduled to be released for public comment in December of 2016. Concurrent development of an Adaptive Management (AM) Plan will lay out the framework for assessing the efficacy of future MRRP actions as well as describe how decisions will be made in the MRRP moving forward.

The Missouri River Recovery Implementation Committee (MRRIC), a 70-member committee authorized by Section 5018 of the 2007 Water Resources Development Act (WRDA) and established by the Assistant Secretary of the Army for Civil Works met in Kansas City, Missouri; Sioux Falls, South Dakota; Omaha, Nebraska; and Rapid City, South Dakota for their quarterly meetings. Four substantive recommendations to the Corps and USFWS were made by the committee and may be found in Section IX of this document.

Productivity surveys for the least tern and piping plover were again conducted in 2015. The 2015 monitoring season began on April 27 and ended on September 1, 2015. Results of the adult census conducted in June 2015 concluded piping plover individuals increased approximately 44% from 2014, with a total of 1,612 adults counted. Least terns also increased from the 2014 count by 27%, with a total of 917 adults counted in 2015. It was determined nesting activity as well as nest success increased in 2015 for both species. Nest counts were up 26% and 28% for the piping plovers and interior least terns, respectively. Nesting success was higher in 2015 with 62% of piping plover nests and 73% interior least tern nests producing at least one chick.

Rising reservoir levels increased the incidental take in 2015, with 96 piping plover nests lost due to operation of the dams and the tern and plover monitoring program on the Missouri River. These 96 nests had 335 eggs and 1 chick, which represent 9.7% of the total piping plover eggs observed in 2015. For least terns, 19 nests with 52 eggs were lost due to operation of the dams and the tern and plover monitoring program on the Missouri River. This represents 3% of the total least tern eggs observed in 2015. Measures taken to reduce mortality included moving nests to higher elevation, where practicable, and translocating chicks off flooded islands. In addition, restriction signs were placed in all segments to deter human disturbance.

The Emergent Sandbar Habitat (ESH) Program once again focused on maintaining vegetation-free habitat on the sandbars created during the 2011 period of record flood. The 2011 flood is estimated to have created over 14,000 acres of ESH from Garrison Dam through Ponca, Nebraska. Raw estimated ESH acreage for 2015 was approximated at 7,280 acres, compared to an estimated 7,792 acres in 2014. The overall decrease in sandbar availability is the result of erosion and vegetation encroachment. In 2015, the Corps identified sandbars suitable for vegetation removal activities in accordance with the 2011 *Programmatic Environmental Impact Statement* (PEIS) and associated *Record of Decision* (ROD) *for the Mechanical and Artificial Creation and Maintenance of Emergent*

Sandbar Habitat and the two vegetation modification Environmental Assessments tiered from the PEIS; the April 2013 *Environmental Assessment for the Restoration of Emergent Sandbar Habitat Complexes in the Missouri River, Nebraska and South Dakota* and the July 2013 *Environmental Assessment for the Restoration of Emergent Sandbar Habitat Complexes in the Missouri River, North Dakota*. Aerial spraying took place September 9 through September 11, 2015 and treated approximately 704 acres in river reaches of South Dakota and Nebraska below Gavins Point Dam in order to maintain substrate required for the least tern and piping plover. An additional 48 acres were sprayed utilizing an all-terrain vehicle (ATV) and approximately 60 acres were mowed. Approximately 694 acres were sprayed on August 23 through September 13, 2015 in river reaches of North Dakota below Garrison Dam.

The pallid sturgeon broodstock collection efforts in the Upper Missouri River occurred over a 4-week period from April through May 2015. Eight adult pallid sturgeon were caught, resulting in one male and two gravid females being sent to the Garrison National Fish Hatchery for spawning. In the lower Missouri River, 343 pallid sturgeon were collected and 66 adults were sent to Blind Pony State Fish Hatchery, Gavins Point National Fish Hatchery or Neosho National Fish Hatchery for spawning. Only 26 fish were reproductively-ready. The three federal hatcheries (Gavins Point National Fish Hatchery, Garrison Dam National Fish Hatchery and Neosho National Fish Hatchery) and two state hatcheries (Blind Pony State Fish Hatchery and Miles City State Fish Hatchery) involved with propagation of Missouri River pallid sturgeon stocked 13,166 fingerlings and yearling-sized pallid sturgeon. This is a decrease of pallid sturgeon stocked from 2014, due to disease and fish health issues at Blind Pony State Fish Hatchery and Neosho National Fish Hatchery. Currently, a hatchery review is underway to analyze and address fish health and other issues for the lower Missouri River hatcheries.

The Habitat Assessment Monitoring Program (HAMP) monitoring and focused investigations were continued to better understand the relationship between age-0 sturgeon habitat use and availability and how current habitat conditions may be limiting pallid sturgeon recruitment. An ongoing primary investigation involves physical and biological sampling at multiple existing shallow water habitat sites to better understand if desired habitat conditions are developing and determine if existing projects are providing the habitat types identified in the Effects Analysis. Another investigation involved physical and biological survey of five distinct reaches of the Missouri River that contained varying amounts of habitats that are hypothesized to benefit age-0 sturgeon. This effort will allow a comparison of age-0 sturgeon densities among reaches as well as the opportunity to assess potential reach effects on the gut contents and condition of age-0 sturgeon. The findings will be relevant to high priority hypotheses in the Effects Analysis. Another ongoing HAMP study designed to determine if pallid sturgeon captured in the Mississippi River originated from the Missouri River was continued. Information from this study will provide a better understanding of the importance of these rivers for various life stages of pallid sturgeon, particularly for those individuals where origin and recruitment may differ.

The Pallid Sturgeon Population Assessment Project (PSPAP) captured a total of 1,256 juvenile and adult pallid sturgeon from the Fort Peck Dam to the confluence of the Missouri and Mississippi Rivers. Monitoring data collected through the PSPAP indicated that stocked pallid sturgeon are surviving to a size and age capable of spawning. Genetic identification of age-0 sturgeon collected in 2014 is complete and six were confirmed as pallid sturgeon. These are the first confirmed age-0 pallid sturgeon ever caught in the lower Missouri River (downstream of Gavins Point Dam). Three of the pallid sturgeon were captured by the Missouri Department of Conservation and Corps' HAMP crews between Kansas City and St. Louis, Missouri. These fish were several weeks old and feeding. The other three fish were captured by the U.S. Geological Survey during sampling for drifting free embryos. These drifting free embryos were collected just upstream of the confluence of the Missouri River and Platte River.

Shallow water habitat (SWH) program efforts continued in the main channel of the Missouri River from Sioux City, Iowa to the confluence of the Mississippi River. Based on criteria set forward by the BiOp, a target of 3,611 to 5,870 acres above baseline estimates (existing 3,025 acres calculated by the USFWS) of SWH was required to be restored along this stretch of the river by 2010; however, a 4-year delay was granted by the USFWS as a result of the Corps implementing the Yellowstone Intake Fish Passage Project. Hydrogeographic surveys and LiDAR datasets were collected and analyzed in 2014 resulting in an estimate of 11,325 acres of SWH from Sioux City, Iowa to the confluence of the Missouri River. Created acres as well as naturally occurring SWH were included in this assessment. This effort was the most comprehensive assessment of SWH on the river to date. Eleven SWH sites were awarded or initiated for habitat creation, repair or enhancement to existing projects in 2015. These projects ultimately have the potential to create or restore up to 322 acres of SWH. To date, the Corps has constructed 53 off-channel projects which have resulted in an estimated 1,612 acres of SWH and completed an additional 23 revetment chute and channel widening projects which have resulted in an estimated 146 acres of SWH.

Litigation proceedings are ongoing in the takings claim filed in the United States Court of Federal Claims on March 5, 2014, by approximately 200 plaintiffs against the Corps for alleged flooding along the Missouri River from 2007 to 2013 (*Ideker Farms, Inc., et al. v. United States*). The claim was later amended to add approximately 170 plaintiffs and 2014 flooding claims. The plaintiffs allege that the Corps, in the operation of the Missouri River Mainstem Reservoir System since the Master Manual was updated in 2004 and 2006, in conjunction with habitat creation efforts to comply with the 2003 Amended BiOp, has caused an increase in flooding along the Missouri River. Plaintiffs contend, therefore, that through these actions the U.S. government has "taken" their property, in violation of the Fifth Amendment of the U.S. Constitution, for which they are entitled just compensation. The litigation is currently in the fact discovery stage, with the first trials likely to begin next year.

The agency has placed a moratorium on the MRRPs ability to acquire land which will be re-evaluated in a future year. Both Omaha and Kansas City Districts were contacted by a number of landowners interested in selling their property to the Corps under the MRRP. Due to the moratorium, these interested parties were informed that the MRRP currently has no plans to resume land acquisition; however, should funding once again become available then they will be contacted.

Work on the Yellowstone Intake Diversion structure continued in 2015. The Corps and Bureau of Reclamation (BOR) completed the Environmental Assessment (EA) for the construction at Intake in 2010. Construction of Phase I was completed in 2012 but significant cost increases on the rock ramp during the design of Phase II then prompted the federal agencies to re-evaluate feasible alternatives. A Supplemental EA was prepared and a Findings of No Significant Impact was signed on April 1, 2015 with a bypass channel and weir as the selected alternative. A contract was awarded to Ames Construction on August 31, 2015. The Natural Resources Defense Council and Defenders of Wildlife (plaintiffs) filed a lawsuit on February 2, 2015 in opposition of this project. Injunctive relief from the plaintiffs was sought resulting in the District Court of Montana enjoining the United States on September 4, 2015 from further construction of the Intake Diversion structure. A stay agreement was signed on January 5, 2016. As part of this agreement, the Government will complete an Environmental Impact Statement (EIS) and give consideration to a “weir-less” alternative proposed by the Plaintiffs.

I. Introduction

I.A. Purpose of Report

The purpose of the 2015 Annual Report is to satisfy reporting requirements for the Biological Opinion (BiOp) on the Operation of the Missouri River Mainstem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project (BSNP) and Operation of the Kansas River Reservoir System, prepared by the U.S. Fish and Wildlife Service (USFWS), dated November 30, 2000, and the amendment thereto, dated December 16, 2003. This annual report is the result of a collaborative effort between the U.S. Army Corps of Engineers (Corps), Omaha District (NWO) and Kansas City District (NWK).

Compliance with the 2003 amended BiOp requirements allows the Corps to operate the Missouri River to meet congressionally authorized project purposes without jeopardizing the continued existence of the federally endangered pallid sturgeon (*Scaphirhynchus albus*) and interior least tern (*Sterna antillarum athalassos*) and the federally threatened piping plover (*Charadrius melodus*). The Missouri River Recovery Program (MRRP), which encompasses both the BSNP Mitigation Project authority and BiOp compliance, allows the Corps to strategically implement management actions that will meet congresionally authorized project purposes while protecting native species and habitats on which they depend.

This report is organized into 11 sections that describe activities and progress towards implementation of the elements of the Reasonable and Prudent Alternatives (RPA), Reasonable and Prudent Measures (RPM), and Conservation Recommendations (CR) outlined in the BiOp for federally-listed threatened and endangered species on the Missouri River and activities implemented for the combined MRRP and BSNP Mitigation Project. Regulation (50 CFR § 402.02) implementing Section 7 of the Endangered Species Act (ESA) defines a RPA as an alternative action, identified during formal consultation, that: 1) can be implemented in a manner consistent with the intended purpose of the action; 2) can be implemented consisted with the scope of the action agency's legal authority and jurisdiction; 3) is economically and technologically feasible; and 4) would, the USFWS believes, avoid the liklihood of jeopardizing continued existence of listed species resulting in the destruction or adverse modification of critcial habitat. The Annual Report serves to fullfill RPA I.C which requires the Corps to provide USFWS an annual report which documents progress towards the implementation of the elmenets of the RPAs.

I.B. Background

The Missouri River is the longest river in the United States and is formed by the convergence of the Madison and Jefferson Rivers, just upstream of the Gallatin River, near Three Forks, Montana. The Missouri River flows 2,341 miles before it empties into the Mississippi River near St. Louis, Missouri and drains one-sixth of the United States. The river flows through the states of Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri. Figure 1 below depicts the geographic extent of the Missouri River and its watershed. The last century has brought many changes to the river's form and function, as its utilization and manipulation has brought many benefits to the nation. Progress has come at the expense of the river's dynamic ecosystem resulting in listing of threatened and endangered species and a decline in native populations. While the Missouri River can never be restored to the wild, untamed river that it once was, some of the river's ecological integrity and function can be recovered.

Figure 1. Missouri River Watershed

I.B.I. History

I.B.I.1. Missouri River Bank Stabilization and Navigation Project (BSNP)

The Missouri River, in its original form, was a wide, dynamic system with murky, muddy water characterized by log jams, snags, whirlpools, chutes, bars, cut-off channels, and secondary channels around bars. The river was laden with sediment and organic nutrients from constant bank erosion and periodic violent over-the-bank flooding. The river moved freely across the floodplain in large, looping meanders and had many channels, which supplied the resident wildlife with a diversity of habitat.

Between 1912 and 1945, Congress, by funding and authorizing seven different acts, charged the Corps with stabilizing the Missouri River and providing a 9-foot deep by 300-foot wide navigation channel. River management actions resulting from these acts have included removing snags and constructing and maintaining the navigation channel. This collection of projects is known as the Missouri River BSNP. The BSNP projects included placing revetments on the riverbanks, closing off sloughs and side channels, and constructing pile dikes (Figure 2). Later work included dredging and rock dike construction. In additon, intermittent private and federally funded levees have been constructed on both sides of the Missouri River from Sioux City, Iowa to the mouth at St. Louis, Missouri to protect over a million acres of bottom lands from flooding. These levees are designed to function in conjuction with the operation of the reservoirs on the Missouri River mainstem and the lower Missouri River Basin tributaries. Permanently stabilized river banks were necessary before the levees could be constructed, so the BSNP is critical to maintaining the integrity of the current levee system

Figure 2. Pile Dikes on the Missouri River Circa 1920

I.B.I.2. The Flood Control Act of 1944

The Flood Control Act of 1944 (also called the Pick-Sloan Act) (P.L. 78–534), authorized a water resources development plan for the Missouri River basin. This plan included the construction of five large dams on the mainstem of the river with the authorized purposes of flood control, navigation, irrigation, hydropower generation, water supply, water quality, recreation, and fish and wildlife. Six mainstem dams (storage projects) from north to south, including the first year storage was available for regulation of flows, are: (1) Fort Peck (1940); (2) Garrison (1955); (3) Oahe (1962); (4) Big Bend (1964); (5) Fort Randall (1953); (6) and Gavins Point (1955). The Fort Peck Dam was constructed prior to the Flood Control Act of 1944.

The Missouri River Mainstem Reservoir System provides benefits to both the natural and human environment with those benefits currently estimated at $1.8 billion/year. These benefits are realized through hydropower, water supply, flood control, upper and lower basin recreation, navigation, drinking water and irrigation water.

I.B.I.3. BSNP Fish and Wildlife Mitigation Project, Other Projects, and Authorizations

To comply with the Fish and Wildlife Coordination Act of 1958, and mitigate the various habitat losses on the lower river associated with the construction and operation of the BSNP, Congress authorized the Missouri River BSNP Fish and Wildlife Mitigation Project in the Water Resources Development Act (WRDA) of 1986, Section 610 (a) to aquire and develop a total of 48,100 acres of fish and wildlife habitat. Section 334 of WRDA 1999 then increased the acreage of habitat to be mitigated for the Mitigation Project by 118,650 acres bringing the total to 166,750 acres to be mitigated. The BSNP Mitigation Project authority was further amended in Section 3176(a) of WRDA 2007, to allow funds for mitigation and recovery activities in the lower basin of the Missouri River to be used for mitigation and recovery activities in the upper basin of the Missouri River, including the states of Montana, Nebraska, North Dakota, and South Dakota.

Other authorities applicable to the basin include:

- Section 514 of WRDA 1999 (Missouri and Middle Mississippi Rivers Enhancement Project): This authority called for the development of a plan to enhance fish and wildlife habitat of the Missouri River and middle Mississippi River.
- Section 33 of WRDA 1988 (Missouri River between Fort Peck Dam, Montana and Gavins Point Dam, South Dakota and Nebraska): This authority amended Section 9 of an Act titled "An Act authorizing the construction of certain public works on rivers and harbors for flood control, and other purposes", approved December 22, 1944 (58 Stat. 891) by adding maintenance and rehabilitation of existing structures, deemed required to alleviate bank erosion and related problems associated with reservoir releases along the mainstem of the Missouri River.
- Section 206 of WRDA 1996 (Aquatic Ecosystem Restoration): This authority provides for the Corps to restore aquatic ecosystems.
- Section 4003 of WRRDA 2014 (Missouri River): This authority calls for flood and drought monitoring in the Upper Missouri River Basin, further amends Section 33 of WRDA 1988, authorizes travel reimbursement for MRRIC members and requires a Biennial Report to Congress on funds expended relating to fish and wildlife mitigation, the BSNP and the MRRP.

I.B.I.4. Missouri River Master Manual

The Master Manual is the guide used by the Corps to operate the system of six dams on the Missouri River Mainstem Reservoir System. The Corps' Master Manual was updated in March 2004 to include more stringent drought conservation measures, unbalancing of the upper three reservoirs, modifications to non-navigation flows, and an Adaptive Management (AM) process. The Master Manual was updated in March 2006 to include technical criteria for the release of spring pulse flows from Gavins Point Dam.

I.B.I.5. Biological Assessment and Biological Opinion Timeline

In accordance with the ESA (7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.), the Corps must ensure, in consultation with the USFWS, that any action carried out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat. The federal action subject to ESA consultation is the Corps' operation of the Missouri River Mainstem Reservoir System, operation of the Kansas River projects, and the Operation and Maintenance (O&M) of the BSNP. Please refer to the below documents for more details.

1. U.S. Army Corps of Engineers. 2000. Biological Assessment on the Operation of the Missouri River Mainstem Reservoir System , the Operation and Maintenance of the Bank Stabilization and Navigation Project, and the Operation of the Kansas Reservoir System.
2. United States Fish and Wildlife Service. 2000. U.S. Fish and Wildlife Service Biological Opinion on the Operation of the Missouri River Mainstem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System.
3. U. S. Army Corps of Engineers. 2003. Biological Assessment on the Operation of the Missouri River Mainstem Reservoir System, the Operation and Maintenance of the Bank Stabilization and Navigation Project, and the Operation of Kansas River Reservoir System.
4. United States Fish and Wildlife Service. U.S. Fish and Wildlife Service 2003 Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Mainstem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System.

1989 - Corps provided an information report to the USFWS to supplement a prior Biological Agreement (BA) for Missouri River operations and had determined in the BA that current management of the river was detrimental to the survival and recovery of the pallid sturgeon, endangered interior least tern and the threatened piping plover.

1990 - USFWS completed formal consultation and issued a jeopardy opinion for the interior least tern and piping plover and a non-jeopardy opinion for the bald eagle (*Haliaeetus leucocephalus*) (USFWS, 1990a). The pallid sturgeon, listed as endangered in late 1990, was not addressed by that opinion.

1991 - USFWS advised the Corps to reinitiate formal consultation on the Missouri River operations due to the recent listing of the pallid sturgeon, lack of compliance with interior least tern and piping plover fledge ratios, other provisions of the RPAs identified and significant changes to annual operations since the 1990 opinion.

2000 – In the BiOp, the USFWS determined that the Corps' action would jeopardize the continued existence of the interior least tern, piping plover, and pallid sturgeon. The USFWS provided the Corps with RPAs that, if accomplished, would likely avoid jeopardizing these species.

2003- The Corps provided to USFWS a BA that indicated desire to reinitiate consultation because of new information about the effects of the action, newly designated piping plover critical habitat, and because the Corps determined portions of the original RPA were not reasonable or prudent.

2003 – The Corps requested re-initiation of formal consultation under Section 7 of the ESA due to the designation of critical habitat (under the ESA) for the piping plover in 2002, and a new report on mortality of terns and plovers.

2003 - USFWS accepted the BA and started formal consultation. The Corps further stated its commitment to implement the RPA found in the 2000 BiOp but proposed replacing certain elements of the RPA in Missouri River management.

2003 - USFWS amended the 2000 BiOp which retained the vast majority of the measures included in the 2000 BiOp, but incorporated a performance-based approach which allowed greater flexibility while providing equal or greater biological benefits to all three listed species.

2009 - USFWS formally revised portions of the BiOp in a letter to the Corps by substituting a new RPA element at Yellowstone, Montana Intake Dam and the irrigation headwaters. The shallow water habitat (SWH) restoration targets have been delayed by four years as a result of implementing the Yellowstone Fish Passage Project.

2013 – USFWS grants an extension to delay SWH restoration targets as resources continue to be utilized for the construction at Intake, "beyond year 2024 for a period equal to the time from commencement to completion of construction; not to exceed three years" (up to year 2027).

I.B.I.5.a. Interior Least Tern, Piping Plover, and Pallid Sturgeon

<u>Interior Least Tern:</u>
Please refer to the "Recovery Plan for the Interior Population of the Least Tern (*Sterna antillarum*)", U.S. Fish and Wildlife Service, Twin Cities, Minnesota (USFWS, 1990b) for the recovery criteria and delisting actions.

<u>Piping Plover:</u>
Please refer to the "Great Lakes and Northern Great Plains Piping Plover Recovery Plan", U.S. Fish and Wildlife Service, Twin Cities, Minnesota (USFWS, 1988) for the recovery criteria and delisting actions.

<u>Pallid Sturgeon:</u>
As outlined in the BiOp, the SWH restoration goal is to achieve an average of 20 to 30 acres of SWH per mile of river. Please refer to 2003 Amended BiOp for set performance standards for the pallid sturgeon recovery by year. Please note above in Section I.B.I.5, SWH restoration targets were granted a deferment of four years due to resources being utilized for Intake.

Please refer to the "Recovery plan for the Pallid Sturgeon (*Scaphirhynchus albus*)", U.S. Fish and Wildlife Service, Denver, Colorado (USFWS, 1993) for the recovery criteria and delisting actions.

I.B.I.5.b. Bald Eagle

In the 2000 BiOp, the USFWS found that the actions proposed by the Corps would not result in jeopardy to the bald eagle. However, the USFWS recommended that the Corps exercise its Section 10/404 permit authority to protect, maintain and enhance riparian forest useable by bald eagles. Though the bald eagle was delisted on July 9, 2007, the Corps is encouraged to continue to protect cottonwood (*Populous deltoides*) forests along the Missouri River.

Please refer to the 2000 BiOp, for the RPMs that were determined necessary and appropriate to minimize take of bald eagles. The USFWS recommends the Corps continue to pursue the recovery tasks assigned to the Corps in the implementation schedules in the Northern States Recovery Plan for Bald Eagles for Missouri and Kansas River habitats.

I.B.II. Missouri River Recovery Program

The MRRP was established by the Corps in 2003. It is an umbrella program that coordinates the Corps' efforts in the following:

- Compliance with the USFWS 2003 Amended BiOp on the Operation of the Missouri River Mainstem Reservoir System, Operation and Maintenance of the BSNP and Operation of the Kansas River Reservoir System;
- Acquiring and developing lands to mitigate for lost habitats as authorized by Section 601(a) of WRDA 1986 and modified by Section 334(a) of WRDA 1999 (collectively known as the BSNP Fish and Wildlife Mitigation Project); and
- Implementation of WRDA 2007 including the Missouri River Recovery Implementation Committee (MRRIC) and Section 3176(a), which expanded the Corps' authority to include recovery and mitigation activities of the Missouri River in the upper basin states of Montana, Nebraska, North Dakota and South Dakota.

As part of continued efforts of the MRRP, the Management Plan/ Environmental Impact Statement (MP/EIS) has become a significant aspect of the program. The goal of the MP/EIS is to address the MRRIC recommendations (see Appendix D), provide National Environmental Policy Act (NEPA) compliance for the current and future management actions and to develop a comprehensive AM plan. The MP/EIS will utilize the latest science to evaluate the reasonableness, effectiveness and the programmatic effects of current actions and potential future actions to avoid jeopardy (see Section VIII).

I.B.II.1. Authority

The funding authority for the MRRP was established following the 2006 appropriations when funding for the BSNP Fish and Wildlife Mitigation Project was made available for use on BiOp compliance activities in the upper basin of the Missouri River in the states of Nebraska, South Dakota, North Dakota and Montana. This was later formalized through WRDA 2007.

The Corps prepared a feasibility report and EIS (USACE, 1981) for the original Mitigation Project that consisted of acquiring and developing fish and wildlife habitat on 48,100 acres of land. After Congress modified the Mitigation Project in WRDA 99 to include acquisition and development of an additional 118,650 acres, the Corps initiated a supplemental EIS (USACE, 2003) in September 2001 to assess the potential impacts of acquiring the additional acreage. The supplemental EIS was completed in early 2003 and the Record of Decision (ROD) was signed in June 2003.

Section 3176(a) of WRDA 2007 further amended the Mitigation Project authorization. This allowed funds made available for recovery or mitigation activities in the lower basin of the Missouri River to also be used for recovery or mitigation activities in the upper basin of the Missouri River, including the states of Montana, Nebraska, North Dakota, and South Dakota. Additionally, Section 3109 of WRDA 2007 allowed the Corps to use funds to assist the Bureau Of Reclamation (BOR) with the planning and construction of a fish passage at the Lower Yellowstone Intake Diversion Dam Modification Project (Intake Diversion Dam Project) near Intake, Montana.

Congress further directed the Corps to develop a Missouri River Ecosystem Restoration Plan (MRERP) and a basin wide stakeholder group known as MRRIC as part of the MRRP. Funding for MRERP had been prohibited in recent appropriation bills and no actions are currently ongoing or planned. Per Section 5018 of WRDA 2007, the Corps is required to:

1. Prepare a study (known as MRERP) to determine the actions required to mitigate losses of aquatic and terrestrial habitat; recover federally-listed species under the ESA; and to restore the ecosystem to prevent further declines among other native species. The Consolidated Appropriations Act of 2012 (Sec 120) included language that prohibited funding MRERP during FY12. The legislation was signed by the President late on December 23, 2011. As a result, all MRERP activities were immediately suspended. No funding or activities have resumed since.
2. Establish a MRRIC Committee to include representatives from federal agencies, Tribes, states, local governments and non-governmental stakeholders in the Missouri River basin. See Section IX for more information on MRRIC.

I.B.II.2. MRRP Mission and Goals

The current mission of the MRRP is an effort to replace lost habitat and avoid a "Finding of Jeopardy" to the three threatened and endangered species resulting from the Corps' projects on the Missouri River. The program is structured into several unique components including habitat creation, hatchery support, scientific research and monitoring and public involvement.

As part of its efforts to most effectively meet the BiOp requirements, MRRP is undertaking an effort to develop a MP/EIS with concurrent creation of an AM Plan as required by the BiOp. This will meet the Corps' legal requirement for NEPA compliance and address cumulative impacts of federal actions as well as address MRRIC recommendations and utilize the latest science to evaluate the effectiveness of current actions and potential future actions to avoid jeopardy.

I.B.II.3. Partnerships

Agency Coordination Team (ACT) - See VII.C for detailed information.
MRRIC - See Section IX for detailed information.

II. Description of the Overall Hydrologic Condition of the Missouri River in 2015

The water management goal is to serve the authorized purposes of the reservoir system and provide releases to promote successful nesting and avoid flooding piping plover and interior least tern nests and chicks. Releases from Fort Randall and Garrison Dams followed a repetitive daily pattern during the nesting season to provide a consistent daily stage downstream of the projects.

In early May, Gavins Point releases were increased from 24,500 to 29,500 cubic foot/second (cfs) to provide full navigation support at Sioux City, Iowa for a commercial tow. It was estimated that the release of 29,500 cfs was the 2015 "steady release" and Gavins Point releases would need to be increased later in the summer to meet full service navigation target flows when tributary flows decreased (flow to target). After the tow exited the Sioux City reach in mid-May, the Gavins Point release was reduced from 29,500 to 28,000 cfs. The release reduction was made because downstream tributary flows were sufficient to meet the Nebraska City, Nebraska and Kansas City, Missouri navigation flow targets of 37,000 and 41,000 cfs, respectively. In early June, rainfall events caused significant tributary inflows below Gavins Point which resulted in further reductions in Gavins Point releases. Releases were decreased to a "2 days up – 1 day down" cycle of 25,000 cfs and 22,000 cfs, respectively. The cycling operation began on 5 June and lasted until 15 June when high downstream flows subsided. The Sioux City target was missed from 9 June until 3 July because no commercial navigation traffic was in the reach. After the cycling operation, Gavins Point releases were held steady at 24,000 cfs until being increased to 27,000 cfs on 3 July to provide full service navigation flow support for a tow headed to Sioux City. The Gavins Point releases were maintained at 27,000 cfs.

Significant tributary inflows from rainfall events necessitated reducing Gavins Point releases to 25,000 cfs on 18 August. This release was maintained until 25 August, which was determined to conclude the 2015 plover and tern breeding season. On 26 August, Gavins Point releases were increased to 27,000 cfs. During the 2015 nesting period, the USFWS and the Corps' Integrated Science Program (ISP) were contacted to ensure no nests or chicks would be impacted by the Gavins Point release changes. Figure 3 displays Gavins Point releases and Missouri River flows at Sioux City and Nebraska City during the 2015 tern and plover breeding season.

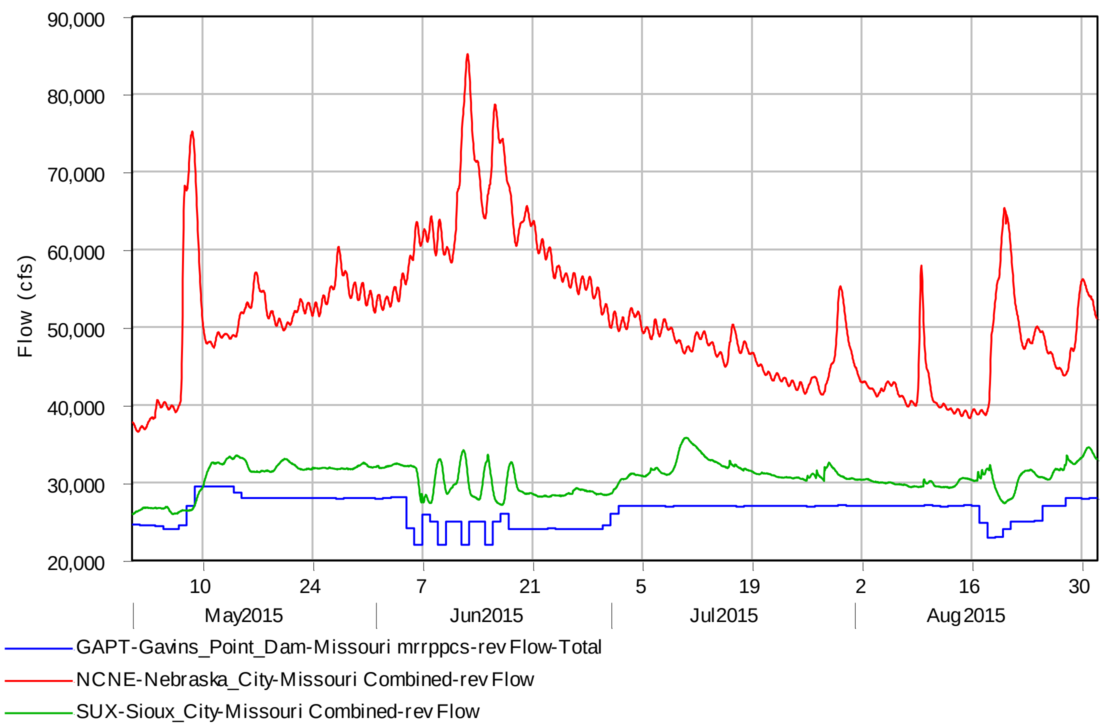

Figure 3. Gavins Point releases and Missouri River flows at Sioux City, Iowa and Nebraska City, Nebraska during the 2015 tern and plover breeding season

Reservoir elevations and release information, snowpack, runoff and other water management information for the Missouri River can be found in the report *titled Missouri River Mainstem Reservoir System Summary of Actual 2015 Regulation* when it becomes available in Spring 2016.

III. MRRP Program Integration

III.A. Program and Project Management

Program and Project Management support for the implementation of the program activities to meet the requirements of the 2003 Amended BiOp and the implementation of the Missouri River BSNP Fish and Wildlife Mitigation Project as outlined in Section 3109, Section 3176, and Section 5018 of WRDA 2007. The activities are critical to the successful implementation of the elements of the RPA to avoid jeopardy for three threatened and endangered species. The Program and Project Management portion of the program includes all activities that are not specifically attributable to one of the other program elements. Senior level management who are responsible for oversight of the entire MRRP program reflect their responsibilities under this element. Project Managers who work on dozens of program wide coordination issues every year in response to inquiries from the Assistant Secretary of the Army, Congressional Representatives, MRRIC, stakeholders and the public also reflect their effort under this element. Additionally, costs not otherwise captured under a specific program are derived from this element.

III.B. Adaptive Management

The 2003 Amended BiOp calls for implementation of management actions within an AM framework. AM strategies were previously developed and implemented for the ESH (2011) and SWH (2012) components of the program. See Section IV.C for additional information on AM activities and accomplishments for 2015.

III.C. Communication and Outreach

In 2015, MRRP Communications staff provided MRRP messaging through a variety of products, outreach venues and multi-media approaches. The following summarizes communication and outreach accomplishments for the year.

III.C.I. Newsletters, Bulletins and Interpretive Displays

The Recovery Channel Bulletin: Three bulletins were created providing public information to basin-wide stakeholders and interested public. The *Recovery Channel Bulletin* is distributed through an email distribution system to over 2,700 individuals and posted online. This publication highlights current program activities and major milestones for the program. The following bulletins were published during 2015:

- December 2014: Preparing to Break Ground at Cora Island, Operations and Maintenance of the MRRP, Studying River Reaches-Shallow Water Habitat, Meet Me at the Confluence, Bird Monitoring and Faces of MRRP.
- March 2015: Larval Pallid Sturgeon Find, Annual Inspections of the River, MRNRC Conference and Faces of MRRP.
- May 2015: Management Plan Update, Broodstock Collection Efforts, Cranberry Bend Progress, MRRP Annual Report and Faces of MRRP.

III.C.II. Outreach Events

The MRRP staff participated in the following outreach events over the course of 2015:

- Missouri River Natural Resources Conference, Nebraska City, Nebraska, 10-12 March 2015.
- Wings over Weston at Weston Bend State Park, Missouri, 9 May 2015.
- Barge Trip from Nebraska City, Nebraska, South 10 Miles and Return, 1 June 2015. Missouri River Stakeholders across all Corps missions were invited and provided opportunity for engagement.
- Missouri River Outdoor Expo at Ponca State Park, Nebraska, 19-20 September 2015. This outreach venue is one of the largest outdoor expos, reaching approximately 50,000 visitors and is the premier outreach event for NGPC.
- Barge Trip showcasing Dalbey Bottoms (River Miles 450 to 423), St. Joseph, Missouri to Atchison, Kansas, 30 September 2015. Missouri River Stakeholders across all Corps missions were invited and provided opportunity for engagement.
- Missouri Partnering Meeting, Lake of the Ozarks, Missouri, 13-14 October 2015.
- Women in Science, Mount Marty College, Yankton, South Dakota, October 2014, 2015
- Missouri River Watershed Festival and River Cleanup, Yankton, South Dakota, May 2016

III.C.III. Public Website

The public website, www.MoRiverRecovery.org, is the Corps of Engineers' online news and information guide for the overall MRRP. The following accomplishments were achieved online during 2015:

- Missouri River Recovery MP/EIS pages further refined plan development.
- Implemented some general content updates related to current program focus
- Continued update of individual MRRP site information

III.C.IV. Social Media

Social media sources have become increasingly relevant and appropriate forums for government agencies and require little to no direct costs while communicating program efforts in broader audience messages. In 2015, the MRRP Facebook posts reached an average of 74 people each, 42,459 total daily impressions (or the number of impressions seen of any content associated with the MRRP Facebook page). The most popular post was a link to a newspaper story discussing William Clark's great-great-great-great grandson traveling the Missouri River in a canoe made of a cottonwood tree; which reached 1,131 people. Over the course of 2015, posts in the MRRP Facebook page had an average reach of 501 views – this reach was from posting external links, including links to the MRRP website.

III.C.V. Collaboration Sites

The Information Data Management Team assisted owners and users of external collaboration sites to enable collaboration and information exchange between the internal team and agency/stakeholder members. The following sites were updated as needed:

- Internal MRRP SharePoint collaboration sites and Missouri River Basin SharePoint calendar
- External APAN collaboration sites for MRRP, MRRIC, and the MP/EIS.

III.C.VI. Public Scoping

The Omaha and Kansas City Districts conducted public scoping on multiple projects for the MRRP in 2015. The purpose of scoping is to help fulfill NEPA requirements by determining the scope and depth of issues to be addressed during the planning process while engaging the public in the project. Public scoping meetings offer the opportunity for the MRRP team to describe proposed actions and, if available, possible alternatives. The process allows the public to have an opportunity to comment and provide input on the purpose and need, scope and objectives after they receive a summary of the project information and the steps to follow toward making a decision. The following public scoping meetings were held in 2015:

- 20 August 2015 - A public meeting was held in Nebraska City, Nebraska to seek comment on the proposed Shallow Water Habitat (SWH) restoration projects at Copeland Bend and Langdon Bend. Approximately 50 people attended.
- 9 July 2015 – A public meeting was held in Arrow Rock, Missouri to seek comment on the proposed Tadpole Island Side Channel Modification Project.

The Omaha District, in accordance with NEPA, also sought the public's input on the following draft environmental assessments by posting the documents on the Omaha District website as well as on the MRRP website :

- Upper Hamburg chute repairs (Otoe County, Nebraska)
- Nishnabotna Bend chute repairs (Nemaha County, Nebraska)
- Ponca backwater repairs (Dixon County, Nebraska)
- Sandy Point Bend chute complex adaptive management (Harrison County, Iowa)
- Fawn Island chute repairs (Harrison County, Iowa)
- Deroin Bend chute repairs (Holt County, Missouri)

III.C.VII. Internal Distribution List

The Information Data Management Team assisted in the creation and maintenance of a new distribution list for the team: DLL-CENWD-MRRP.

III.C.VIII. Tribal Engagement

As part of the federal Trust responsibility, the Corps is required to offer consultation on all projects that may affect Tribal land or cultural sites. In order to ensure that the Corps is meeting this responsibility, the MRRP offers additional Tribal outreach and coordination support to ensure that Tribes are aware of all efforts made along the Missouri River.

MRRP engaged in 10 individual Tribal meetings to ensure Tribes are aware, updated and engaged in the various programs and activities. Additionally, the Corps held four Tribal-Management Plan meetings to discuss the MP/EIS with the Tribes. The first of these four meetings, hosted by the Oglala Sioux Tribe, had eight Tribes participate. The second, hosted by Flandreau Santee Sioux Tribe, brought in six Tribes. The third meeting was hosted by the Crow Tribe, in which three Montana Tribes participated. Letters of invitation were distributed to all 29 Tribes in the Missouri River basin for the first two of these meetings. The third meeting invitations went to Montana, Wyoming and those Tribal members who missed the first two and requested invites to the third. A fourth meeting was held for Standing Rock Sioux and Three Affiliated Tribes in Bismarck to discuss the possible effects of the various proposed alternatives.

In addition to these outreach efforts, a concerted effort was made to address strong concerns expressed by several Tribes regarding the Cultural Resource modeling in the MP/EIS. After several meetings, in-person and by phone, Tribes who expressed these concerns were more comfortable with the additional information provided.

MRRIC has increased Tribal participation by four Tribes. The additional Tribes and outreach done throughout the year has assisted in the above-mentioned meetings and has encouraged those participating Tribes to work closely with the Corps and to encourage other Tribes to provide input to the MRRP and MP/EIS efforts.

IV. MRRP Implementation of Measures

IV.A. Integrated Science Program

The MRRP's ISP strives to understand and enhance the knowledge of the complex Missouri River system to ensure that management decisions are based on the best available science. To complete this mission, the ISP has many ongoing monitoring and research efforts aimed at informing management decisions.

IV.A.I. Interior Least Tern and Piping Plover

Over the years, the Corps has been charged by Congress to remove snags, protect banks, construct navigation channels and build flood risk management structures (levees and dams) on the Missouri River to provide social and economic benefits to the nation. Some of these development activities on the Missouri River have come at the expense of the river's native fish and wildlife. The interior least tern and piping plover prefer sparsely vegetated sandbars that are not connected to adjacent banks as nesting and foraging habitat. As a result of managing the river for a variety of authorized purposes, the quantity and quality of sandbar habitat within the river channel has declined. Activities to maintain and/or create additional sandbar habitat are underway and will continue as needed based on BiOp requirements and species' needs.

IV.A.I.1. Summary of the Approach for Monitoring and Research

Productivity surveys for the interior population of least terns and piping plovers on the Missouri River began on April 27, 2015 and concluded on September 1, 2015. Monitoring crews followed the historic Tern and Plover Monitoring Program (TPMP) protocol in 2015 (USACE, 2009, updated in 2015), and surveyed all available habitat on the river and reservoirs for nests and chicks within a 7-day return interval. Field data were collected using a Trimble© Geoexplorer hand held GPS, as well as field notes. Data was subsequently uploaded to the Tern and Plover Data Management System (TPDMS; https://rsgisias.crrel.usace.army.mil/intro/dms.dmsintro.main). Survey locations were generally accessed by boat, and occasionally by ATV. While some survey work was done from a boat (such as adult census), most areas were walked to find nests and chicks. Surveyors utilized binoculars and spotting scopes as well as auditory cues and visual sightings to locate terns and plovers and their nests. Upon nest discovery, at least one egg from each nest was floated, regardless of clutch size, to estimate incubation stage. Eggs that showed signs of hatching or that were damaged were not floated. Nests were visited weekly and once hatched the chicks were tracked through fledging.

Overall, population numbers and productivity for piping plovers on the Upper Missouri River were up in June 2015, with 1,612 adults counted compared to 1,116 adults counted in 2014 and a fledge ratio (the number of chicks fledged per pair of adult birds) of 1.4. The adult count was up 44% from 2014, and the number of fledglings produced was 80% higher than in 2014.

The interior least tern adult count was also up, with 917 adults counted in 2015 compared to 720 in 2014; an increase of 27%. Productivity was also higher in 2015, with a fledge ratio of 1.31, and a 174% increase in the number of least tern fledglings observed.

Nesting activity for piping plovers and least terns was higher in 2015 (nest counts were up 26% and 28% respectively from 2014), and nest success was improved with 62% of the observed piping plover 73% of the observed interior least tern producing at least one chick.

Incidental take was also higher in 2015, with 96 piping plover nests lost due to operation of the dams and the tern and plover monitoring program on the Missouri River. These 96 nests had 335 eggs and 1 chick, which represent 9.7% of the total piping plover eggs observed in 2015. For least terns, 19 nests with 52 eggs were lost due to operation of the dams and the tern and plover monitoring program on the Missouri River. This represents 3% of the total least tern eggs observed in 2015.

Summer rains across the northern portion of the Missouri River basin resulted in high run-off in the Oahe reach that was 302% of normal in May. In June, run-off in the Garrison reach was 129% of normal and in the Oahe reach, 252% of normal. The precipitation pattern continued into July, resulting in run-off in the Oahe reach that was 218% of normal, and in August, 353% of normal. As a result, Lake Sakakawea and Lake Oahe reservoir elevations increased quickly during the breeding season and were slow to drop. Between May 1 and July 23, 2015, Lake Oahe elevation came up 6.59 feet, peaking at 1613.52 msl. Lake Sakakawea elevation increased 6.77 feet, peaking on July 28 at 1845.24 msl. Corps personnel moved 38 nests to higher ground during the breeding season; 40% of the nests moved on Lake Oahe were successful, and 47% of the nests moved on Lake Sakakawea were successful. In addition, staff from the Corps, U.S. Geological Survey (USGS), and USFWS partnered to translocate 10 broods of piping plover chicks that were at risk of inundation on Lake Sakakawea and Lake Oahe. Please see Tables 5 and 6 in Section IV.A.I.2.c for piping plover and interior least tern productivity data. Reduction of incidental take was challenged by high runoff during nesting season and high abundance of birds on both reservoir and riverine reaches.

IV.A.I.2. System Monitoring Requirements

IV.A.I.2.a. Adult Census on the Missouri River

Adult census of least terns and piping plovers on the Missouri River was conducted from June 15 through July 1, 2015. Table 1 shows the results by species and segment. Overall, the number of piping plover adults observed on the upper Missouri River in 2015increased 44%, with 1,612 adults counted during the adult census compared to 1,116 in 2014. The interior least tern adult count was up 27% with 917 adults compared to 720 in 2014.

Table 1. 2015 piping plover and interior least tern adult census by segment

Segment	Piping Plover	Interior Least Tern
Fort Peck Lake	4	0
Fort Peck River	0	12
Lake Sakakawea	252	18
Garrison River	392	157
Lake Oahe	251	93
Fort Randall River	145	155
Lewis & Clark Lake	188	164
Gavins Point River	380	318
Total	1,612	917

IV.A.I.2.b. Fledge Ratios and Incidental Take

The fledge ratio represents the number of chicks fledged per pair of adult birds. It is used as a measure of productivity and as a compliance metric in the BiOp for evaluating success in meeting habitat goals and evaluating the effects of incidental take.

Habitat Goals

The 2003 Amended BiOp states that "natural tern and plover nesting habitat shall be provided as a priority" to provide successful reproduction and recruitment and "should be available to nesting birds at a minimum of one out of three years." The BiOp sets fledge ratios as a measure of habitat quality on the Missouri River. For the interior least tern the 1994-2003 observed fledge ratio of 0.94 fledglings per adult pair is the target, and for piping plover the target fledge ratio is 1.22, both applied to a 3-year running total (Figure 4 and Figure 5).

Table 2 shows the habitat quality indicators for interior least terns and piping plovers on the Missouri River, as represented by the fledge ratio for the last 3-years running total (2013-2015).

Table 2. Habitat Quality Indicators for Interior Least Terns and Piping Plovers, 2013-2015

Species	BiOp Target 3-yr Total Fledge Ratio	2013 – 2015 Fledge Ratio
Least tern	0.94	**0.89** (1,041 fledglings/(2,327 adults/2))
Piping plover	1.22	**1.26** (2,177 fledglings/(3,448 adults/2))

As described in the 2013 Annual Report, the TPMP used a stratified random sub-sampling protocol in 2013 which did not include productivity monitoring on Lake Sakakawea or Lake Oahe. Therefore the 3-year running totals of fledglings and breeding adults do not include observations from these waterbodies in 2013, which in previous years contributed approximately 9 -15% of the total population of breeding adult terns and fledglings and 40 -50% of the total population of breeding adult piping plovers and fledglings.

It should also be noted that for least terns in particular, observing fledge success with current methods is particularly difficult in years with abundant habitat as the young birds are difficult to find due to their cryptic coloration and elusive behavior. The combination of abundant sandbar habitat created in 2011 and encroaching vegetation make it particularly difficult to find least tern chicks.

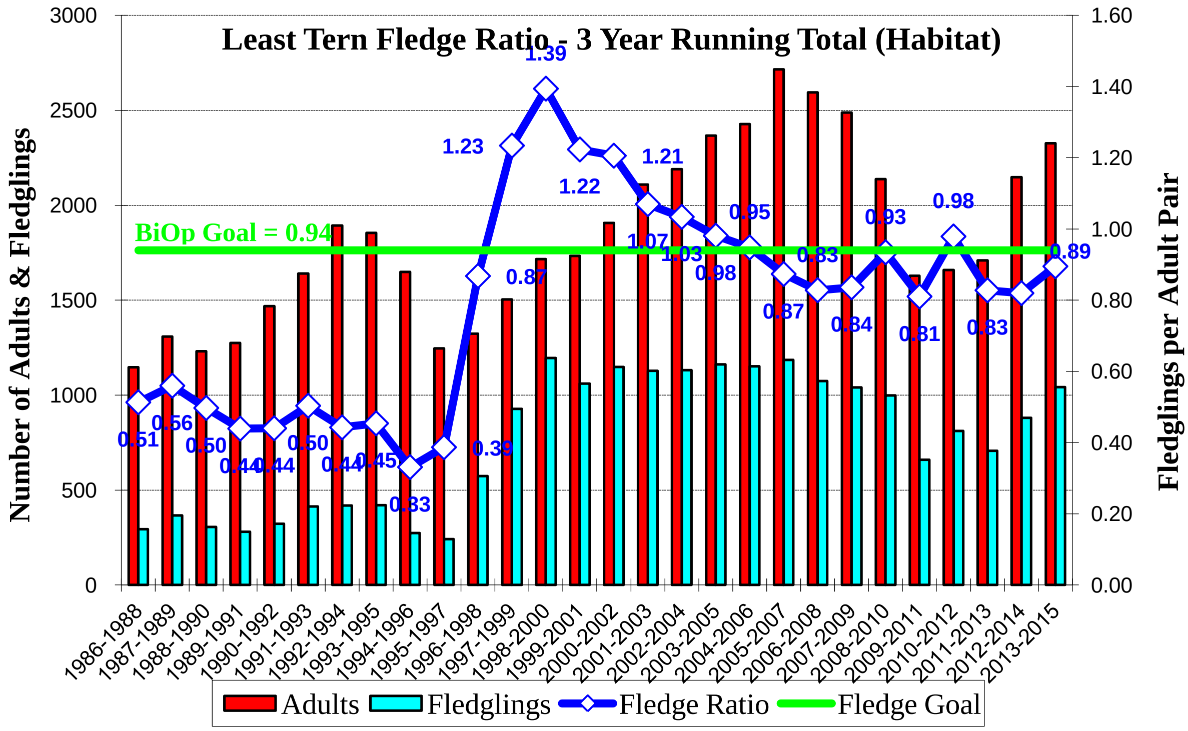

Figure 4. Interior least tern fledge ratio (3-year running total)

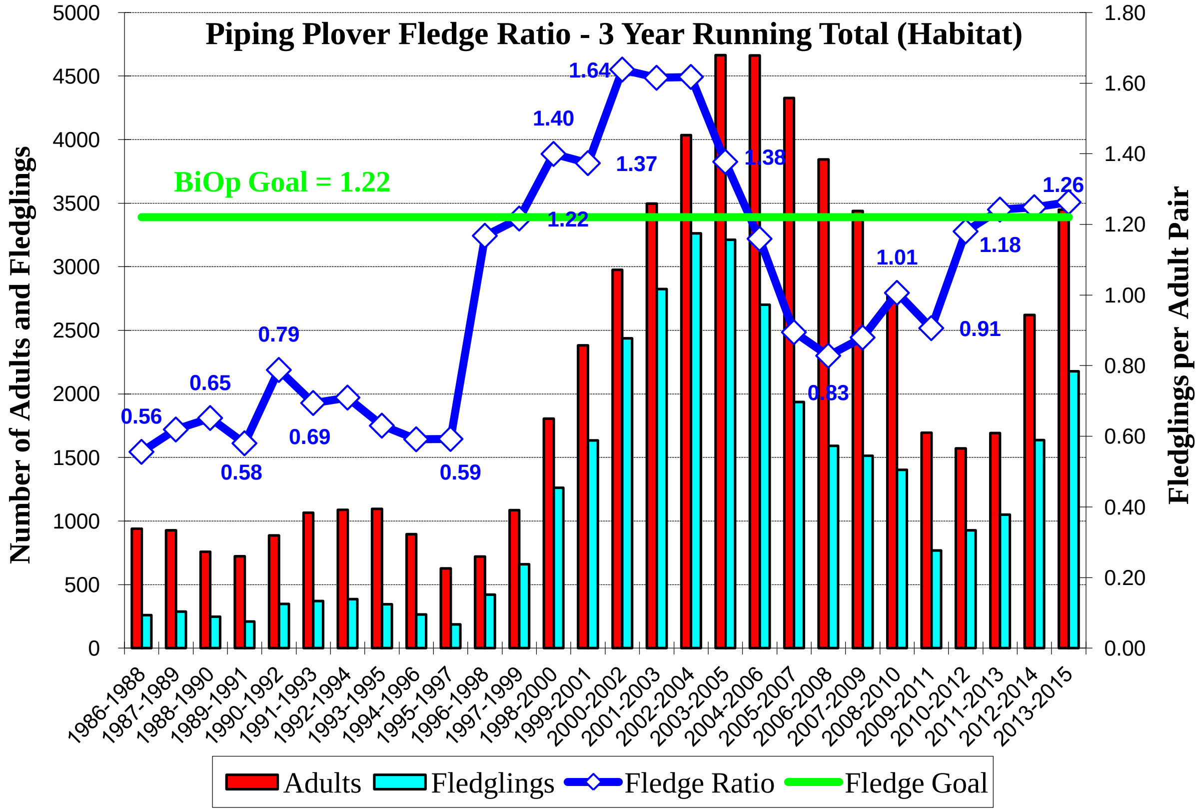

Figure 5. Piping plover fledge ratio (3-year running total)

<u>Interior Least Tern Incidental Take:</u>

1. Take of eggs and chicks by flooding on the river and reservoir reaches that result from the Corps' operations of the water control system.

The 2003 Amended BiOp states, "…re-initiation of consultation will be required if the Corps' actions result in take of more than 180 eggs in a 3-year consecutive period." As described previously, the 2013 change in the monitoring protocol eliminated productivity sampling on Lake Sakakawea and Lake Oahe, except for the adult census. Therefore, the 2013 incidental take for these waterbodies was estimated using historic water level and bird data for Lake Sakakawea and Lake Oahe. In 2014 and 2015, all suitable reservoir and riverine habitat was surveyed, so the data represent the actual observed incidental take.

Table 3 shows the incidental take losses for the Missouri River for 2013-2015, which were below the 180 eggs (and chicks) trigger set forth in the 2003 Amendment of the BiOp.

Table 3. Incidental Take: Interior Least Terns 2013-2015

Year	Eggs	Adults/Chicks	Total
2013	20	0	20
2014	68	0	68
2015	52	0	52
3-Year Total	140	0	140

In 2015, 52 least tern eggs were lost due to operation of the dams and the TPMP on the Missouri River. Eighteen nests (49 eggs) were either flooded or washed out by wave action exacerbated by the high water levels. One nest (three eggs) was accidently stepped on by a member of the Corps' monitoring crew on an island in Lake Sakakawea.

2. Take of eggs, chicks, and adults by factors influenced by but not directly attributable to the Corps.
The Corps' modification of the historical hydrograph reduces the number of scouring events that would limit vegetation encroachment on sandbars and beaches used for nesting by least terns. Vegetation encroachment on sandbars used by least terns may increase the potential for predation of eggs, chicks and adults by predatory mammals and birds. In addition, management of reservoir beaches may result in incidental take due to the disturbance of breeding birds and destruction of nests by recreationist (USFWS, 2003). Fledge ratios provide an index of incidental take that is influenced by the Corps' activities but which cannot be quantitatively attributed to the Corps' actions, such as predation, weather, livestock, erosion, and recreation. The 2003 Amendment to the BiOp states "The Corps should reinitiate consultation if the running 5 year average fledge ratio is less than 0.94." In 2015, the 5-year running fledge ratio (2011-2015) for least tern was 0.91 fledglings per adult pair (1,515 fledglings/ (3,326 adults/2); Figure 6).

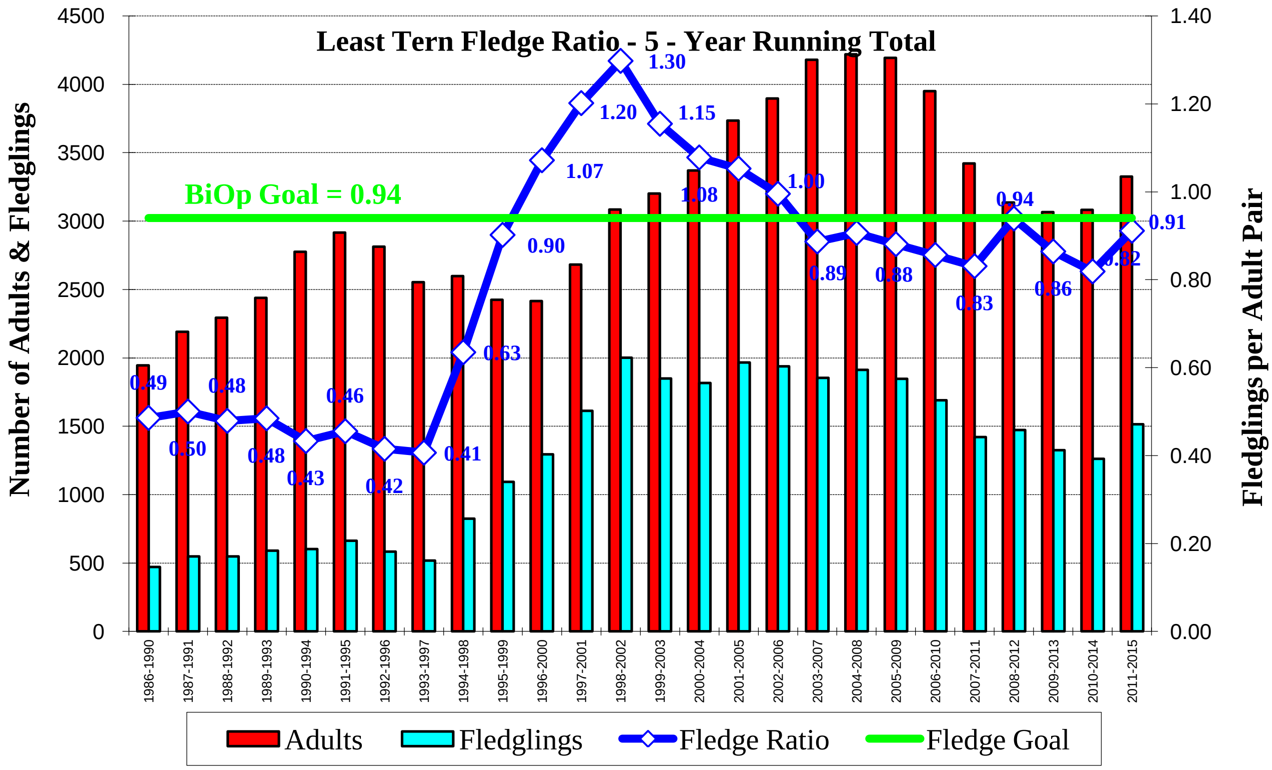

Figure 6. Interior least tern fledge ratio (5-year running total)

As described previously, the 2013 monitoring program did not monitor productivity on Lake Sakakawea or Lake Oahe. Therefore the number of fledglings and the number of breeding adults does not include observations from these waterbodies; they are estimated from subsampling in the river segments. The 2011-2015 fledge ratio reported here represents a combination of data from observed productivity on lake and river segments (2011-2012, 2014-2015) and estimated productivity of the riverine segments (2013).

Piping Plover Incidental Take:
In the 2003 Amended BiOp the USFWS listed six categories in which incidental take for the piping plover was expected to occur.

1. Take (killing) of eggs and chicks by flooding on the river and reservoir reaches that result from the Corps' operation of the water control system.
In the 2003 Amended BiOp, the USFWS set two standards of incidental take with regard to the Corps' water control system operations:

a) Incidental take by flooding should not exceed 8.4% of all eggs in the action area, +/- 10%, expressed as a 10-year running average (8.4% is the amount of incidental take of eggs that occurred due to Corps operations from 1993-2003). The 10% variance results in a limit of 7.6% to 9.2%.
   i. Determining the 10-year running average is problematic because in 2013, the Tern and Plover Monitoring Program implemented a modified protocol, wherein tern and plover habitat was sub-sampled in the riverine segments only. Birds on the reservoirs (Lake Sakakawea, Lake Oahe) were not monitored, so the 2013 estimate of 1,782 piping plover eggs pertains to the river segments only. The 2013 Incidental Take for the reservoirs was estimated using historical averages from those waterbodies.
   ii. Using the (under-)estimated egg count of 1,782 eggs on the river segments in 2013, the 10-year running average of Incidental Take is calculated at 7.8%, slightly less than the BiOp threshold. Had egg counts on the reservoirs been monitored and estimated in 2013, this 10-year running average would be well below the BiOp threshold.

b) Incidental take should not exceed that observed from 1993-2003 in any single year. This was quantified as the lesser of 294 eggs (1995) or 46% of all eggs (1996).

   In 2015, 96 piping plover nests with 335 eggs and 1 chick were lost due to Corps water control system operations and the tern and plover monitoring program on the Missouri River.

   - 129 eggs from 36 nests were lost on Lake Oahe, and 206 eggs and one chick from 60 nests were lost on Lake Sakakawea, due to a combination of factors (Table 4). The 336 eggs/chick lost represent 9.7% of the 3,450 known piping plover eggs on the Missouri River in 2015.

Table 4. 2015 Piping Plover Incidental Take by Monitoring Segment.

	Number of Piping Plover Nests (and Eggs) Lost as Incidental Take				
Segment	**Nest was abandoned after it was moved**	**Nest was flooded**	**Corps crew stepped on nest**	**Wave action took out nest eggs/chick**	**Total**
Lake Oahe	2 (7)	29 (103)		5 (19)	36 (129)
Lake Sakakawea	2 (5)	52 (181)	1 (3)	5 (18)	60 (207)
Total	**4 (12)**	**81 (284)**	**1 (3)**	**10 (37)**	**96 (336)**

   - Four nests (12 eggs) were abandoned by the adults after crews moved the nests upslope to higher ground, and 91 nests (321 eggs) were either flooded or washed out by wave action exacerbated by the high water levels. One nest (three eggs) was accidentally stepped on by a member of the Corps' monitoring crew. This was a "new" nest (not previously found) and with the rise in the reservoir pool, this nest was at the land/water interface when it was accidentally stepped on.

   - One recently hatched piping plover chick drowned when the nest was destroyed by wave action in the deepwater area of Lake Sakakawea (river mile (RM) 1443.4).

2. Take (harm) of eggs, chick, or adults by predation.

The Corps' modification of the historical hydrograph reduces the number of scouring events that would limit vegetation encroachment on sandbars and beaches used for nesting by piping plovers. This expansion of vegetation on existing sandbars and decreased frequency of new sandbar formation may increase the frequency of nest predation, predation of adults on and away from nests, as well as predation of chicks. In the 2003 Amendment of the BiOp, nest predation is used as a surrogate for the take by predation of eggs, chicks and adults that is attributable to the Corps' operations. The USFWS noted that 4.0% of monitored nests were lost to predation from 1993-2003; therefore, incidental take by predation should not exceed 4.0% of all nests in the action area, +/- 10%, expressed as a 10-year running total. The 10% variance results in a limit of 3.6% to 4.4%.

In 2015, 38 of the 944 piping plover nests were lost to predation, or 4.0%. The 10-year running average (2006-2015) was 5.0% (298/5917), which is above the upper limit of the 3.6%-4.4% tolerance set forth in the 2003 Amendment of the BiOp. As described previously, the change in the 2013 monitoring protocol resulted in no productivity monitoring on Lake Sakakawea or Lake Oahe in 2013, and thus the number of 2013 monitored nests does not include observations from these waterbodies. Therefore, the 2006-2015 running average reported here under-represents the total number of nests. For reference, in 2015, nests from Lake Sakakawea and Lake Oahe accounted for 38% of all monitored piping plover nests.

3. Take (harm) of eggs, chicks, or adults by human disturbance.
A portion of the take caused by human disturbance is likely attributable to the general reduction in the number and size of open beach habitats on riverine reaches due to the Corps' management. This increases the likelihood that humans who are seeking such open areas for recreation will directly or indirectly kill piping plovers or increase the frequency of nest abandonment. In the 2003 Amendment of the BiOp, the USFWS noted that 1.5% of monitored nests on the riverine segments were lost to human disturbance from 1993-2003. Therefore, expected take could be quantified as 1.5%, +/- 10%, or 1.4% to 1.7% expressed as a 10-year running total.

In 2015, five piping plover nests were lost to human disturbance on the riverine segments. Two nests were destroyed by ATVs, despite the posting of human restriction signs on the shoreline. The public was suspected in the failure of two additional nests on the Ft. Randall segment; human tracks and refuse were all that remained. One nest was lost on the Ft. Randall segment when a researcher from Virginia Tech stepped on the nest. The 10-year running total (2006-2015) was estimated at 0.7% (19 nests lost to human disturbance/2842 nests), which is below the 1.4%-1.7% tolerance set forth in the BiOp.

4. Take (harm) of chicks as a result of insufficient forage in river reaches affected by hypolimnetic releases.
Hypolimnetic hydropower releases at Fort Peck, Garrison and Fort Randall Dams result in cold water temperatures below the mainstem dams. The colder releases may negatively impact production at all trophic levels and thereby take piping plover chicks through insufficient forage. In the 2003 Amendment of the BiOp, the USFWS quantified piping plover take from hypolimnetic releases in the form of fledge ratios for these three segments with a 10% variance, as observed from 1993-2003.

The 1993-2003 fledge ratios for the river segments are:

1. below Fort Peck Dam was 1.33 +/- 10% (1.20-1.46),
2. below Garrison Dam it was 1.18 +/- 10% (1.06-1.30), and
3. below Fort Randall Dam it was 0.92 +/- 10% (0.83-1.01).

For the **Fort Peck river segment**, productivity monitoring was not conducted in 2015 as per a letter received by the Corps from USFWS in 2012. Therefore this metric could not be calculated.

For the **Garrison river segment**, the 2015 fledge ratio is calculated from the number of adults and fledglings observed on the river segment below Garrison Dam. The 2015 fledge ratio was 1.26, above the fledge ratio threshold set in the 2003 Amendment of the BiOp.

For the **Fort Randall river segment**, the 2015 fledge ratio is calculated from the number of adults and fledglings observed from the river segment below Fort Randall Dam. The 2015 fledge ratio was 2.34, above the fledge ratio threshold set in the 2003 amended BiOp.

5. Take (harm) of eggs in nests assigned fates of destroyed-unknown, nest abandonment, sandbar erosion, and unknown fates.
Some nests are likely destroyed as a direct or indirect result of the Corps' operations. These include nests fated as destroyed-unknown, abandoned, destroyed by sandbar erosion, and undetermined. All of these types of take reduce fledge ratios; however, there is no reasonable way to accurately determine what portion of destroyed nests are attributable to the Corps' operations. In the 2003 Amendment of the BiOp, the USFWS quantified take for nests assigned fates of destroyed – no evidence, nest abandonment, sandbar erosion, and undetermined as being within 10% of the 1993-2003 observed fledge ratio of 1.36, expressed as a 10-year running total, or within 1.22-1.47.

The 10-year running fledge ratio for 2006-2015 was estimated at 1.05 (5,121 fledglings/(9,770 adults/2)), which is below the 10% variance set by the USFWS (Figure 7). Many factors contribute to the low fledge ratio, including low productivity in the years when habitat was limited (2005-2010) and very low productivity in 2011 during the flood event, as well as change in the 2013 monitoring protocol that resulted in no productivity monitoring on Lake Sakakawea or Lake Oahe. The 2013 fledge ratio was estimated from sub-sampling in the river segments only. However, these reservoirs typically contribute approximately 30 to 40% of the total population of breeding adult piping plovers and fledglings. Therefore, the 2006-2015 fledge ratio reported here represents a combination of data from observed productivity on all segments (2006-2012 & 2014-2015) and estimated productivity of the riverine segments only (2013).

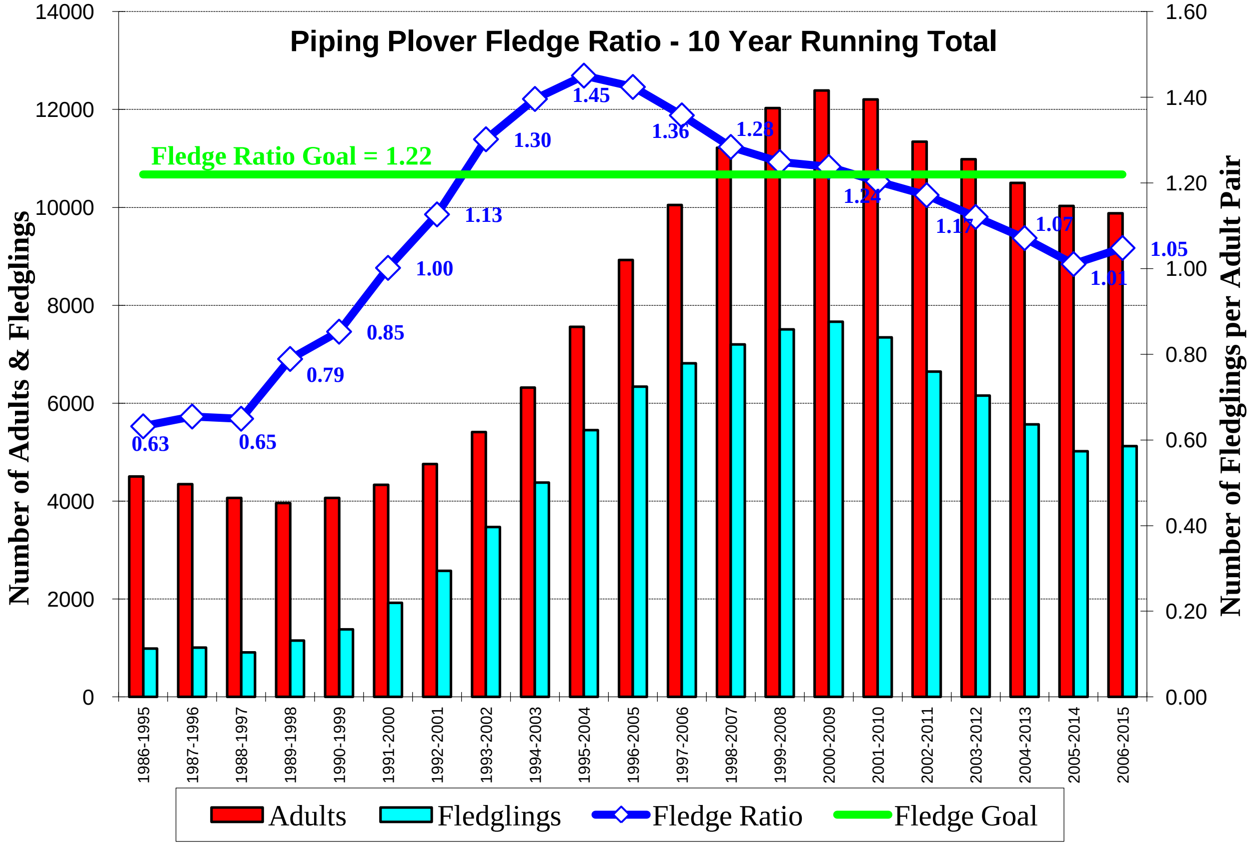

Figure 7. Piping plover fledge ratio (10-year running total)

6. Take (harm) of chicks as a result of insufficient forage on created habitats.

In the 2003 Amendment of the BiOp, the USFWS noted that piping plover chicks may starve on created habitats due to insufficient forage, and that chick starvation on created habitats could be expressed by the fledge ratios observed within those habitats. The threshold was set as the 1993-2003 fledge ratio (1.36) +/- 10%, or 1.22-1.47, based on a 10-year running total.

Habitat was created at 10 sites on the Gavins Point river segment between 2004 and 2009. In the Lewis and Clark Lake, a sandbar complex was completed in 2008 at river mile RM 826.5. A second constructed sandbar was started at RM 842.2 in 2011, but never finished. The high releases in 2011, which created considerable acreage of sandbars, eliminated all of the constructed sandbars below Gavins Point Dam and the site at RM 842.2, leaving the site at RM 826.5 on the Lewis and Clark Lake as the only constructed habitat. In 2015, there were six piping plover nests on the constructed complex at RM 826.5; two nests were successful with six chicks on site. One of the chicks was observed as fledged.

For 2006-2015, the fledge ratio for created habitat sites was 1.17 fledglings per adult pair (759 fledglings/(1,300 adults/2)), which is below the fledge ratio range of 1.22-1.47 set forth in the 2003 Amendment of the BiOp. The low fledge ratio is likely a reflection on the quality of the habitat and the number of birds nesting there rather than insufficient forage. The constructed complex at 826.5 has less than 47.3 acres of ESH, with the remaining 155 acres covered in vegetation.

IV.A.I.2.c. Summary of Monitoring Data

In 2015, monitoring crews followed the historic TPMP protocol (USACE, 2009), and surveyed all available habitat on the rivers and reservoirs for nests and chicks within a 7-day return interval.

Interior Least Terns

Nest Fates: TPMP crews observed 635 least tern nests on the monitored segments of the Missouri River in 2015. Of these nests, 386 were successful (at least one egg hatched from the nest), with an overall nest success of 73%. There were 104 nests with undetermined fate, meaning egg incubation at these nests was far enough along so that the eggs could have hatched between site visits. However, the crews did not find evidence of egg hatching or that the nests had been destroyed prior to the last nest visit (Table 5).

Table 5. Adult census and productivity monitoring of the interior population of least terns on the Missouri River, 2015

Segment	Adult Census	Nests	Broods	Undetermined Fate	Nests Hatched	% Nest Success (a)	Number of Eggs (b)	Number of Chicks	Chicks Fledged	Fledge Ratio (c)
Fort Peck Lake	0	0	0	0	0	0	0	0	0	0.00
Fort Peck River	12	0	0	0	0	0	0	0	0	0.00
Lake Sakakawea	18	34	0	7	11	41	79	25	8	0.89
Garrison River	157	92	14	21	52	73	232	133	83	1.06
Lake Oahe	93	85	6	19	23	35	206	62	23	0.49
Fort Randall River	155	101	4	15	70	81	250	175	126	1.63
Lewis and Clark Lake	164	121	5	18	74	72	293	192	120	1.46
Gavins Point River	318	202	6	24	156	88	520	396	232	1.46
Total	917	635	35	104	386	73	1580	983	592	1.31

(a) % Nest Success = ((NH/ (N-U))*100, where NH = nests hatched, N = number of nests, and U = undetermined fate.

(b) Includes eggs from the 35 broods

(c) Fledge Ratio = number of chicks fledged per pair of adult birds (adult census/2).

Piping Plovers

Nest fates – TPMP crews observed 944 piping plover nests on the monitored segments of the Missouri River in 2015. Of these nests, 535 were successful (at least one egg hatched from the nest), with an overall nest success of 62%. There were 87 nests with undetermined fate, meaning egg incubation at these nests was far enough along so that the eggs could have hatched between site visits. However, the crews did not find evidence of egg hatching or that the nests had been destroyed prior to the last nest visit (Table 6).

Table 6. Adult census and productivity monitoring of the piping plover on the Missouri River, 2015

Segment	Adult Census	Nests	Broods	Undetermined Fate	Nests Hatched	% Nest Success (a)	Number of Eggs (b)	Number of Chicks	Chicks Fledged	Fledge Ratio (c)
Fort Peck Lake	4	0	0	0	0	0	0	0	0	0.00
Fort Peck River	0	0	0	0	0	0	0	0	0	0.00
Lake Sakakawea	252	167	21	8	85	53	616	322	92	0.73
Garrison River	392	183	53	28	107	69	657	404	247	1.26
Lake Oahe	251	174	5	23	66	44	629	231	62	0.49
Fort Randall River	145	86	6	9	57	74	312	219	170	2.34
Lewis and Clark Lake	188	140	7	12	60	47	493	233	129	1.37
Gavins Point River	380	194	35	7	160	86	743	596	424	2.23
Total	1612	944	127	87	535	62	3450	2005	1124	1.40

(a) % Nest Success = ((NH/ (N-U))*100, where NH = nests hatched, N = number of nests, and U = undetermined fate.

(b) Includes eggs from the 127 broods

(c) Fledge Ratio = number of chicks fledged per pair of adult birds (adult census/2).

Adult and chick mortality - Survey crews were instructed to try to determine a cause of death for least tern and piping plover adults and chicks found dead on site. If a cause of death could not be determined and the specimen was fresh (little to no decomposition), the specimen was sent to the National Wildlife Health Center (NWHC) in Madison, Wisconsin for necropsy. In 2015, Corps survey crews found 41 least tern (LETE) and piping plover (PIPL) carcasses: 10 least tern adults and seven chicks, and eight piping plover adults, one fledgling and 15 chicks. Fourteen carcasses were sent to NWHC for necropsy to determine cause of death (Table 7). Twenty-seven birds were either too decayed to send in for necropsy, or cause of death was determined in the field. There were several significant rain and hail storms that moved through the area during breeding season. Many of the chicks found dead were newly hatched and likely died as a result of these weather events.

Gavins Point

- 1 least tern adult, 4 piping plover adults and 1 piping plover chick were killed by predators
- 3 least tern adults, 1 least tern chick and 3 piping plover chicks died from unknown causes

Lewis and Clark Lake

- 1 piping plover adult and 1 piping plover chick died of unknown causes

<u>Bismarck (river segment)</u>

- 2 least tern adults were killed by predators
- 2 piping plover chicks died of unknown causes
- 1 least tern chick was ran over by an ATV

<u>Lake Sakakawea</u>

- 1 piping plover adult and 1 piping plover chick were killed by predators
- 1 least tern chick, 1 piping plover chick and 1 piping plover fledgling died of unknown causes
- 2 piping plover chicks were killed by humans- both appeared to be stepped on

Table 7. Results from NWHC necropsy of piping plover and least tern carcasses, 2015

Segment	Species	Age	Cause of death determined by NWHC
Gavins Point	LETE	Chick	Undetermined; Botulism/hyperthermia/electrocution?
Gavins Point	PIPL	Adult	Trauma; suspect Predation
Gavins Point	LETE	Adult	Undetermined; Botulism/hyperthermia/electrocution?
Gavins Point	PIPL	Chick	Exposure with possible drowning
Gavins Point	LETE	Adult	West Nile Virus; Egg yolk peritonitis with E. coli
Gavins Point	LETE	Chick	Kidney Failure - renal & visceral gout
Gavins Point	LETE	Chick	Undetermined; Botulism/hyperthermia/electrocution?
Gavins Point	LETE	Adult	Undetermined
Bismarck	PIPL	Chick	Suspect drowning due to storm event
Bismarck	PIPL	Chick	Suspect drowning due to storm event
Bismarck	LETE	Chick	Emaciation and asphyxiation due to tracheal occlusion
Bismarck	PIPL	Adult	Unknown; unsuitable for necropsy
Lake Sakakawea	PIPL	Chick	Inconclusive- Botulism/hypothermia/electrocution
Lake Sakakawea	LETE	Adult	Starvation; malnutrition

Measures taken to reduce mortality: The Corps implements actions to reduce mortality for least terns and piping plovers, where appropriate. These include predator management and nest moving and chick relocation. There were no predator control efforts in 2015.

Due to the rising water levels on Lake Oahe and Lake Sakakawea in 2015, least tern and piping plover nest moving and placement of cages over piping plover nests were enacted as follows (Table 8 and Table 9):

Table 8 Piping Plover Nests Moved by Corps Survey Crews in 2015

	Piping Plover Nest Outcome			
Segment	**Failure**	**Successful**	**Undetermined**	**Grand Total**
Gavins Point		1		1
Lake Oahe -	9	6	4	19
Lake Sakakawea	9	8	1	18
Grand Total	**18**	**15**	**5**	**38**

- 38 piping plover nests were moved – one nest was moved on the Gavins Point segment, 19 nests were moved on Lake Oahe, and 18 nests were moved on Lake Sakakawea. These nests were all moved to higher ground or inland from an eroding bank.
- Fifteen of the moved nests were ultimately successful with chicks observed on site,

- Five nests were terminated as "undetermined" the week following the move because there was no evidence of either success or failure.
- 18 moved nests ultimately failed –
  - Four nests were abandoned by the adults after the nest move,
  - Twelve nests failed from flooding or wave action, due to higher than predicted water level increases or storm events,
  - Two nests were destroyed by a predator.

Table 9. Least Tern Nests Moved by Corps Survey Crews in 2015

	Least Tern Nest Outcome			
Segment	**Failure**	**Successful**	**Undetermined**	**Grand Total**
Lake Oahe-Mobridge			1	1
Lake Oahe-Pierre	1	1	2	4
Grand Total	**1**	**1**	**3**	**5**

- 5 least tern nests were moved on Lake Oahe – one nest was moved on the Mobridge segment and four nests were moved on the Pierre segment. These nests were all moved to higher ground as the reservoir level increased in late June/early July.
- One of the moved nests was terminated as successful, with chick droppings observed around the nest bowl.
- Three nests were fated as "undetermined" when crews returned the week following the move and observed no evidence of either success or failure.
- One of the moved nests was destroyed by a predator.

In 2015, 26 piping plover nests were caged.

- Nineteen of those nests were caged prior to a nest move. Caging nests prior to a nest move gives the adults time to habituate to the cage, which sometimes aids in their finding the nests after they have been moved to a new location.
- Six additional nests were caged prior to a nest move, and four of those nests successfully hatched before the nests could be moved. One nest failed when it washed out before it could be moved, and one nest failed because all eggs were missing from the nest before it could be moved. The eggs did not have adequate incubation time to hatch, and it was assumed that the nest failed.
- One additional nest was caged to protect it from human use at a recreation area on Lake Sakakawea, and it successfully hatched.

No least tern or piping plover nests were moved, caged, or raised on the Fort Randall or Garrison river segments.

Lake Sakakawea Chick Translocation: During the nesting season, Lake Sakakawea's rising water began to submerge existing islands, as well create and submerge islands formed by peninsulas that became cut off from the mainland. A multi-agency discussion about chick translocation was initiated by Corps personnel and included representatives from the USFWS and the USGS. In the end, it was decided that USGS personnel would move broods and adults from areas facing inundation as a result of the rising water. Representatives from the USFWS and Corps also participated in the chick translocation efforts. Corps and USGS personnel agreed to collaboratively monitor the status of relocated broods twice a week. Seven piping plover broods were moved from islands in danger of inundation to shoreline sites with higher elevation:

1. On June 20, 2015, one adult and one 6-10 day old plover chick were moved from their natal island at RM 1443.5 to a larger nearby island to prevent loss from the rising lake level. The pair were observed on two subsequent visits, and on July 6 the chickwas found dead due to predation, with identification confirmed by the bands placed on the chick by the USGS research team.

2. On June 20, 2015, one adult and four 6-10 day old plover chicks were moved from their natal island at RM 1443.5 to a larger nearby island. The adult and two chicks were observed by the Corps' TPMP crew on June 26, but not on later visits on June 30 or on July 6. The USGS crew observed chick 1 on June 22, chick 1 and 2 on June 25, and chick 1 and 4 on July 1. On July 8, only the adult was observed. By this time, the lake level was up into the shoreline vegetation, so it is possible that the chicks were not observed because they had moved into the vegetation or to another shoreline area. The chicks would have been approximately 25 days old on July 6, when 3 fledglings were observed at RM 1443.5, so it is possible that they fledged and left the area.
3. On June 20, 2015, one adult and two 6-10 day old plover chicks were moved from their natal island at RM 1443.7 to the mainland. The adult and chicks were observed by USGS on June 22, but were never observed by Corps personnel despite two subsequent searches. On July 11, the USGS crew observed the adult and two chicks of the appropriate age. The chicks would have been fledge-age around July 6.
4. On June 20, 2015, one adult and three 1-5-day old plover chicks were moved from their natal island at RM 1443.7 to the mainland. The adult and chicks were never observed by Corps or USGS personnel despite three subsequent searches. By the end of June, the lake level was up into the shoreline vegetation, so it is possible that the chicks were not observed because they had moved into the vegetation.
5. On June 20, 2015, two adults and two 11-15 day old plover chicks were moved from their natal island at RM 1443.8 to the mainland. One adult and two chicks were observed by USGS on June 22, and on June 23 all four birds were identified by the Corps. The last observation was on June 26, when one adult and one chick were re-sighted by the Corps. The chicks would have been approximately 24 days old on June 30, so it is possible that they fledged and left the area.
6. On June 22, 2015, two adults and one 6-10 day old plover chick were moved from their natal island at RM 1392.6 to a larger island nearby. The adults were re-sighted by USGS on June 23, but the chick was never re-sighted by USGS or Corps personnel despite two subsequent searches. By the end of June, the lake level was up into the shoreline vegetation, so it is possible that the chick was not observed because it had moved into the vegetation.
7. On June 23, 2015, two adult piping plovers and one 16-day old chick were moved from an island at RM 1450.3 to the mainland. The adults and chick were re-sighted by USGS on June 29 and July 6. The chick was last observed, as a fledgling, on July 16.

Lake Oahe Chick Translocation: During the nesting season, rising water began to submerge Demry Island, on which a piping plover nest had successfully hatched with one chick observed. As described above, a multi-agency discussion about chick translocation was initiated by Corps personnel and included representatives from the USFWS and USGS. In the end, it was decided that USGS personnel would move broods and adults from areas facing inundation as a result of the rising water.

1. One piping plover chick and one adult were moved from Demry Island to the Kenel Flats shoreline area on Lake Oahe on June 24, 2015. Although piping plover chicks were observed in the Kenel Flats area, it is unknown whether or not the Demry Island chick was one of those observed because the bands were not observed and not reported. Two near-fledglings (21+ days old) were observed at Kenel Flats on July 1, 2015 and one piping plover fledgling was observed on July 9, 2015.

Water Management Coordination - Representatives of the Corps' Missouri River Basin Water Management Division, Threatened & Endangered Species Section and the USFWS held weekly conference calls from May 13 through August 26, 2015, to discuss water releases from the Missouri River dams and their effects on piping plovers and least terns. Topics discussed included water release schedules from the dams, reservoir elevations, navigation targets in the navigation channel, nest locations and status, and chick fledging schedules.

Summer rains across the northern portion of the Missouri Basin resulted in high run-off in the Oahe reach that was 302% of normal in May. In June, run-off in the Garrison reach was 129% of normal and in the Oahe reach, 252% of normal. The precipitation pattern continued into July, resulting in run-off in the Oahe reach that was 218% of normal, and in August, 353% of normal. As a result, Lake Sakakawea and Lake Oahe reservoir elevations came up quickly during the breeding season and were slow to drop. Between May 1 and July 23, 2015, Lake Oahe elevation came up 6.59 feet, peaking at 1613.52 msl, and Lake Sakakawea elevation increased 6.77 feet, peaking on July 28 at 1845.24 msl. As a result, nesting habitat on the reservoirs became very limited in 2015, and the rising water levels flooded 96 piping plover and 19 least tern nests on the reservoirs over the breeding season. There was considerable discussion as to whether anything could have been done to prevent flooding of nests on the reservoirs. For example, many nests on Lake Sakakawea and Lake Oahe were moved to higher ground, but eventually high ground became limited. Reduction of incidental take was challenged by high runoff during nesting season and high abundance of birds on reservoir and riverine reaches.

Human Restriction Measures - To deter human disturbance and increase awareness of T&E species, restriction signs were placed around interior least tern and piping plover nesting sites. Listed below are the sites where restrictions were posted. The Fort Randall river segment suffered the most human disturbance as well as the Lewis and Clark lake segment. Both segments had human traffic, evidence of ATV activity, as well as restriction sign removal and harassment of listed species.

<u>Riverdale Segment:</u> More than 70 restriction signs were placed around recreation area parking lots and shoreline areas that had nesting piping plovers. These included: Sportsman's Centennial (RM 1392.8), Steinke Bay (RM 1393.4), four islands at RM 1392.7 and 1392.6, RM 1415.4, and the following river miles in the Deepwater area: 1443.8, 1443.7, 1443.5, 1443.4, and Party Point (1448.1), Douglas Bay (1397.1), Parshall Bay (RM 1448.1), Rock Island (RM 1391.5), the area north of Blueridge (RM 1415.6-1415.8), South Pouch Point (RM 1451.8 and 1451.9), Parshall Bay (RM 1448.1), Thunder Island (RM 1449.5), Rodeo Island (RM 1449.3 & 1449.4).

<u>Garrison River Segment:</u> More than 100 Restriction signs were placed on sandbars at RMs 1380, 1374 – 1373, 1357.6, 1348.2, 1340, 1338, 1328, 1326.7, 1321, 1319, 1308.4.

<u>Lake Oahe Segment</u>: Human restriction signs were placed at RM 1303.8 and 1294.4.

<u>Fort Randall River Segment</u>: Restriction signs were placed on RM 870.1, RM 870, RM 869.1, RM 866.3, RM 864.8, RM 863.3, RM 855, RM 853.8, RM 853.4, RM 853, RM 851.6, RM 848.2, and RM 846.2. Human disturbance seemed elevated this season compared to last. Human activity was seen on RMs 870, 869.1, 868.4, 855, and 853.8, and 853. RM 861.9 had disturbance for the first time in years this season, and TPMP crews observed beer cans, bug spray bottles, and footprints that stretched over the entire sandbar. RM 868.4 was the most disturbed sandbar on the river this summer, with ATV traffic from late May through July. A few tracks came close to nests and some terminated nests were caused by human actions. The state game wardens were contacted, who then followed up on the issue. RM 855 is a popular beach location for local residents and the crew observed several footprints, beer cans, and sand castles along the shoreline. At RM 853.8, one of the most productive bars in this segment, the crew observed fireworks, beer cans, dog tracks, and other human disturbances. On RM 853 heavy ATV tracks were observed, but stopped after being signed. On RM 853.4, the crew witnessed a person walk remove a restriction sign and laid it on the ground. That bar was then signed heavily, and there were no further problems.

<u>Lewis and Clark Lake Segment</u>: Restriction signs were placed on all sandbars where least tern or piping plover were present. This included RMs 843.5, 842.5, 841.6, 841.5, 840.5, 840.4, 840.3 839.6, 839, 838.4, 837.7, 837.6, 837.5, 837.4, 837.3, 836.8, 835.1, 834.5, 826. There was little issue with disturbance on any of these sandbars and the use of restriction signs appeared to work well. The sandbar at RM 840.4 is a difficult spot to access by boat due to shallow water, and one sign was placed on the sandbar. One day the TPMP crew observed two older gentlemen and a grandchild on the sandbar. The grandchild was chasing the piping plover chicks around the sandbar when the crew arrived. They politely left the sandbar after the crew explained why the sandbar was signed.

<u>Gavins Point River Segment</u>: Restriction signs were placed on 38 sandbar complexes at RM 807.1, 804.1, 802.2, 800.8, 798.8, 798.6, 797.2, 795.7, 795.4, 793.5, 791.3, 790.1, 789.7, 788.0, 784.5, 783.1, 782.5, 782.2, 782.0, 781.5, 780.5, 779.3, 778.6, 777.5, 776.0, 774.0, 772.0, 770.7, 769.5, 766.5, 766.3, 761.8, 759.4, 759.0, 756.5, 755.8, and 754.0, and 753.5. Human disturbance was prevalent all along this segment during the 2015 season, but seemed somewhat less than the 2014 season. In several areas, vandals were passing right by the restriction signs. In some cases, the signs themselves were vandalized or destroyed. Contact was made with several landowners concerning human disturbance on sandbars adjacent to their property. Although these landowners were not happy that the sandbars were closed to the public, they understood the situation. In some cases, human disturbance continued on the sandbars – further contact with the landowners resulted in them indicating that people were trespassing on the sandbars through their neighboring property and that they couldn't keep them out of the areas. ATV tracks were found on several sandbars throughout the segment and throughout the season. Several contacts were made with law

enforcement on specific sandbars, and those sandbars subsequently ceased having human disturbance issues. Additionally, recreational boat traffic has increased substantially compared to previous years.

IV.A.I.2.d. Emergent Sandbar Habitat Acreage

The Corps estimates annual quantities of ESH using remote sensing classifications derived from satellite imagery. Annual estimates of ESH area have been produced utilizing a consistent methodology beginning in 2006. The Corps attempts to capture satellite imagery between May and August of each nesting season. Since 2012, imagery has been captured during a two-week time frame beginning July 15. Sandbar and landcover datasets were prepared by the Northern Prairie Wildlife Research Center (NPWRC) using an object-based classification system. Estimates of ESH acreage were summed for all features that fell into eight landcover classes and which occurred on six sandbar classes that qualify as ESH. These landcover and sandbar classes have characteristics of tern and plover habitat which may provide suitable habitat for the birds. Sandbar classes that qualify as suitable habitat include both terrestrial and interchannel dry sandbars, wet sandbars, and wet sand dominated sandbars. Landcover classes counted include dry sand, wet sand and sparse vegetation classes. This method provides a raw estimate of ESH available on the river annually. Raw estimates of available habitat are presented below in (Table 10). These estimates are derived from imagery that was collected at different times within the nesting season as well as different flows among years. It should be noted, data are not completely comparable from one year to the next.

Table 10. Raw ESH estimates (acres) for 2006-2015. Bold numbers indicated years where ESH area was above targets.

	Gavins Point	Lewis and Clark Lake	Ft. Randall	Garrison	Ft. Peck	**Total**
Target (Alt 3.5)	**1912**	**354**	**212**	**1327**	**565**	**4370**
2006	657	18	502	474	237	1,888
2007	514	505	1,679	1,037	758	4,494
2008	1,427	123	1961	903	853[(a)]	4,415
2009	273	233	27[(a)]	737	291[(a)]	1,243
2010	187	249	19	545	NA	999
2011	0	117	0	0	NA	117
2012	**4,743**	**2,768**	**1,250**	**4,270**	NA	**13,031**
2013	**3,748**	**1,694**	**1,389**	**3,903**	NA	**10,734**
2014	**3,022**	**1,048**	**808**	**2,914**	NA	**7,792**
2015	**2,839**	**633[(b)]**	**953**	**2,900**	NA	**7,325**
Deviation from Target	**927**	**279**	**741**	**1,573**	**NA**	**2,955**

(a) Imagery was incomplete for this reach and year; thus, reported acreages are likely underestimates of actual acreage.

(b) Imagery for this reach and year had high cloud cover; thus, reported acreages are likely underestimates of actual acreage.

While raw estimates provide the acres present during the time of imagery capture and represent the amount of habitat during the actual nesting season, flow correction is needed to compare estimates across years. A max July-flow correction is applied to compare the change in ESH structure over time and examine the role of river stage during the nesting season. Max July-flows and max July-ESH acres estimates are available in Table 11 and Table 12 below. The data are also flow-corrected to a baseline flow to compare the ESH estimates across years available in Table 13.

Table 11. July maximum outflows/reservoir elevation from upstream reservoir for 2006-2015

Year	Gavins Point	Lewis and Clark Lake*	Ft. Randall	Garrison	Ft. Peck
2006	31,300	1,206.6	32,700	21,200	8,800
2007	24,500	1,207.1	23,100	16,500	7,500
2008	19,000	1,206.8	18,800	14,500	7,500
2009	27,500	1,207.7	26,100	16,300	6,900
2010	38,000	1,208.6	36,400	16,300	NA
2011	160,300	1,206.8	160,000	141,700	NA
2012	35,500	1,206.5	34,500	24,600	NA
2013	27,500	1,206.5	26,600	20,300	NA
2014	28,100	1,206.6	28,100	30,100	NA
2015	27,100	1,206.6	26,200	21,000	NA

Table 12. Available ESH estimates (acres) for 2006-2015, corrected to July-maximum outflows to compensate for differences in flows at time of imagery collection. Bold numbers indicate years where ESH area was above target.

	Gavins Point	Lewis and Clark Lake	Ft. Randall	Garrison	Ft. Peck	**Total**
Target (Alt 3.5)	**1912**	**354**	**212**	**1327**	**565**	**4370**
2006	464	17	137	409	184	1211
2007	696	**487**	**444**	724	522	2,874
2008	1,627	125	**355**	763	346[(a)]	3,072
2009	311	220	23[(a)]	707	206[(a)]	1,602
2010	166	226	6	502	282	1,182
2011	0.7	117	0	0	0	117
2012	**4,528**	**2,748**	**789**	**4,042**	0	**12,001**
2013	**2,236**	**1,673**	**973**	**3,056**	0	**9,244**
2014	**2,923**	**1,035**	**737**	**1,918**	0	**6,613**
2015	**2,868**	**623[(b)]**	**889**	**2,900**	NA	**7,280**
Deviation from Target	**956**	**269**	**677**	**1,573**	NA	**3,475**

(a) Imagery was incomplete for this reach and year; thus, reported acreages are likely underestimates of actual acreage.

(b) Imagery had high amounts of cloud cover for this reach and year likely resulting in low acreage estimates.

Table 13. ESH baseline area estimates for 2006−2015. Baseline flows are 9.9 kcfs for Ft. Peck, 23.9 kcfs for Garrison, 30.5 kcfs for Ft. Randall, and 31.6 kcfs for Gavins Point reaches. They are provided as a method of comparing trends in ESH absent of flow effects. The baseline elevation for Lewis and Clark Lake is 1,206 ft MSL. (These numbers do not represent nesting habitat availability in the MRMS in the denoted years. Bold numbers indicate years where ESH area was above targets.)

	Gavins Point (31.6 kcfs)	Lewis and Clark Lake	Ft. Randall (30.5 kcfs)	Garrison (23.9 kcfs)	Ft. Peck (9.9 kcfs)	**Total**
Target (Alt 3.5)	**1,912**	**354**	**212**	**1327**	**565**	**4,370**
2006	458	18	176	239	116	1,108
2007	522	**510**	190	166	192	1,579
2008	944	129	90	117	127[b]	1,334
2009	315	236	14[b]	156	59[b]	853
2010	408	252	12	110	37[a]	818
2011	367.2[a]	126[a]	11[a]	99[a]	31[a]	634
2012	**5,261**	**2,806**	**1,250**	**4,647**	NA	**14,000**
2013	**3,145**	**1,709**	**621**	**1,492**	NA	**6,967**
2014	**2,658**	**1,061**	**559**	**6,596**	NA	**10,874**
2015	**2,458**	**638[c]**	**543**	**1,628**	NA	**5,267**
Deviation from Target	**546**	**284**	**331**	**301**	NA	**1,462**

(a) Acreage measurements for this reach and this year were not available; this number represents a projection of acreage available due to measured flows and assumed loss rates.

(b) Imagery was incomplete for this reach and year; thus, reported acreages are likely underestimates of actual acreage.

(c) Imagery for this reach and year had high cloud cover; thus, reported acreages are likely underestimates of actual acreage.

ESH acreage available for nesting declined from 2008 to 2010 (Figure 8), due in part to losses from erosion and vegetation growth, as well as increased releases from Gavins Point and Fort Randall reservoirs during 2009 and 2010. Nesting habitat was essentially absent in 2011 due to extremely high flows. Those flows created the large amount of new habitat seen in 2012. In 2015, the total ESH acreage available declined from 2012, but still exceeds the target value.

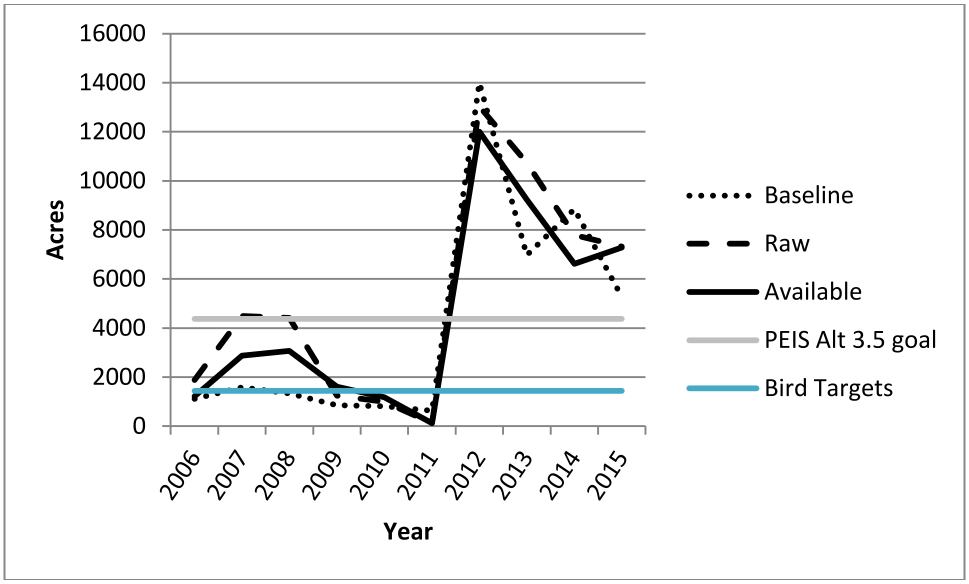

Figure 8. Raw, baseline and available acreage for 2006-2014. Available acreage is adjusted to July-maximum flows for each year. Baseline flows are given in Table 13. Fort Peck is not included after 2010.

IV.A.I.2.e. Interior Least Tern and Piping Plover Listing Status

Interior least tern listing status under the ESA

In October of 2013, the USFWS completed a 5-year review of the interior least tern's listing status (currently listed as endangered) in accordance with requirements of the ESA. The 5-year review evaluated a wide range of scientific information and data, which allowed the USFWS to conclude that the least tern is biologically recovered, and it was recommended for removal from the threatened and endangered species list (delisting). However, the USFWS will not initiate a formal delisting proposal until the following three conditions are met:

1. The USFWS will complete and review a range-wide population model to determine if it confirms the USFWS' assessment of tern population status and trends. This meta-population model is on track for completion in late 2015.
2. The USFWS intends to seek and obtain conservation agreements that will insure continued management actions are undertaken to benefit terns. This conservation agreement/management plan is being incorporated into the MP/EIS, which will be completed in 2016.
3. Finally, federal agencies, in cooperation with the states are required to monitor a species delisted due to recovery for a minimum of five years following its removal from the protections of the ESA. A cost-effective, statistically rigorous range-wide survey design to monitor long term least tern trends is in development through a multi-Landscape Conservation Cooperative project funded by the USFWS. A final draft of the sampling design was released in November 2014, and the Corps participated in a field trial of the sampling protocol in 2014 and 2015. Fifteen sandbars having 10 or more least terns were included in the field trial in 2015.

Once these three actions have been completed, a rule to delist the species will be formalized, according to a timeline established by the Service. The Corps is obligated to continue to execute all of its current programs conducted on behalf of least terns in accordance with the 2003 BiOp until a formal delisting rule is in place.

Table 14 shows the Missouri River population goals for delisting the interior population of the least tern, the 2015 numbers, and the difference between the two numbers (Recovery Plan for the Interior Population of the Least Tern, September 1990). The least tern adult numbers were taken from an analysis of the 2015 minimum breeding population (MinBPop). The MinBPop is calculated for the date with the highest number of active nests and broods by multiplying the total number of active nests plus broods times two to represent two adults providing parental care for each nest and brood.

The Missouri River goal of 900 adults was met in 2015, and segments meeting the adult goals were in South Dakota – Nebraska with a minimum breeding population of 356 adults; South Dakota- Ft. Randall (188 adults), South Dakota – Other (212 adults), and South Dakota- Oahe (124 adults). South Dakota – Other refers to Lake Sharpe, Lake Francis Case and Lewis & Clark Lake.

Table 14. Least tern Missouri River recovery plan goal

State	Goal (Adults)	2015 (Adults)	Difference
Montana	50	12	-38
North Dakota	250	234	-16
South Dakota – Oahe	100	124	+24
South Dakota – Ft. Randall	80	188	+108
South Dakota – Other	20	212	+192
South Dakota – Nebraska (Gavins Point)	400	356	-44
Total	900	1126	+226

Piping plover listing status under the ESA

In September of 2009, the Service completed a 5-year review of the piping plover's listing status in accordance with requirements of the ESA. The 5-year review process evaluated a wide range of scientific information and data, which allowed the USFWS to recommend maintaining the piping plover's current listing status as a threatened species. There is currently an internal draft of a revised recovery plan for the piping plover in review by the USFWS. Completion of the revised final plan is anticipated in late 2015. Until there is a change in the piping plover's listing status, the Corps is obligated to continue to execute all of its current programs conducted on behalf of piping plovers in accordance with the 2003 BiOp.

Table 15. Piping plover Missouri River recovery goal

State	Goal (Pairs)	2015 (Pairs)	Difference (Pairs)
Montana	0	2 (4 adults)	+ 2
North Dakota	100	413 (826 adults)	+313
South Dakota	75	236 (472 adults)	+161
South Dakota/Nebraska	250	207 (414 adults)	-43
Total	425 (850 adults)	858 (1,716 adults)	+433 (866 adults)

Table 15 shows that the MRRP overall goal for piping plover was met and exceeded by 431 pairs (USFWS, 1988). Piping plover adult numbers were taken from an analysis of the 2015 MinBPop. The MinBPop is calculated for the date with the highest number of active nests and broods by multiplying the total number of active nests plus broods times two to represent two adults providing parental care for each nest and brood. For failed and undetermined fate nests, a nest was counted as active from the date of nest initiation to the last survey date where the nest had not been terminated. For successful and probable successful nests, a nest was considered active from the date of nest initiation to the calculated hatch date. Broods were associated with successful and probable successful nests and were tracked until they were not seen during a survey or were observed in the age group prior to fledging (16-20 days for least tern chicks and 21-24 days for piping plover chicks). The dates for maximum number of active nests by location are listed below.

Montana (Fort Peck Lake) – no nests tracked; number of adults (4) is taken from the adult census, June 27- July 2
North Dakota (Lake Sakakawea, Garrison River, Lake Oahe North Dakota) – June 10, 17 & 19, 2015
South Dakota (Lake Oahe SD, Fort Randall River, Lewis & Clark Lake) - June 5, 17, & 20, 2015
South Dakota/Nebraska (Gavins Point River) – June 30, 2015

IV.A.I.2.f. Comparison of Estimated Population with Prior Years

Figure 9 shows the piping plover and interior least tern adult census results for the Missouri River from 1986 through 2015.

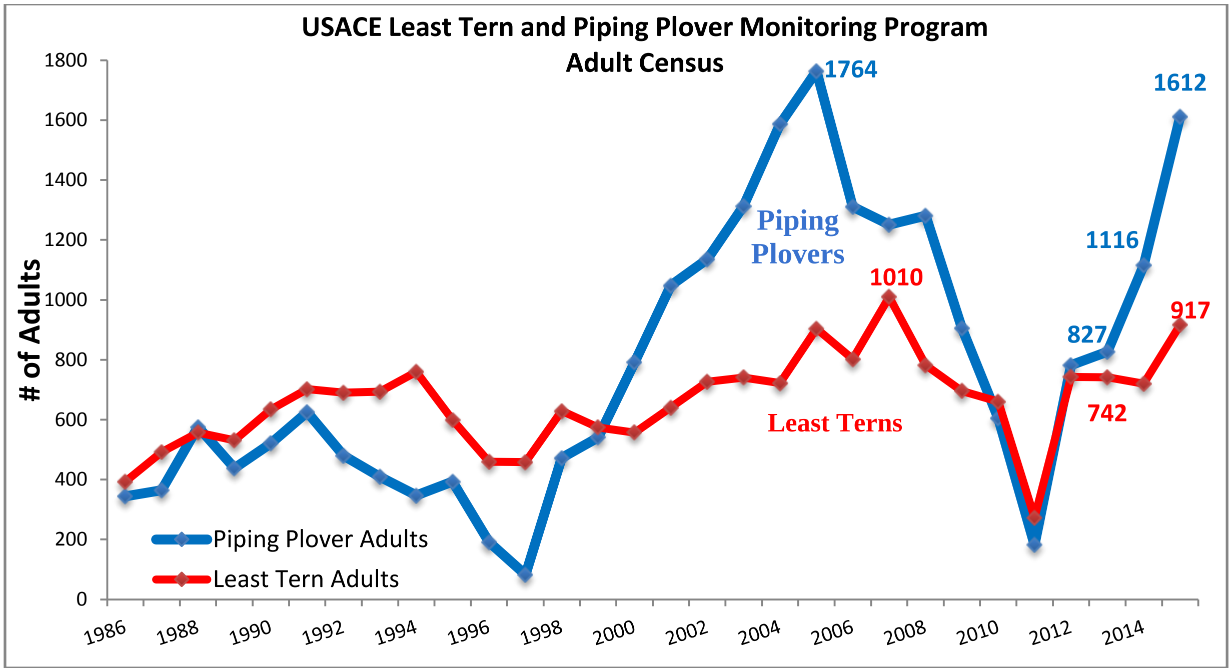

Figure 9. Interior least tern and piping plover adult census for the Missouri River from 1986 – 2015

Least tern adult numbers on the Missouri River have varied from a low of 273 in 2011 to a high of 1,010 in 2007. The 30 year average is 660 adults. Least tern adult numbers sharply increased to 743 in 2012 following record high runoff in 2011 that inundated reservoir shoreline and sandbars and created additional habitat on the Missouri River. Tern numbers remained high in 2013, dropped slightly in 2014 to 720 adults, and increased 27% in 2015 to 917 adults.

Piping plover adult numbers on the Missouri River have varied from a low of 82 in 1997 to a high of 1,764 in 2005. The 30 year average is 776 adults. As with the least tern, piping plover adult numbers continue to respond sharply upward following the record high runoff of 2011, with 827 adults in 2013, 1,116 adults in 2014, and 1612 adults in 2015 (Figure 9).

IV.A.I.2.g. Kansas River Surveys

Nesting conditions on the Kansas River were unsuitable during 2015. High river levels inundated the least tern and piping plover nesting habitat on the Kansas River for the majority of the nesting season.

IV.A.I.3. Science Integrated with Management Actions

IV.A.I.3.a. Predation Monitoring

See Section IV.A.I.2.c "Summary of Monitoring Data" for information on predation monitoring.

IV.A.I.3.b. ESH Biological Habitat Quality Monitoring

The habitat monitoring program has several purposes. The first purpose of habitat monitoring is to assess the efficacy of our vegetation control efforts for maintaining quality tern and plover nesting habitat. The second purpose is to examine the differences in sandbar habitat where nesting does and does not occur in order to better understand suitable habitat characteristics. Finally, these data are used for ground truthing the remote sensing habitat classifications. To meet all of the data needs for habitat monitoring we used a line intercept method to collect vegetation and substrate data in the field on representative sandbars within the Missouri River below Gavins Point Dam, Fort Randall Dam, and Garrison Dam during the 2012-2015 nesting seasons. Analysis of this data will begin this winter and results will be available by April 2016.

IV.A.I.3.c. Monitoring Program for Assessing Management Actions

See Section IV.A.I.2.c "Summary of Monitoring Data" for information on assessing management actions.

IV.A.I.3.d. North Dakota and South Dakota ESH Bank Erosion Study
A bank erosion study with the primary focus to identify bank erosion response to emergent sandbar habitat construction projects was previously identified with initial data collection and analysis efforts started in 2010. The study scope focused on examining reach erosion rates and the correlation between construction and non-construction zones by reviewing aerial photos, construction plans, and available river surveys. Due to the extreme 2011 flood event and major river changes, ESH construction activities have not been conducted in the last several years. Limited field data collection efforts were performed in 2015 at two sandbar sites in the Gavins to Ponca reach. Additional analysis is ongoing to assist with evaluating the interaction between sandbar features and bank erosion. This study is an ongoing effort with a flexible scope to meet ESH program needs and respond to issues raised by private landowners and other state and federal agencies.

IV.A.I.3.e. ESH Vegetation Modification Study
The goal of this study is to determine a method(s) to maintain suitable tern and plover nesting and brood rearing habitat through vegetation modification. This study is being conducted on the river below the Gavins Point Dam. A before/after control impact study design is being used to examine the influence of various treatments on vegetation. Plots were laid out on three sandbars and treated in the fall of 2013 and spring of 2014. Vegetation and substrate data were collected prior to and two years following treatment. Data collection was completed in August of 2015 and results will be available by April 2016.

IV.A.I.3.f. Gavins Point Geomorphic Change Analysis
The purpose of this study was to evaluate the physical data collected at the six ESH sites within the study reach and characterize the formation and degradation of the sandbar habitat. The scope and study objectives are summarized below.

The first phase of this study was completed in July of 2014. Data and conclusions provided substantial information including:

- Sandbar physical characteristics such as size and wetted perimeter
- Insight to the sandbar growth and decay process for a range of flows and conditions during the survey period between 2010 and 2013, including the high flows experienced in 2010 and 2011
- Thalweg depth and movement at each site
- Sandbar area projections at each site into the future using observed growth / decay rates
- Results from the study proved valuable for the Hydrogeomorphic Effects Analysis completed for the MP/EIS

The second phase has been initiated and is anticipated to be completed March of 2016. The second phase will further analyze volumetric changes in the reach and describe the evolution of bed material availability over the next 100 years. Detailed study objectives of the second phase are as follows:

1. Evaluate the volumetric change in the river channel due to redistribution of sediment.
    a. Was surface acreage increased significantly?
    b. How does channel change affect downstream load?
    c. Can the change in bed over time be correlated to cumulative mass as the nearest downstream gage?
    d. Can the sources of sediment other than the channel bed and banks be identified?

2. Develop a long-term sediment calibration of the existing HEC-RAS sediment model between Gavins Point Dam and Sioux City, Iowa.
    a. The model was developed for short-term flushing scenarios. Developing a long-term historical calibration from 1955-2011 will allow for projection of future channel change.
    b. Once calibrated the model will be run for 100 years into the future to project channel degradation and sediment loss in the system?
    c. The intent of the effort is to answer the question: When do we run out of sand for ESH habitat building?

IV.A.I.4. Interior Least Tern and Piping Plover Focused Research

Spatial variation in population dynamics of northern Great Plains Piping Plovers (metapopulation study). Field work on this project began in 2014 and is scheduled through 2017. The purpose of this study is to estimate the degree of connectivity for piping plovers recruiting among four breeding areas of the northern Missouri River system while exploring how fluctuating water levels drive this connectivity. This study is being conducted on Lake Oahe, Lake Sakakawea, the river below the Garrison Dam and on the Alkali Lakes in North Dakota.

IV.A.II. Pallid Sturgeon

IV.A.II.1. Summary of the Approach for Monitoring and Research

Pallid sturgeon science efforts require a comprehensive approach to provide information to decision-makers to better inform actions on the Missouri River. Many of these actions focus on providing increased understanding of key pallid sturgeon life history uncertainties. The 2015 pallid sturgeon science activities included:

1. Numerous comprehensive sturgeon research projects including:
    a. habitat dynamics for spawning, incubation, and hatch;
    b. verification of embryo hatch and dispersal from known spawning locations;
    c. factors determining egg deposition, adhesion, and hatch;
    d. effects of hydrology and hydraulics on transport, retention, and fate of larval drift, free-embryo to exogenously feeding larvae;
    e. hatch, dispersal and settling behavior of early life-stage pallid sturgeon from egg through first feeding; and
    f. assessment of factors influencing pallid sturgeon spawning in the Missouri River and tributaries.
2. Habitat Assessment and Monitoring – collection of *Scaphirhynchus* larvae drifting in the Missouri River and lipid content analysis of the larvae to determine food availability for young sturgeon;
3. Pallid sturgeon population level monitoring and survival assessment;
4. Hatchery propagation;
5. Pallid sturgeon broodstock collection;
6. Lake Sakakawea Headwaters Dissolved Oxygen study started (2-year study);
7. Initiated hatchery review of Neosho National Fish Hatchery and Blind Pony State Fish Hatchery due to disease and fish health issues;
8. Completion of Draft Effects Analyses Reports by the Effects Analysis Groups;
9. Completion of Draft AM Plan by the Effects Analyses and the AM Groups;
10. MRRIC and Independent Science Review of agency actions and science efforts;
11. Since 2011, 12 wild pallid sturgeon larvae have been collected in the Upper Missouri River (n=6) and below Gavins Point Dam (n=6) (note: this marks reproduction and not recruitment);
12. Continued efficiencies with the creation of new applications for field collection tools; and
13. Continuation of Environmental Life History/River of Origin study.

Corps management actions require riverine monitoring to determine the species response, or effectiveness of the action, and any unintended effects. These assessments are further developed through research activities to clarify critical uncertainties. Research activities are focused on factors limiting recruitment. These elements, in tandem with hatchery propagation, seek to identify and remove any bottlenecks or obstacles to pallid sturgeon recruitment.

IV.A.II.2. Downlisting and/or Delisting Requirements

The pallid sturgeon recovery plan outlines the criteria for reclassification of the pallid sturgeon from endangered to threatened and for complete delisting (USFWS, 2014). The following information is taken from the 2014 "U.S. Fish & Wildlife Service Revised Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*)".

IV.A.II.2.a. Criteria for Reclassification to Threatened Status

Pallid sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria are sufficiently addressed such that a self-sustaining genetically diverse population of 5,000 adult pallid sturgeon is realized and maintained within each management unit for 2 generations (20-30 years). In this context, a self-sustaining population is described as one that experiences spawning and recruitment of naturally-produced fish into the adult population at levels sufficient to maintain a genetically diverse minimum wild adult population (i.e., incremental relative stock density of stock-to-quality-sized naturally produced fish {[Shuman et al. 2006] being 50-85 naturally produced, wild, adult fish observed every 5-year sampling period, catch-per-unit-effort data indicative of a stable or increasing population, and survival rates of naturally produced sub-adult fish [age 2+] equal to or exceeding those of the adults; see Justification for Population Criteria below for details). Additionally, in this context a genetically diverse population is defined as one in which the effective population size (N_e) is sufficient to maintain adaptive genetic variability into the foreseeable future ($N_e \geq 500$) (USFWS, 2014).

IV.A.II.2.b. Criteria for Delisting Species

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

IV.A.II.3. Population Augmentation

IV.A.II.3.a. Broodstock Collection

The Pallid Sturgeon Propagation and Population Augmentation element (RPA IV) is a direct effort to supplement year class structure to the pallid sturgeon population due to the lack of spawning and/or recruitment in the Missouri River. It also ensures survival of the species, retention of the remaining population genetics and structure, provides adults to test management actions and recruitment hypotheses, and provides a reliable source of progeny for addressing uncertainty related to age-0 pallid sturgeon survival.

Wild pallid sturgeon are collected each spring and brought into hatcheries for spawning and the eventual stocking of their progeny. Pallid sturgeon broodstock collection activities in the Upper Missouri River basin (Upper Missouri and Lower Yellowstone Rivers) took place from April through May 2015. Eight adult pallid sturgeon were collected and three pallid sturgeon were sent to Garrison National Fish Hatchery in Riverdale, North Dakota for spawning.

Four natural resource agencies (Nebraska Game and Parks Commission (NGPC), Missouri Department of Conservation (MDC), USFWS-Columbia and South Dakota Game, Fish, and Parks (SDGFP)) conducted broodstock collection efforts in the lower Missouri River (Missouri River below Gavins Point Dam) in 2015. The largest broodstock collection effort was led by NGPC. One-hundred-seventy-five volunteers assisted NGPC crews during 12 days of broodstock collection. A total of 212 pallid sturgeon were captured during this effort with 43 transferred to hatcheries; four females and 18 males were subsequently determined to be in reproductive condition. The USFWS-Columbia crews spent 18-crew days targeting broodstock pallid sturgeon; four potential broodfish were sent to the hatchery during this effort but none were in reproductive condition. SDGFP conducted a mid-March broodstock collection and caught 12 pallid sturgeon; three were sent to the hatchery for evaluation, but none were used. MDC captured 91 pallid sturgeon from late March to early April; 16 were sent to Blind Pony State Fish Hatchery but only one male was used.

IV.A.II.3.b. Propagation and Stocking

The three federal hatcheries (Gavins Point National Fish Hatchery in Yankton, South Dakota; Garrison National Fish Hatchery in Riverdale, North Dakota; and Neosho National Fish Hatchery in Neosho, Missouri) and two state hatcheries (Blind Pony State Fish Hatchery in Sweet Springs, Missouri and Miles City State Fish Hatchery in Miles City, Montana) involved with propagation of Missouri River pallid sturgeon stocked a combined 13,166 fingerling and yearling-sized pallid sturgeon from the 2014 and 2015 year classes (all pallid sturgeon stocked in 2015 equate to 4,251 yearling equivalents; 1,272=2014 year class, 2,979=2015 year class) into RPMA's 1-4 during 2015 (Figure 10). Monitoring data collected through the Pallid Sturgeon Population Assessment Project (PSPAP) indicate that stocked pallid sturgeon are surviving (Figures 12 through 14), growing, and reaching a size and age that is capable of spawning. Recent survival estimates for hatchery fish stocked into the Missouri River show relatively high rates of survival (Hadley and Rotella 2009, Rotella 2012; Steffensen et al. 2015) that are similar to other sturgeon species (Irelands et al. 2002). Since 2001, over 290,000-yearling equivalent pallid sturgeon have been stocked into the Missouri River (Figure 10). Survival rates for hatchery pallid sturgeon stocked into the Missouri River (1994-2011 cohorts) are as follows: age-0 = 0.048; age-1 = 0.403 and; age-2> = 0.931 (Steffensen et al. 2015). Continued monitoring of the stocked population will determine how these fish contribute to the next generation of pallid sturgeon.

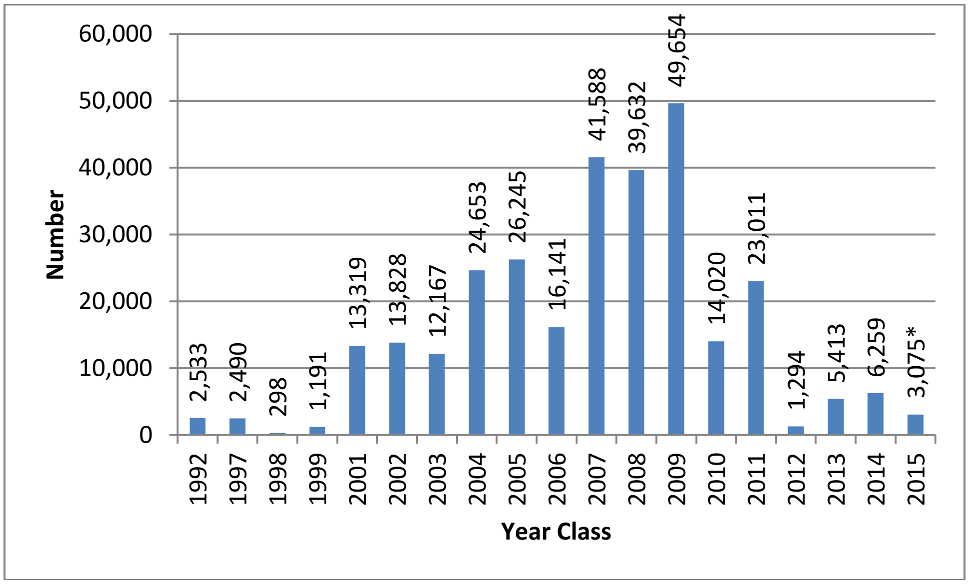

Figure 10. Number of pallid sturgeon stocked (as yearly equivalents) since 2001in the Missouri River within RPMAs 1-4**

* Note a portion of the 2015 Year Class is not represented here and will be stocked in 2016; year class indicates the year in which the pallid sturgeon were produced, not the year they were stocked.

** "Yearly equivalents" represents the number of pallid sturgeon adjusted according to age-related survival. In general, a pallid sturgeon stocked at 1 year of age (yearling) counts as 1 pallid sturgeon and those less than 1 year old (fingerling) equate to 0.25 pallid sturgeon; this approach provides a "common currency" for comparing stocking numbers between year classes

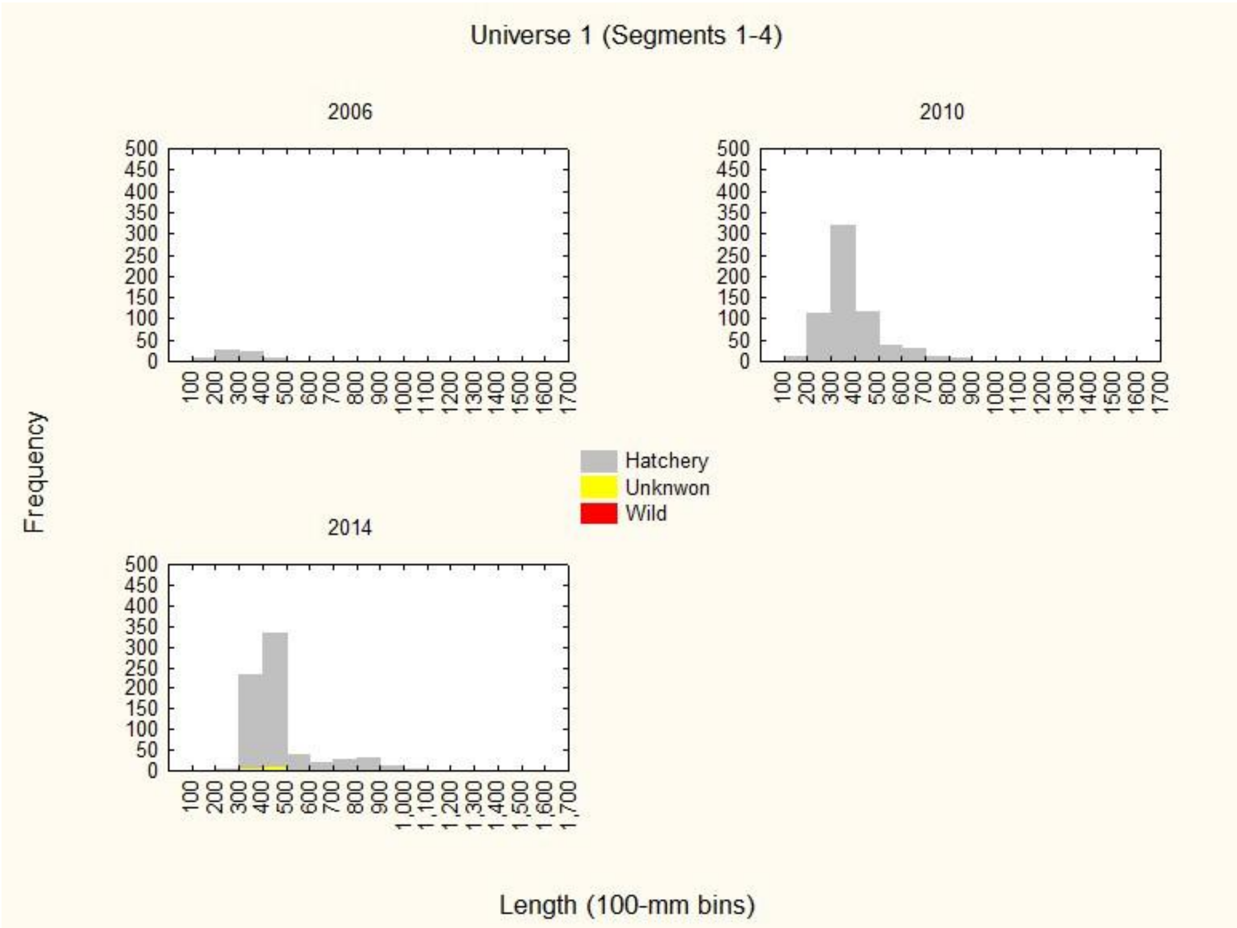

Figure 11. Length frequency of hatchery, wild, and unknown-origin (unknown origin = species identification could not be determined or genetic identification is pending) pallid sturgeon sampled in universe 1 (Fort Peck Dam to Lake Sakakawea; see Figure 14 for location) using standard gear types during the 2006, 2010, and 2014 sampling years. Parental genetics from known hatchery crosses are incomplete; therefore, 'wild' fish listed in the figures may not be wild.

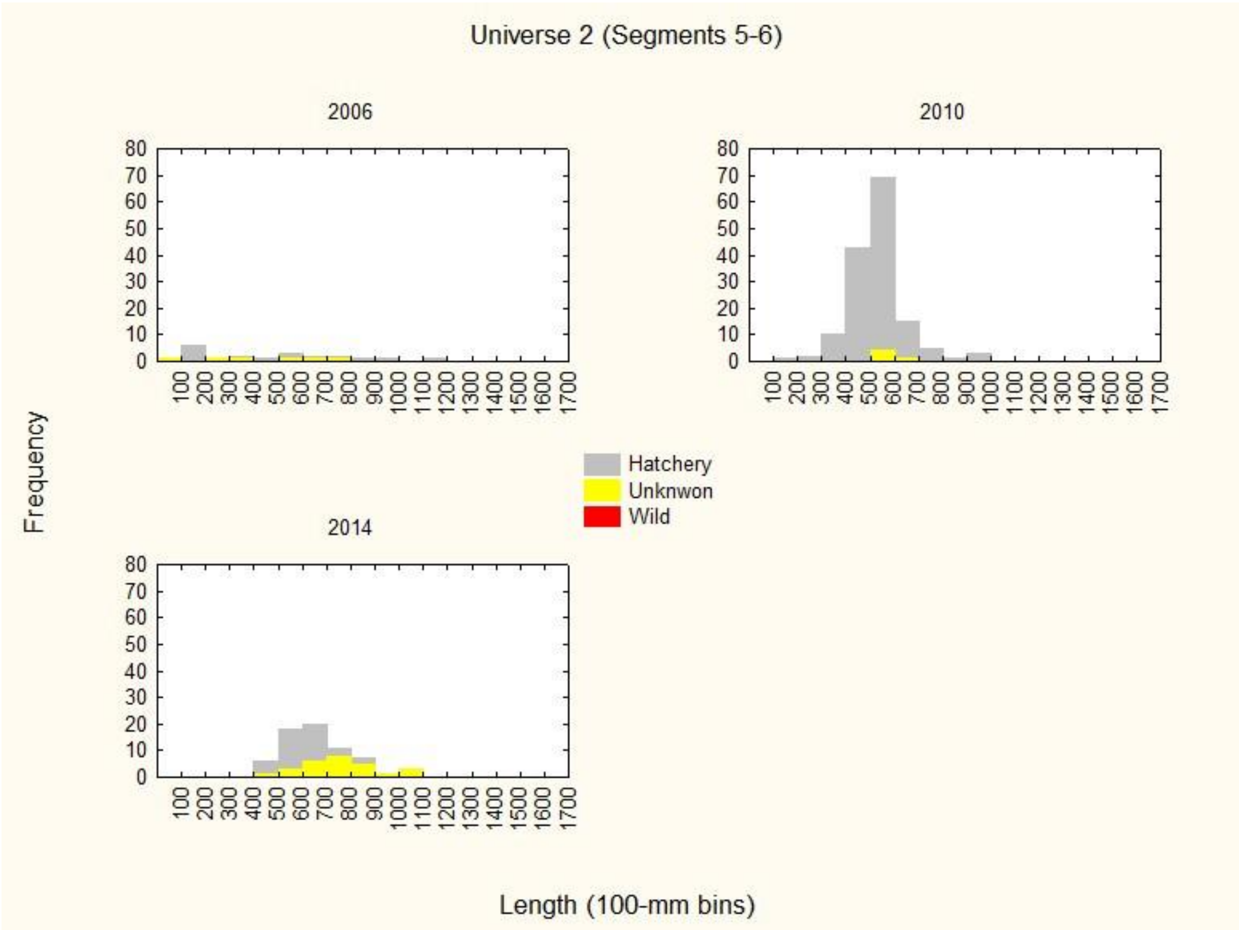

Figure 12. Length frequency of hatchery, wild, and unknown-origin (unknown origin = species identification could not be determined or genetic identification is pending) pallid sturgeon sampled in universe 2 (Fort Randall Dam to the headwaters of Lewis and Clark Lake; see Figure 14 for location) using standard gear types during the 2006, 2010, and 2014 sampling years. Parental genetics from known hatchery crosses are incomplete; therefore, 'wild' fish listed in the figures may not be wild.

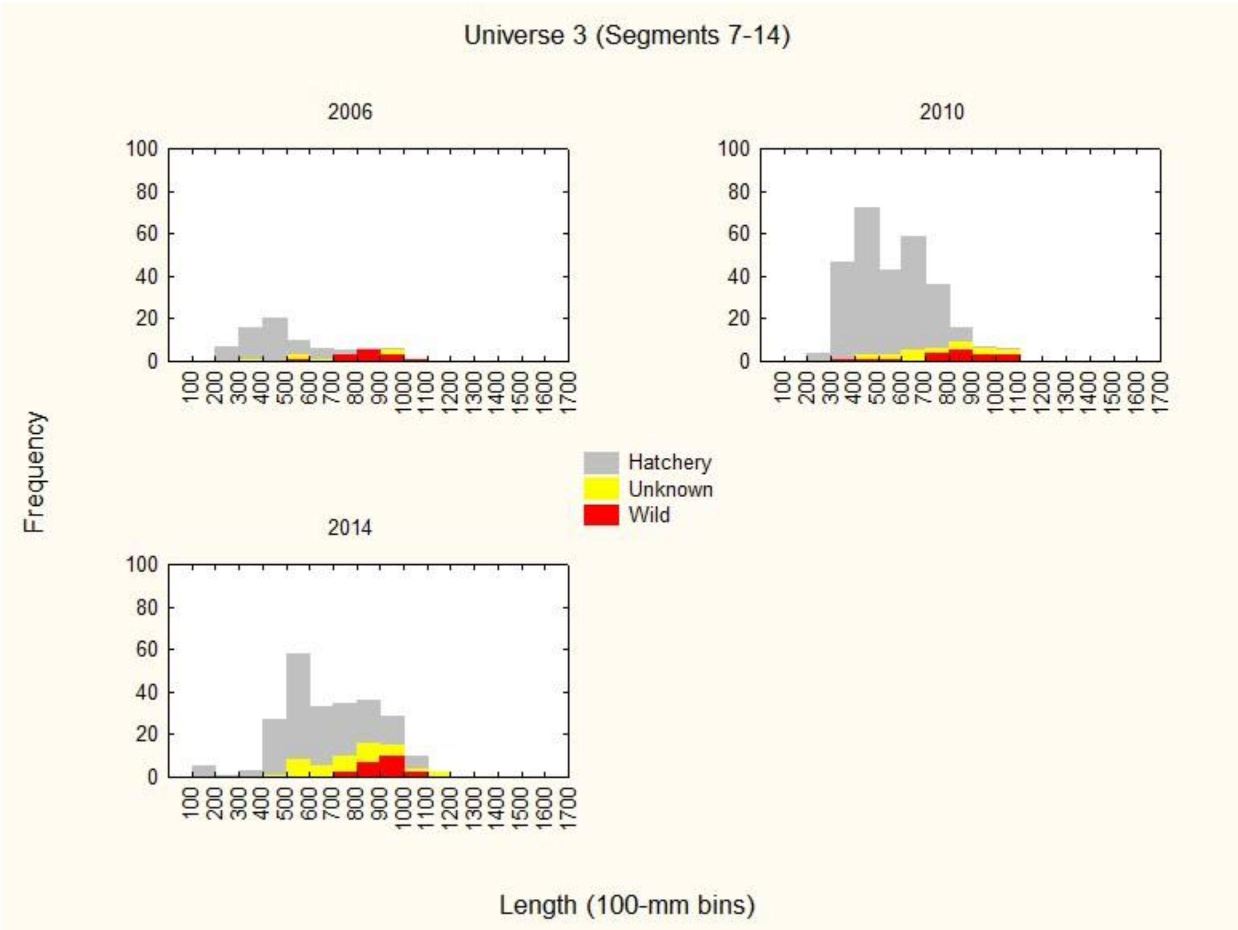

Figure 13. Length frequency of hatchery, wild, and unknown-origin (unknown origin = species identification could not be determined or genetic identification is pending) pallid sturgeon sampled in universe 3 (Gavins Point Dam to the Missouri River mouth; see Figure 14 for location) using standard gear types during the 2006, 2010, and 2014 sampling years. Parental genetics from known hatchery crosses are incomplete; therefore, 'wild' fish listed in the figures may not be wild.

In 2016, refined survival estimates will be available for the Upper (Fort Peck Dam to Lake Sakakawea and the Yellowstone River, RPMA 2; Fort Randall Dam to Lewis and Clark Lake, RPMA 3) and Lower (Gavins Point Dam to mouth of the Missouri River, RPMA 4) Missouri River. The data for these estimates come primarily from the PSPAP.

IV.A.II.3.c. 2015 Broodstock Collection and Augmentation Summary

The following list summarizes partnering agency efforts, the number of pallid sturgeon that were collected and receiving hatcheries during the 2015 broodstock collection effort. Females in reproductive condition and of appropriate genetics were spawned and the males were primarily used to harvest milt which was cryopreserved.

Nebraska, Game and Parks Commission:

- 18 reproductively-ready males and 4 reproductively-ready females were collected and shipped to Blind Pony State Fish Hatchery
- 43 total pallid sturgeon shipped to Blind Pony State Fish Hatchery for evaluation
- 212 pallid sturgeon captured during the 2015 broodstock collection
- 175 volunteers assisted Nebraska staff during broodstock collection (3,560 hours worked by NGPC staff and volunteers)

South Dakota Game, Fish & Parks:

- 12 pallid sturgeon captured during broodstock collection; 3 sent to Gavins Point National Fish Hatchery
- None of those sent to the hatchery were reproductively-ready
- South Dakota staff collected sturgeon for 7-days with 1 boat

Upper Basin (Montana Fish, Wildlife & Parks, USGS, and USFWS-Bismarck):

- 1 reproductively- ready male and 2 reproductively-ready females were sent to Garrison National Fish Hatchery
- 8 pallid sturgeon captured during broodstock collection; 3 sent to the hatchery
- Bismarck staff fished for 7-days in 2 boats

USFWS (Columbia):

- 28 pallid sturgeon captured during broodstock collection
- 4 sent to the hatchery but none were in reproductive condition
- 2 hybrids captured and removed
- 21 volunteers assisted Columbia staff (18 crew days) for 166 volunteer hours

Missouri Department of Conservation:

- 1 reproductively-ready male was used
- 16 total pallid sturgeon shipped to Blind Pony State Fish Hatchery for evaluation
- 91pallid sturgeon captured during 2015 broodstock collection
- 80 volunteers assisted MDC staff during broodstock collection

IV.A.II.3.d. Disease and Fish Health Affect Hatcheries Raising Pallid Sturgeon in the Lower Missouri River

Recently, disease and fish health issues were discovered in two pallid sturgeon hatcheries below Gavins Point Dam, Neosho National Fish Hatchery and Blind Pony State Fish Hatchery. In early 2015, the Corps learned that pallid sturgeon larvae from Blind Pony State Fish Hatchery were affected by a lethal outbreak of *rana*virus. *Rana*virus is a frog virus that leads to high mortality in pallid sturgeon (Chinchar and Waltzek 2014).

More recently, we learned that Neosho National Fish Hatchery has been stocking pallid sturgeon with fin curl and likely doing so for several years. Fin curl reduces sturgeon fin function which is critical for swimming performance and ability to hold station in the water column without the energetic costs associated with continuous swimming (Adams et al. 1999; Shuman et al 2011); it is expected that sturgeon exhibiting fin curl have lower survival and are not likely to recruit to the population (Oldenburg 2008, Hadley and Rotella 2009).

Approximately 80% of hatchery raised pallid sturgeon in the Missouri River below Gavins Point spent time in Blind Pony State Fish Hatchery and Neosho National Fish Hatchery, (Coral Huber and Tim Welker, pers. comm.). The apparent stocking of fin curl pallid sturgeon for multiple years will affect, at a minimum, previously reported estimate of population size, structure and survival in hatchery-released pallid sturgeon since stocking began in the 1990s.

IV.A.II.4. System Monitoring Requirements

IV.A.II.4.a. Pallid Sturgeon Population Assessment Project

The PSPAP is the primary fish monitoring element for the 2003 amended BiOp and the MRRP. Data collected through the PSPAP are used to evaluate the Pallid Sturgeon Propagation and Population Augmentation Management Action (RPA IV) and provide long-term assessment of fish metrics (RPA V; e.g., population trends, survival, movement, distribution, and habitat use by wild and stocked pallid sturgeon). The Implementation Strategy for the PSPAP is built on partnerships, common goals and objectives, and sound science. The Corps, as the Action Agency, is responsible for ensuring that these long-term assessment activities occur to meet BiOp required monitoring and evaluation. The Corps has developed partnerships with state and federal agencies already active on the Missouri and Kansas Rivers and has provided the funding, standardized protocols, and quality control oversight necessary to implement the monitoring strategy of the PSPAP. The PSAP and its partners also collect pallid sturgeon broodstock each spring for meeting BiOp stocking requirements (RPA IV) and the stocking levels identified for Recovery Priority Management Areas 1-4.

The Project Area for the PSPAP encompasses the Missouri River from Fort Peck Dam, Montana at RM 1771.5 downstream to the confluence of the Missouri and Mississippi Rivers near St. Louis, Missouri (RM 0) and the lower reach of the Kansas River. Thirteen priority river segments are sampled within the Project area (Figure 14). Within a segment, a minimum of 25.2% of all bends are sampled in a sample year. The number of bends required within each segment is outlined in Table 16. For the 2015 sample year, the required number of bends was sampled in each segment by the responsible agency partner. Reports that provide the 2015 fish monitoring results for each segment will be available in Spring 2016. Long-term trends are assessed through periodic synthesis analyses (Oldenburg et al. 2008; Oldenburg et al. 2010) that cover longer time periods (e.g., 2-4 years). The most recent synthesis of fish trends was completed in 2014 (see Wildhaber et al. 2014).

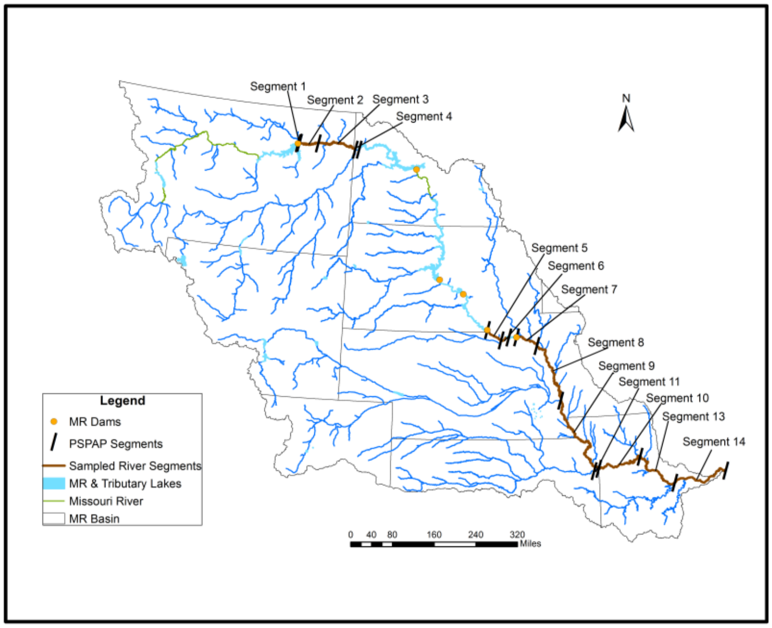

Figure 14. Study area for the PSPAP project

Table 16. Required sampling effort (river bends-replication) for each river segment

Segment Number	Description	Randomly Selected River Bends
1	Fort Peck Dam to Milk River	0
2	Milk River to Wolf Point (Hwy 13 bridge)	12
3	Wolf Point to Yellowstone (confluence)	21
4	Confluence to headwaters (Sakakawea)	12
*5	Fort Randall Dam to Niobrara (confluence)	10
*6	Confluence to headwaters (Lewis & Clark)	combined w/segment 5
7	Gavins Point Dam to Lower Ponca Bend	12
8	Lower Ponca Bend to Platte River (confluence)	15
9	Platte River to the Kansas River (confluence)	20
10	Kansas River to the Grand River (confluence)	10
11	Kansas River from the Hwy 7 bridge to the confluence with the Missouri River	3
13	Grand River to Osage River (confluence)	11
14	Osage River to the mouth	14

The PSPAP is a major contributor to other evaluations of pallid sturgeon status including: pallid sturgeon recruitment, catch trends, data analysis and assessments, and provides sturgeon for the genetic analyses. It continues to provide data for the Pallid Sturgeon Effects Analysis and pallid sturgeon population modeling. The PSPAP will be the primary project that provides data and information for any future down-listing or delisting of the pallid sturgeon under the ESA.

IV.A.II.4.b. Pallid Sturgeon Catch and Trends

Total pallid sturgeon captures provide some insight into the population trends and effectiveness of a monitoring project to sample the pallid population from year to year; however, scientifically valid trends in abundance need to be formed from abundance data that are standardized by the amount of effort utilized during a specific period of time (e.g., the sample year). Past pallid capture data is included in Table 17 and Table 18. Pallid captures, in general, have increased over time for the PSPAP. As the project has evolved, more pallid sturgeon have been captured from adjustments to the sampling protocol (e.g., increased effort, adjustments to gear types, etc.) and a larger number of pallid sturgeon in the system provided by the Propagation and Population Augmentation Management Action. A synthesis analysis that provides abundance trends over time for pallid sturgeon and other native fishes targeted by the PSPAP was completed (Wildhaber et al., 2014). Catch trends from this effort indicated that abundance trends tended to increase in the Upper, Middle, and Lower Missouri rivers (i.e., trammel nets and otter trawls in all basins) paralleling stocking efforts, although this relationship was less pronounced in the lower Missouri River. Future assessment of pallid sturgeon trends will likely rely on a combination of catch, survival, and population size analyses.

Table 17. Total number of pallid sturgeon captured through <u>standard and non-standard</u> sampling by year through the PSPAP

	Year												
Segment	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
2				14	22	16	35	43	71	166	101	123	591
3				49	92	130	190	180	215	253	260	166	1535
4			30	25	27	99	148	721	235	318	340	439	2382
5	41	22	25	15	40	14	49	61	60	42	53	18	440
6	10	6	19	35	67	88	128	89	19	54	93	48	656
7			1	9	83	69	48	198	123	347	184	82	1144
8			15	17	34	104	123	83	83	61	86	96	702
9	3	11	13	31	32	235	314	251	288	171	249	328	1926
10			4	11	10	47	109	56	43	46	49	97	472
11					1		4	7	3	1		1	17
13	4	18	26	7	38	79	68	41	70	35	44	32	462
14	3	4	12	9	19	22	34	23	28	36	19	19	228
Total	**61**	**61**	**145**	**222**	**465**	**903**	**1250**	**1753**	**1238**	**1530**	**1478**	**1449**	**10555**

Table 18. Total number of pallid sturgeon captured through standard sampling only by year through the PSPAP

	Year												
Segment	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
2				14	22	16	32	42	25	157	96	123	527
3				36	86	128	121	134	132	236	233	166	1272
4			25	24	27	65	147	491	162	282	340	439	2002
5	12	17	21	13	40	14	49	61	60	42	53	18	400
6	4	5	18	35	67	88	128	89	18	54	93	48	647
7			1	9	50	53	47	54	49	83	68	17	431
8			13	17	32	61	99	83	81	55	83	73	597
9	2	8	10	31	32	77	107	88	65	78	57	84	639
10			4	11	10	38	48	41	22	14	23	19	230
11					1		2	2	3	1		1	10
13	4	15	19	6	13	60	14	23	35	24	39	29	281
14	3	3	12	9	8	13	11	13	14	31	11	17	145
Total	**25**	**48**	**123**	**205**	**388**	**613**	**805**	**1121**	**666**	**1057**	**1096**	**1034**	**7181**

IV.A.II.4.c. Is There Evidence of Pallid Sturgeon Recruitment?

A preliminary assessment of the current "suspected wild" pallid sturgeon captured from the Upper Missouri River should be interpreted cautiously (Steffensen et al., 2014). It appears recruitment is very minimal to non-existent in RPMA 2 (Lower Yellowstone River; Missouri River from Fort Peck Dam to Lake Sakakawea), and especially over the past two decades or potentially longer. Aging work conducted by Dr. Pat Braaten (USGS) indicates the majority of the large adult pallid sturgeon that have been sampled are likely much older than the predicted ages from the Shuman et al. (2011) growth models . Additionally, recruitment in RPMA3 (Fort Randall Dam to Lewis and Clark Lake) appears minimal to non-existent as only four potentially wild fish have been captured. As the parental genetics are recovered, it is likely these fish will be identified as hatchery stock. Lastly, recruitment in RPMA4 (Missouri River below Gavins Point Dam to the confluence of the Mississippi River) may be occurring but, if so, at very low levels. Length data at time of capture and back-calculated age to year class predicts that potentially 46 have recruited to the wild population since 2000. Artificial supplementation began with the 1992 year class and has occurred annually throughout RPMA 4 since 1999. Categorizing pallid sturgeon in RPMA4 as wild is difficult due to incomplete broodfish genetics and tag loss by the stocked population and prevents definitively identifying recent recruitment in the Lower Missouri River.

Artificial propagation efforts utilize the existing population to artificially spawn and rear pallid sturgeon to increase their likelihood of survival in the wild. The hatchery propagated and reared pallid sturgeon are later stocked at a variety of ages and sizes to supplement the natural population; however, genetic samples were not collected and retained for some early broodfish. Since 2012, Dr. Ed Heist (Southern Illinois University – Carbondale) has been reconstructing the parental genetic structure of adult pallid sturgeon that did not have a genetic sample archived. As fish are analyzed against this evolving baseline, origins of the pallid sturgeon used for this analysis are likely to change.

IV.A.II.4.d. Data Analysis and Assessments for Pallid Sturgeons

The following assessments will be used to meet BiOp RPA elements and further the understanding of factors that limit pallid sturgeon populations.

1. *Pallid Sturgeon Capture Probability, Survival Rate and Population Size in the Lower Missouri River (USGS- Columbia Environmental Research Center and University of Missouri-Columbia).* This effort will assess pallid sturgeon survival rates and population size and develop a spatially referenced (e.g., segment

level) model for population size and survival rate for hatchery and wild pallid sturgeon populations in the Lower Missouri River.

Status: Analysis is ongoing through the University of Missouri-Columbia. Expected completion is early 2016.

2. *Population Viability Analysis for Pallid Sturgeon (USGS-Columbia Environmental Research Center and University of Missouri-Columbia).* Bajer and Wildhaber (2007) developed initial age-structured models for pallid sturgeon and shovelnose sturgeon populations in the Lower Missouri River to conduct population viability analyses (PVA) for both species. The value of these models is the ability to provide a form of forecast of future populations under changing environmental and management conditions. Because of the limited knowledge of the biology of the pallid sturgeon at the time, many of the parameter estimates for these models were either taken from other sturgeon species or were based on anecdotal observations. The current analysis will update the Bajer and Wildhaber (2007) population model for pallid sturgeon using current parameter estimates and inclusion of parameter uncertainty. As part of the development of the model, sensitivity analyses will be done to assess how the new parameter estimates and model structure may have changed what was previously concluded from Bajer and Wildhaber (2007).

   Status: Recently published.

3. *Effects Analyses Documents and Adaptive Management Plans*. Several basin scientists led by the USGS-CERC drafted the Pallid Sturgeon Effects Analysis document and assisted in the development of a draft Pallid Sturgeon section of the MRRP AM Plan. This will culminate with a complete summary of information learned since pallid sturgeon monitoring and research efforts first began and lay out a road map for future science efforts.

   Status: Documents drafted.

IV.A.II.5. Science Integrated with Management Actions

IV.A.II.5.a. Habitat Assessment Monitoring Program

The Habitat Assessment and Monitoring Program (HAMP) began in 2004 and was developed by representatives of state and federal agencies and academia that collectively possess knowledge and expertise on the Missouri River, pallid sturgeon and other native Missouri River fishes, research, experimental design, and statistical analysis. This team included the MDC, University of Missouri, USGS, USFWS, Iowa Department of Natural Resources (IDNR), NGPC, SDGFP, Corps and others. The HAMP focuses on the endangered pallid sturgeon, other big river native fishes and their habitats as recommended by the BiOp. The SWH PDT has developed a component of the MRRP AM strategy focused on SWH creation actions described in the BiOp. This SWH AM strategy (USACE, 2012) is being used to guide habitat creation actions and evaluations while helping inform a more comprehensive AM strategy for the MRRP focused on the three endangered species. While the more comprehensive AM strategy is being developed (part of the MP/EIS) the SWH AM strategy will be instrumental in directing monitoring efforts at evaluating specific hypotheses related to SWH creation and pallid sturgeon.

IV.A.II.5.a.i. Program Goal

The goal of the HAMP is to assess the physical and biological responses to habitat creation actions that are expected to benefit pallid sturgeon and related fish communities. For details regarding past HAMP monitoring efforts see Section IV.C.II SWH AM.

IV.A.II.5.a.ii. Program Status Update

Physical habitat assessments (Kansas City District) - In coordination with HAMP biological teams (Corps and USFWS-FWCO), the Kansas City District River Engineering and Restoration Section performed surveys of unidentified larval sturgeon capture sites between June and October of 2015. When high captures of age-0 sturgeon were made survey crews were notified and attempted to survey the site the following day or at another day with similar river stages. Velocities were surveyed with an Acoustic Doppler Current Profiler (ADCP) and depths were surveyed using single-beam sonar. Cross-sections were spaced 10 to 30 meters and proceeded from the capture site to 1 to 2 miles upstream. The intent of this data collection is to assess captures sites with respect to physical processes in an attempt to identify unique physical characteristics of areas that intercept larval sturgeon. High water conditions limited age-0 sturgeon sampling efforts in 2015, therefore, a total of three high capture sites were surveyed within the HAMP study reaches. These data will be used to help refine future physical habitat surveys with the intent of providing better information regarding the habitat use of age-0 sturgeon.

Main-channel bathymetric surveys and ADCP data were collected at the Searcy's Bend and Baltimore Bottoms locations. This data was collected to support the development of the Adaptive Hydraulics (AdH) model of these potential interception rearing complex (IRC) habitat restoration sites. This will allow a particle tracking module to be used to evaluate alternatives and refine project design. The AdH modeling effort will also be used and modified as part of the post construction AM evaluation process.

Bathymetric and ADCP data was collected during high and low water conditions from Pelican, Little's and Cranberry chutes in support of the Chute Reference Condition study (see below). An additional survey was also conducted at the Jameson Island site in support of the chute study. These data and surveys have been provided to the MDC to assist in the analyses and interpretation of biological data collected within these chutes.

Physical habitat assessments (Omaha District) - Physical data in NWO consisting of hydrographic surveys and velocity sampling (ADCP) was collected at five constructed chutes in 2015 – Nishnabotna, Kansas, Deroin, Council Bend, and Sandy Point. Data was collected in the vicinity of the entrance, both in the river and chute to investigate the river-chute connection dynamic.

Full-channel bathymetric surveys and ADCP data was conducted at Lower Decatur, Lower Little Sioux (Deer Island) and Hamburg Bends. Sediment sampling was completed at Deer Island. Sediment samples were collected on a cross-section pattern with cross sections spaced approximately 500 feet apart and five samples collected on each section.

As part of on-going monitoring of chutes and backwaters, sediment rangelines were established and/or surveyed at Rush Bottom Chute, Deroin Chute, Council Bend Chute, Soldier Backwater and Tyson Backwater.

Biological assessments - In 2015 monitoring and focused investigations were continued to better understand the relationship between age-0 sturgeon habitat use and availability and how current habitat conditions may be limiting pallid sturgeon recruitment. Details regarding each of the monitoring and focused investigation efforts are provided below:

Age-0 shovelnose sturgeon prey consumption in the lower Missouri River (Partners include USGS, Oklahoma Cooperative Fish and Wildlife Research Unit and the Department of Natural Resources Ecology and Management, Oklahoma State University). This study utilized data previously collected by HAMP to evaluate the type and number of prey items consumed by age-0 sturgeon. The abstract from this study is below:

A lack of nutritious food during the first year of life is a hypothesized factor that may limit survival of endangered pallid sturgeon *Scaphirhynchus albus* in the lower Missouri River (LMOR). Unfortunately, information for age-0 pallid sturgeon diets remains limited but diet analyses for age-0 *Scaphirhynchus* spp. (sturgeon hereafter) have occurred. Little information, however, exists on age-0 sturgeon diets in the LMOR; thus, our primary objective was to document age-0 sturgeon diets in this system. We examined guts contents from 30 individuals, which were genetically identified as shovelnose sturgeon *Scaphirhynchus platorynchus*, and three stomachs were empty. The remaining age-0 shovelnose sturgeon consumed chironomid larvae almost exclusively (> 98% of prey items consumed). Our results were similar to studies conducted in other systems and it appears unlikely that a lack of nutritious food was a major factor affecting the individuals captured during this study. This effort provides important information to help guide ongoing adaptive management efforts in the LMOR (for the full report, please see Appendix E).

<u>Lower Little Sioux Bend (Deer Island) Physical and Biological Assessment (Partner includes IDNR)</u>
The Iowa Department of Natural Resources was contracted by the Corps under HAMP to evaluate the biological response to SWH construction at Deer Island and Lower Decatur Bend. The objective was to compare catch of larval, young of the year and small bodied fishes, including pallid sturgeon, at constructed habitats with those already available in river. A 16-foot, small mesh otter trawl, push trawl and mini fyke nets were selected as sampling gear. Four-hundred-and-fifty gear deployments were conducted between May 19th and October 1st, 2014. A total of 5,419 fish were collected representing 39 species. Catch was dominated by cyprinids, freshwater drum (*Aplodinotus grunniens*) and gizzard shad (*Dorosoma cepedianum*). No pallid sturgeon were collected. Thirteen of the 15 total shovelnose sturgeon collected were sampled at Deer Island including one young of year (YOY). This is the second consecutive year that YOY shovelnose sturgeon were collected at Deer Island. Mini fyke net catch per unit effort (CPUE) at the two SWH sites exceeded the control for 14 species but only one species each for otter trawl and push trawl. The only significant difference detected (*P*=0.02) was for silver chubs (*Macrhybopsis storeriana*) collected with the otter trawl where catch at the control site, Middle Little Sioux Bend, was higher than Decatur Bend. (For the full report, please see Appendix E).

<u>Evaluating the Effects of Shallow Water Habitat Implementation on *Scaphirhynchus* sp. (Partners include USFWS-FWCO)</u>
The HAMP began an intensive sampling protocol during 2005 with the spatial sampling unit defined as a river bend. The statistical design components of this approach therefore assumed independence among river bends, however, Schapaugh et al. (2010) suggest that the appropriate spatial sampling unit may extend beyond the river bend scale. A pilot study during 2010 reported data that suggested expansion of the spatial scope of a sampling unit from a single river bend to a larger extent (20 mile reach of river) may be appropriate to detect changes in small-bodied (e.g., < 140 mm TL) fish abundance (i.e., response metric) in light of management actions (i.e., habitat restoration) on lower Missouri River (Ridenour et al. 2011). Therefore, in line with a recommendation from the Corps commissioned, Independent Science Advisory Panel (ISAP) and the current AM strategy for creation of SWH, adjusting the spatial scope of sampling units represents an opportunity to adapt an existing monitoring program to improve data collection efforts to quantitatively address relationships between fisheries data and management actions (Doyle et al. 2011; USACE 2011).

This study focuses on five reaches of river from Kansas City to St. Louis. Three of the selected reaches represent areas that are near or exceed the BiOp goal of 20-30 acres/mile of SWH (natural or created) and have had ample time to "condition". The length of these sites range in length from 15-25 miles and are identified in Table 19.

Table 19. Length of sites

River Mile	Length	Acres/Mile Water < 5'
307-327	20	5.8
215-237	22	21.5
157-180	23	14.8
94-110	16	9.0
33-54	21	34.7

The purpose is to evaluate the efficacy of existing SWH to support early life stages of age-0 sturgeon to facilitate adaptive decision making for future habitat construction action. Specific objectives will be to 1) compare density (e.g., #/area) of age-0 sturgeon between reaches with high acreages of SWH (existing or restored) against reaches with no or minimal SWH; and 2) identify and prioritize the types, or suite of types, of SWH that best promote use by age-0 sturgeon to guide management decisions on future SWH restoration. It is anticipated this will be completed in May 2016 (an interim progress report with results from the 2014 field season can be found in Appendix E).

<u>Evaluating the Effects of Shallow Water Habitat Implementation on Age-0 *Scaphirhynchus* sp. Gut Contents and Body Condition (Partners include USFWS-FWCO, Oklahoma State University and USGS)</u>
It is currently unknown if created SWH is providing the hypothesized benefits for age-0 sturgeon. The purpose of this study is to assess and compare resource use (prey) of sturgeon that have been collected from reaches representing areas that are near or exceed BiOp targets of SWH and areas with little SWH (see project description above). A primary hypothesized benefit of SWH is that increased prey items are present and result in improved condition of YOY sturgeon. Therefore, the main tasks associated with this project include 1) an assessment of the

gut contents, level of fullness, and condition (lipid concentration) of age-0 sturgeon collected in the five distinct reaches mentioned above and 2) examine changes in diet according to differences in age (size). It is anticipated this will be completed in May 2016 (an interim progress report with results from the 2014 field season can be found in Appendix E).

Chute Reference Condition (Partners include MDC and NGPC)
Evaluating the development of habitat restoration projects, such as constructed chutes, is necessary to understand if projects are meeting the desired objectives and to determine if desired habitat conditions are developing. To evaluate the current state of habitat restoration projects requires an estimate of best-achievable conditions. Unaltered portions of the Missouri River that exhibit habitat characteristics similar to those of the historic Missouri River and support an abundance and diversity of native larval, YOY and small-bodied fishes are lacking. Therefore, members of the SWH AM PDT have identified a number of sites based on best professional judgment, that they believe exhibit the best-achievable conditions to use as potential reference sites. The habitat characteristics and the fish communities in these best-achievable sites will be used to set biological and environmental criteria to compare against those of other constructed MRRP SWH sites. This information will be used to evaluate progress towards restoration objectives by focusing on relative abundance and species diversity of age-0 sturgeon and other native larval and small bodied fishes in the constructed sites compared to those of the best-achievable sites. Information from this study is important so that reasonable expectations regarding species response can be understood in addition to providing insight as to whether project modifications should be made. It is anticipated this will be completed in May 2016 (interim progress reports with results from the 2014 field season can be found in Appendix E).

Pallid Sturgeon Environmental Life History in the Missouri River and Mississippi River (Partners include MDC, USFWS and Southern Illinois University)
Determining the relationships among fishes and their associated habitats that may be important at various life stages is vital for conservation efforts (Schlosser 1995; Fausch et al. 2002). This is especially important for large river fishes that exhibit movement patterns (e.g., drift during early life stages or exhibit long-range movement patterns) that may enter novel rivers or cross political boundaries. In many aquatic environments, microchemical fingerprinting has recently materialized in fisheries as a promising approach to determine origin (i.e., location of hatch) and evaluate environments previously occupied during life (e.g., Thorrold et al. 1998; Wells et al. 2003; Brazner et al. 2004; Phelps et al. 2012). This approach allows for the determination of environmental history without the difficulties associated with traditional marking techniques. Using this approach allows researchers to document the broad scale movements of an individual over its entire life.

As with many other large river fishes, pallid sturgeon exhibit extensive movement patterns throughout the Mississippi and Missouri Rivers. However, the importance of these rivers at various life stages particularly those where origin and recruitment occur for pallid sturgeon has not been fully evaluated. Therefore, this study investigates the relative importance of these two large interconnected rivers (Mississippi River and Missouri River) at various pallid sturgeon life stages. To determine environmental history, pectoral fin rays will be obtained from 400 pallid sturgeon captured in the Missouri and Mississippi rivers. Water chemical signatures from the Mississippi River and Missouri River will then be used to determine origin and environmental history using a relationship between water and sturgeon fin ray Sr:Ca (See Phelps et al. 2012). Additionally, each potentially-wild pallid sturgeon will be genotyped at 19 DNA microsatellite loci and compared to databases at Southern Illinois University Carbondale to identify each specimen to species or hybrid category and to discriminate hatchery-origin fish from wild fish. It is anticipated this will be completed in September 2017 (an interim progress report with results from the 2014 field season can be found in Appendix E).

IV.A.II.5.b. Water Quality Monitoring

The project area for water quality monitoring efforts within the MRRP is the Missouri River from Gavins Point Dam (RM 811) downstream to the confluence of the Missouri and Mississippi Rivers near St. Louis, Missouri (RM 0). The MRRP Water Quality Program was initiated during FY08 in response to water quality questions and concerns posed by the Missouri Clean Water Commission. In 2011, this program received increased priority in response to the National Academy Science Study (Missouri River Planning Recognizing and Incorporating Sediment Management) to further investigate the impacts of SWH construction on water quality of the Missouri River.

IV.A.II.5.b.i. Program Goal
The goal of the Water Quality Program is to assess the chemical and biological variables of the mainstem River, tributaries, and created habitats relative to the mitigation, recovery, and restoration of the pallid sturgeon, other native fish species and aquatic communities.

IV.A.II.5.b.ii. Program Status Update
A fixed-site monitoring program has been implemented at multiple mainstem River and tributary sites to monitor the status and trends of ambient water quality parameters in the project area. Sampling is targeted to occur monthly March through October (weather permitting) to provide spatial and temporal status and trends. In 2015, samples were collected at 13 mainstem sites and 20 tributary sites by NWK and NWO Corps staff. Data collected from this effort will be used to support the application of the HEC-RAS hydrodynamic and water quality model on the lower Missouri River and will be available to aid in the evaluation of potential alternatives in the MP/EIS. Results from this monitoring are currently being summarized and will be available spring of 2016.

Additionally, the Water Quality Program completed a study during construction of the Benedictine Bottoms chute project. It is anticipated that the final report will be completed in March 2016.

IV.A.II.5.c. Physical and Sediment Analysis
Physical data in NWO consisting of hydrographic surveys was collected at all constructed chutes and backwaters in 2014. Missouri River main channel data was also collected at selected bends. Data processing and analysis was used in the 2014 SWH accounting effort and for review of constructed project performance.

Funds were provided by the Corps to the USGS to collect bed material sediment samples on the mainstem Missouri River from Gavins Point Dam to Rulo, Nebraska, and also in selected tributaries. This sampling was completed in 2014.

IV.A.II.6. Pallid Sturgeon Focused Research
Significant steps were taken in 2015 to address remaining critical pallid sturgeon information gaps including the identification and better understanding of key pallid sturgeon life history transitions, objectives and prioritized hypotheses. These completed or in-progress tasks include:

1. *Spatial and Temporal Extent of the Suspected Hypoxic Zone in the Headwaters of Lake Sakakawea (Montana State University).* Guy et al. (2015) found that anoxic conditions exist in the transition zone from riverine to lacustrine environments in the headwaters of Fort Peck Reservoir in eastern Montana. The anoxia is a function of reduced river velocities and the concentration of fine particulate organic material with high microbial respiration. Their results indicate that Fort Peck Reservoir is an ecological sink for larval pallid sturgeon. It has been hypothesized that these same conditions exist in the headwaters of Lake Sakakawea and that they impede pallid sturgeon recruitment in RPMA 2. The goal of this research is to determine the spatial and temporal extent of hypoxic and anoxic zones in the headwaters of Lake Sakakawea.

2. *Importance of the Interconnectedness of the Mississippi and Missouri Rivers at Various Pallid Sturgeon Life Stages (Missouri Department of Conservation and Southern Illinois University at Carbondale).* Strontium-calcium ratios (Sr:Ca) were identified from water samples collected from 2006-2013 throughout the Mississippi and Missouri rivers. These ratios were bench-marked using high-resolution, inductively coupled plasma mass spectrometry at the University of Southern Mississippi. Analysis of Sr-Ca signatures using pallid sturgeon pectoral fin ray samples from the Missouri and Mississippi rivers are being reviewed to help determine source location (including river of origin and source reach on the Missouri River), river of recruitment, and the relative occupation time in these rivers. This information will guide habitat enhancement projects and management actions throughout the Missouri River basin.

3. *Development of a Spatially Explicit Growth Model for Larval Pallid Sturgeon (South Dakota State University).* Development of a growth model that will allow researchers to evaluate habitat quality and survival potential for age-0 pallid sturgeon. Quantified foraging dynamics and energetics of age-0 sturgeon that served as inputs in the model including feeding response, respiration rate, swimming performance, evacuation rate and feeding satiation as functions of water temperature (12-24°C) and fish size (10-150

mm). In addition, the model was evaluated by quantifying growth in small scale mesocosms simulating natural conditions. Using empirical data, the model was applied to various sites in the Missouri River to evaluate spatially-explicit growth patterns for age-0 pallid sturgeon. This model will help identify important rearing areas and potential habitat restoration sites for pallid sturgeon in the Missouri River.

4. *Development and Evaluation of a Larval Pallid Sturgeon Energetics Model (South Dakota State University).* An understanding of feeding and growth dynamics of larval pallid sturgeon is important for identifying rearing areas and monitoring habitat restoration efforts. Use of ecological models to estimate growth potential of larval pallid sturgeon represents a new approach for assessing habitat suitability for this critical life stage. South Dakota State University (SDSU) developed a bioenergetics model to determine optimal temperature for growth in YOY pallid sturgeon. Metabolic demands and growth of pallid sturgeon subjected to a range of temperatures commonly found in the Missouri River (13–24°C) were used to parameterize the model. Static respirometry was used to quantify routine respiration rate. Exogenously feeding larvae were fed chironomids over a range of ration levels (0-50% body weight) to determine maximum consumption and estimate growth. Larval pallid sturgeon exhibited a 77% increase in metabolic rates and a 52% increase in consumption rates from 13-24°C. Critical thermal maximum was evaluated by increasing temperatures 1°C every half hour from acclimation temperatures until lethal temperatures were achieved (34°C). Upper, lethal temperatures were significantly different between endogenous and exogenous larvae acclimated at water temperatures of 13-24°C. On the average, lethal temperatures for endogenous larvae were 2.6 to 3.5°C lower than those for exogenous fish. The quantification of these bioenergetic parameters will allow us to estimate energetic requirements of larval pallid sturgeon, to make growth predictions from field observations, and to determine availability of optimal temperature ranges within the Missouri River.

5. *Hatchery Review (Bozeman Fish Technology Center).* Site Visit and Technology Transfer to Neosho National Fish Hatchery and Blind Pony State Fish Hatchery to Improve Conservation Propagation of Pallid Sturgeon. Neosho and Blind Pony hatcheries are primary conservation propagation facilities in the middle basin of the Missouri River tasked with spawning, rearing, and releasing endangered pallid sturgeon into their native habitat. These hatcheries are currently experiencing disease and fish health issues that have severely impacted hatchery augmentation efforts. The USFWS at Bozeman Fish Technology Center has developed a team to provide recommendations to help improve the disease and fish health issues currently plaguing these hatcheries. The review will result in recommendations to improve the spawning and culture of pallid sturgeon at both hatcheries.

6. *Evaluating the effects of Shallow Water Habitat implementation on Age-0 Scaphirhynchus species. Prey Consumption and Zooplankton availability and use by big-river larval and age-0 fishes in constructed shallow-water habitats of the lower Missouri River (Oklahoma State University).* Study to identify food availability for Age-0 and larval Scaphirhynchus species in the lower Missouri River constructed SWH.

7. The USGS-CERC Comprehensive Sturgeon Research Project (CSRP) continued this year with minor adjustments to the project objectives. Reproductively ready pallid sturgeon were monitored within the upper Missouri River providing valuable clues regarding spawning site physical conditions, spawning aggregations, spawning, incubation and hatch; verification of embryo hatch and dispersal from known spawning locations; evaluation of factors affecting egg deposition, adhesion, and hatch; evaluation of the effects of hydrology and hydraulics on transport, retention, and fate of larval drift, free-embryo to exogenously feeding larvae; assessment of hatch, dispersal and settling behavior of early life-stage pallid sturgeon from egg through first feeding; and an assessment of factors influencing pallid sturgeon spawning in the Missouri River and tributaries.

IV.B. Habitat Creation

IV.B.I. Northern Great Plains Population of the Piping Plover and Interior Population of the Least Tern

IV.B.I.1. BiOp requirements

RPA IV requires the Corps to restore ESH on the Missouri River.

RPA IV.B.1. Minimum ESH per River Mile.
See page 210 in the BiOp for detailed information on minimum ESH required per river mile.

RPA IV.B.2. Establish ESH within Corps Reservoirs.
See page 211 in the BiOp for detailed information on establishing ESH within Corps Reservoirs.

RPA.IV.B.3. Artificially or Mechanically Created Habitat.
See page 213 in the BiOp for detailed information on artificially or mechanically creating habitat.

RPM 3: Designing, Constructing, and Managing Created Sandbars as Required by RPA IV.B.
See Section IV.B.I.2 below for actions that were undertaken to meet RPA.IV.B.3. and RPM 3.

IV.B.I.2. Actions to meet BiOp Requirements

IV.B.I.2.a. Management Decisions

Over 14,000 acres of ESH were formed during the 2011 Missouri River flood event. Following the flood, the Corps contracted with the USGS NPWRC to classify the newly developed sandbar habitat. Sandbars were assessed to determine whether or not they could be classified as ESH suitable for tern and plover use. NPWRC used a combination of aerial and satellite imagery to perform habitat classifications on these sandbars.

Habitat classification was conducted on all the sandbars in each river reach. Sandbars were analyzed based on four criteria: dry sand, dry sand sparse vegetation, wet sand, and wet sand sparse vegetation. Once it was determined that a sandbar habitat area meets ESH criteria, its size was measured in acres. The sandbars that were classified during 2012 exceeded the amount of acreage recommended in the 2003 Amended BiOp (11,886 acres) for all river reaches: below Garrison Dam, Fort Randall Dam, Gavins Point Dam, and in Lewis and Clark Lake as well as the selected plan in the *Programmatic Environmental Impact Statement* (PEIS) *for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River*. The focus of the ESH program since 2012 has been to maintain as much of that habitat classified as ESH as possible through vegetation control and minor reshaping activities.

The sandbars formed by the 2011 flood immediately began to experience varying degrees of natural erosion from the river and the wind. The amount of erosion the sandbars experience will depend on many factors, but will be most directly affected by the hydrology associated with the magnitude of releases from the dams and the tributaries upstream of them. In addition to erosion, rapid vegetation encroachment typically begins to occur on newly deposited sandbars. The ESH Program's goal is to control vegetation to the maximum extent possible to maintain ESH. In 2015 it was estimated that in the Gavins river reach, there were 2,868 acres of ESH, the Fort Randall river reach had 889 acres, Lewis and Clark Lake had 623 acres and the Garrison river reach had 2,900 acres of ESH, for a System total of approximately 7,280 acres.

IV.B.I.2.b. Vegetation Removal Environmental Assessments for North Dakota and South Dakota/ Nebraska

In August 2011, a PEIS and associated ROD for the *Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat* was released. Two vegetation removal environmental assessments (EAs) with coverage spanning an approximate five-year time period were prepared during late 2012 into early 2013 in order to assess the impacts of vegetation removal efforts in North Dakota, Nebraska and South Dakota. The Nebraska and South Dakota EA was conducted together because the states share boundaries with the Missouri River. Findings of No Significant Impacts (FONSIs) were signed for both documents after coordination with Tribes and federal and state agencies in April 2013 for Nebraska and South Dakota and North Dakota in August 2013. In addition to the two EAs, separate annual coordination are conducted with the agencies in order to determine which sandbars to treat for vegetation removal activities each year. The EAs cover the types of vegetation removal activities that would be conducted but left the exact sites to be treated to be determined annually based on where the vegetation grows or is anticipated to grow each year. In addition to annual coordination, the Corps will seek annual Sovereign Lands Permits from the state of North Dakota in order to conduct vegetation removal activities.

IV.B.I.2.c. Efforts Undertaken by the MRRP

IV.B.I.2.c.i. ESH Construction

No ESH construction activities were conducted in 2015. Sandbars were identified for potential modifications during the Nebraska/South Dakota ESH PDT meeting held on 29 and 30 October 2014 in Yankton, South Dakota. Modifications to existing sandbars will be identified as a capability for FY17 if funding would become available. Proposed modifications would include creating additional forage habitat on existing sandbars by creating low elevation ponds and streams within the sandbars.

IV.B.I.2.c.ii. Vegetation Removal

Multiagency teams in North Dakota, South Dakota, and Nebraska met several times during spring and summer of 2015 to determine which sandbars vegetation removal activities should be conducted on. Vegetation removal was conducted in 2015 in North Dakota, Nebraska, and South Dakota. Approximately 704 acres were treated in Nebraska and South Dakota by contractors utilizing a helicopter equipped with boom sprayers and an additional 48 acres were sprayed utilizing an ATV. Sixty acres were also mowed. In North Dakota, in river reaches below Garrison Dam, approximately 694 acres of sandbars were aerially sprayed with herbicide.

IV.B.I.2.d. FY 2015 Accomplishments

The FY15, Nebraska and South Dakota interagency teams met on 29 and 30 October 2014 at the Gavins Point Project Office Visitor Center. Representatives from the USFWS, the National Park Service, Nebraska Game and Parks Commission, the Missouri River Institute, and the University of South Dakota participated. The North Dakota team meeting was held in January of 2015. Meetings continued throughout the year introducing reshaping alternatives for sandbars.

The overall program was below budget while expending approximately 3,000 labor hours of field work and awarding two contracts for approximately 1,500 acres of vegetation management that will reduce habitat encroachment.

The numerous efforts contributed to the increase of bird numbers. There was a 44% increase in piping plovers and a 27% increase in least tern. Not only was there a rise an adult numbers, but there was a significant increase in productivity with an overall fledge ratio of 1.4 for piping plovers and 1.31 for least terns. For further information regarding piping plover and least tern productivity and population numbers, refer to Section IV.A.I.2.

IV.B.II. Pallid Sturgeon

IV.B.II.1. BiOp Requirements

The 2003 Amended BiOp originally defined SWH as areas where water depth is greater than 0 (zero) but less than 5 feet (0-1.5m) and current velocity is less than 2 feet/second (0.6 meters/second).

In a letter dated June 29, 2009, the USFWS provided the following clarification of the original definition of SWH:

> *"Shallow water habitats include side channels, backwaters, depositional sandbars detached from the bank, and low lying depositional areas adjacent to shorelines.*
>
> *Key physical components of SWHs are their dynamic nature with depositional and erosive areas, predominance of shallow depths intermixed with deeper holes and secondary side channels, lower velocities, and higher water temperatures than main channel habitats.*
>
> *Several critical questions that large-river ecology research needs to address is the issue of relative habitat size, the importance of SWH location relative to other habitat types, the influence of organic input and deposition and hydrograph influence."*

The USFWS also formally revised portions of the BiOp in a letter dated October 23, 2009 to the Corps by substituting a new RPA element at Intake Dam and the irrigation headwaters on the Yellowstone River, Montana for one which was originally identified to be taken at Fort Peck Dam.

IV.B.II.1.a. SWH Creation / Yellowstone Intake / Fort Peck

The WRDA of 2007 authorized the Corps to use Missouri River Recovery and Mitigation funds to assist the U.S. Bureau of Reclamation (BOR) with design and construction of the Intake Diversion Dam Project for the purpose of ecosystem restoration. The restoration of the dam and diversion canal will address long standing issues related to fish passage and entrainment at this location and will open up more than 150 miles of new aquatic habitat to the highly imperiled pallid sturgeon.

The current RPA element reads as;

1. The Corps shall or is to provide funding necessary for NEPA analysis and construction leading to sturgeon passage at the Intake, Montana irrigation dam and diversion.
Status: No change.

2. The Corp shall provide funding necessary for NEPA analysis and subsequent construction of the Intake Diversion Dam Project to address native fish entrainment near Intake, Montana.
Status: No change.

3. As resources are being used for construction of the Intake Diversion Dam Project, the 2020 shallow water habitat milestone will be deferred by an equal amount of time – not to exceed 4 years or 2024.
Status: No change.

4. The Corps will not be required to conduct the Fort Peck Dam tests until after assessing the efficacy of the Intake Diversion Dam Project. This determination will be made within the first 8 years following conclusion of the construction at Intake.
Status: No change.

5. The Corps will complete its feasibility report related to temperature improvements at Fort Peck Dam, including a review of the Milk River for possible sources of warm water.
Status: No change.

6. The Corps, Reclamation and Service will, in cooperation with Montana Fish Wildlife and Parks, determine the requirements and funding necessary for post-construction monitoring associated with the project.
Status: No change.

IV.B.II.1.b. List Specific Objectives and Alternatives

The objectives are currently under review by the SWH PDT. Once finalized, they will be incorporated through an AM strategy.

IV.B.II.2. Actions to meet BiOp Requirements

IV.B.II.2.a. SWH Construction and Acreage Estimates

The existing BiOp concludes that the restoration of 12,035 acres to 19,565 acres (20 to 30 acres per mile) of SWH is needed, and contains performance standards and check-ins tied to the acres of restored SWH. It is important to note that the 30 acres per mile performance metric is utilized by the Corps for the check-in with USFWS.

The check-in dates and SWH acreage targets to achieve 20 acres/mile are as follows:

30% (3,611) by 2010 (deferred until 2014)
60% (7,221) by 2015 (deferred until 2019)
100% (12,035) by 2020 (deferred until 2024)

The check-in dates and SWH acreage targets to achieve 30 acres/mile are as follows:

30% (5,870) by 2010 (deferred until 2014)
60% (11,739) by 2015 (deferred until 2019)
100% (19,565) by 2020 (deferred until 2024)

During 2014, the Corps completed the 2014 "Check-In" report. The report was prepared to (1) summarize the amount of SWH available compared against the 2014 targets contained in the BiOp; (2) analyze the distribution of SWH by river segment for comparison against the targets provided in the BiOp; and (3) summarize SWH construction actions taken to date. The methodology in this report utilizes a far more spatially comprehensive dataset than past efforts. While previous SWH estimates used datasets that covered less than 15% of the river, the estimates in this report are based on datasets that cover approximately 95% of the current river.

While this report is the most comprehensive assessment of SWH on the river, there are several factors which affect the accuracy of this assessment. For example, due to excessive time and cost for data collection, processing, and analysis, it is not feasible to model or collect velocity data within the entire channel and approximations must be used. Due to this limitation, it is necessary to quantify SWH using the single attribute of depth of water during median August flows. Engineering analysis suggests that applying the velocity component and other sources of error may reduce the reported amount of SWH up to 20%. Table 20 summarizes the BiOp targets, the available amount of SWH on the system, and the amount of SWH acres constructed by the Corps.

Table 20. Estimate of SWH Acreage Compared to BiOp Goals

River Segment	Segment Length (mile)	Target[1]		Current Total (acres)	Current Total (acres/mile)	Constructed (acres)[2]
		2014	2019			
11	18	133 (187)	230 (338)	120	7.8	0
12	240	1,016 (1,436)	1,781 (2,621)	1,682	11.1	689
13	228	2,102 (2,786)	3,155 (4,524)	2,560	11.2	797
14	237	2,185 (2,896)	3,280 (4,702)	3,710	15.7	230
15	130	1,198 (1,589)	1,799 (2,579	3,253	25.0	42
Total[3]	753	6,636 (8,895)	10,246 (14,764)	11,325	14.9	1,758

[1]Targets shown are 20 acres/mile (30 acres/mile in parentheses)
[2]Includes off-channel, revetment chutes, and channel widening projects
[3]The tabulated values are only a portion of Corps constructed actions, refer to the 2014 "Check-in Report" for further details

The Corps has constructed 53 off-channel projects which have resulted in an estimated 1,612 acres of SWH. The Corps has also completed 23 revetment chute and channel widening projects (e.g. Deer Island) which have resulted in 146 acres of SWH. In addition, over 2,100 modifications to BSNP structures have increased, diversified, and enhanced thousands of acres of SWH on the system. The full report shares the number, year, type, and river mile location of actions taken.

The existing BiOp directs the Corps to provide 20 to 30 acres per mile of SWH on the lower 753 miles of the Missouri River which corresponds to a total of 15,060 to 22,590 acres of SWH. Based on measurements at the time, it was estimated that 3,025 acres of SWH were existing on the system; however refined methodology has shown that the BiOp likely underestimated the existing SWH available in 2003. Due to the inaccuracies in previous estimates of SWH acres, the difference between previous estimates of SWH and estimates in this report does not reflect acres added to the system through Corps actions. Rather, the difference reflects the acres constructed by the Corps and the improved methodologies for measuring total acres on the system.

IV.B.II.2.b. Yellowstone Intake

The WRDA of 2007 authorized the Corps to use funds appropriated to carry out the MRRP to assist BOR in the design and construction of BOR's Lower Yellowstone Project for the purpose of ecosystem restoration. Subsequent to the passage of WRDA 2007, the USFWS issued a letter formally revising the Missouri River BiOp for protection and recovery of threatened and endangered species on the Missouri River. This letter (dated October 23, 2009) substituted elements of the RPA related to pallid sturgeon to include the Intake Dam Modification Project for fish passage and entrainment protection and defer activities associated with flow and temperature modifications at Fort Peck Dam until an evaluation of the efficacy of the Intake project is complete. In addition, the RPA revision included delaying the acreage milestones for shallow water habitat on the lower Missouri River for a number of years equal to the timeline required for completion of the Intake Dam Modification Project. A subsequent letter from the USFWS (dated February 6, 2013) further modified the RPA to say that if success criteria are met at Intake, the Corps will not be required to conduct any further studies of or make any structural or operational modifications at Fort Peck or Garrison Dams. The success criteria were modified to state that the Corps is responsible for conforming to the design criteria developed by the Biological Review Team (BRT) and once construction and successful performance of the project to the BRT's hydraulic and physical criteria are met, the Corps will achieve its responsibility under the RPA.

The Corps and Reclamation jointly prepared an EA in 2010 that recommended a new headworks and fish screens to address entrainment reduction (Phase I) and a rock ramp to address fish passage (Phase II). The Corps completed construction of Phase I in 2012. During design of Phase II, significant cost increases on the rock ramp prompted the federal agencies to re-evaluate feasible alternatives at Intake for fish passage. Based on new information on pallid sturgeon use of side channels in the Yellowstone River, a bypass channel with a new weir was evaluated through a Supplemental EA. The Final Supplemental EA was completed in early 2015, and a FONSI was signed on 01 April 2015, with the bypass channel and weir as the selected alternative. The bypass channel and weir designs were completed in June 2015, and a construction contract was awarded to Ames Construction on 31 August 2015.

The Natural Resources Defense Council and Defenders of Wildlife (Plaintiffs) filed a Complaint for Declaratory and Injunctive Relief, based on alleged violations of the ESA on February 2, 2015 opposing the project. Subsequent pleadings added counts concerning alleged violations of NEPA, the Clean Water Act and the Administrative Procedure Act.

Plaintiffs moved for a Preliminary Injunction. A hearing was held before a United States District Court Judge on August 27, 2015. By Order dated September 4, 2015, the Government was enjoined for further implementing the project on NEPA grounds (notice to proceed on the awarded construction has not been issued). A Stipulated Stay was negotiated and signed on February 5, 2015. While the Stay is in effect, the Government will prepare an EIS for the project and give consideration to a "weir-less" alternative proposed by the Plaintiffs. A Draft EIS will be circulated for public comment in July 2016, with a final EIS completed by December 31, 2016.

IV.B.II.2.c. FY 2015 Accomplishments

IV.B.II.2.c.i. SWH Project Implementation Reports and Environmental Assessments

Project Implementation Reports (PIRs) are planning documents that include the process the PDT undergoes to arrive to a proposed alternative for a project. These documents include an integrated EA in accordance with NEPA requirements. During plan formulation, a number of alternatives are assessed to meet project purposes and needs. A preliminary screening ensures concepts considered meet Corps and USFWS criteria while considering costs and benefits of the project as well as make certain no negative or adverse impacts occur to the human environment and have no negative impact on flood risk reduction structures and private property.

<u>Omaha District</u>

Middle Decatur Bend River Top-Width Widening Project PIR – A PIR was completed for a river top-width widening project at Middle Decatur Bend on the Iowa side of the river in Burt County, Nebraska. This project would involve lowering the revetment and widening the top-width of the river by approximately 150 feet. The proposed project would result in the creation of approximately 14 acres of SWH. A public scoping meeting was held in Decatur, Nebraska on August 6, 2014 that was attended by approximately 65 people. The majority of people at the meeting were opposed the project and the MRRP.

Sandy Point Bend Chute Complex Adaptive Management Supplemental Environmental Assessment – A supplemental Environmental Assessment for adaptive management construction at Sandy Point Bend in Harrison County, Iowa was completed in August of 2015. Adaptive management at the chute was required to maintain the desired split flow of 8 to 10% of the main channel flow through the chute, and to improve access to the chute for larval and young of the year fish.

Fawn Island Supplemental Environmental Assessment – A supplemental Environmental Assessment was completed for the Fawn Island Chute Repair Project in August of 2015. The 2011 flood significantly eroded the banks within the chute and the east bank eroded past the original construction footprint in some locations. Proposed repairs to the chute included the addition of rip rap bank stabilization structures constructed to an elevation approximately equal to the ordinary high water mark. The total estimated quantity of rock required is approximately 24,000 tons.

<u>Kansas City District</u>
Tadpole Island – Work was completed on the Environmental Assessment for the adaptive management of this SWH to address side channel flow, geometry and diversity, and to improve connectivity between with the Missouri River and the side channel while maintaining adequate flows within the navigation channel. This land is owned by the Corps and is managed as part of the USFWS Big Muddy National Fish and Wildlife Refuge. A FONSI was signed on September 3, 2015, and a construction contract was awarded on September 29, 2015.

IV.B.II.2.c.ii. SWH Construction

<u>Omaha District</u>
Deroin Bend/Indian Cave State Park backwater SWH restoration project - A construction contract was awarded to Big River Construction Company on November 7, 2013 for the construction of a 3,500-foot long, 20-acre backwater on land owned by the NGPC at Indian Cave State Park between RM 518 and 517. Construction of this project was completed in 2015. This project will provide approximately 20 acres of SWH.

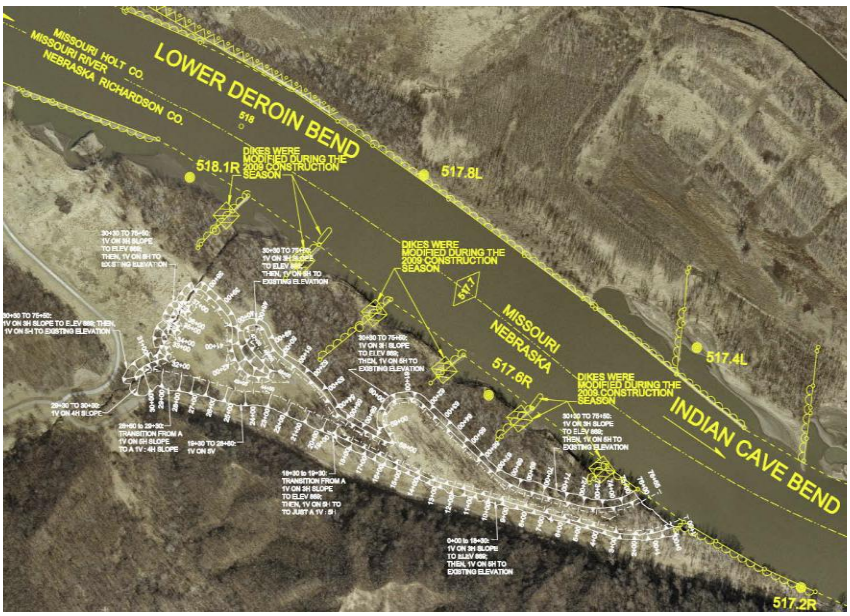

Figure 15. Deroin Bend/Indian Cave State Park backwater design

Adaptive Management to Existing Structures (Middle Decatur Bend Chute and Hole-In-The-Rock Backwater) – A construction contract was awarded to Newt Marine Service on July 30 2014 for the construction of the Hole-In-The-Rock Backwater Repair in Thurston County, Nebraska, and the repair of the Middle Decatur Chute in Burt County, Nebraska. The Hole-In-The-Rock Backwater Repair project consists of the excavation of approximately 30,000 cubic yards of material from the backwater to restore it to its originally constructed lines and grades. Excavation within the backwater would restore the connection between the backwater and the Missouri River main channel, and it would restore the original depths and side slopes that existed in the originally constructed backwater. This project also includes the restoration of two overwintering holes for fish that will be 10 to12 feet deep during the winter.

Figure 16. Hole-in-the-Rock Backwater

The 2011 Missouri River Flood deposited a significant amount of sediment into the Middle Decatur Bend Chute and the flood caused the bed of the river adjacent to the chute to degrade by approximately 2 feet. As a result, there was little to no flow in the chute during normal flows, and it no longer provided quality habitat for fish or other aquatic species. Restoration activities at Middle Decatur Chute included the creation of a 4,300 foot long pilot channel with a 50-foot bottom width by removing 88,000 cubic yards of flood-deposited sediment with a hydraulic dredge. In addition, the existing chute inlet was lowered by approximately 2 feet to compensate for the bed degradation that has occurred in the adjacent Missouri River.

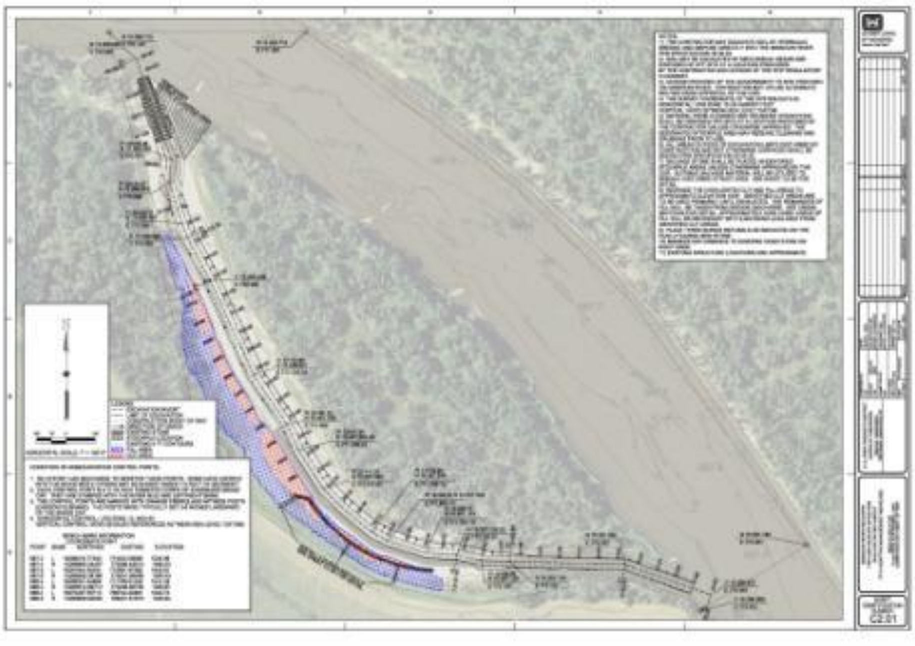

Figure 17. Middle Decatur Bend Chute Repair Project

Little Sioux Bend Chute – Construction of this project was completed in 2015. This project consisted of the excavation of approximately 400,000 cubic yards of river-borne sediment to create a 7,600-foot long flow through chute that is connected to the main channel of the Missouri River. The chute was excavated to an approximate width of 70-feet with an inlet structure that is approximately 150-feet wide. This would allow the 70-foot wide pilot channel to widen through natural river processes to an ultimate design width that is roughly the same as that of the inlet (150 feet). In addition, one tie channel that connects the chute to the main channel at a mid-point location was also constructed. The tie channel was excavated to the same dimensions as the chute. This project resulted in the creation of approximately 19 acres of SWH immediately after construction, with the potential for 33 acres of SWH once the chute expands to its projected ultimate width of 150 feet.

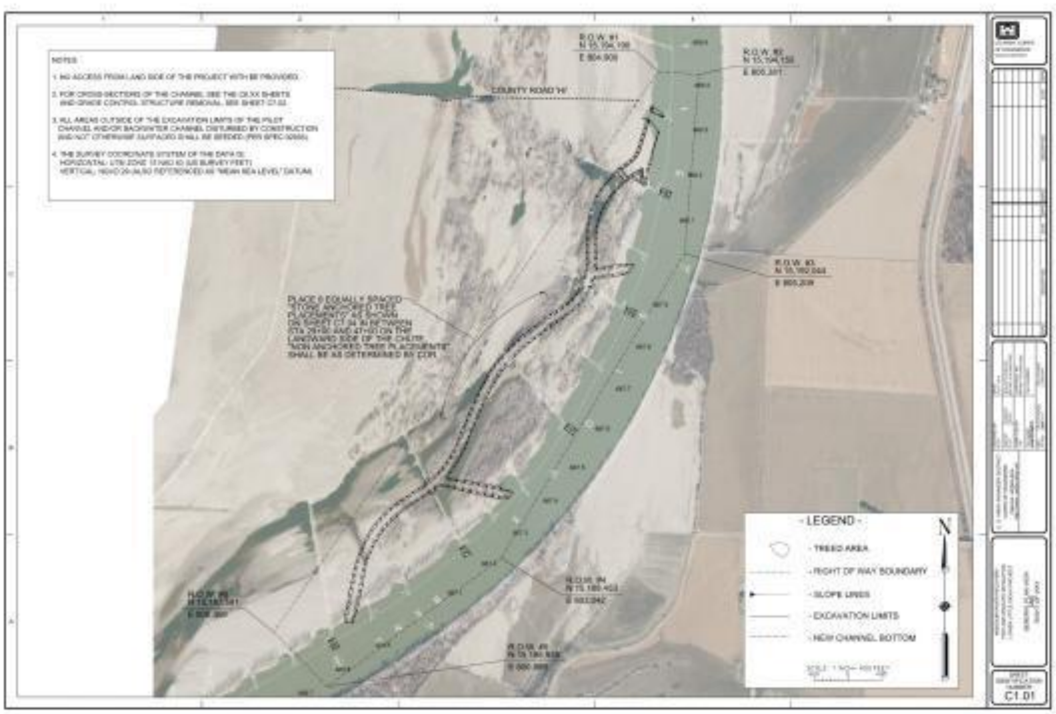

Figure 18. Little Sioux Bend Chute

River Structure Modifications – A construction contract was awarded to Western Contracting Corporation on September 29, 2014 for the construction of the River Structure Modifications Project. So far (as of December 2015) construction of this project has not been started. This project will restore SWH within a 48-mile section of the channelized Missouri River by further modifying 73 dikes adjacent to publicly owned land that were previously notched to create SWH. The proposed work would occur at Manawa Bend and Upper Plattsmouth Bend in Nebraska, and Pin Hook Bend, Upper Copeland Bend, Nebraska Bend, and Rock Bluff Bend in Iowa, located between RMs 609.0 and 561.0. Modifications to the previously notched dikes will consist of a number of different actions depending on the conditions observed at each individual dike. Modifications at each dike include one or more of the following actions:

1. Extension of the riverward side of the dike to force more flow through the existing notch.
2. Raising degraded dikes back to their design elevation of 1 to 3 feet above construction reference plane.
3. Filling in portions of existing notches to concentrate more flow against the river bank to encourage erosion.
4. Extension of notches further into the bank to encourage erosion farther into the bank.
5. Excavation of portions of the remaining rock rubble side-cast piles from the original dike notch construction to make the bank more erodible.

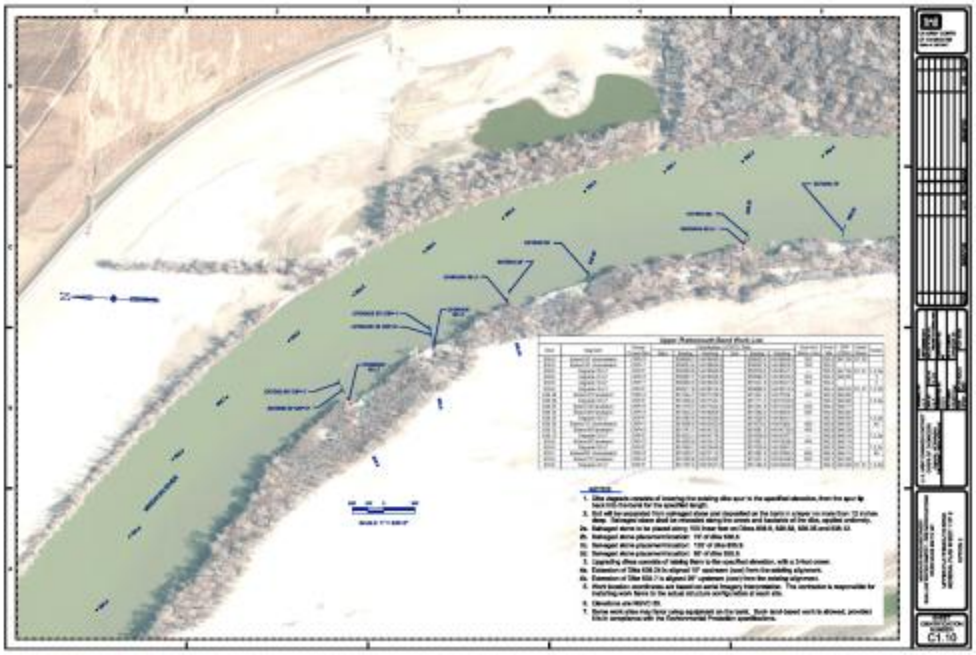

Figure 19. River Structures Modification Project

Louisville Bend SWH Enhancement – A construction contract was awarded to Western Contracting Corporation on September 29, 2014 for the construction of the Louisville Bend SWH Enhancement Project. This project restored capabilities and original design features of Louisville Bend to pre-2011 flood condition. This project consists of the excavation of approximately 30,000 cubic yards of material to create a new 2,700-foot long, 30-foot wide water supply channel with 2 horizontal on 1 vertical side slopes to restore the ability to transport water from the pump to a backwater wetland complex. The transportation of water from the pump to the backwater wetland complex would restore the Corps ability to manipulate pool levels within the backwater wetland complex using the existing pump station. An additional 60,000 cubic yards of material would be removed from an area within the existing pool near the downstream end of the backwater complex to create approximately 2.4 acres of overwintering habitat for fish that will be 12 to15 feet deep during winter.

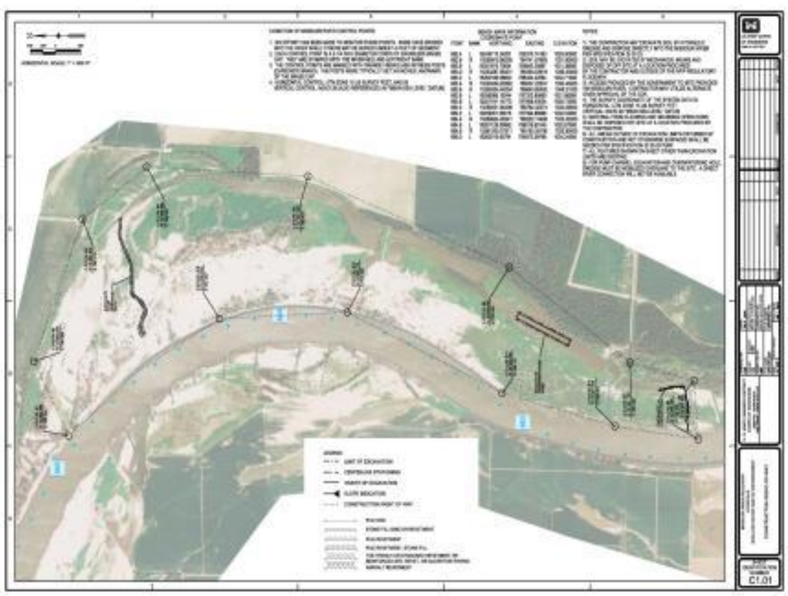

Figure 20. Louisville Bend SWH Enhancement Project

Glovers Point Bend SWH Enhancement – A construction contract was awarded to Newt Marine Service on September 27, 2013. Construction of this project was completed in 2015. This project consisted of removing flood deposited sediment from a constructed 30-acre backwater located on the Winnebago Indian Reservation, and expanding the size of the backwater to approximately 55 acres. Construction activities consisted of creating 10 to 1 side slopes along the shores of the backwater, construction of an L-head dike at the backwater entrance to control sediment deposition, and excavating over 900,000 cubic yards of material using a hydraulic dredge to create approximately 55 acres of SWH with two overwintering holes for fish that will be 10 to 12 feet deep during the winter.

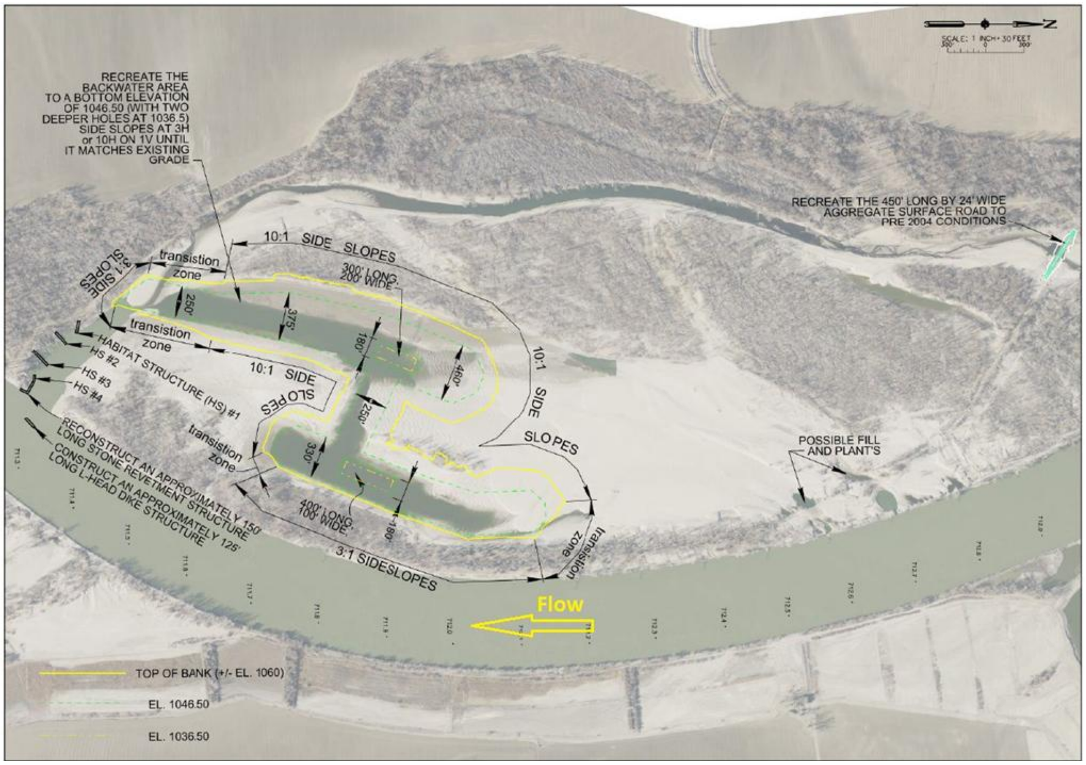

Figure 21. Glovers Point Bend SWH Enhancement Project

<u>Kansas City District</u>

Cora Island SWH restoration – A contract was awarded in September 2014 to construct up to three side-channel chutes at this site. The planned chutes would total 24,000 linear feet, naturally develop into 111 acres of SWH, and improve floodplain connectivity to approximately 1,200 acres of land. Two of the chutes were funded and construction began on them in October 2014. To date, Chute "C" has been constructed and remaining contract work and Chute "A" are expected to complete early summer 2016.

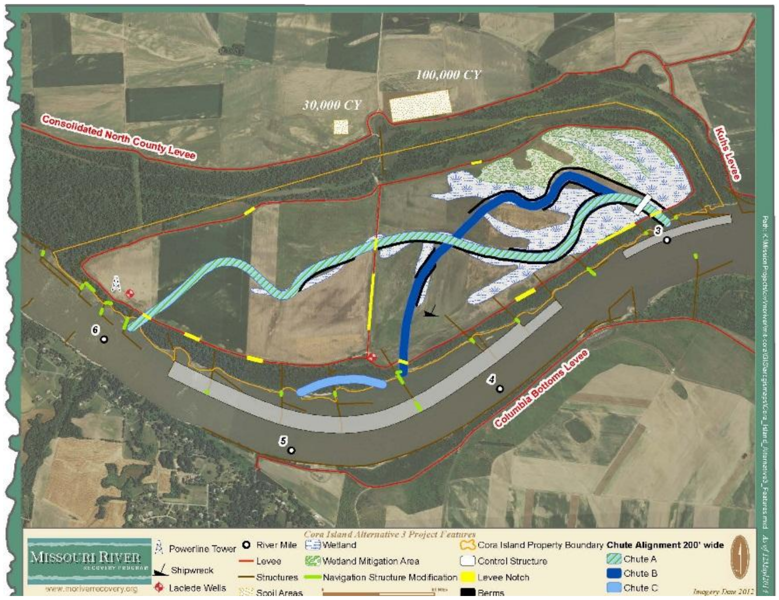

Figure 22. Cora Island MRRP Site

Cranberry Bend SWH restoration – A contract was awarded in October 2014 for construction of a side-channel chute at this site. The planned chute would total 8,900 linear feet, naturally develop into 41 acres of SWH, and improve floodplain connectivity to approximately 450 acres of land. Planned alterations to existing dikes will provide resiliency to the island and offset changes to water elevations in the main portion of the river. Construction began in November 2014 and is expected to complete in the spring of 2016.

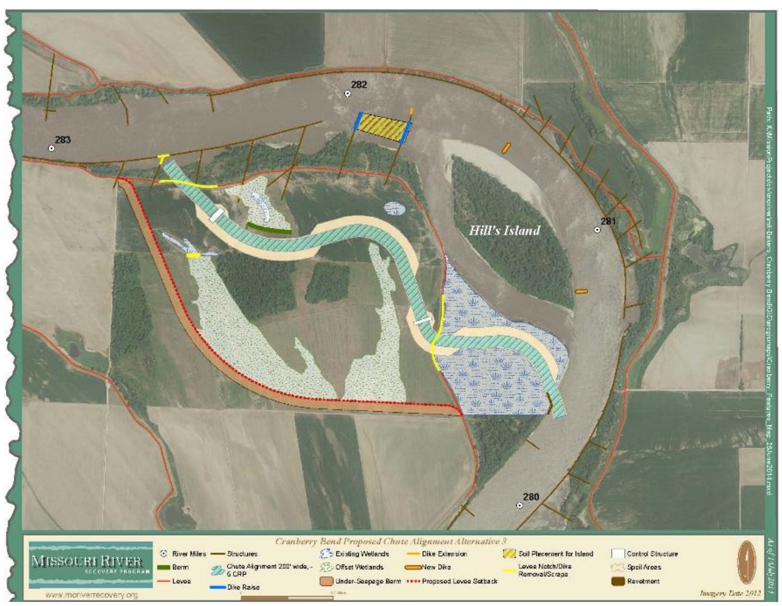

Figure 23. Cranberry Bend MRRP Site

Benedictine Bottoms SHW restoration – A contract was awarded in September 2013 to create two side-channel chutes at this site. The first side-channel chute is approximately 7,700 feet long and has multiple connections to the Missouri River at varying river stages. The mouth of the second side channel chute joins with the mouth of Independence Creek at the Missouri River. The project construction completed in September 2015 and will create approximately 65 acres of SWH upon full development.

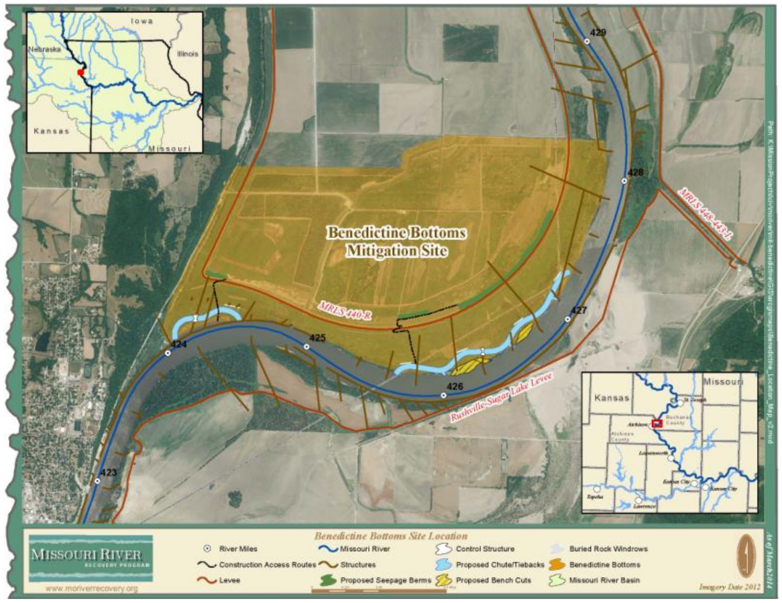

Figure 24. Benedictine Bottoms MRRP Site

Tadpole Island SWH adaptive management – A contract was awarded in September 2015 for modifications to the side channel chute at this site. The project will improve connectivity with the main stem Missouri River while maintaining the navigation channel. A series of alternating dikes will be placed in the side channel to further create more meander, lengthen the side channel, and slow water velocities. Project construction is scheduled to begin in November 2015 and complete in October 2016.

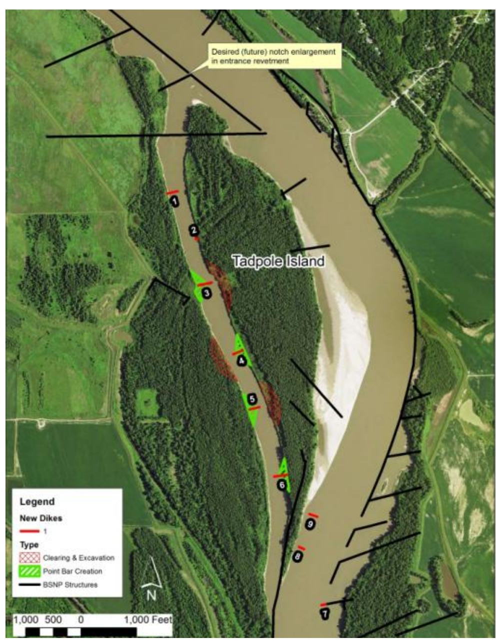

Figure 25. Tadpole Island MRRP Site

IV.C. Adaptive Management

AM efforts began on the Missouri River in conjunction with the drafting of the 2000 BiOp (and included in the 2003 Amended BiOp), and monitoring and research efforts to support AM began soon thereafter (Table 21). Previous efforts have included development of an ESH AM Strategy (2011), a SWH AM Strategy (2012) and an AM Process Framework in 2011 to describe the MRRP AM process and to explain how AM principles are used in the MRRP. As recommended by the ISAP (Doyle et al., 2011) and MRRIC in its 2012 recommendations (MRRIC, 2012), the

MRRP is developing a programmatic AM Plan that will guide future implementation of management actions for the three federally listed species on the Missouri River. The AM Plan is being developed in conjunction with the MP/EIS to provide NEPA coverage for a suite of actions intended to remove or preclude jeopardy status for the piping plover, interior least tern, and the pallid sturgeon. The AM Plan and MP/EIS are informed by a recently completed Effects Analysis (similar to Murphy et al., 2011) focused on assessing management hypotheses through multiple lines of evidence that will inform the MP/EIS process and the AM process.

Table 21. Timeline of MRRP AM Activities

Year	AM Effort/Milestone
2000	Biological Opinion (BiOp) called for an AM framework for resource management actions on the Missouri River
2001	Corps began funding Virginia Tech to initiate monitoring and research efforts on least tern and piping plover
2003	Amended BiOp reiterated need for an AM framework for resource management actions on the Missouri River
2005	Corps began funding USGS to conduct monitoring and research efforts on pallid sturgeon, least tern, and piping plover
2006	Revised Master Manual, which includes AM appendix documenting previous and new AM actions for system regulation
2007	Held AM workshop prior to the NRC review
	AM strategy to use Structured Decision Making process to develop AM components begun
2008	ESH team sent to NCTC to attend Rapid prototype Workshop to establish ESH AM Plan
	SWH structured decision making workshop was held to develop AM Plan for SWH
	Draft ESH AM Plan initiated; workshop on ESH scenarios
	AM '101' document titled "Adaptive Management: Background for Stakeholders in the Missouri River Recovery Program" published
2009	Draft AM discussed at MRRIC meeting
	HAMP analysis recommended changes to monitoring
	SWH AM plan development initiated
2010	Agencies and MRRIC seek Third Party Science Neutral to establish ISAP action approved by MRRIC on July 21, 2010
	MRRP Produced General Science Questions and Key Findings Report, a compilation of questions regarding the Science behind the MRRP
2011	MRRIC approved engagement approach for development and implementation of AM strategies
	Produced the first ESH Annual AM Report in a series, (Year 1: 2010), containing assessment of monitoring data and recommendations for adjustments
	AM Process Framework developed to describe how AM principles will be used to reduce uncertainties affecting Program objectives
	ESH AM Strategy (published as part of Programmatic EIS) described uncertainties, performance metrics, monitoring, and adjustment process for ESH management actions
	Final PEIS for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River
	ISAP called for a comprehensive MRRP AM plan in their "Final Report on Spring Pulses and Adaptive Management"
2012	Produced the Emergent Sandbar Habitat Annual Adaptive Management Report (Year 2: 2011)
	ESH program shifted focus from mechanical habitat creation to maintaining large amounts of habitat created by 2011 flow event and managing vegetation on existing sandbars.
	SWH program began to test different chute entrance control design in order to potentially improve accessibility for sturgeon drifting in lower portion of water column.
	Operational Draft SWH AM Strategy developed, describing objectives, performance metrics, management actions, monitoring, and research for SWH sub-program
2013	Missouri River Recovery Management Plan EIS initiated
	Produced the ESH Annual AM Report (Year 3: 2012)
	MRRP rolled out an online interactive application called the Missouri River Basin Explorer
	SWH Program constructed Deer Island top-width widening project to provide information regarding the potential benefits of mechanically widening the main channel
	MRRP Effects Analysis (EA) initiated
	Plover/Tern monitoring protocol changed from previous years to a sub-sampling design to cover abundance of available habitat resulting from 2011 flood and subsequent drought
2014	Produced the ESH Annual AM Report (Year 4: 2013)

	Effects Analysis AM Concept Paper prepared, describing recommended AM process and components for overarching AM plan; MRRP AM Plan formally initiated
2015	Development of AM Plan iteratively with input from MRRIC, ISAP and ISETR; a completed draft is expected in December 2016; the final AM Plan will accompany the final MP/EIS estimated late 2017.
	Adaptive Management Plan version 3 Draft circulated to MRRIC, ISAP, and ISETR for comments; multiple meetings and conference calls to inform and discuss comments with reviewers/stakeholders; revisions incorporated into next draft
	Attributes of Effective Governance paper prepared and distributed to inform and guide development of AM governance
	Preliminary data from HAMP research project indicates first genetically confirmed wild age-0 pallid sturgeon collected in lower Missouri River; data used to inform AM Plan Chapter on pallid sturgeon and Level 1-2 action planning

IV.C.I. Programmatic Adaptive Management Plan

IV.C.I.1. Purpose of the Adaptive Management Plan

The purpose of the aforementioned programmatic AM Plan is to describe a formal AM process led by the Corps and USFWS in implementing actions to avoid jeopardy for the three federally listed species. AM is a management concept that promotes collaboration, flexible decision-making and learning from the outcomes of management actions. Given uncertainties about the listed species and how they will respond to implemented management actions, the 2003 Amended BiOp called for an AM framework for management actions on the river. While previous AM documents have been developed for the MRRP (2011 AM Process Framework; 2011 ESH AM Strategy), until now there has not been a comprehensive AM plan for the Program, as called for by the ISAP in their 2011 Final Report on Spring Pulses and AM (Doyle et al. 2011).

The AM Plan for the MRRP provides a framework for conducting Program activities to deliberately and explicitly reduce management uncertainties. Based on an assessment of best available information and the building blocks for AM, the Plan describes a process featuring both policy/management and technical roles recommended for the MRRP to move towards a comprehensive AM Plan, as highlighted by the ISAP report. The MRRP is using a structured decision making process called PrOACT to assist in the construction the AM Plan. It involves a systematic assessment of alternative sets of actions and creates a highly collaborative engagement process with MRRIC stakeholders. This effort will help explore what will best meet the MRRP's goals and reduce critical management uncertainties under a wide range of possible future conditions. The result will be a scientifically defensible, stakeholder-coordinated AM design to be implemented, monitored, and evaluated.

The AM Plan and MP/EIS, outline a process for developing an alternative to remove or preclude jeopardy status for the piping plover, the interior least tern, and the pallid sturgeon. It builds on several of the products developed within the Effects Analysis conducted as part of the MP/EIS, including the conceptual ecological models for each species and updated species objectives, performance measures, and targets. This AM Plan will guide implementation of and adjustments to those MP/EIS management actions with uncertainty, and associated monitoring, research, and evaluation activities after the Record of Decision (ROD) has been signed. Utilizing the PrOACT process, the AM Plan:

1) Establishes a clear problem statement, objectives, actions and a monitoring program to measure and evaluate program performance and decision triggers that define the range of possible adaptive actions;
2) Establishes an efficient, transparent, and collaborative process involving stakeholders where information is shared, progress can be tracked, and decisions are understood;
3) Describes and formalizes the decision making process, identifies roles and responsibilities, including stakeholder participation, for MRRP implementation and decision making, and outlines a transition plan from the currently used practices (formal and informal) to the proposed approach; and
4) Outlines framework for adjusting management actions.

IV.C.I.2. Management Hypothesis

AM focuses attention on those highest priority components of decision problems to ensure actions are directly related to the information or decision needs. To help with that focus, high priority management questions, in the form of management hypotheses, will be used to guide evaluation of the system relative to the program goals and objectives, and to prioritize research to help reduce uncertainty over time. This approach has been used by other AM programs (e.g., Platte River Recovery Implementation Program, Upper Columbia) and is seen as a cornerstone of those programs. These management-relevant questions come directly from the management hypotheses developed as part of the Effects Analysis. The questions were separated into the upper and lower river specifically as follows.

Upper River:

1. Can spring pulsed flows from Fort Peck synchronize reproductive fish, increase chances of reproduction and recruitment?
2. Can naturalization of the flow regime from Fort Peck contribute to increased food production, foraging habitat, and survival of age-0 sturgeon?
3. Can water-temperature manipulations at Fort Peck contribute significantly to increased chance of reproduction and recruitment?
4. Can sediment bypass at Fort Peck contribute significantly to increased chance of reproduction and recruitment?
5. Can combinations of flow manipulation from Fort Peck, drawdown of Lake Sakakawea, and fish passage at Intake Dam on the Yellowstone River increase probability of successful dispersal of free embryos and retention of exogenously feeding larvae?
6. Can population augmentation (stocking) processes be enhanced to increase survival and genetic fitness of stocked fish?

Lower River:

1. Can spring pulsed flows synchronize reproductive fish, increase chances of reproduction and recruitment?
2. Can water-temperature manipulations at Fort Randall and/or Gavins Point contribute significantly to increased chance of reproduction and recruitment?
3. Can naturalization of the flow regime or channel reconfiguration (alone or in combination) contribute to increased food production, foraging habitat, and survival of age-0 sturgeon?
4. Can naturalization of the flow regime or channel reconfiguration (alone or in combination) contribute to decreased direct mortality and increased interception of free embryos into supporting habitats?
5. Can channel reconfiguration and spawning substrate construction increase probability of survival through fertilization, incubation, and hatch?
6. Can population augmentation (stocking) processes be enhanced to increase survival and genetic fitness of stocked fish?

IV.C.I.3. Components of the MRRP AM Plan

The process outlined in the AM Plan will improve MRRP implementation through a transparent governance and decision-making structure. The MRRP AM Plan is incorporating lessons learned from other large-scale AM programs (i.e. the Platte River Recovery Implementation Program, Columbia River Channel Improvement Project and Glen Canyon Dam) to maximize use of approaches and processes that have already been developed and are in use in the region for some of the same species. Material from other large-scale adaptive management plans has been incorporated into the MRRP AM Plan to ensure best practices are being used. The MRRP AM Plan can be summarized in a five-step sequential process, which is a modification of the AM cycle discussed in the US Department of Interior's technical guide to AM (Williams et al. 2009). Based on feedback from MRRIC, there are ongoing discussions about producing two AM graphics to show the process; a simple version and one with more detail. This basic AM process is outlined below:

Step 1: Assess, Plan, and Design
Step 2: Implement
Step 3: Monitor
Step 4: Evaluate
Step 5: Continue/Adjust/Complete

IV.C.I.4. AM Governance

A new approach to AM governance is being developed in concert with the AM Plan. The modified approach is in the development stages and is taking shape in close concert with MRRIC. The revised approach would not be formally adopted until signing of the MP/EIS ROD in 2016. The AM team has brought in expert AM governance help to assist with the development of governance structure and process. A recommendation from MRRIC on their involvement in AM governance is expected by August 2016. The agencies have met with the MRRIC AM Ad Hoc working group to further discuss options for interaction within the context of needing to create and promote decision space in AM governance.

IV.C.II. Shallow Water Habitat Adaptive Management

As a result of the 2003 Amended BiOp, the Corps began actively restoring SWH to benefit pallid sturgeon. Evidence suggests little, if any, pallid sturgeon recruitment has occurred (Steffensen et al., 2014) even though spawning has occurred on the lower Missouri River (Delonay et al., 2015). Continued evaluation of the SWH management action is needed. Increasing abundance of wild pallid sturgeon through increased natural recruitment is a fundamental objective of SWH creation, and although other objectives are important for evaluating hypothesized linkages between SWH actions and pallid sturgeon, the primary objective (pallid sturgeon population increase via increased natural recruitment) will ultimately determine if SWH creation efforts successfully reduce negative impacts of Corps operations.

Initial SWH efforts have focused on creating specific amounts of habitat projects that provide a depth and velocity combination of water < 1.5 m and < 0.61 m/s. Both the NRC (2011) and Doyle et al. (2011) have criticized this approach and recommended a programmatic adaptive management strategy focused on measurable species outcomes with defined targets. Following recommendations from these two reviews, the Corps has undertaken the development of a comprehensive AM strategy which will use a structured decision making approach to evaluate and implement existing and potential management actions. The primary hypothesis linking habitat restoration to pallid sturgeon population growth is founded on the assumption that poor larval survival, due to reduced nursery habitat, is currently limiting pallid sturgeon populations (USFWS, 2003). Ridenour et al. (2011), however suggest that slow and shallow areas may have little direct benefit as nursery habitat for age-0 sturgeon in the lower Missouri River. Similarly, results from Gosch et al. (2014) show that capture sites for exogenously feeding age-0 sturgeon were usually deeper (i.e., >1.5 m) and faster (i.e., > 0.5 m/s) than non-sturgeon sites in chute and adjacent mainstem habitats suggesting that slow and shallow habitats may not be used by age-0 sturgeon as frequently as other habitat types in the lower Missouri River. Subsequent analyses utilizing PSPAP capture data and HAMP physical habitat data (USACE, 2014) showed age-0 sturgeon were usually sampled in water > 1.5 m and catch rates were usually highest in the upper half (i.e., river kilometer [RKM] 400 to 800) of the lower Missouri River, whereas the availability of water < 1.5 m was usually highest in the lower half (i.e., RKM 0 to 400). Similarly, there was no relationship between age-0 sturgeon mean CPUE and ha/km of water < 1.5 m at any studied scale. These results may suggest that shallow water, as currently defined, may not be a suitable surrogate for assessing efforts to address pallid sturgeon population declines. Thus, future research initiated in 2014 and consistent with the ongoing Effects Analysis is focusing on determining if habitat availability is a limiting factor for pallid sturgeon and, if so, what type of habitats are required for increased survivorship and population growth.

The Effects Analysis developed the concept of addressing early life history recruitment with IRC habitat to more effectively address three specific aspects of early life history bottleneck to recruitment. It is intended that IRC provides the functions to support interception of drifting/migrating young, food production appropriate for exogenously feeding larvae and juveniles, and foraging habitat for developing young sturgeon. How IRC will be designed and built is not yet fully understood, and will be informed within the AM process through the pallid sturgeon AM and research framework Level 1 and Level 2 actions. It is expected that some of the existing SWH may be useful for some or all functions of IRC. These questions are now part of the overall SWH AM strategy and will be incorporated as needed in the updated AM Plan.

IV.C.II.1. Previous SWH-related monitoring and investigations

This information below is included for awareness of previous recommendations and conclusions from habitat monitoring and evaluations. This information is an integral component of current HAMP studies and objectives. The HAMP approach from 2006 through 2009 focused on two key questions:

1. Assess and monitor physical changes between control river bends and modified river bends by evaluating the following hypothesis:

Hypothesis: Dike notching increases habitat diversity and increases the amount of SWH in treated bends compared to control bends (river bends without notching). [This hypothesis and others related to expected physical responses of habitat creation efforts are identified in the SWH AM strategy.]

2. Assess and monitor responses of pallid sturgeon and other big river native fishes between control bends and modified bends by evaluating the following hypothesis:
Hypothesis: Species richness, diversity, and relative abundance of native target species *(i.e., YOY and juvenile pallid sturgeon, YOY and juvenile shovelnose sturgeon, sicklefin chubs, sturgeon chubs, speckled chubs, plains and western silvery minnow, YOY and juvenile blue sucker, and sauger)* increase in treated river bends (river bends treated with dike notches) compared to control river bends (river bends without dike notching). [This hypothesis is identified in the SWH AM strategy as well as other hypotheses related to the role of SWH and pallid sturgeon.]

IV.C.II.2. Assessment of fish response to structure modifications

All fish data collected over the initial six years of the HAMP were evaluated according to the BACI study design to answer the above questions. Results to date indicate there were no detectable changes in the fish community as a result of dike notching (Schapaugh et al. 2010). Similarly, Schloesser et al. (2011) compared fish communities among natural sandbars, notched, and un-notched dikes and found few differences. This work indicates that short-term changes resulting from dike notching do not result in increased use by native fishes. There are several hypotheses as outlined in these reports that could explain the results to date and that need to be evaluated moving forward, for example:

1. **Hypothesis: Dike notching has not yet resulted in enough physical habitat change to result in a detectable fish response.** Dike notches, especially those near the bank, are intended to widen the main channel over time within controlled ranges and locations, and to some degree restore habitats that were lost with channelization. These changes may require many years or decades to occur. Future evaluations need to include tracking of those habitat changes compared to expectations as well as monitoring of effects on native fishes following the guidance in the SWH AM Strategy.
2. **Hypothesis: The habitat changes that result from notching are not limiting for the target species.** To help address this hypothesis, a HAMP pilot project completed by the USFWS in 2010 (Ridenour et al. 2011) compared catches of the target HAMP species in river reaches with high abundance of SWH to reaches with low abundance of SWH to determine if there was a difference in the catches of target fishes and if so, provide support for setting expectations of fish community changes due to SWH creation efforts. Fish sampling methods were the same as used in previous HAMP monitoring. The pilot study indicated "a positive response by fishes to shallow water habitat MRRP Sites" but also provided several recommendations for future research and monitoring efforts to further our understanding of fish habitat needs and was used in the development of the SWH AM Strategy.
3. **Hypothesis: The benefits of SWH creation may not be measureable on an individual project basis.** Past studies assume that effects are contained within a bend or an individual dike structure. Effects which occur on larger scales would not be detectable with these designs. The HAMP pilot project (Ridenour et al. 2011) and HAMP analysis (Schapaugh et al. 2010) also provided several findings and recommendations regarding scale of analysis which were considered in development of the SWH AM Strategy.

IV.C.II.3. Age-0 sturgeon accessibility to constructed and modified chutes in the lower Missouri River chute access

SWH is hypothesized to provide nursery habitat for young fishes. The construction of side-channel chutes to restore shallow water habitat is common in the lower Missouri River; however, a recently developed adaptive management strategy document as well as previous research have suggested that chute accessibility of age-0 *Scaphirhynchus* sturgeon may be limited. Access is a critical prerequisite to young fishes utilizing chute habitat; thus, we investigated chute-specific accessibility for age-0 sturgeon at seven chutes (constructed and natural). Age-0 sturgeon were capable of accessing most chutes; however, accessibility appeared limited at sites with highly-restrictive inlet structures. Our results suggest that future consideration of chute inlet designs that meet authorized Missouri River purposes while providing improved fish access is warranted. Additionally, capture sites for exogenously feeding age-0 sturgeon were usually deeper (i.e., > 1.5 m) and faster (i.e., > 0.5 m/s) than non-sturgeon sites in chute and adjacent mainstem habitats; this finding is consistent with previous research (Ridenour et al., 2011) suggesting that slow and shallow habitats may not be used by age-0 sturgeon as frequently as other habitat types in the lower Missouri River (for the full report, please see Appendix E).

IV.C.II.4. Lessons Learned and Project Adjustments

In evaluating SWH projects, one of the main challenges is defining expectations (i.e. what does success look like and how do we determine when it is achieved?). These expectations occur at several levels and each is important. First, it is necessary to understand whether management actions are creating the desired physical habitat characteristics. Second, it is necessary to understand whether the anticipated biological responses are occurring at the project scale, and finally, if the desired physical and biological responses are occurring at the project scale, the system-wide response (i.e. increasing abundance of pallid sturgeon and other native fishes) must be evaluated to determine if SWH creation is having the desired effect or if other means need to be considered. To date, AM has focused primarily at the project scale with modifications being undertaken to improve SWH habitat. Actions to improve accessibility, increase sinuosity, and provide a better understanding of species response to structure modifications (river widening) were all initiated in 2012 and 2013, and age-0 *Scaphirhynchus* sturgeon were collected in Deer Island.

As previously indicated, the accessibility of chutes to age-0 sturgeon has received relatively little attention despite the fact that access is a prerequisite to retention. Previous efforts and anecdotal information suggest that access may be an issue, therefore modifications to project designs were undertaken to assess if accessibility could be improved through project modifications. The control structure at the Jameson Island site (completed in 2012) was the first attempt to improve accessibility. A modified control structure utilizing a "V" notch was implemented at the Jameson site and allows unobstructed flow from all depths of the water column. It is hypothesized that this design will allow increased access of sturgeon drifting in the lower portions of the water column. Other control structure modifications are currently being implemented at other locations. At the Benedictine Bottoms site (currently under construction) placement of the control structure will be within the downstream portion of the chute as opposed to the traditional location near the chute entrance. Again, it is hypothesized that this will increase the accessibility of the chute to sturgeon that may be drifting in the lower portions of the water column. Over time these design modifications will provide better understanding of maximizing age-0 sturgeon access to and use of chutes.

For chutes, an important factor in their physical progression that may be used to trigger AM adjustments is the achievement of "design width". Chutes are typically constructed as pilot channels with constructed channel widths that are far less than the ultimate future top width. Chutes constructed in this manner are intended to widen and develop over time and meander via natural cut and fill processes, within designed areas. In instances where a chute is not developing as desired (i.e. Upper Kansas), structures may be added to a chute to direct the flow to encourage these processes. As such, the Upper Kansas chute was modified in 2012 with the addition of 3 rock dikes to increase sinuosity, develop depth diversity, and speed the development rate of desirable chute characteristics. Monitoring at this site will allow better understanding of this type of existing project modification and lessons learned may be applied to additional chutes in the future.

IV.C.III. Emergent Sandbar Habitat Adaptive Management

In 2015, terns and plovers returned to the Missouri River to nest on habitat created by extreme high flows in 2011. It is estimated that 7,280 raw acres of ESH were available during the 2015 nesting season. Monitoring data from 2015 indicate that population sizes of both the piping plover and least tern increased from 2014 numbers, (tern adults = 720 in 2014 compared to 917 in 2015; plover adults = 1,116 in 2014 compared to 1,612 in 2015). In 2015, monitoring crews followed the historic TPMP protocol and surveyed all available habitat on the rivers and reservoirs for nests and chicks within a 7-day return interval.

With the large amount of habitat, the FY15 work plan continued to emphasize habitat maintenance and investigations focused upon learning about the dynamics of ESH and bird response after high flow events. No ESH construction activities were conducted in 2015. Sandbars identified for potential modifications were further evaluated during the Nebraska/South Dakota ESH PDT meeting held on October 29 and 30, 2014 in Yankton, South Dakota. Priority work was identified and the associated modeling and NEPA processes were initiated. Proposed modifications would include creating additional forage habitat on existing sandbars by creating low elevation ponds and streams within the sandbars. Multiagency teams in North Dakota, South Dakota, and Nebraska met several times during spring and summer of 2015 to determine which sandbars vegetation removal activities should be conducted on. Vegetation removal was conducted in 2015 in North Dakota, Nebraska, and South Dakota. Approximately 694 acres of sandbars were treated with herbicide in North Dakota by a contractor utilizing a helicopter equipped with boom sprayers. Approximately 704 acres of sandbar habitat were treated with herbicide in

Nebraska and South Dakota by a contractor utilizing a helicopter equipped with boom sprayers and 48 acres were sprayed utilizing an ATV. An additional 60 acres were mowed and cleared by Corps hired labor crews.

Two tern and plover research projects continued in 2015. The Spatial Variation in Population Dynamics of Northern Great Plains Piping Plovers (metapopulation study) will be used to estimate the degree of connectivity among four breeding areas of upper Missouri River system. The ESH Vegetation Modification Study is a study to determine methods to maintain suitable least tern and piping plover nesting and brood rearing habitat through vegetation modification. This study concluded in the fall of 2015.

IV.C.III.1. Lessons Learned and Future Adjustments

The ongoing Effects Analysis and subsequent development of the AM Plan are the primary focus of AM efforts related to least terns and piping plovers. The USFWS, assisted by the bird Effects Analysis team, used lessons learned and new information to update the current bird population targets and ESH targets. New targets will be available in the final AM Plan. The use of off-channel habitat for future management was identified as a potential resource to address habitat targets. Definitions of what constitutes off-channel will be discussed and appropriateness for MRRP evaluated, and a planning aid letter from USFWS is expected in 2016. The least tern and piping plover Effects Analysis team modeled and synthesized information to support management hypotheses developed during the Effects Analysis process, and in support of the MP/EIS alternatives formulation process, which will also be included in the final AM Plan.

IV.C.III.2. Recommendations for 2016

The following recommendations highlight the main areas of focus for 2016:

- In the near term, focus on maintaining existing habitat, especially through vegetation management. Balance the need for cottonwood regeneration with maintaining sandbars for terns and plovers.
- Implement measures to improve habitat quality on existing sandbars where acreage is high but nesting density is well below capacity.
- Continue to focus efforts on evaluating the characteristics of ESH sites that were created by the high flows and bird response to habitat characteristics and overall habitat acreage. Use this information to determine potential adjustments to the strategy for creating, adjusting, and replacing ESH.
- Use the Effects Analysis results and potential revised ESH targets and bird population targets to shape management for terns and plovers in coming years.

V. Flows and Sediment

V.A. Fort Peck

This has been suspended due to the Intake Diversion Dam Project. Please refer to past MRRP Annual Reports (2002, 2003, 2005, and 2006) for historical information.

V.B. Lewis and Clark Lake Sediment Study

The Lewis and Clark Lake Sediment Management Study (LCLSMS) was developed to examine the engineering viability of moving deposited sediments from the Lewis and Clark Lake into the Missouri River downstream of Gavins Point Dam. In Element IV.C of the 2000 Biological Opinion, the USFWS stated, “The Corps shall research and develop a way to restore the dynamic equilibrium of sediment transport and associated turbidity in river reaches downstream of Fort Peck, Garrison, Fort Randall, and Gavins Point Dams”. In addition, the conservation recommendations for pallid sturgeon in the 2003 Amended BiOp note “Based on the Corps’ 2002 Conceptual Analysis of Sediment Issues on the Niobrara and Missouri Rivers, there appears to be a feasible alternative to manage reservoir sediment (e.g., reservoir flushing). We strongly encourage the Corps to heed the advice of the contractor that prepared the report and proceed to a Feasibility Study.”

Sediment bypass around large dams has been shown to be feasible (Singh and Durgunoglu 1991), however any type of sediment bypass has not been used as a management technique on the Missouri River Mainstem Reservoir System. Initial consideration of using flows through Gavins Point Dam to transport deposited sediment was not strongly supported. Additional research on the Lewis and Clark Lake reach showed that there is the possibility of physically transporting sediments through Lewis and Clark Lake (Engineering and Hydrosystems, 2002). A number of different flow and stage scenarios were suggested by this research.

With the conservation recommendation for a study at Gavins Point Dam by the 2003 Amended BiOp and proof of concept provided by the 2002 Engineering and Hydrosystems' study, the LCLSMS was initiated in 2005.

Project Goals: The LCLSMS is an engineering viability study. As defined, the study will deal only with the physical processes of hydraulic flow, sediment erosion, sediment transport, and sediment deposition. Environmental, economic, political, and quality of life issues are not considered in the scope of this study. The project goals are:

- Evaluate the engineering viability of using varying discharges and stages through/in Lewis and Clark Lake to transport currently deposited sediments in the lake to/through Gavins Point Dam.
- Develop modeling tools that will allow for analysis of most upstream and downstream flow and sediment transport scenarios.
- Design a test flow that would verify the model (there is no physical test as part of this study)
- Draw conclusions about the viability of the flow alternatives modeled

Timeline: The LCLSMS began with the development of the study plan and scope of work for modifying GSTARS3 by the Colorado State University, Hydroscience and Training Center in 2005. Award of the work to develop GSTARS4 signaled the beginning of the study in late 2005. All the modeling efforts were completed during 2011 and a presentation of the results was offered in Yankton, South Dakota in November 2011. This initial phase (Phase I) was completed in May 2013 and published to the MRRP website.

Phase II was initiated by the ISP in late 2012 to examine additional questions that had been identified from the phase I results and stakeholder interaction and meetings. The reservoir model was converted to HEC-RAS modeling software to match the downstream model and make use of new sediment transport tools in the model. The reservoir model was completed in late 2013 and the downstream model was started in 2014. In order to reduce the uncertainly in the model results, and additional modeling study of an existing flush at Spencer Dam on the Niobrara River has been included into the Phase II effort. The Spencer Dam model results will be used to refine the reservoir model, and is expected to be completed by early 2016.

Phase I Study Results: The GSTARS4 modeling of Lewis and Clark Lake was completed in early 2011. The model output showed that some sediment, composed of silt and clay particles could be flushed from the reservoir (Yang and Ahn, 2011). However, none of the sediment that passed the dam in the models was sand, which is the primary focus for building downstream habitats. Any sand that was mobilized from the Lewis and Clark Lake delta appear to re-deposit in the deep part of the lake before passing the dam spillway. Table 22 shows the flushing scenarios modeled.

The GSTARS4 report, as well as the presentation materials, is available on the LCLSMS page of the MRRP website. The study, with recommendations was published to the MRRP website in early 2013.

Phase II Study Results: Table 22 lists the scenarios that were developed for this phase. They include flow levels that are much more common in the reach than those modeled in Phase I.

Table 22. Phase II Flushing Scenarios Modeled with HEC-RAS through Lewis and Clark Lake

Scenario	Flushing Flow	Flushing Duration	Description
II-1	None	None	No Action
II-2	60,000 cfs	7 days	Base alternative – Single drawdown flushing event
II-3	60,000 cfs	7 days	Scenario II-2 with 2064 geometry
II-4	60,000 cfs	7 days	Seven spillway gate inverts lowered to 1,170 ft
II-5	30,000 cfs	7 days	Half magnitude version of II-2
II-6a	60,000 cfs	7 days	Low Elevation Tunnels (invert 1,157 ft)
II-6b	30,000 cfs	7 days	Low Elevation Tunnels (invert 1,157 ft)
II-7a	180,000 cfs	~8 days	Repeat of Scenario I-1 from Phase I

II-7b	88,000 cfs	~10 days	Repeat of Scenario I-2 from Phase I
II-8	30,000 cfs	7 day repeating	Annual flushing event through 2064
II-9	30,000 cfs	7 day repeating	Annual flushing event with longitudinal revetment through 2064
II-10	30,000 cfs	7 days	Annual flushing event with dredging 675 tons per day through 2064

Once the Spencer Dam flushing model is completed, revisions will be made to the Lewis and Clark Lake model to more accurately predict the sediment transport associated with the flushing events. The Spencer Dam model results will be included in the Phase II reports.

In addition to the modeling, the study is developing a detailed cost estimate to continually dredge Lewis and Clark Lake using currently available dredging technologies. This estimate will assist in comparing the costs and benefits of sediment management in the reach. The dredging estimate summary will be released in early 2016.

Reports and fact sheets for the project can be downloaded from:
http://moriverrecovery.usace.army.mil/mrrp/f?p=136:155:12158203768534::NO::PIS_ID:28.

VI. Conservation: Cottonwoods

VI.A. Cottonwood Program

In late 2012 the Corps' Omaha and Kansas City Districts provided the Corps Ecosystem Center of Expertise (ECO PCX) all the necessary information to begin the certification process for the Cottonwood Model. A scope of work was initiated in February of 2014 and a contract was awarded to Battelle Memorial Institute in July 2014. Two panel members were selected for the model review; Dr. Brad Wilcox provided expertise in Research Community Ecology and Dr. Richard Stiehl provided expertise in Habitat Evaluation Procedures (HEP)/ Habitat Suitability Index (HSI) for the technical evaluation. A total of six comments were received. Once the comments are addressed and the model documentation is updated, the ECO PCX will prepare the recommendation for Regional Certification which is anticipated in early FY16.

VII. Land Acquisition

VII.A. Introduction

Land acquisition has been a key part of the BSNP Fish and Wildlife Mitigation Project and MRRP since their inceptions. Purchasing land from willing sellers provides the areas conducive to performing habitat restoration activities in support of the BiOp RPA elements related to SWH and Mitigation Project authorization. In FY15 land acquisitions were put on hold and only those negotiations which were started in the previous fiscal year were completed. The results of those acquisitions from FY15 are set out in section VII.C of this report. Corps Real Estate Divisions in both NWO and NWK continued to receive interest from several landowners indicating that they had land which they might be interested in selling to the MRRP.

VII.B. Background

The original authorization for the Land Acquisition and Habitat Restoration Project (Project) was based upon a report of the U.S. Army Corps of Engineers, Chief of Engineers, dated April 24, 1984, entitled "Missouri River Bank Stabilization and Navigation Project, Final Feasibility Report and Final EIS for the Fish and Wildlife Mitigation Plan." The authority to prepare the feasibility report was the 1958 Fish and Wildlife Coordination Act (P.L. 85-624). The final feasibility report described the fish and wildlife and habitat losses that have occurred due to the BSNP. Also described in the report are various measures to mitigate for these losses and a recommended plan to mitigate, preserve, or develop 48,100 acres of habitat. During the public involvement process for the EIS and feasibility report, a policy of obtaining lands only from willing sellers was established. Section 601 of WRDA 1986 authorized land acquisition and fish and wildlife mitigation based on the Chief of Engineers' recommendations. Preconstruction Engineering and Design (PED) for the Project was initiated in December 1989. As a part of PED work, the Corps completed the "Missouri River Bank Stabilization and Navigation Fish and Wildlife Mitigation Reaffirmation Report, July 1990." The purpose of the reaffirmation report was to confirm that the plan recommended in the 1984 feasibility report and final EIS was still viable. PED was completed in September 1991 and the Project has been in a "construction" status since that time. The reaffirmation report explains the various aspects of the Project such as the approval process, funding levels, costs, schedules, documentation and involvement of other state and federal agencies.

An additional portion of the reaffirmation report was dedicated to the establishment of roles and responsibilities for execution of the program in accordance with an Agency Coordination Team (ACT). Because the BSNP was constructed and maintained by federal action, the Project, now part of the MRRP, is 100 percent federally-funded. However, even though there is not a cost share sponsor, federal and state fish and wildlife agencies participate in the implementation of the MRRP. The agency participation is primarily through an ACT that was developed to formulate and decide upon the various acquisition sites and appropriate mitigation for the sites. Members of the ACT are the IDNR, the NGPC, the Kansas Department of Wildlife and Parks (KDWP), the MDC and the USFWS. Other agencies have also been invited to participate in team meetings.

"Real Estate Design Memorandum No. 1" was completed in March 1990. This report established the real estate requirements for the acquisition in fee or easement of 29,900 acres of privately-owned lands and for any real estate requirements for development of 18,200 acres of existing public lands within the four affected states. WRDA 1999 expanded the amount of acres authorized for the Project from 48,100 acres to a new total of 166,750 acres. As directed in the authorization, the Corps worked with the ACT to develop a cost estimate to implement the additional acres authorized by WRDA 1999.

In December 2001, the Corps completed a document titled "Missouri River Mitigation Project, Missouri, Kansas, Iowa, and Nebraska, Report to Congress, in Compliance with the Water Resources Development Act of 1999." This document presented a cost range for implementation of the WRDA 1986 authorization and WRDA 1999 modification from $826 million (includes development of 7,000 acres of shallow water habitat) to $1.425 billion (includes development of 20,000 acres of shallow water habitat) based on October 2001 price levels.

Since the expanded authorization of WRDA 1999 resulted in a significant change to the Project, from August 2001 to June 2003, the Corps prepared a supplemental EIS for the Project. The draft supplemental EIS was published in September 2002. The final supplemental EIS was published March 1, 2003. The Corps issued a ROD on June 12, 2003. This decision, along with the final supplemental EIS, reflects the programmatic plan for implementation of the current mitigation program. As per the June 12, 2003 ROD, the plan includes development of 7,000 to 20,000 acres of SWH to address pallid sturgeon habitat goals established by the USFWS in the 2003 Amended BiOp.

The Corps recognizes its Fish and Wildlife Mitigation responsibilities for the construction of the BSNP set forth through the Fish and Wildlife Coordination Act (FWCA) process and enacted in WRDA 1986 and 1999. Habitat development on acquired lands does result in mitigation credit. However, in 2014, federal budget priorities shifted to actions that also meet ESA obligations. In carrying out the WRDA authorities, efforts and land acquisition are currently focused on mitigation actions that meet BiOp requirements.

VII.C. Real Estate Acquisition

The Real Estate acquisition element of the Missouri River Recovery Program is based on a "willing seller" approach. Relying, as this approach does, on landowners being willing to sell their property to the Corps, this means that it is often difficult for the Corps to quickly acquire *all* of the real estate necessary to construct a specific project at a given river bend at one time.

Instead the Corps acquires property only from those landowners with whom it is able to reach mutually agreeable terms. When arriving at these terms, the Corps is required by law to pay fair market value for a given parcel of property. The determination as to what the fair market value of a specific piece of land will be is determined by a certified appraiser valuing the property in accordance with the Uniform Appraisal Standards for Federal Land Acquisition ("Yellow Book" standards). Once the fair market value has been determined, a landowner is free to accept the appraised price or to reject it.

Prior to any more extensive acquisition efforts by the Corps, each prospective real estate purchase is evaluated by a PDT for its restoration potential and suitability. If the parcel does not show sufficient restoration potential, the parcel will be rejected and will not be acquired. Prospective acquisitions that have been approved by the PDT are also prioritized in terms of restoration potential and the extent to which a particular parcel will work to allow construction at a given river bend. As in previous years, effort was undertaken to ensure that the tracts acquired in 2014 were particularly suitable for the establishment of SWH. This was done in an effort to allow for the Corps to continue developing SWH in keeping with the rates of construction anticipated by the BiOp, in spite of the cessation of real estate acquisition in FY15.

In FY15, NWO did not acquire real estate as a result of the moratorium noted above. Nevertheless, the NWO was contacted by a number of landowners interested in possibly selling their property to the Corps for the MRRP. All such interested parties were notified that the MRRP had no plans to resume land acquisition for the immediate or foreseeable future. In the event that funds should once again become available for land acquisition through the MRRP, these potentially interested landowners would be contacted.

In FY15, NWK received a fair amount of interest in selling to the Corps for the MRRP. Those interested parties were told that we have no funds for acquisition, but if in the near future we would receive authorization and funding, we would contact them.

Appendix C of this Annual Report is comprised of a spreadsheet that lists all of the acquisitions that have been accomplished for the combined program/project. This year it includes information on updates that have been made to site names and corrections to information in previous annual reports.

VII.D. Mitigation Agency Coordination Team Activities

The Mitigation ACT met three times in FY15 to discuss implementation of the Mitigation Project. ACT efforts are centered around the FWCA, which calls on the Corps to coordinate with the USFWS and state fish and game agencies on water resource development projects. As mentioned above, the four fish and game agencies for the Mitigation Project are the IDNR, the NGPC, the KDWP and the MDC. However, several other agencies and non-governmental organizations interested in conservation are invited to attend such as the EPA, USGS, Natural Resources Conservation Service, MDC, and The Nature Conservancy. In addition, one or two members of the MRRIC typically attend the ACT meeting. Coordination meetings in FY15 were held as follows:

- October 27, 2014 – MDC Office, St. Joseph, MO
- January 29, 2015 – MDC Office, St. Joseph, MO
- April 22, 2015– MDC Office, St. Joseph, MO

Topics discussed included a review of FY14 Program Execution, FY14 Real Estate Accomplishments, FY14 SWH Accomplishments, the FY15 Budget, FY15 Planning and Engineering Projects, Outreach/Educational Opportunities and Strategies, the Lewis and Clark Sediment Transportation Study update, ACT meeting frequency, SWH and ESH creation efforts, Annual Land Management activities and concerns, SWH Check-in updates, larval pallid sturgeon discoveries, HAMP updates, the collaborative research project between USGS-University of Missouri: Floodplain Science Needs, AM and Mitigation/SWH Monitoring and MRRP AM updates.

VII.E. Mitigation Project Monitoring

In 2005, a monitoring and evaluation (M&E) plan was prepared by an M&E Committee appointed by the Mitigation ACT. The goal of the M&E plan is to understand the physical and biological responses to the Mitigation Project's actions within an adaptive management context. The objectives of the M&E plan include the following:

- Track location, type, and physical characteristics of each MRRP Site.
- Quantify habitat use and population responses of key species.
- Recommend adaptations based on new information.
- Gain understanding of the physical and biological responses through time.
- Formalize information transfer among all to communicate lessons-learned and increase the effectiveness of project actions.

This information was intended to help determine the Mitigation Project's level of success and provide a basis for future adaptive management. By monitoring the MRRP Sites and collecting basic habitat data, the ACT can determine whether the MRRP Sites are performing as expected.

The Mitigation M&E Subcommittee last met at the end of 2009, and has since disbanded. All monitoring and evaluation for the MRRP is now coordinated through the ISP. The last mitigation specific monitoring study recommended by the Mitigation M&E Subcommittee was the Missouri River Mitigation Wetland Restoration Functional Assessment. This was a five year study that monitored herpetofauna (primarily amphibians) to determine wetland quality at MRRP Sites in Iowa, Nebraska, Kansas and Missouri. Wetland quality was determined by quantifying the occurrence and recruitment of amphibians at existing MRRP Sites and formulating models of quality wetland restorations. These models can then be used in the future to guide wetland restorations and adaptively manage existing restoration projects. This study commenced in 2009 and the draft final report was received by the Corps in August of 2014.

VII.E.I. Physical Monitoring

Physical monitoring activities performed in FY15 include ongoing monitoring and mapping of land cover and limited hydrographic surveys to document how some of the shallow water habitat sites are developing as part of the Corps engineering assessment.

VII.E.II. Land Cover Mapping

Habitats are classified using the National Wetland Inventory (NWI) for aquatic and wetland areas and the National Land Cover Data (NLCD) classification system for all upland habitats. The existing habitat conditions are being documented for each site to establish the habitats that existed prior to acquisition by the MRRP under the BSNP Fish and Wildlife Mitigation authority. This data will be established and maintained by the Corps as a GIS land-cover data layer. MRRP funds are used to complete land-cover maps at all sites and to document the baseline conditions for use in NEPA documents. Newly purchased sites are typically mapped within the first year. Previously mapped sites are updated at least once every five years to track changes over time and monitor progress, but may be done more frequently, such as after major phases of work or as needed to create NEPA compliance documents. Baseline conditions at all sites were completed in 2008. All baseline conditions for sites acquired since 2008 will be mapped and then placed into the 5-year update cycle. Desired-conditions maps are often completed when going through the NEPA process and can be a useful tool for tracking progress towards the goals for each site. Table 23 presents the status of all site land-cover maps.

Table 23. MRRP Site landcover mapping status

District	No.	State	Site Name	Baseline Edition	Land Cover Status
NWK	1	MO	Aspinwall Bend	3rd	Final
NWO	2	NE	Audubon Bend	2nd	Final
NWO	3	IA	Auldon Bar	6th	Final
NWK	4	MO	Baltimore Bend	5th	Final
NWK	5	MO	Bean Lake	2nd	Final
NWK	6	KS	Benedictine Bottoms	4th	Final
NWK	7	MO	Berger Bend	4th	Final
NWO	8	IA	Blackbird Bend	5th	Final
NWK	9	MO	Bootlegger Bend	2nd	Final
NWO	10	NE	Brownville Bend	3rd	Final
NWK	69	MO	Bryan Island	1st	Final
NWK	11	KS	Burr Oak	3rd	Final
NWO	12	IA	California Bend	5th	Final
NWK	13	MO	Cambridge Bend	2nd	Final
NWK	14	MO	Camden Bend	2nd	Final
NWO	70	IA	Civil Bend (IA)	1st	Final
NWO		NE	Civil Bend (NE)	1st	Final
NWK	15	MO	Columbia Bottom	4th	Final
NWK	16	MO	Confluence Point	2nd	Final
NWO	17	IA	Copeland Bend	5th	Final

NWK	18	MO	Cora Island	2nd	Final
NWK	19	MO	Corning	5th	Final
NWO	71	NE	Cottier Bend	1st	Final
NWO	20	IA	Council Bend	3rd	Final
NWK	21	MO	Cranberry Bend	2nd	Final
NWK	22	KS	Dalbey Bottoms	3rd	Final
NWK	23	MO	Deroin Bend	5th	Final
NWK	24	MO	Eagle Bluffs	4th	Final
NWK	25	KS	Elwood Bottoms	4th	Final
NWO	26	IA	Fawn Island (Little Sioux)	2nd	Final
NWO	28	NE	Glovers Point Bend	3rd	Final
NWK	29	MO	Grand Pass	4th	Final
NWK	30	MO	Grand River Bend	2nd	Final
NWO	31	NE	Hamburg Bend	5th	Final
NWK	32	MO	Heckman Island	2nd	Final
NWO	33	NE	Indian Cave Bend	2nd	Final
NWK	34	MO	J and O Hare Wildlife Area	4th	Final
NWO	35	NE	Kansas Bend	5th	Final
NWK	36	MO	Kickapoo Island	2nd	Final
NWO	37	NE	Langdon Bend	6th	Final
NWO	38	IA	Little Sioux Bend	4th	Final
NWO	39	IA	Louisville Bend	6th	Final
NWO	40	IA	Lower Dakota Bend	2nd	Final
NWK	41	MO	Lower Hamburg Bend	5th	Final
NWO	27	IA	M.U. Payne	2nd	Final
NWO	42	IA	Middle Decatur Bend	5th	Final
NWK	43	MO	Nishnabotna	5th	Final
NWO			Nishnabotna Bend	5th	Final
NWO	44	IA	Noddleman Island	5th	Final
NWO	45	SD	North Alabama Bend	2nd	Final
NWK	46	KS	Oak Mills	2nd	Final
NWK	47	MO	Overton Bottoms	5th	Final
NWO	48	NE	Plattsmouth Chute	4th	Final
NWO	49	NE	Ponca State Park	2nd	Final
NWK	50	MO	Providence Bend	2nd	Final
NWK	51	MO	Rush Bottom Bend	5th	Final
NWO	52	IA	Sandy Point Bend	3rd	Final
NWK	53	MO	Sni Bend	2nd	Final
NWO	54	IA	Snyder-Winnebago Complex	5th	Final
NWO	55	NE	Sonora Bend	2nd	Final
NWO	56	IA	St Marys Island	5th	Final
NWK	57	MO	Tammerlane Bend	2nd	Final
NWK	58	MO	Tate Island	4th	Final
NWO	59	IA	Three Rivers (Little Sioux)	2nd	Final
NWK	60	MO	Thurnau	5th	Final
NWO	61	IA	Tieville Bend	5th	Final
NWO	62	NE	Tobacco Island	6th	Final

NWO	63	IA	Tyson Bend	4th	Final
NWO	64	IA	Upper Decatur Bend	5th	Final
NWO	65	NE	Van Horns Bend	5th	Final
NWK	66	MO	Weston Bend	3rd	Final

Due to the acquisition of the ENVI suite of Remote Sensing software we were able to map all 73 MRRP sites in FY15. This far exceeds the stated prior year goal and establishes a new benchmark for the program going forward. All individual sites' data will be combined to establish a summer of 2014 project-wide database. This database will be combined with existing land cover data so that multi-year programmatic comparisons can be derived.

Imagery acquisition has undergone similar improvements. Due to the federal contract with Digital Globe (a commercial satellite imagery provider), imagery can now be ordered and obtained within a two week window. This will provide the Land Cover Mapping Team with more timely deliverables in the future and will improve the overall accuracy of our collection.

VII.F. Land Management Activities

The U.S. Army Corps of Engineers regulation ER 1130-2-540 established land management policy for Corps-administered project lands and water, based on various authorizing legislation and the principles of good environmental stewardship. Corps policy is to ensure the conservation, preservation, or protection of those natural resources for present and future generations. Land and natural resource management activities at the MRRP sites are on-going and include, but not limited to, restoring native vegetation, invasive species control, habitat improvements, public access, Title 36 enforcement, and other operational and maintenance activities. Management measures are being identified to implement the USFWS Pollinator Initiative based on the Corps Pollinator Protection Plan. A key component of land management at these sites is the partnerships established with several State and Federal agencies to conserve and protect fish, wildlife and their habitat, along with other compatible uses such as hunting and fishing. Annual management plans are developed jointly between the Corps and the land management partners to determine activities and funding for each site. Funding sources include agricultural lease funds, O&M funding for completed sites, and MRRP funding for sites that are still in development or planning stages. Natural resource managers for both NWO and NWK oversee implementation of these management activities.

VIII. MRRP Management Plan/Environmental Impact Statement

The MP/EIS process was developed to address the MRRIC recommendations (discussed below), provide NEPA compliance for current and future management actions, and develop a comprehensive AM plan. The MP/EIS is utilizing the latest science to evaluate the reasonableness, effectiveness, and the programmatic effects of current actions and potential future actions to avoid jeopardy.

In 2012, MRRIC recommended actions based on a report produced by the ISAP, *Final Report on Spring Pulses and Adaptive Management* (ISAP, 2011). MRRIC's proposed actions based on ISAP recommendations:

1. An effects analysis should be developed that incorporates new knowledge that has accrued since the 2003 Amended BiOp. As part of this analysis the effects of the Missouri and Kansas River operations on the listed species should be reviewed and analyzed in the context of other stressors on the listed species; the quantitative effects of potential management actions on the listed species should be document to the extent possible; and these potential management actions should be incorporated into the conceptual ecological models.
2. Conceptual Ecological Models (CEMs) should be developed for each of the three listed species, and these models should articulate the effects of stressors and management actions (including but not limited to flow management, habitat restoration actions, and artificial propagation) on species performance.
3. Other managed flow programs and adaptive management plans should be evaluated as guidance in development of the CEMs and AM strategy for the MRRP.
4. An overarching adaptive management strategy should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction, and this strategy should be used

to guide future management actions, monitoring, research, and assessment activities within the context of regulatory and legal constraints.

5. Monitoring programs along the Missouri River should be designed so as to determine if hypothesized outcomes are occurring and the extent to which they are attributable to specific management actions.
6. The agencies should identify decision criteria (trigger points) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.
7. Aspects of how the entire hydrograph influences the three listed species should be evaluated with assessing the range of potential management actions.

In responding to the MRRIC recommendations, the Corps has been working on an initial Effects which developed CEMs, quantitative models (where possible), analyzed how the entire hydrograph influenced the listed species, and identified key areas for future research and monitoring in order to fill current data gaps. Due to the still limited information on the lower basin pallid sturgeon, an expert elicitation process was conducted to prioritize key hypotheses for near-term implementation. The team utilized this information and quantitative bird models to develop alternatives to be discussed with MRRIC, basin stakeholders and members of the public.

MRRIC and ISAP are actively involved in the development of the MP/EIS facilitating buy-in and increasing transparency. This level of involvement is one of the benefits to the informal consultation approach in the MP/EIS. The ISAP in particular has been involved in reviewing multiple components of the alternatives, species effects, and the adaptive management plan.

Human considerations are also being developed in collaboration with MRRIC to have a better understanding of what social, economic, and cultural resources may be affected by any action considered in the MP/EIS as well as develop approaches to implementation that considered acceptability. Proxies for each human consideration resource have been developed in order to facilitate a trade-off discussion with MRRIC regarding the alternatives. Once an alternative has been recommended a detailed analysis of all human considerations (organized by the four accounts as described in the Principles and Guidelines) will be conducted for a full understanding of the effects to important stakeholder resources. MRRIC has established an Independent Socioeconomic Technical Review panel to review the development and implementation of human considerations analysis.

The team will continue to refine and further develop the overarching adaptive management plan including revising the monitoring plan, laying out clear triggers for changes to implementation, and fully fleshing out the governance structure for the program. This will address one of the remaining MRRIC recommendations.

Results of the MP/EIS are anticipated to lead to consultation with USFWS resulting in potential amendments to the current BiOp that will avoid jeopardy to the listed species using the latest science. An adaptive management plan for the MRRP will allow for further definition of success, monitoring of progress, refinement of BiOp requirements, and establishment of a program end state.

IX. Missouri River Recovery Implementation Committee

MRRIC is a 70-member committee made up of federal, state, tribal, and stakeholder representatives from throughout the basin. MRRIC is authorized by Section 5018 of WRDA 2007 and established by the Assistant Secretary of the Army for Civil Works (ASA). The duties of the Committee, as outlined in Section 5018 of WRDA 2007, include making recommendations and providing guidance on a study of the Missouri River and its tributaries (currently not funded), as well as on the existing MRRP and Mitigation Plan. MRRIC may make recommendations related to the MRRP on the following: changes to Program implementation through adaptive management; development and coordination of consistent policies, strategies, plans, programs, projects, activities, and priorities; exchange of information to promote the Program goals; establishment of working groups as necessary; facilitating resolution of interagency and intergovernmental conflicts associated with the Program; coordination of scientific and other research associated with the Program; and preparation of an annual work plan and budget requests. The Committee includes broad stakeholder representation to ensure a comprehensive approach to MRRP implementation while providing for congressionally authorized Missouri River project purposes and to ensure public values are incorporated into the study (currently not funded) and the recovery and mitigation plans.

Meetings
During 2015, MRRIC continued to meet at different locations throughout the basin. Quarterly meetings were held at Kansas City, Missouri (24-26 February 2015); Sioux Falls, South Dakota (19-21 May 2015); Omaha, Nebraska (25-27 August 2015); and Rapid City, South Dakota (17-19 November).

Organization
MRRIC selects its Chair and Vice Chair and has input into the selection of the facilitation team. The US Institute for Environmental Conflict Resolution provides support services to MRRIC through a Memorandum of Understanding with the Corps, and in turn contracts with the Chair and the facilitation team. Dr. Michael Mac, retired from the US Geological Survey, served as Chair during 2015. Jim Becic, stakeholder member representing Fish and Wildlife, was the Vice Chair for 2015.

The Committee has established standing Work Groups consisting of MRRIC members, alternates, agency staff, and others who have been approved by the full MRRIC. Work Groups allow MRRIC members to better understand the actions at hand and work directly with the agencies to make recommendations on how the MRRP can be as effective as possible while ensuring public values are incorporated into the plans. The Work Groups are indispensable for carrying out MRRIC's work. The groups meet by facilitated conference calls and occasional in-person meetings. They help prepare and review presentations for plenary session and develop recommendations for MRRIC's consideration. Work Groups active for at least part of 2015 included the: Adaptive Management Ad-Hoc Group, Agenda Work Group, Communications Work Group, Human Considerations Ad Hoc Group, Membership Process and Procedures Ad Hoc Group, Science and Adaptive Management Workgroup, Strategic Planning and Assessment Taskgroup, Tern and Plover Taskgroup, and the Tribal Interests Workgroup. Details on the organization of MRRIC and accomplishments of the Work Groups can be found in MRRIC's Annual Report.

Accomplishments
Because MRRIC approves its recommendations by consensus, each proposal is fully vetted through work group deliberations and discussions at one or more MRRIC meetings. While this process is often tedious, it encourages informed decision-making and widespread agreement for adopted recommendations.
During 2015, MRRIC made several substantive recommendations to the lead agencies (USACE and USFWS).

- FY16 Work Plan Recommendations for the Missouri River Recovery Program, August 2015
- Expedite Implementation of Reimbursing Travel Expenses, February 2015
- Encourage Regular Attendance and Engagement of the Environmental Protection Agency
- Letter to ASA Jo Ellen Darcy Regarding Real Property Acquisition

During 2015 MRRIC also began work on the important task of developing a recommendation on MRRIC involvement in the AM Process. The AM process is expected in the August 2016 timeframe. For the complete texts of the recommendations and the agencies' responses, see www.mrric.org.

X. Acknowledgements

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2. USFWS, Bismarck Ecological Services Field Office, North Dakota
3. USFWS, Columbia Fish and Wildlife Conservation Office, Missouri
4. U.S. Army Corps of Engineers (USACE), Threatened & Endangered Species Section, Omaha District, Nebraska

5. USFWS, Northern Rockies Fish and Wildlife Conservation Office, Billings, Montana
6. USFWS, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota
7. USFWS, Missouri River Fish and Wildlife Conservation Office, Bismarck, North Dakota
8. USFWS, Columbia Ecological Services Field Office, Missouri
9. U.S. Geological Survey**,** Columbia Environmental Research center**,** Missouri
10. USFWS, Bozeman Fish Technology Center, Bozeman, Montana
11. USACE, Omaha District, Omaha, Nebraska
12. Nebraska Game and Parks Commission, Lincoln, Nebraska
13. USACE, Kansas City District, Kansas City, Missouri
14. USACE, Northwest Division, Omaha, Nebraska
15. USACE, Fort Randall Project Office, Pickstown, South Dakota
16. National Park Service, National Park Service Office, Yankton, South Dakota
17. USFWS, Gavins Point Fish Hatchery, Yankton, South Dakota

XI. References

Adams, S. R.; Hoover, J. J.; Killgore, K. J., 1999: Swimming endurance of juvenile pallid sturgeon, Scaphirhynchus albus. Copeia 3, 802–807.

Bajer, P.B., and M.L. Wildhaber. 2007. Population viability analysis of Lower Missouri River shovelnose sturgeon with initial application to the pallid sturgeon. Journal of Applied Ichthyology 23:457–464.

Braaten, P. J., D. B. Fuller, and N. D. McClenning. 2007. Diet composition of larval and young-of-year shovelnose sturgeon in the upper Missouri River. Journal of Applied Ichthyology 23:516-520.

Braaten, P. J., D. B. Fuller, L. D. Holte, W. Viste, T. F. Brandt, and R.G. Legare. 2008. Drift dynamics of larval pallid sturgeon and shovelnose sturgeon in a natural side channel of the Missouri River, Montana. North American Journal of Fisheries Management 28:808-826.

Braaten, P. J., D. B. Fuller, R. D. Lott, M. P. Ruggles, and R. J. Holm. 2010. Spatial distribution of drifting pallid sturgeon larvae in the Missouri River inferred from two net designs and multiple sampling locations. North American Journal of Fisheries Management 30:1062–1074.

Brazner, J.C., S.E. Campana and D.K. Tanner. 2004. Habitat Fingerprints for Lake Superior Coastal Wetlands Dervied from Elemental Analysis of Yellow Perch Otoliths. Transactions of the American Fisheries Society. 133(3):692-704.

Chinchar, V.G. T.B. Waltzek. 2014. Ranaviruses: Not Just for Frogs. PLoS Pathog. 10(1): e1003850. Published online 2014 Jan 16. doi:10.1371/journal.ppat.1003850

DeLonay, A.J., R.B. Jacobson, K.A. Chojnacki, K.A., P.J. Braaten, K.J. Buhl, B.L. Eder, C.M. Elliott, S.O. Erwin, D.B. Fuller, J.D. Haas, B.J. Haddix, H.L.A. Ladd, G.E. Mestl, D.M. Papoluias, J.C. Rhoten, C.J. Wesolek and M.L. Wildhaber. 2015. Ecological Requirements for Pallid Sturgeon Reproduction and Recruitment in the Missouri River- Annual Report 2013. U.S. Geological Survey Open-File Report 2015-1197, 99 p.

Doyle, M., D. Murphy, S. Bartell, A. Farmer, C. Guy, M. Palmer, and R. Turner. 2011. Independent Science Advisory Panel Draft Report of Charge Number 1, Spring Pulse and Adaptive Management. Missouri River Independent Science Advisory Panel and Oak Ridge Associated Universities.

Fausch, K.D., C.E. Torgersen, C.V. Baxter, and H.W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. Bioscience 52:483–498.

Gosch, N. J. C., D. M. Morris, T. R. Gemeinhardt, and J. L. Bonneau. 2014. Pre- and post-construction assessment of nutrient concentrations at shallow water habitat restoration sites on the lower Missouri River. Journal of Water Resource and Protection 5:249-258.

Guy, C.S., H.B. Treanor, K.M. Kappenman, E.A. Scholl, J.E. Ilgen and M.A.H. Webb. 2015. Broadening the Regulated-River Management Paradigm: A Case Study of the Forgotten Dead Zone Hindering Pallid Sturgeon Recovery. Fisheries 40(1):6-14.

Hadley, G.L. and J.J. Rotella. 2009. Upper basin pallid sturgeon survival estimation project. Final Report. 34p.

Heist, E., J. Eichelberger, A. Asher, S. Youngs, A. DeLonay and K. Chojnacki. 2014. Genetic tools indicate low pallid sturgeon recruitment and high rates of hybridization in the Lower Missouri and Mississippi River. 75th Annual Midwest Fish and Wildlife Conference, Quebec City, Quebec.

Irelands, S.C., J.T. Siple, R.C.P. Beamesderfer, V.L. Paragamian, and V.D. Wakkinen. 2002. Success of hatchery-reared juvenile white sturgeon (Acipenser transmontanus) following release in the Kootenai River, Idaho. Journal of Applied Ichthyology 18:642–650.

Murphy, D. and P. Weiland. 2011. The Route to Best Science in Implementation of the Endangered Species Act's Consultation Mandate: The Benefits of Structured Effects Analysis: Environmental Management. 47:161-172.

NRC (National Research Council). 2011. Missouri River Planning-Recognizing and Incorporating Sediment Management. National Academies Press. Washington DC.

Oldenburg, E., T. Hanrahan, R. Harnish, B. Bellgraph, J. Duncan, and C. Allwardt. 2008. 2006 annual synthesis report- Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River. Prepared for the Missouri River Integrated Science Program, U.S. Army Corps of Engineers, Yankton, South Dakota. 306p.

Oldenburg, E.W., B.J. Goodman, J.W. Boyd, and T.P. Hanrahan. 2010. 2007–2008 Annual Synthesis Report - Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River. Prepared for the Missouri River Integrated Science Program, U.S. Army Corps of Engineers, Yankton, South Dakota. 224p.

Oldenburg, E.W., C.S. Guy, E.S. Cureton, M.A.H. Webb and W.M. Gardner. 2010. Effects of Acclimation on Poststocking Dispersal of Age-1 Pallid Sturgeon. J. Appl. Ichthyol. 27, 436–443.

Phelps, Q. E., G. W. Whitledge, S. J. Tripp, K. T. Smith, J. E. Garvey, D. P. Herzog, D. E. Ostendorf, J. W. Ridings, J. W. Crites, R. A. Hrabik, W. J. Doyle, and T. D. Hill. 2012. Identifying river of origin for age-0 *Scaphirhynchus* sturgeons in the Missouri and Mississippi rivers using fin ray microchemistry. Canadian Journal of Fisheries and Aquatic Sciences 69:930-941.

Ridenour, C. J., W. J. Doyle, and T. D. Hill. 2011. Habitats of age-0 sturgeon in the lower Missouri River. Transactions of the American Fisheries Society 140:1351-1358.

Rotella, J. J. 2012. Upper basin pallid sturgeon survival estimation project. 2010 Update. Report prepared for Upper Basin Pallid Sturgeon Workgroup. Montana State University, Bozeman. 39p.

Schapaugh, Adam, Tim L. Hiller, Andrew J. Tyre. 2010. The Pallid Sturgeon Habitat Assessment and Monitoring Program 2007-2009. University of Nebraska Lincoln School of Natural Resources.

Schloesser, J.I. 1995. Critical Landscape Attributes that Influence Fish Population Dynamics in Headwater Streams. Hydrobiologia 303: 71-81.

Schloesser, J.I., C.P. Paukert, W.J. Doyle, T.D. Hill, K.D. Steffensen and V.H. Travnichek. 2011. Fish assemblages at engineered and natural channel structures in the lower Missouri River: implications for modified dike structures. River Research and Applications 28:1695-1707.

Shuman, D.A., D.W. Willis, and S.C. Krentz. 2006. Application of a length-categorization system for pallid sturgeon (*Scaphirhynchus albus*). Journal of Freshwater Ecology 21(1):71-76.

Shuman, D.A., R.A. Klumb, R.Wilson, M. Jaeger, T. Haddix, B. Gardner, W. Doyle, P. Horner, M. Ruggles, K. Steffensen, S. Stukel, and G.A. Wanner. 2011. Pallid sturgeon growth, condition, and size structure within the Missouri River basin. Journal of Applied Ichthyology 27:269-281.

Singh, K. P., and A. Durgunoglu. 1991. Remedies for sediment buildup, Hydro Review: 90-95.

Steffensen, K. D., and T. W. Huenemann. 2014. Pallid sturgeon stocking and recapture synthesis report for the lower Missouri River. Nebraska Game and Parks Commission, Lincoln, NE.

Steffensen, K.D., T.W. Huenemann, K.R. Winders, C.J. Ridenour, R. Wilson, S. Stukel, D.A. Shuman, T. Haddix, and T.L. Welker. 2014. Pallid Sturgeon *Scaphirhynchus albus*: Is there evidence of recruitment in the Missouri River? Pallid Sturgeon Population Assessment Project Technical Report to the U.S. Army Corps of Engineers. 10 p.

Steffensen, K.D., L.A. Powell, S.M. Stukel, K.R. Winders, and W.J. Doyle. 2015. Updated assessment of hatchery-reared pallid sturgeon (Forbes & Richardson, 1905) survival in the lower Missouri River. Journal of Applied Ichthyology 2015: 1-8.

Thorrold, S.R., C.M. Jones , S.E. Campana , J.W. McLaren , and J.W.H. Lam. 1998. Trace element signatures in otoliths record natal river of juvenile American shad (*Alosa sapidissima*). Limnology and Oceanography 43:1826–1835.

USACE (U.S. Army Corps of Engineers). 1981. Missouri River Fish and Wildlife Mitigation: Iowa, Nebraska, Kansas and Missouri Final Feasibility Report and Final Environmental Impact Statement. Missouri River Division, Omaha, Nebraska.

USACE. 2003. Missouri River Fish and Wildlife Mitigation Project, Final Supplemental Environmental Impact Statement. Kansas City and Omaha Districts.

USACE. 2009. Least tern and piping plover monitoring handbook, U.S. Army Corps of Engineers, Omaha District. Unpublished report. 154 pp. with appendices.

USACE. 2012. Adaptive Management Strategy for the Creation of Shallow Water Habitat. USACE Document v 5.3, July. Omaha District.

USACE. 2014. Is shallow water a suitable surrogate for assessing efforts to address pallid sturgeon population declines? Kansas City District.

USACE. 2014. Missouri River shallow water habitat accounting report- 2014. Kansas City District and Omaha District.

USFWS. 1988. Great Lakes and Northern Great Plains Piping Plover Recovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota.

USFWS. 1990a. Biological Opinion on the Operations of the Missouri River Main Stem System. Letter from the USFWS, Denver, Colorado, to USACE, dated November 11, 1990.

USFWS. 1990b. Interior Population of the Least Tern (*Sterna antillarum*) Recovery Plan. Prepared by John. G Sidle and William F. Harrison. 90pp.

USFWS. 1993. U.S. Fish and Wildlife Service Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*). Prepared by the Pallid Sturgeon Recovery Team for Region 6, U.S. Fish and Wildlife Service, Denver, Colorado. 55pp.

USFWS (U.S. Fish and Wildlife Service). 2003. Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Mainstem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. 308 pp.

USFWS. 2007. Pallid sturgeon (*Scaphirhynchus albus*) 5-year review summary and evaluation. US Fish and Wildlife Service, Bismarck, North Dakota. 120p.

USFWS. 2014. Revised recovery plan for the pallid sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service, Denver, Colorado. 115 pp.

Wells, B.K., B.E. Rieman, J.L. Clayton, D.L. Horan, and C.M. Jones. 2003. Relationships between water, otolith, and scale chemistries of westslope cutthroat trout from the Coeur d'Alene River, Idaho: the potential application of hard-part chemistry to describe movements in freshwater. Transactions of the American Fisheries Society 132:409–424.

Wildhaber, M.L., W.S. Yang, and A. Arab. 2014. Population trends, bend use relative to available habitat, and within river-bend habitat use of eight indicator species of Missouri and lower Kansas River Benthic Fishes: 15 years after baseline assessment. River Research and Applications DOI: 10.1002/rra.2846.

Williams, B.K., R.C. Szaro and C.D. Shapiro. 2009. Adaptive Management: the U.S. Department of Interior Technical Guide. U.S. Department of Interior, Washington D.C., USA. http://www.doi.gov/initiatives/AdaptiveManagement/TechGuide.pdf .

Yang, C.T., and J.K. Ahn. 2011. Lewis and Clark Lake Sediment Management Study: Sediment Transport and Flow Analysis with GSTARS4, for the US Army Corps of Engineers Omaha District.

Appendix A

MRRP Performance Assessment Matrix

MRRP Mission - 2015 Annual Report

Water Resources Development Act (WRDA)

07 WRDA Section 3109	2007 WRDA Section 3109: The Secretary may use funds, appropriated to carry out the Missouri River recovery and mitigation program to assist the Bureau of Reclamation in the design and construction of the Lower Yellowstone project of the Bureau, Intake, Montana, for the purpose of ecosystem restoration.
07 WRDA Section 3176	2007 WRDA Section 3176 Part A: Use of Funds-Notwithstanding the Energy and Water Development Appropriations Act, 2006 (Public Law 109-103), funds made available for recovery or mitigation activities in the lower basin of the Missouri River may be used for recovery or mitigation activities in the upper basin of the Missouri River, including the States of Montana, Nebraska, North Dakota, and South Dakota. 2007 WRDA Section 3176 Part B: The matter under the heading "MISSOURI RIVER MITIGATION, MISSOURI, KANSAS, IOWA, AND NEBRASKA" of section 601(a) of the Water Resources Development Act of 1986 (100 Stat.4143), as modified by section 334 of the Water Resources Development Act of 1999 (113 Stat. 306), is amended by adding at the end the following: "The Secretary may carry out any recovery or mitigation activities in the States of Montana, Nebraska, North Dakota, and South Dakota, using funds made available under this paragraph in accordance with the Endangered Species Act of 1973 (16U.S.C. 1531 et seq.) and consistent with the project purposes of the Missouri River Mainstem System as authorized by section 10 of the Flood Control Act of December 22, 1944 (58 Stat. 897).".
07 WRDA Section 5018	2007 WRDA Section 5018 Part A: The Secretary, in consultation with the Missouri River Recovery Implementation Committee to be established under subsection (b)(1), shall conduct a study of the Missouri River and its tributaries to determine actions required—(A) to mitigate losses of aquatic and terrestrial habitat; (B) to recover federally listed species under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.); and (C) to restore the ecosystem to prevent further declines among other native species.
	2007 WRDA Section 5018 Part B: MISSOURI RIVER RECOVERY IMPLEMENTATION COMMITTEE.— (1) ESTABLISHMENT.—Not later than 6 months after the date of enactment of this Act, the Secretary shall establish a committee to be known as the Missouri River Recovery Implementation Committee (in this section referred to as the ''Committee'')
99 WRDA Section 334	1999 WRDA Section 334 Part A: The project for mitigation of fish and wildlife losses, Missouri River Bank Stabilization and Navigation Project, Missouri, Kansas, Iowa, and Nebraska, authorized by section 601(a) of the Water Resources Development Act of 1986 (100 Stat. 4143) is modified to increase by 118,650 acres the amount of land and interests in land to be acquired for the project.
	1999 WRDA Section 334 Part B: STUDY-(1) The Secretary, in conjunction with the States of Missouri, Kansas, Iowa, and Nebraska, shall conduct a study to determine the cost of restoring, under the authority of the Missouri River fish and wildlife mitigation project, a total of 118,650 acres of lost Missouri River fish and wildlife habitat. (2) Not later than 180 days after the date of enactment of this Act, the Secretary shall report to Congress on the results of the study.
86 WRDA Section 601	1986 WRDA Section 601: The project for mitigation of fish and wildlife losses, Missouri River Bank Stabilization and Navigation Project, Missouri, Kansas, Iowa, and Nebraska: Report of the Chief of Engineers, dated April 24, 1984, at a total cost of $51,900,000, with a first Federal cost of $51,900,000. The secretary shall study the need for additional measures for mitigation of losses of aquatic and terrestrial habitat caused by such project and shall report to Congress, within three years after the date of enactment of this Act, on the results of such study and any recommendations for additional measures needed for mitigation of such losses.
Section 10 of 1944 Flood Control Act	Authorized Purposes: Flood Control; Navigation; Hydropower; Irrigation; Recreation; Water Supply; Water Quality; Fish and Wildlife
1959 Fish and Wildlife Coordination Act	This act outlines requirements for fish and wildlife habitat mitigation for constructed water resources projects.

2003 Amended Biological Opinion to the 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System

Biological Opinion of 2000

Reasonable and Prudent Measures*

Least Tern, amount of extent of incidental take, p.242, 2003 amended BiOp.		
LT RPM 1	1	Measure 1: Survey and monitor least terns, mortality and incidental take
LT RPM 2	1	Measure 2: Monitor, evaluate and adjust operations to minimize take of least terns
LT RPM 3	1	Measure 3: Design, construct and manage created sandbars as required by RPA IV.B.
LT RPM 4	1	Measure 4: Monitor, evaluate and modify created and rehabilitated sandbars
LT RPM 5	1	Measure 5: Evaluate effective measures to reduce least tern predation
LT PRM 6	1	Measure 6: Reduce human disturbances of least terns and conduct outreach and education
Complete	1	Measure 7: Revise Contingency Plan for moving eggs
Piping Plover, amount of extent of incidental take, p. 247, 2003 amended BiOp.		
PP RPM 1	1	Measure 1: Survey and monitor piping plovers
PP RPM 2	1	Measure 2: Monitor, evaluate and provide information to minimize take of piping plovers
PP RPM 3	1	Measure 3: Coordinate System Monitoring and evaluation
PP RPM 4	1	Measure 4: Contingency Plan for Moving Eggs
PP RPM 5	1	Measure 5: Reduce human disturbances of piping plovers and conduct outreach and education
PP RPM 6	1	Measure 6: Evaluate and implement effective measures to reduce piping plover predation
PP RPM 7	1	Measure 7: Design, construct and manage created sandbar habitat
PP RPM 8	1	Measure 8: Implement program to monitor and evaluate the effectiveness of created sandbars
Pallid Sturgeon, amount of extent of incidental take, p. 256, 2003 amended BiOp.		
PS RPM 1	2	Measure 1: Research, monitoring, and evaluation of effects of Incidental take outcomes a. through d.
PS RPM 2	1	Measure 2: Corps shall minimize the effect of incidental take associated with dredging and construction of ESH & SWH through entrainment of early life stages of pallid sturgeon. Incidental take outcomes e.
PS RPM 3	1	Measure 3: Meet annually with service to address how and where mortality associated with propagation can be minimized. Incidental take outcomes f. and g.
Bald Eagle, p. 266, 2000 BiOp		
BE RPM 1**	1	Measure 1: Map and evaluate current health of cottonwood forests on Missouri River
	1	[a.] Identify stands with periodic flooding
	1	[b.] Determine baseline morality and tree vigor
BE RPM 2	1	Measure 2: Develop a management plan for cottonwood regeneration
BE RPM 3	2	Measure 3: Implement actions to ensure no more than 10% eagle habitat is lost
Amended Biological Opinion of 2003 Reasonable and Prudent Alternative (RPA)*		
I. Adaptive Management (LT - pg 182, PP - pg 203, PS - pg 220, 2003 Amended BiOp)		
RPA 1.A	1	I.A. Agency Coordination Team
RPA 1.B	1	I.B. Endangered Species and Habitat Monitoring Program
RPA 1.C	1	I.C. Annual Report
II. Flow Modifications (LT - pg 186, PP - pg 207, PS - pg 224, 2003 Amended BiOp)		
RPA 2	4	II.C. Other Segments - Investigate flow enhance at Garrison by 2005 and implement, if appropriate
III. Unbalanced Intrasystem Regulation (LT - pg. 186, PP - pg 207, 2003 Amended BiOp)		
RPA 3	4	III. Unbalanced Intrasystem Regulation
		Note : Letter received from FWS acknowledging no unbalancing in 2011 due to floods. Developing alternative concepts with other states to present to FWS.
IV. Habitat Restoration/Creation/Acquisition (LT - pg 186 [PS info included in this section], PP - pg 208, PS - pg 225 [listed RPA as III], 2003 Amended BiOp, 2009 Amended from USFWS letter dated 23 OCT 09)		
		IV.A. Restoration of shallow water habitat (SWH)
RPA 4.A.1	1	IV.[A.]1. No-net-loss of existing shallow water habitat
RPA 4.A.2	1	IV.[A.]2. Develop habitat restoration plans and strategies in segs 10-16 (2001)
RPA 4.A.3	1	IV.[A.]3. Implement habitat restoration plans and strategies (2002)
RPA 4.A.4	1	IV.[A.]4. Continued implementation of habitat restoration plans and strategies (2003)
Metric	1	IV.[A.]5. 8% of goal (1,700 acres) (2004)
	1	IV.[A.]6. 10% of goal (2,000 acres) (2005)
	1	IV.[A.]7. 30% of goal (5,870 acres) (2014)
	2	IV.[A.]8. 60% of goal (11,739 acres) (2019)
	2	IV.[A.]9. 100% of goal (19,565 acres) (2024)

		IV.B. Restoration of Emergent Sandbar Habitat
RPA 4.B.1		IV.B.1. Provide natural sandbar habitat complexes
	1	IV.B.1.a. Min. ESH acres per RM measured late July: (2005) Garrison Seg 4 (25), Fort Randall Seg 8 (10), L&C Lake Seg 9 (40), GP Seg 10 (40)
	1	IV.B.1.b. Min. ESH acres per RM measured late July: (2015) Garrison Seg 4 (50), Fort Randall Seg 8 (20), L&C Lake Seg 9 (80), GP Seg 10 (80)
	1	IV.B.1.c.[1.] Complete 1998 baseline habitat evaluations Fort Peck Seg. 2 (2003)
	2	IV.B.1.c.[2.] Meet min. ESH acres in Fort Peck Seg 2 (2015)
		IV.B.2. Reservoir Habitat
RPA 4.B.2.a	2	IV.B.2.[a.] Maintain reservoir habitat through intrasystem regulation (2001)
RPA 4.B.2.b	1	IV.B.2.[b.] ID all potential habitat enhancements of Seg. 1, 3, & 5 (2005)
Metric	4	IV.B.2.[c.] Complete 25% of projects (2010)
	4	IV.B.2.[d.] Complete 50% of projects (2015)
	4	IV.B.2.[e.] Complete 100% of projects (2020)
Metric	2	IV.B.3. Artificially or Mechanically Created Habitat (in lieu of flow mod created)
RPA 4.C	1	IV.C. Initiation of Sediment Transport/Habitat Studies (initiate 2003, complete 2005)
RPA 4.D	1	IV.D. Monitoring of Tern and Plover Nesting Habitat (mapping & data collection)
V. Dropped from 2000 - least tern fledge ratios not an RPA		
V. Least Tern & Piping Plover (PP - pg. 214, 2003 Amended BiOp)		
		V.A. Kansas River
Completed	1	V.A.[1.] Develop a study plan (2002)
Completed	1	V.A.[2.] Kansas River a source or sink determination (2005)
RPA 5.B		V.B. Provide Habitat to meet or exceed fledge ratio goal of 1.22 for piping plovers
	1	3-year running total to meet or exceed 1.22
	2	10-year running total to meet or exceed 1.22
Completed	1	V.C. Piping plover foraging ecology study on MO River
IV. Pallid Sturgeon Propagation and Augmentation Efforts (PS - pg 228, 2003 Amended BiOp)		
PS RPA 4.A	1	IV.[A.] Collect and spawn female broodstock
Metric	1	IV.[B.] Produce 4,700 juveniles to 1-year old/yr (Corps 2,973)
PS RPA 4.C	1	IV.[C.] Production, rearing, and release of juveniles
PS RPA 4.D	1	IV.[D.] Monitor stocked juvenile pallid sturgeon
Metric	1	IV.[E.] Meet annually through ACT
V. Pallid Sturgeon Population Assessment (PS - pg 229, 2003 Amended BiOp)		
PS RPA 5.A	4	V.[A.] ID causes of lack of recruitment, hybridization, & ID restoration plans
PS RPA 5.B	1	V.[B.] ID and map spawning habitat
PS RPA 5.C	1	V.[C.] Channel training structure maintenance
PS RPA 5.D	1	V.[D.] Prioritize research needs
VI. Feasibility, Flow Development & Adaptive Management (PS - pg 230, 2003 Amended BiOp)		
		VI.1. Feasibility & Flow Development
RPA 6.A.1	4	VI.1.a. Prepare and finalize feasibility report (FR)
RPA 6.A.2	4	VI.1.b. Establish (develop & complete) long term flow management plan
RPA 6.A.3	4	VI.1.c. Evaluate in the FR, methods to provide flows, determine impediments and identify measures to mitigate impediments
RPA 6.A.4	1	VI.1.d. Establish an independent group of scientists to develop an adaptive management plan
Metric	2	VI.1.f. Modify operations, if appropriate
VII. Flow Modification (PS - pg 232, 2003 Amended BiOp, 2009 Amended from USFWS dated 23 OCT 2009)		
		VII.[A]. Flows below Gavins Point
RPA 7.A.1	4	VII.[A.]1.a. <25kcfs beginning July 1, for 30 days, ramp up & down 7 days, modification to flow to optimize habitat may occur through adaptive mgmt
RPA 7.A.2	1	VII.[A.]1.b. Nav. Suspended during low summer flow, modified to optimize (aka. VII.1.b.) - met with construction of 1,200 acres FWS letter 2004.
RPA 7.A.3	1	VII.[A.]1.c. Ensure Master Manual provides for spring rise and summer low flow
RPA 7.A.4	1	VII.[A.]1.d Conduct experimental spring pulse
RPA 7.A.5	4	VII.[A.]1.e Implement long-term flow management plan
N/A	1	VII.[A.]1.f Service recommended operation
		VII.[B.] Yellowstone River Intake Diversion Construction
RPA 7.B.1	1	VII.[B.]1.a. Corps provide funding necessary for NEPA analysis, design and construction leading to sturgeon passage at the Intake, Montana irrigation dam and diversion
RPA 7.B.2	1	VII.[B.]1.b. Corps provide funding necessary for NEPA analysis and subsequent construction of Lower Yellowstone irrigation district headworks at the Intake, Montana, to address native fish entrainment at this location
N/A	1	VII.[B.]1.c. As resources are being used for planning, design and construction at Intake, the 2020 shallow water habitat milestone will be deferred by an equal amount of time, not to exceed 4 years or 2024, 2nd letter received 2/6/13 from FWS deferring the 2024 SWH milestone for a period equal to the time from commencement to completion, not to exceed 3 years
N/A	1	VII.[B.]1.d. The Corps will not be required to conduct Fort Peck tests unless the success criteria are not achieved. This determination will be made within the first 8 years following conclusion of the construction at Intake.
N/A	2	VII.[B.]1.e. The Corps, Reclamation, and Service will, in cooperation with Montana Fish Wildlife and Parks, determine the requirements and funding necessary for post-construction monitoring associated with the project. Funding this monitoring will not be a responsibility of the Corps
VIII. Fort Peck Water Temperature Control Device Feasibility (PS - pg 236, 2003 Amended BiOp)		
RPA 8	1	VIII.1.a Fort Peck Water Temperature Control Device Feasibility
IX. Habitat Development, Shallow Water and Floodplain (PS - pg 237, 2003 Amended BiOp)		
		IX.1. Habitat Development
		IX.1.a. Shallow Water and Floodplain habitat
Metric	1	IX.1.a.i To maximize potential of the above, consult FWS to develop sufficient habitat
Metric	1	IX.1.a.ii. Implement in priority areas, with flow regime in mind
RPA 9.1.a.iii	2	IX.1.a.iii. Provide sediment in the lower river
Metric	2	IX.1.a.iv. Design and implement floodplain connectivity
New RPA Elements from 2003 Biological Assessment (LT - pg 198, PP - pg 215, 2003 Amended BiOp)		
		[1.] Description of Corps' Alternative to the Gavins Point RPA (Proposed Action)
2003 RPA 1.A	1	[1.]a. Drought Conservation Measures
Duplicate	4	[1.]b. Unbalancing of Upper Three Lakes
		Note : Letter received from FWS acknowledging no unbalancing in 2011 due to floods. Developing alternative concepts with other states to present to FWS.
2003 RPA 1.C	1	[1.]c. Gavins Point Summer Releases
		2. Research, Monitoring & Evaluation
		2.a. Regional Population Assessment
2003 RPA 2.A.1	1	2.a.1. Interior Least Tern & Piping Plover
		2.b. Flow Tests
2003 RPA 2.B.1	4	2.b.1. Gavins Point Reach Fall Test
2003 RPA 2.B.2	4	2.b.2. Fort Randall Reach Fall Rise
2003 RPA 2.B.3	4	2.b.3. Gavins Point Spring Sandbar Habitat Conditioning
2003 RPA 2.B.4	1	2.b.4. Fort Peck Flow Tests
		3. Accelerated Actions
Metric	1	3.a. Shallow Water Habitat
Metric	1	[4.] Three-Year Re-evaluation (three-year check-in)
Conservation Recommendations		
Least Tern and Piping Plover (LT & PP - pg 261, 2003 Amended BiOp)		
LT CR A		A. Research intraspecific exchange of least tern and piping plover
Least Tern	✓	
Piping Plover	✓	

LT CR B	B. Modify development activities that adversely impact least tern and piping plover reproduction success and lead to habitat modification and/or destruction	
Least Tern		
Piping Plover		
LT CR C	C. Assess the feasibility of intensively managing a limited number of plover and tern breeding areas for high reproductive output	
Least Tern		
Piping Plover	✓	
LT CR D	D. Develop a population model for plovers and terns using the Missouri River to predict effects of river management on the survival and long-term trends and ensure levels of take on the Missouri River will not appreciably diminish the survival and recovery of listed plover and terns	
Least Tern	✓	
Piping Plover	✓	
LT CR E	E. Investigate Missouri River sandbar habitat complexes for migration, staging and pre-winter conditioning of plovers and terns	
Least Tern		
Piping Plover	✓	
LT CR F	F. Work with the Service and other partners to research the over-winter survival of plovers and terns	
Least Tern		
Piping Plover	✓	
LT CR G		G. Help fund the Piping Plover Recovery Biologist position in North Dakota and Montana
LT CR H	✓	H. Establish a clearinghouse for information/data/literature online or by other means for piping plover information
Pallid Sturgeon (pg 262, 2003 Amended BiOp)		
PS CR A		*1. Reconstruct the Yellowstone River intake diversion dam to allow pallid sturgeon spawning migration (Moved to RPA VII.[B.])*
PS CR B	✓	2. Sediment transport and availability, reservoir flushing
Bald Eagle, Pursue Recovery tasks assigned in the implementation schedules (BE - pg 280, 2000 BiOp)		
BE CR A		1. Conduct or participate in wintering and nesting bald eagle surveys.
BE CR B		2. Determine population dynamics of wintering and nesting birds.
BE CR C		3. Protect and manage habitat.
BE CR D		4. Conduct public outreach on the value of river habitat to the bald eagle.
BE CR E		5. Protect, maintain and enhance riparian forest usable by bald eagles through the Section 10/404 permit authorities.

* Numbering within the 2000 BiOp and the 2003 amended BiOp is frequently inconsistent and sometimes nonconsecutive. For the descriptor (i.e. second) column, an effort was made to keep the
** This column lists the requirement as listed on the Work Plan. The second column reflects the numbering system found in the BiOp and its amendment.

BE = Bald Eagle — BiOp = Biological Opinion
LT = Least Tern — CR = Conservation Recommendation
PP = Piping Plover — RPA = Reasonable and Prudent Alternative
PS = Pallid Sturgeon — RPM = Reasonable and Prudent Measure

1 Metric on target
2 Metric slightly below target <u>or</u> conditions have not allowed implementation
3 Metric below target
4 Awaiting outcome of Management Plan
✓ Conservation Recommendation complete

Appendix B

ISP-Science Questions and Findings

Missouri River Recovery Program:

Integrated Science Program General Science Questions & Key Findings

November 2014

The General Science Questions are a summation and interpretation by the US Army Corps of Engineers' Integrated Science Program of work conducted by multiple agencies and individuals to convey science progress to date for the general public of issues related to the three federally listed Missouri River species: the pallid sturgeon, least tern and piping plover.

The intent of this document, originally, was to internally explain knowledge of US Army Corps of Engineers funded science efforts. While the genesis of the document was to initially inform US Army Corps of Engineers leadership of the current science efforts and state of knowledge related to the three Missouri River federally listed species, it is now shared as a public informational document.

The source information for the General Science Questions began with a summation of work funded and conducted by the US Army Corps of Engineers. Additional effort has been made to incorporate the wealth of knowledge available from other science organizations, agencies and individuals to provide a more comprehensive overview of available science information. Although we pull information directly from source material and supply references, this information should be viewed as our interpretation of work conducted by many entities and those interested in specifics to directly consult with those research entities.

Missouri River Recovery Program:
Integrated Science Program
General Science Questions & Key Findings
November 2014

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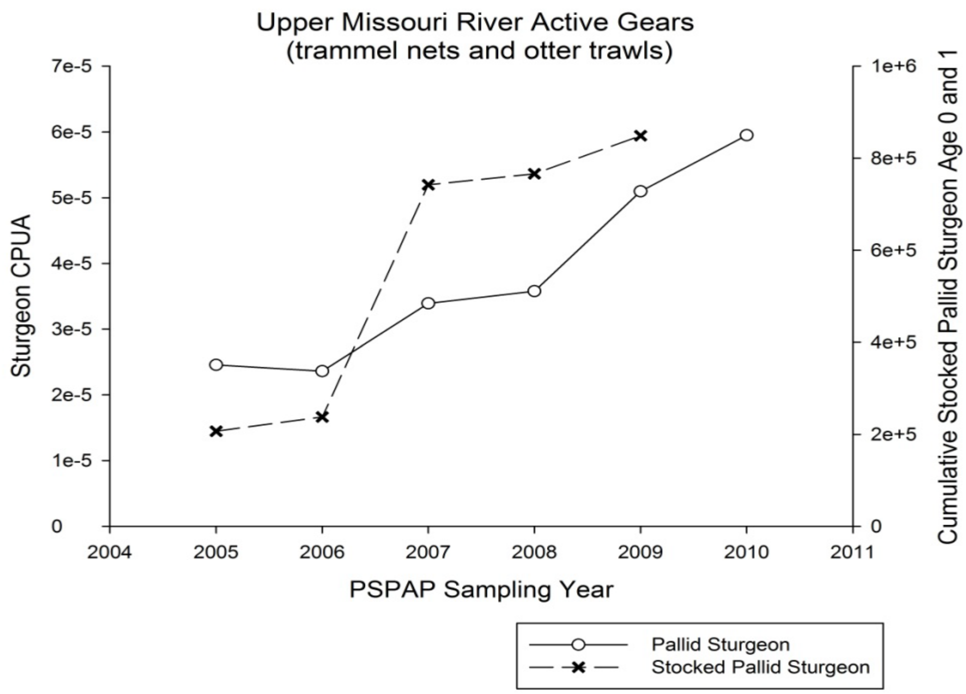
General Pallid Sturgeon Questions:

I. What is the population of pallid sturgeon in the Missouri River and its tributaries?

Service Providers: ACE LAB GS FWS MT MO NE SD

1. **What are the population trends over time?**

- "(T)he abundance of pallid sturgeon has been increasing through time in both the upper and lower monitoring areas of the Missouri River" (Murray et al. 2014).
- Approximately 90% (2,720 of 3,131) of the pallid sturgeon sampled were identifiable as stocked fish. Pallid sturgeon populations are increasing and age structure is improving due to stocking (see below example for gill net catch in the lower Missouri River for the period 2006-2008).
- A population estimate has been developed for the Fort Peck and Yellowstone River reaches (158 wild adults in 2004; Klungle and Baxter 2005); Steffensen et al. (2012) found that population estimates for pallid sturgeon in the segment of Missouri River that extends 80.5 km below the Platte River mouth varied from 5.4 to 8.9 individuals per river kilometer (rkm) for "wild" origin and from 28.6 to 32.3 individuals for hatchery-reared pallids. Winders and Steffensen (2014) estimate the population size of pallid sturgeon near Missouri City ranges from 0.6 to 0.9



Catch per square meter (O's) for active gear (i.e., otter trawl and trammel net) for pallid sturgeon captured in the Pallid Sturgeon Population Assessment Program from 2005-2010 in the Upper Missouri River (Segments 1-4) after data filtering (See Wildhaber et al. 2011) to allow analysis. X's represent the cumulative number of pallid sturgeon stocked into the Missouri River.

fish/rkm of "wild" origin to 5.5 to 10.2 fish/rkm hatchery-reared pallid sturgeon. Other estimates for the lower Missouri River are under development by scientists at the USGS and are anticipated to be available in 2014.

- Population viability and a sensitivity analysis of the critical population parameters for pallid sturgeon have been completed and published for the lower Missouri River (Bajer and Wildhaber 2007; Steffensen 2012). Results suggest that management which increases population-level fecundity and improves survival of

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age-0, juveniles, and young adults should most effectively benefit sturgeon populations.

- Sampling indicates that reproductive adults remain very rare. The first genetically confirmed reproduction of wild, naturally-spawned pallid sturgeon above Gavins Point Dam occurred in 2011 upstream of Wolf Point, Montana in the Missouri River. In 2012, reproduction of another naturally-spawned pallid sturgeon was confirmed from a one-day old pallid sturgeon embryo near the Yellowstone River and Missouri River confluence. Genetic assessment confirmed that both egg-yolk embryos were the product of wild parentage. Given that no recruitment has been documented in the upper basin (Steffensen et al. 2014), it is expected that the wild parents are remnants of the pre-dam subpopulation that is expected to be locally extirpated by 2018 (Dryer and Sandvol 1993).
- "It is likely that pallid sturgeon occurred in greater numbers with increasing distance below dams and may have occurred more frequently in areas with greater valley floor and wetted width," (Murray et al. 2014)
- Recruitment downstream of Gavins Point Dam to the mouth is extremely rare if it occurs at all (USFWS 2007; Steffensen et al. 2014).

ISP Projects Addressing Questions:

- Pallid Sturgeon Population Assessment
- Pallid Sturgeon Propagation and Population Augmentation
- Other Sturgeon Investigations
- System Status Reports

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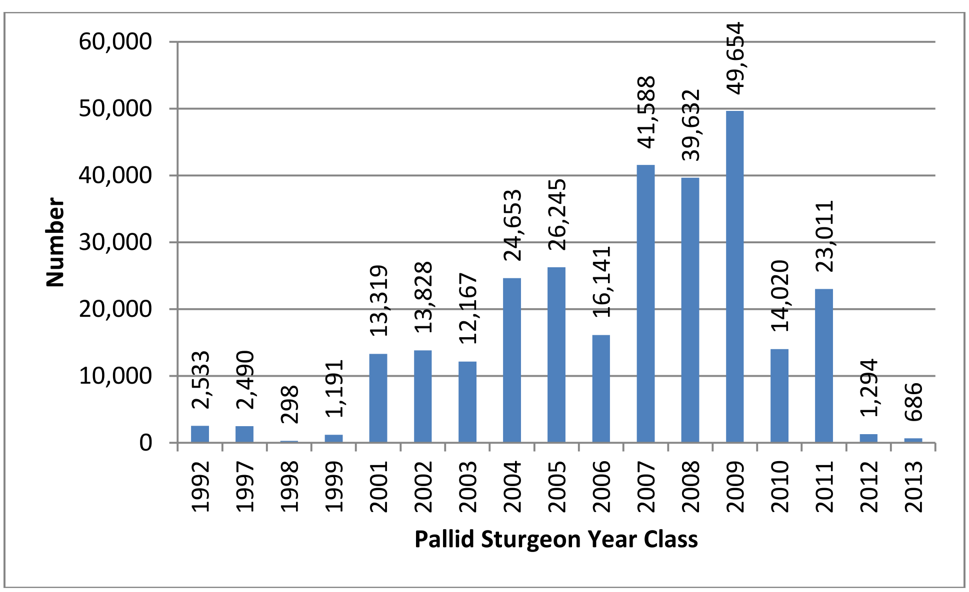
II. Is propagation a viable short-term solution to augment pallid sturgeon populations?

Service Providers: ACE GS FWS MT MO NE SD U

2. **Can pallid sturgeon be propagated?**

- Since the 2000 Biological Opinion was issued, over 465,000 fingerling-sized or larger pallid sturgeon have been stocked into the system.
- "Overall, it is clear that the abundance of pallid sturgeon has been increasing through time in both the upper and lower monitoring areas of the Missouri River." (Murray et al. 2014)



The number of juvenile pallid sturgeon (reported as yearling equivalents) stocked from each year class (*heat stress and disease reduced hatchery propagation success for the 2012 year class; the majority of the 2013 year class will be released in spring 2014). Hatchery upgrades were completed in 2007.

- Hatchery improvements have increased the maximum production capability of 8"-sized pallid sturgeon from approximately 20,000 to 60,000 per year.
- Iridovirus is a natural pathogen of pallid and shovelnose sturgeon, which can induce significant mortality in hatcheries and is being successfully managed. In addition, the propagation program continues to struggle with other emerging diseases (e.g., ranavirus and herpes virus) and rearing difficulties (gas supersaturation and fin curl).

3. **Will stocked fish survive in the river?**

- Stocked fish are surviving and growing in the river. Pallid sturgeon stocked as larvae, fingerlings and age-1 juveniles are surviving and their growth rates are comparable to wild sturgeon (Hadley and Rotella 2009; Rotella 2012; Steffensen et al. 2010). Survival rates for pallid sturgeon stocked as age-1 and older in the Missouri River generally exceed 70%.
- Female pallid sturgeon stocked into the river through the Propagation and Augmentation Program are approaching sexual maturity.

4. **Will stocked fish spawn in the river?**

- Hatchery origin pallid sturgeon are reaching reproductive age and appear to exhibit characteristic migration and spawning behaviors (DeLonay et al. 2009). It is unknown, however, whether adult hatchery sturgeon are spawning at the right time, right place or under the right conditions with other wild or stocked pallid sturgeon.
- 2011 and 2012 observations of spawning migrations and successful spawning aggregations above Lake Sakakawea in the Missouri River (Fuller and Haddix 2012) and in the Yellowstone River near the confluence (Fuller and Haddix 2012) included both hatchery-reared and wild pallid sturgeon.

5. **Why are pallid sturgeon stocked into the Missouri River?**

- The BiOp requires an annual stocking rate of 4,700 juvenile to 1-year old sturgeon, 2,973 of which are the responsibility of the USACE; the BiOp additionally requires USACE to monitor stocked hatchery pallid sturgeon to determine habitat use, distribution, movement and survival (RPA IV & V).
    - Survival rates for hatchery propagated white sturgeon were initially used as surrogate survival rates to set pallid sturgeon stocking objectives.
    - Survival rates for stocked pallid sturgeon (Hadley and Rotella 2009, Rotella 2012; Steffensen et al. 2010) derived from USACE and State monitoring program data were similar to white sturgeon, indicating that the original assumptions of the stocking program were accurate.
    - Survival rates of stocked pallid sturgeon (Hadley and Rotella 2009, Rotella 2012) and estimates of original population levels (Braaten et al. 2009) have been used to adjust stocking levels for populations above Lake Sakakawea.
- Growth and survival analyses on hatchery fish have been mostly limited to year classes of hatchery fish that have yet to transition to a fish diet or reach reproductive maturity. It is unknown what the carrying capacity for adult pallid sturgeon is in most portions of its range, whether there are sufficient forage fish to support large numbers of predatory adults, or what constitutes a threshold

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population for adequate spawning success. Continued monitoring and adaptive management of stocking goals will be necessary.

- Determination of survival rates and carrying capacity is ongoing to refine the appropriate level of stocking.

ISP Projects Addressing Questions:

- Pallid Sturgeon Population Assessment
- Pallid Sturgeon Propagation and Population Augmentation
- Development of Management Tools for the Pallid Sturgeon Iridovirus (PSIV)
- Fishing for Cytokines and Immune Molecules to Better Understand Pallid Sturgeon Health
- Genetic Analysis – Species and wild origin determination
- Comprehensive Sturgeon Research Project (CSRP)

III. Do pallid sturgeon spawn in the Missouri River?

Service Providers: ACE LAB GS FWS MT MO NE SD

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6. **Where are the locations of spawning sites?**
   - Female sturgeon have been documented releasing eggs; primarily in areas of converging flow, in the deepest, faster water available over or adjacent to coarse substrate on outside revetted bends (DeLonay et al. 2009).
   - These documented occurrences are spread out over 100's of river miles and occur upstream in the Gavins Point reach to the confluence with the Mississippi.
     - Spawning in the lower basin has been identified over a wide range of modified habitats. Spawning has occurred at locations between Gavins Point Dam and Sioux City, between Sioux City and Omaha, and between Kansas City and Boonville for the period 2007-2010.
     - Spawning in the upper basin has been documented in the Yellowstone River near its confluence with the Missouri and below the Missouri and Milk River confluence in 2012, 2013 and 2014.
   - Small flow pulses similar to those under consideration for dam releases are capable of transporting sediment and substantially rearranging the bed (Elliott et al. 2009; DeLonay et al. 2009); hence, such flows have the potential to condition coarse spawning substrate by flushing fine sediment. Presently identified spawning patches (deep, turbulent water on outside revetted bends), however, are likely to be persistently free of fine sediment.
7. **What is the timing of the spawn?**
   - Spawning of shovelnose and pallid sturgeon has occurred over extended periods (weeks to months).
   - Pallid sturgeon in the lower Missouri River are typically spawning at temperatures from 15 to 18°C (DeLonay et al. 2009).
   - While the data are still limited, documented spawning times for pallid sturgeon in the lower Missouri River have occurred over a narrower time frame than shovelnose sturgeon. Spawning in the lower 400 miles of the Missouri River typically occurs at the very end of April through the first two weeks of May (DeLonay et al. 2009). Pallid sturgeon further upstream near Gavins Point Dam generally spawn later. Spawning near the dam may not occur until the end of May.
   - However, warmer than normal spring water temperatures (i.e., 2012) can alter the pallid sturgeon spawn to occur earlier in the spring than normal and potentially result in a later spawn in the fall (Wrasse et al. 2013; Aaron DeLonay et al. 2013).

- In river reaches below dams, it is believed that cooler water temperatures may inhibit spawning by sturgeon (e.g., below Fort Peck Dam).

8. **What are the cues that induce spawning?**

- Temperature, photoperiod (day length), and flow magnitude are emerging as potential migration and spawning cues (DeLonay et al. 2009). At this time, the individual effects of these factors on spawning cues cannot be isolated.
- Other factors that may affect spawning include substrate type, proximity of fish of the opposite sex, reproductive health, and water quality.
- Pallid sturgeon have spawned without intentional pulsed flow releases from Gavins Point Dam (DeLonay et al. 2009), but the importance of flow variability due to other sources (such as tributaries) is unknown. While pallid sturgeon can spawn under a wide range of flows it is unknown how flow influences spawning success, development and hatch of eggs, predation, or dispersal of resulting larvae.

ISP Projects Addressing Questions:

- Comprehensive Sturgeon Research Project (CSRP)
- Pallid Sturgeon Population Assessment
- Pallid Sturgeon Habitat Assessment and Monitoring Program (HAMP)

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IV. What are potential limiting factors to the reproduction, survival, and growth of the pallid sturgeon?

Service Providers: ACE LAB GS FWS MT MO NE SD U IA O

9. **What are the specific requirements for pallid sturgeon to successfully transition between life-stages?**

Life Stage	Life Stage Component	Current Understanding	Current and Future Investigations
Adult	Pre-spawn	Research indicates that pallid sturgeon mature, become reproductive and exhibit extensive migratory movements in the Missouri River.	What are the effects of temperature, flow regime, channel morphology, and food supply on migration and readiness to spawn?
	Spawn	Research has addressed barriers to spawning and concludes that pallid sturgeon can spawn in the Missouri River. Scientists have observed isolated occurrences of deposited eggs and larval pallid sturgeon associated with documented spawning events. Cold water-temperature events can disrupt spawning migrations.	What are the combined effects of water temperature, flow regime, and water quality in cueing reproductive stages in pallid sturgeon? Does the occurrence of hermaphroditism affect pallid populations?
Egg to 1 yr. (Age 0 to 1)	Egg development	Wild and hatchery raised adults in reproductive condition have been successfully captured. They have been successfully spawned in the hatchery, and their progeny have hatched and recruited to larval stage, indicating that pallid sturgeon in the Missouri River are healthy, and have normal egg and larval development.	Do eggs adhere to river substrate? What factors affect fertilization success in the wild? Is predation an issue at the egg stage?
	Hatch to yolk absorption	Hatchery born larvae have been successfully moved to feeding on external food sources after yolk absorption. Laboratory and field studies have established that larval pallid sturgeon drift hundreds of km during this stage (Braaten et al. 2008); larvae are concentrated in the thalweg and near the river bottom (Braaten et al. 2012).	Are embryos susceptible to predation? Are yolk sac resources sufficient to sustain embryos to a stage where they can feed on external resources? How do temperature, flow regime, and channel morphology affect drift distance, survival and where in the channel embryos drift? Is

			entrainment (e.g. water intakes, diversions, dredges) a problem for drifting sturgeon embryos?
	Larvae	In the upper basin, hatchery-released larvae have recruited to a larger juvenile size.	Where do larval fish drop out of the drift? Are resources necessary for survival available where larvae drop out? What are larval fish habitat requirements (e.g., nursery habitat)? Currently investigating drift and diet shift, habitat preferences, and feeding behavior.
	Post-larvae to one year	Post-larvae to age 1 pallid sturgeon have not been documented in the wild. Laboratory research has shown negative or neutral selection for pallid sturgeon as prey by some species of native, predatory fish (French 2009).	What is larval and juvenile pallid habitat? What food resources are necessary for survival?
Juvenile to Adult		Evidence provided by hatchery releases shows that pallid sturgeon released one-year of age or older have relatively high survival (Hadley and Rotella 2009, Steffensen et al. 2010).	What are pallid sturgeon habitat needs at each life history stage?
		Larval pallid sturgeon eat primarily macroinvertebrates and transition to piscivory during juvenile life history (Grohs et al. 2009; Gerrity et al. 2006)	What prey types and amounts are optimal for growth, survival, and reproductive maturation?
		Larger juveniles and adults feed primarily on fish (e.g., sicklefin chub, sturgeon chub, Johnny darter, flathead chub, sand shiner (Gerrity et al. 2006).	What prey types and amounts are optimal for growth, survival, and reproductive maturation? What are the ecological requirements for preferred prey species?

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10. **What are the details of larval drift?**

- Water temperature, velocity, and channel form have been shown to influence pallid sturgeon embryo drift distance and time (Braaten et al. 2010).
- Drifting sturgeon embryos have been documented in the river indicating that successful wild spawning of *Scaphirhynchus* sturgeon has occurred in the Missouri River. Three embryos collected from the lower Missouri River near Lisbon Bottom were identified as pallid sturgeon (Mauldin 1999, cited in Hrabiket al. 2007); however these identifications were not confirmed with genetic tests.
- Montana Fish Wildlife and Parks and USGS-CERC collected wild-borne pallid sturgeon embryos from the mainstem Missouri River near Frazier Rapids, Montana in 2011 and near the Yellowstone and Missouri River Confluence in 2012. These embryos are the first genetically confirmed successful pallid sturgeon spawning in the upper Missouri River.
- During USGS sturgeon reproductive studies in 2010, day-0 shovelnose sturgeon embryos were collected just downstream of a confirmed pallid sturgeon spawning site (Aaron DeLonay, pers. com), indicating that conditions at that site were suitable for *Scaphirhynchus* spawning and hatch.
- Upper Missouri River models of cumulative drift distance as a function of velocity suggest that the average pallid sturgeon embryo would drift about 152 miles at a mean water column velocity of 1 ft/sec, but drift distance for the average embryos would increase to 329 miles at mean water column velocities of 2 ft/sec. (Braaten et al. 2008). However, variability in drift rates and cumulative drift distance were exhibited by the embryos. Drift rates for pallid sturgeon have not yet been validated in the lower Missouri River or tributaries.

- Calculations based on ranges of larvae maturation times (Braaten et al. 2008) and typical water velocities in the lower Missouri River downstream from Gavins Point dam indicate that total drift distance could be between 189 to 1100 miles, which could place Missouri River drifting embryos in the Mississippi River (DeLonay et al. 2009).

11. **Is the abundance or diversity of forage a limiting factor for young and / or adult sturgeon?**
   - Results to date indicate that sturgeon (pallid and shovelnose) under 24 inches share similar diets, and above 24 inches, the pallid shifts to a fish dominated diet (Grohs et al. 2009).
   - Research indicates that there are differences in growth and condition by geographic region. More analysis needs to be conducted to better understand the relationships that exist (Population Assessment Annual Reports, 2002-2010).
12. **How is disease affecting recruitment?**
   - Iridovirus occurs in both hatchery and wild populations. Iridovirus is a natural pathogen of pallid and shovelnose sturgeon, which can induce significant mortality in hatcheries and is being managed.
   - Sturgeon surviving Iridovirus infection can be virus carriers and potentially transmit the virus to unaffected fish (Hedrick et al. 2009).
13. **What substrate types are important for pallid sturgeon life history?**
   - Early observations of potential spawning substrate indicate that spawning habitat includes gravel and larger rock on outside bends of the river (DeLonay et al. 2009). Abundance of this habitat type in the lower river indicates that this may not be a limiting factor. However, it is not known if stabilized river bends are adequate or ideal for spawning and subsequent survival of progeny.
   - Lab studies show juvenile pallid sturgeon prefer sand and avoid gravel and wood (see Allen et al. 2007, Personal communication with Tobias Rapp, SDSU).
   - Field studies of pallid and shovelnose sturgeon habitat selection indicate selection for sand substrate during adult life stages, with the exception of during spawning (Reuter et al. 2009; Bramblett and White 2001).
14. **How does water quality (e.g. temperature, dissolved oxygen, turbidity, endocrine disrupters) affect recruitment of pallid sturgeon?**
   - In one study, 12% of the male shovelnose sturgeon also had female characteristics in their reproductive systems (DeLonay et al. 2009); however, the cause of this condition is unknown at this time. In other fish species, this has been tied to endocrine disrupting chemicals such as estrogen mimicking compounds from waste-water systems. It has been established that endocrine disrupting chemicals can have population level impacts.
   - An altered temperature regime has been identified as a factor limiting condition, growth, and survival in warm water fishes (e.g., shovelnose sturgeon in the upper Missouri River; Kappenman et al. 2009).
   - Anoxic conditions exist in the transition zone from riverine to lacustrine in the headwaters of Fort Peck Reservoir in eastern Montana and is an ecological sink for pallid sturgeon (Guy et al. *In Review*).
15. **Is predation impacting recruitment?**
   - In a laboratory study, pallid sturgeon vulnerability to predation was shown to be low (French et al. 2013).
     - Pallid sturgeon were not selected as food by walleye and smallmouth bass under all tested conditions.
     - Flathead catfish consumed 1.5 to 2 inch pallid sturgeon at the same frequency as other foods. Flathead catfish did not select 3 to 4 inch pallid sturgeon as food.

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- Capture and non-consumption by predators appears to have little effect on survival of >2.8 inch pallid sturgeon (French et al. 2013).
- To date, many of the pallid sturgeon stocked were 8 inch yearlings, which need a large investment in feed, time, and hatchery space. Stocking smaller sturgeon would allow managers to increase the number of fish stocked, while decreasing costs in space and time required.

16. **What habitat types are necessary during pallid sturgeon migration, how much is available and are there missing habitat components?**
    - Migratory sturgeon appear to select areas where slow and fast water meet and habitat transitions from shallow to deep water (Reuter et al. 2009, Bonnot et al. in review; DeLonay et al. 2009).
    - Migratory and rearing habitat appears to be more limited from the Platte River to Sioux City, than in the segments upstream of Sioux City, or downstream of Kansas City (Reuter et al. 2009; Reuter et al. 2008; Elliott et al. 2009; Jacobson et al. 2009; DeLonay et al. 2009).
17. **How is hybridization affecting sturgeon populations?**
    - Hybridization between pallid sturgeon and shovelnose sturgeon has been documented in the Missouri River (Hartfield and Kuhajda 2009). Potential population level effects and the factors that contribute to hybridization, however, have not been studied.
    - The level of hybridization appears to be greater in the lower Mississippi and lower Missouri Rivers than in the upper Missouri and lower Yellowstone Rivers (Carlson et al. 1985, Keenlyne et al. 1994, Tranah et al. 2004).
    - Genetic distinctiveness between presumably wild Pallid and Shovelnose Sturgeon morphotypes decreases from the upper Missouri River to the lower Missouri River and the species are difficult to discriminate in the middle Mississippi River and lower Mississippi River where they likely comprise a hybrid swarm (Heist et al 2014).
    - Hybridization does occur naturally among sturgeon at a very low rate. High rates of hybridization typically occur in sturgeon when individuals of one species are very rare and the other much more common, when barriers prevent species from reaching the spawning grounds, and when habitat alterations break down the mechanisms that synchronize and separate reproduction of the species in time and space (e.g., altered temperatures and flows, too little or too much spawning habitat) (Hartfield and Kuhajda 2009).
18. **What role does flow regime play in the survival and growth of young pallid sturgeon?**
    - Flows are assumed to be critical in providing essential biological and physical functions (spawning cues, habitat conditioning, larval dispersal) (Fisher 1983, Poff et al. 1997, Arujo-Lima 2005, King et al. 2009) and providing essential organic resources into the channel for increasing primary and secondary production (i.e., food and energy required for all pallid sturgeon life stages), (Junk et al. 1989, Bayley 1995, Galat et al. 1998, Ward et al. 1999). The BiOp also assumes that flows in the summer should be sufficiently low to provide for shallow, slow velocity habitats offering refuge and foraging habitat for these life history stages.
    - A significant assumption of the BiOp is that without some semblance of the natural hydrograph pallid sturgeon will continue to decline. While evidence demonstrates that spawning can occur at certain times in the reach without a pulse from the dam, there is limited understanding of the effects that the altered hydrograph has on pallid life history.
19. **Is lack of sediment a limiting factor?**

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- Prior to the 1950s, the Missouri River carried more than 320 million tons of suspended sediment per year at Hermann, Missouri. The construction of dams, channel structures and levees allowed easier river navigation and controlled flooding but drastically decreased the amount of sediment flowing in the river. Today, the Missouri River near Hermann carries only 20 to 25 percent of its original sediment volume (Jacobson et al. 2009; Meade and Moody 2010).
- Reintroducing sediment to the river could temporarily and partially restore other natural river functions and could provide the building blocks for natural habitat creation.
- Transport of sediment around Gavins Point dam has the potential to sustainably increase annual suspended sediment load by approximately 5 million tons per year, or about 10% of the present total suspended load (as measured at Hermann, Missouri).
- Sediment carries nutrients which are essential for primary productivity but may exacerbate gulf hypoxia (Jacobson et al. 2009). "A comparison of potential phosphorus loads from Corps SWH projects, with load increments required to produce measureable changes in the areal extent of Gulf hypoxia, shows that these projects will not significantly change the extent of the hypoxic area in the Gulf of Mexico" (NRC of the National Academies 2010).
- The pallid sturgeon evolved adaptations to persist in a naturally turbid environment (Blevins 2006). "High concentrations of sediment and high turbidity in the pre-regulation river were important to the evolution and adaptation of native species such as the pallid sturgeon" (NRC of the National Academies 2010).

ISP Projects Addressing Questions:

- Comprehensive Sturgeon Research Project (CSRP)
- Pallid Sturgeon Habitat Assessment and Monitoring Program (HAMP)
- Water Quality Monitoring Program
- Genetic Hybridization Studies
- Determinants of Growth and Survival of Larval Pallid Sturgeon
- Quantification of Pallid Sturgeon Shovelnose Sturgeon Trophic Position in the Missouri River
- Substrate Mapping
- Vulnerability of Age-0 Sturgeon to Fish Predation: Assessing the Influence of Body Size and Water Turbidity
- Fort Peck Flow Modification Biological Data Collection Plan
- Fort Peck Temperature Control Device

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V. How are management actions (flow modifications, habitat creations) affecting pallid sturgeon spawning, recruitment and population trends?

Service Providers: ACE LAB GS FWS MT MO NE SD U IA O

20. **Do habitat creation activities affect pallid sturgeon reproduction, survival, and growth?**

- The goal of habitat creation efforts, based on the Biological Opinion, is to provide nursery habitat and increased primary and secondary production, as well as increasing the fish forage base for pallid sturgeon. These effects are expected to occur slowly and in step with habitat maturation.

21. **Could a fall pulse achieve ecological outcomes?**
   - ➢ It is thought that there are some benefits to a fall pulse flow physically as it has the potential to rework sediments and bring organics into the main channel. These effects may be beneficial for pallid sturgeon and could even create some emergent sandbar habitats for the terns and plovers (2003 BiOp RPA element II.2.b.2 page 201- 202).
22. **Do pulse flows from Gavins Point have the ability to condition spawning habitat?**
   - ➢ Flow pulses, similar to those under consideration for dam releases, have transported sediment and rearranged material on the bed of the river, (Elliot et al. 2009); indicating the ability to condition habitat.
23. **What is the value of floodplain connectivity/ seasonal inundation for pallid sturgeon reproduction, survival, and growth?**
   - ➢ Access to the floodplain has demonstrated value for certain life history stages for native fishes in large rivers (Bayley 1988, Junk et al. 1989, Galat et al. 1998, Ward et al. 1999). The value of floodplain connectivity to the pallid sturgeon would have to be established by defining food webs or other biotic interactions.
24. **What other life history processes are potentially influenced by management actions (e.g., larval drift distances)?**
   - ➢ High velocities and low channel diversity on the Missouri River from the Platte River to Sioux City may hinder migration (Reuter et al. 2009); shallow-water habitat construction is designed to potentially mitigate this effect.
   - ➢ Long drift distances of larval sturgeon indicate that shallow-water habitat intended for rearing larval sturgeon may be more beneficial downstream of the Kansas River (DeLonay et al. 2009).

ISP Projects Addressing Questions:

- Comprehensive Sturgeon Research Project (CSRP)
- Pallid Sturgeon Population Assessment
- Pallid Sturgeon Habitat Assessment and Monitoring Program (HAMP)
- Fish Community Monitoring and Habitat Assessment of Off-Channel Mitigation Sites "Chute Study"
- Gavins Point Spring Pulse Flow Modification – Groundwater Monitoring
- Gavins Point Spring Pulse Flow Modification – Interior Drainage Monitoring
- Fort Peck Flow Modification Biological Collection Plan
- Fort Peck Temperature Control Device

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C	Contractors
O	Other

VI. What are the trends in availability of shallow water habitat (both constructed and natural)?

Service Providers: ACE LAB GS FWS MT MO NE SD U IA O

25. **What trends are shown through monitoring/documentation of the physical habitat?**
   - ➢ It is estimated that prior to any construction activities the Missouri River below Ponca, NE contained 3,025 acres of naturally occurring Shallow Water Habitat (SWH).
   - ➢ In 2009, it was estimated that there were 8,863 acres of natural and created SWH

ISP Projects Addressing Questions:

- Pallid Sturgeon Habitat Assessment and Monitoring Program (HAMP)
- Population Structure and Habitat Use of Benthic Fishes along the Missouri and Lower Yellowstone Rivers
- Two-dimensional Hydraulic Model of the Missouri River

in the Missouri River below Ponca, NE (Annual BiOp Compliance Report 2009).

VII. Can data on other biological factors and fish species (shovelnose sturgeon, chubs, etc.) provide meaningful information about pallid sturgeon?

Service Providers: ACE LAB GS FWS MT MO NE SD U IA O

26. **Does primary and secondary production provide meaningful information for the pallid sturgeon?**
    - ➢ Shallow water habitat can provide locations for increased abundance of algae and phytoplankton (primary productivity), aquatic invertebrate production and zooplankton (secondary productivity), and larval/young-of-year nursery habitat (USFWS Clarified SWH Definition 2009).
    - ➢ Primary and secondary productivity are attributes that can be used to assess overall river health (USFWS Clarified SWH Definition 2009).
27. **Do other native fish species provide meaningful information for the pallid sturgeon?**
    - ➢ Evaluation of the responses of other native Missouri River fish species (e.g., shovelnose sturgeon, paddlefish, blue sucker, sicklefin chub, sturgeon chub, flathead chub, etc.) to changes in habitat, flow modifications, or water quality will provide valuable feedback as to the biological benefits of those changes, including:
        - o A short-term assessment of the management action as opposed to a long-term assessment (e.g., pallid sturgeon recruitment).
        - o Strengthens the overall evaluation of the management action (improved weight of evidence).
        - o Improved understanding of pallid sturgeon trends.
        - o Insight into life history needs of species that share similar life history components with pallid sturgeon (surrogate species; Wildhaber et al. 2007).
        - o Improved understanding of pallid sturgeon food species.

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ISP Projects Addressing Questions:

- Pallid Sturgeon Habitat Assessment and Monitoring Program (HAMP)
- Population Structure and Habitat Use of Benthic Fishes along the Missouri and Lower Yellowstone Rivers
- Water Quality Monitoring Program
- Comprehensive Sturgeon Research Project (CSRP)

VIII. How do different populations interact?

Service Providers: ACE GS FWS MT MO NE SD U O

28. **What is the relationship between the Mississippi and Missouri River habitats for the pallid sturgeon population?**
    - ➢ "Genetic tagging using genotypes of known broodstock parents and reconstructed genotypes of unsampled parents based on known offspring demonstrate that a large fraction of unmarked pallid sturgeon in the LMO and MMR are hatchery origin fish, especially in the MMR, where a single year class is dominant." (Heist et al. 2014)
    - ➢ Analysis of Sr-Ca signatures using samples from Missouri and Mississippi River pallid sturgeon pectoral fin rays are being reviewed to determine source location (including river of origin and source reach on the Missouri River), river of recruitment, and the relative occupation time in these rivers.

- To-date, we have found that some Missouri River adult pallid sturgeon migrate into the Mississippi River and vice-versa (Garvey et al. 2009, DeLonay et al. 2009).

ISP Projects Addressing Questions:
- Pallid Sturgeon Population Assessment – Informal Communication (MOU)
- Pallid Sturgeon Work Groups
- Pallid Sturgeon Research Prioritization Workshops

IX. What are the effects of management actions on non-target resources?

Service Providers: ACE GS

29. **How do management actions affect water quality?**
    - Water quality monitoring efforts are ongoing. Prior to any shallow water habitat creation efforts, the Corps conducts water, soil, and sediment testing to ensure that these efforts will not negatively impact water quality in the Missouri River.
30. **How do management actions affect interior drainage/ groundwater?**
    - This is being explored as part of the Spring Rise monitoring efforts. Two years of monitoring data has shown that groundwater levels are influenced by Missouri River flows (McAllister, 2010).
    - Duration of river rises appears to influence the amount of groundwater rise; however, not all changes in groundwater depth correlate with river stage.
    - Changes in groundwater depth exhibit lag when compared with changes in river stage (Kelly 2000, 2004, and 2006).
31. **How do management actions affect cultural resources?**
    - Effects of the spring pulse on cultural resources have been monitored. No significant effects to known cultural resources sites have been identified to date.

ISP Projects Addressing Questions:
- Water Quality Monitoring Program
- Gavins Point Spring Pulse Flow Modification – Groundwater Monitoring
- Gavins Point Spring Pulse Flow Modification – Interior Drainage Monitoring

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General Least Tern and Piping Plover Science Questions:

X. What are the population trends of interior population of least tern and Northern Great Plains population of the piping plover?

Service Providers: ACE GS FWS MT MO NE SD U O

32. **What are the Range wide population trends?**
    - An international census for the piping plover has been done in 1991, 1996, 2001, 2006 & 2011 for the Northern Great Plains population. In 1991 3,469 adults were counted (Haig 1992). In 1996 the population declined to 3,286 (Plissner 1997) and in 2001 the population declined to 2,953 adults (Ferland 2002). In 2006 the population rebounded to 4,662 adults (Elliott-Smith 2009). The 2006 results are broken down as follows (Elliott-Smith 2009):
        - Canada – 1,703 adults (Goal 2,500 adults)
        - U.S. Northern Great Plains – 1,213 pairs (Goal 1,300 pairs)
            - i. Montana 46 pairs (Goal 60 pairs)
            - ii. North Dakota 646 pairs (Goal 650 pairs)

- Missouri River 282 pairs (Goal 100 pairs)
- Missouri Coteau 364 pairs (Goal 550 pairs)

iii. South Dakota 244 pairs (Goal 350 pairs)

- Missouri River Gavins Point 117 pairs (Goal 250 pairs)
- Missouri River Other 109 pairs (Goal 75 pairs)
- Other 18 pairs (Goal 25 pairs)

iv. Nebraska 268 pairs (Goal 465 – 250 for the Missouri = 215 pairs)

v. Minnesota 2 pairs (Goal 25 pairs)

vi. Kansas, Iowa, Colorado 14 pairs (Goal 0 pairs)

- In 2005 the first range wide adult census was completed for the interior population of the least tern. Range wide, 17,591 adults were counted (Lott 2006) (Goal 7,000).
- 11, 281 were counted on the lower Mississippi River System (Goal 2,000-2,500)
- 1,821 were counted on the Red River System (Goal 300)
- 2,129 were counted on the Arkansas River System (Goal 1,600)
- 2,044 were counted on the Missouri River System (Goal 2,100)
- 138 were counted on the Rio Grande River System (Goal 500)

33. **What are the population trends of least terns and piping plovers on the Missouri River?**

- In 2013, the Corps implemented a new protocol for monitoring least tern and piping plover, incorporating a probability-based sampling design with sub-sampling in fixed river reaches only. No monitoring, beyond the adult census, was completed on Lake Oahe or Lake Sakakawea. Productivity of the river segments was estimated from sub-sampling in the river reaches (USACE 2013).
- From 1986-2013 an average of 649 adult least terns have been counted with a high of 1,010 in 2007 and a low of 273 in 2011. For comparison, the interior population of the least tern recovery plan sets a goal of 900 adults for the Missouri River. From 1986 – 2012 the number of fledglings (chicks able to fly) has varied from a low of 26 in 1986 to a high of 494 in 2005 with an average of 237 (USACE 2013).
- Least tern adult numbers remained high in 2013 and an estimated 229 chicks were fledged in the river segments, with an overall nest success of 82.3% (USACE 2013).
- In 2014, the Corps will implement the historic Tern and Plover Monitoring Program as prescribed in the 2003 BiOp until an improved protocol can be agreed upon.

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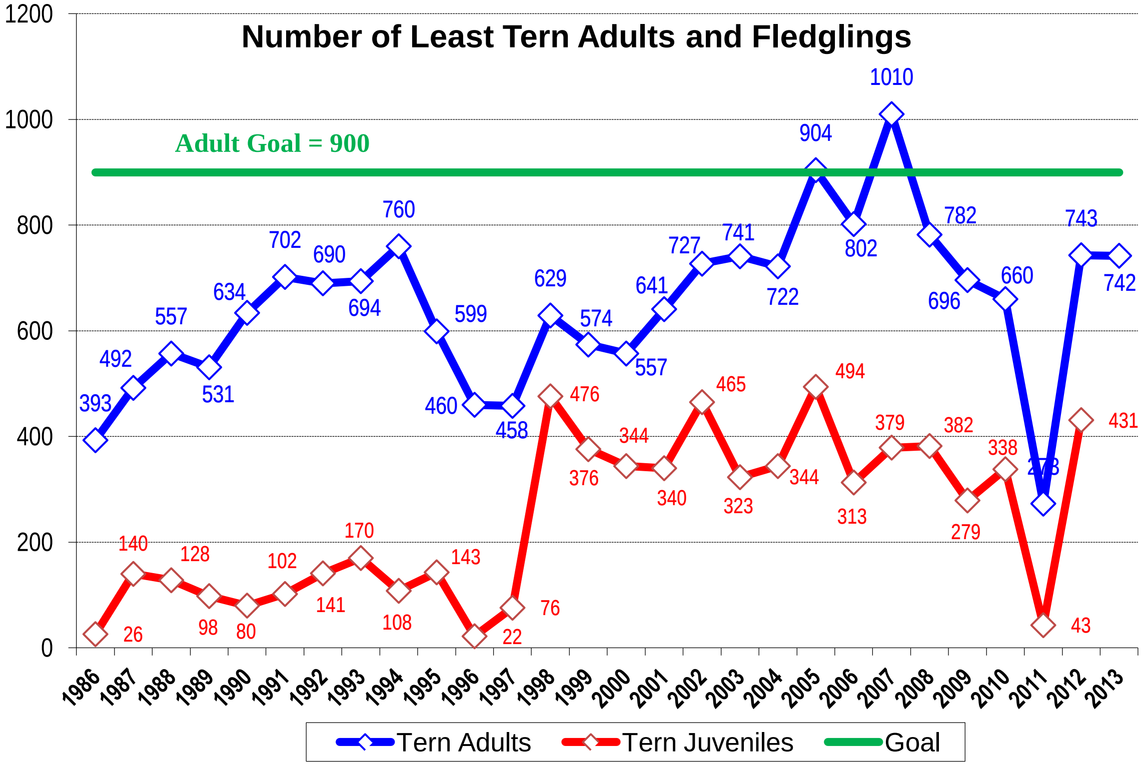
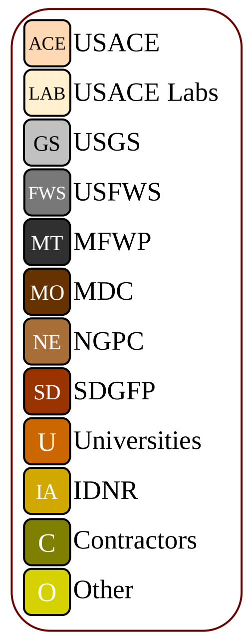
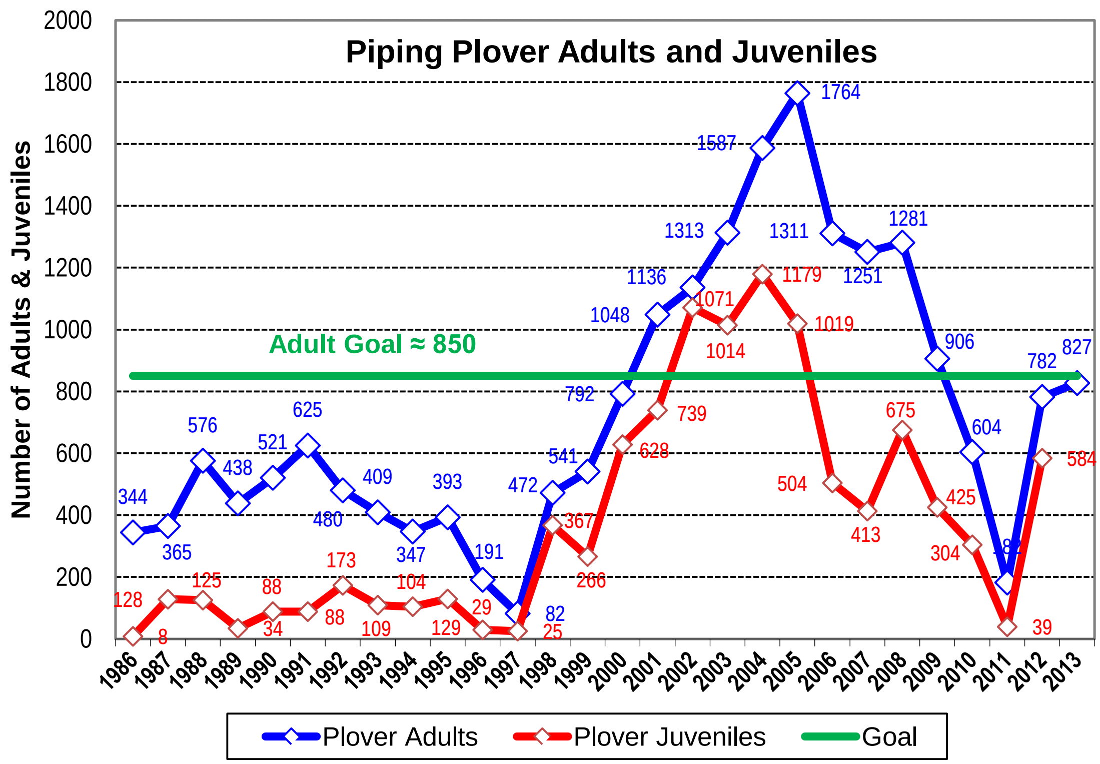




- From 1986-2013 an average of 735 adult piping plovers have been counted with a high of 1,764 in 2005 and a low of 82 in 1997. For comparison, the Northern Great Plains population of piping plover recovery plan sets a goal of 425 adult pairs (interpreted by the FWS as 1139 total – includes estimated non-nesting birds) for the Missouri River. From 1986 – 2012 the number of fledglings (chicks able to fly) has varied from a low of 8 in 1986 to a high of 1,179 in 2004 with an average of 380 (USACE 2013).
- With the change in the 2013 Tern and Plover Monitoring Program, piping plover productivity was estimated for the river segments only. Piping plover adult numbers remained high in 2013, and an estimated 427 chicks were fledged in the river segments, with an overall nest success of 62.7% (USACE 2013).
- The chart below shows piping plover adult census and fledgling results for 1986 – 2013.



XI. How are management actions affecting tern and plover productivity and population numbers?

ISP Projects Addressing Questions:

- Least Tern and Piping Plover Adult Census
- Least Tern and Piping Plover Productivity Monitoring
- Status, Distribution, and Production of Terns and Plovers
- Distribution and Abundance of the Interior Population of the Least Tern
- International Plover Census

Service Providers: ACE GS FWS MT MO NE SD U O

34. **How are releases from dams affecting productivity and populations?**
   - Runoff on the Missouri River has greatly influenced both tern and plover population. During years of high runoff, such as 2010-2011, water covered most habitat areas during the breeding season resulting in reduced numbers of both species observed. Years of low runoff, such as 2000-2007, saw increased numbers of both species as habitat was available both on the river and reservoir shorelines.
   - Periodic high releases from the dams can create or restore sandbar habitat resulting in a positive reproductive response of piping plovers and least terns.
   - Low releases from the dam can provide nesting and foraging habitat by exposing sandbars that are normally submerged. However continuous low flows during the nesting period over several years will marginalize this effect as habitat degrades due to vegetation encroachment.
   - At the beginning of the nesting season, dam releases may be used to influence nest site selection. This is done to prevent the two species from nesting on sandbars that otherwise could be inundated when higher releases are needed later in the nesting season to meet navigation targets.

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- ➢ Hydropower peaking releases from the dams can reduce nesting habitat for both species and foraging habitat for plovers by temporarily inundating sandbars on a daily basis.
- ➢ Cold water releases out of the dams may provide unsuitable water temperatures that can lead to a reduction in forage food for both species.

35. **How did habitat creation activities (2004 – 2009) affect the productivity and populations of both species?**

- ➢ New habitat (both natural and constructed) leads to high initial productivity by both species.
- ➢ Data shows a high nest success on constructed sandbars for both species (USACE 2009). Chick survival is generally highest in the first year and declines in subsequent years (USACE 2009), possibly due to factors such as predation and habitat quality.
- ➢ On constructed sandbars, piping plovers have higher nesting densities than on natural sandbars (Catlin 2009).
- ➢ Both species used constructed habitat more frequently than natural habitat. However, this was likely a result of the marginal quality of natural habitat, which had not been replenished since high flows in 1997. New information comparing the habitat preference of the species will be gained after assessing bird use of the high quality natural habitat created by the 2011 high water event.
- ➢ The movement of both species to constructed sandbars can cause increased densities leaving the birds more vulnerable to predators and random weather events (hail and thunderstorms) (2006-2009 Biological Opinion Compliance Reports) and in the case of the plovers, increased aggression amongst plovers (Catlin 2009).
- ➢ Studies indicate that piping plover chicks on constructed sandbars have a higher growth rate than plover chicks on natural sandbars. This may be tied to decreased habitat quality on natural sandbars (that existed before 2011) (Catlin 2009).
- ➢ Decreased productivity over time and declining population trends suggest that the quantity and quality of habitat has been inadequate to sustain population growth.
- ➢ Studies indicate high site fidelity by returning piping plover adults. Newly available constructed habitat is more likely to be used by first breeding season plovers, which arrive later than older adults (Catlin 2009).
- ➢ The chart below shows the increasing concentration of piping plovers on constructed sandbars over natural sandbars from 2004 through 2009 (USACE 2009), and the decline in constructed sandbar habitat, especially after the 2011 flood.

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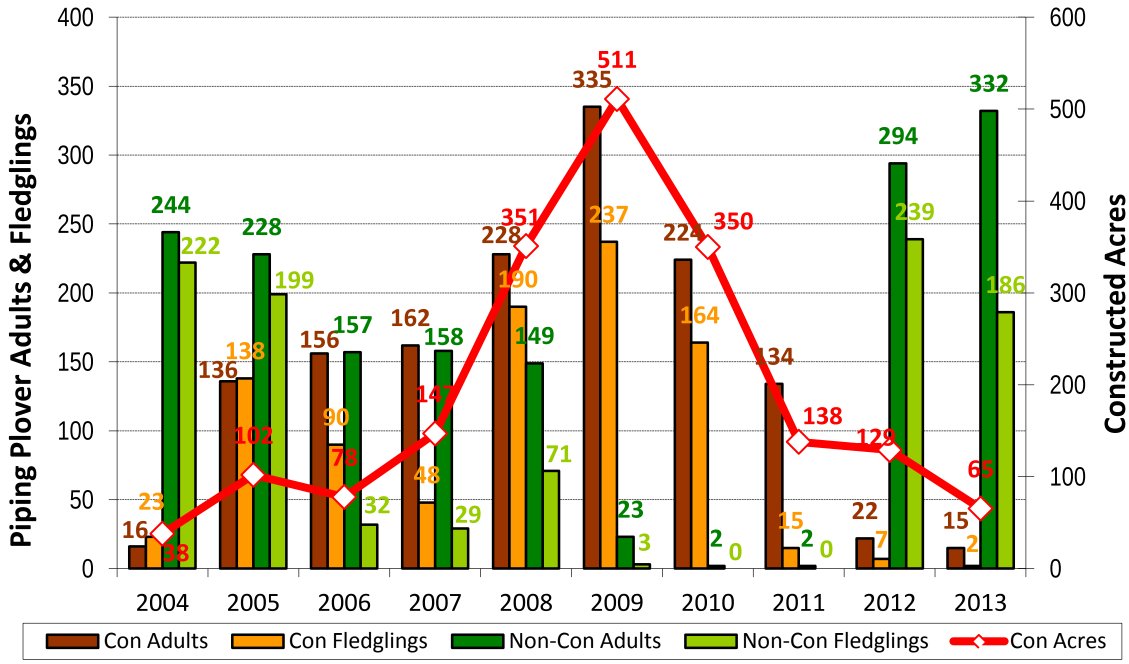
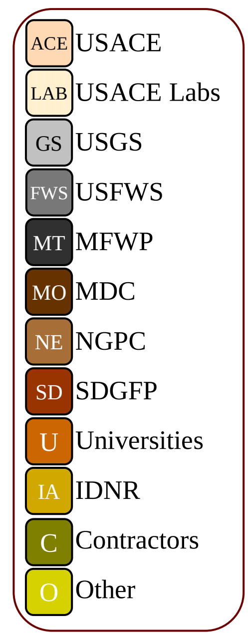
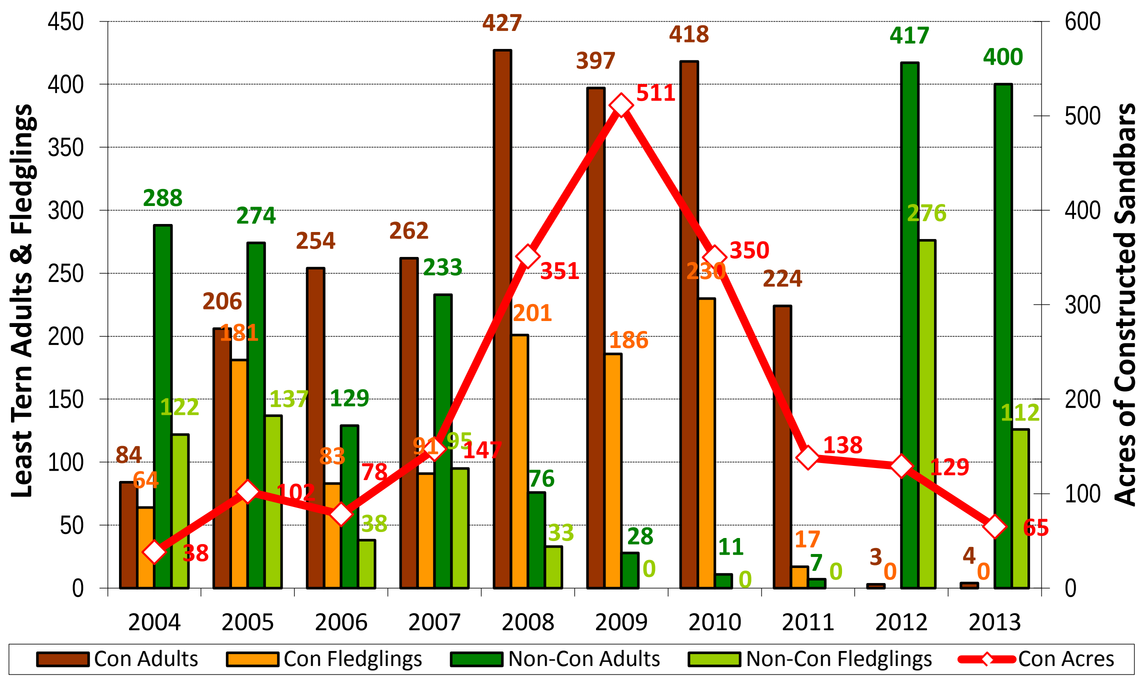




- The chart that follows shows the increasing concentration of least terns on constructed sandbars over natural sandbars from 2004 through 2009 (USACE 2009), and the decline in constructed sandbar habitat, especially after the 2011 flood.



36. **How are fluctuations in reservoir levels affecting productivity and populations?**
    - Declines in reservoir levels can expose shoreline habitat and islands used for nesting.
    - Declining reservoir levels over a series of years on Lake Sakakawea led to a substantial increase in piping plover adult numbers (USACE 2009).
    - Declining reservoir levels over a series of years on Lake Oahe led to a substantial increase in least tern and piping plover adult numbers (USACE 2009).

- ➢ Rising reservoir levels over a series of years on Lake Sakakawea cause loss of shoreline habitat has led to decreased piping plover adult numbers, decreased productivity and an increase in incidental take (USACE 2009).
- ➢ Rising reservoir levels over a series of years on Lake Oahe has led to decreased piping plover and least tern adult numbers, decreased productivity for the two species and an increase in incidental take for the two species (USACE 2009).
- ➢ Changes in reservoir levels at Fort Peck have not demonstrated substantial effects on terns and plovers due to low usage of this reservoir by the birds (USACE 2009).

37. **How are predator controls and nest caging affecting productivity and populations?**
    - ➢ Predator control methods include use of exclosures (cages), use of predator traps and other removal techniques.
    - ➢ Studies have shown implementation of predator controls increases the likelihood of successful piping plover egg hatching and fledging of chicks.
    - ➢ Caging of piping plover nests increases the likelihood of the eggs successfully hatching (USACE 2009).
    - ➢ Protecting nests early in incubation provides maximum effectiveness.
    - ➢ Caging of plover nests can lead to predation of adult plovers, juveniles, and eggs if a predator learns to key in on cages (Murphy et al. 2003).
    - ➢ The effects of caging plover nests on least terns are unknown. Due to a different behavior (flying off of nest if alarmed), least tern nests are not caged.
    - ➢ Likelihood of successful fledging of a chick increased with more days the nest was protected.

XII. What other opportunities exist to positively affect tern and plover productivity and population numbers?

Service Providers: ACE GS FWS NE SD U IA C O

38. **Can vegetation modification positively affect terns and plovers?**

ISP Projects Addressing Questions:

- Least Tern and Piping Plover Adult Census
- Least Tern and Piping Plover Productivity Monitoring
- Influence of Predation on Least Tern and Piping Plover Productivity
- Piping Plover Foraging Ecology in the Great Plains.
- Population Dynamics of Piping Plovers on the Missouri River, South Dakota.
- Piping Plover population dynamics on natural and engineered sandbars on the Missouri River.
- Least Tern Productivity and Foraging Ecology on the Gavins Point Reach of the Missouri River.
- Habitat Selection, Productivity, and Estimation of Available Nesting Habitat for Piping Plovers on Lake Sakakawea
- Habitat and Reservoir Elevations and RDEIS Alternatives performance as described by equivalent habitat acres
- Reservoir Habitat Assessment
- ESH Monitoring and Evaluation

- ➢ Over 90% of nests of both species occurred in areas with less than 10% vegetation (Vander Lee 2002).
- ➢ Initial test sites of vegetation removal methods had limited usage by terns and plovers (1991-1994 and 2005-2007).

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- An ongoing study is investigating the most effective methods of removing vegetation.
- Future studies will investigate usage of vegetation removal sites by terns and plovers.

39. **Can created reservoir habitat positively affect terns and plovers?**
    - Constructed sandbars at River Mile 826.5 on Lewis & Clark Lake and at Dredge Island on Lake Oahe have been used by both species, sometimes providing significant numbers. (In 2009, 33% of all least tern nests on the Missouri were on the Lewis & Clark Lake complex.) (USACE 2009)
    - The opportunity to create reservoir habitat and its availability following creation is dependent upon dam operations which can lead to large fluctuations in water levels of the reservoirs, particularly Lake Sakakawea and Lake Oahe.
40. **Can flow modification positively affect terns and plovers?**
    - Tern and plover habitat in the Gavins Point segment was positively affected by the sustained high flows in 1997 (Vander Lee 2002) and 2011.
    - Vegetation was reduced by 50% from 1996 to 1998 on existing sandbars, demonstrating the ability of high flows to scour vegetation (Vander Lee 2002).
    - Average sandbar size increased from 11 acres to 44 acres from 1996-1998 (Vander Lee 2002).
    - Bare sand areas greater than one acre in size increased from 151 in 1996 to 250 in 1998 (Vander Lee 2002).
    - Flow from the Gavins Dam increased in 1999 and 2000 compared to 1998. During this time, total sandbar acres decreased by 60% and the average site size decreased by 55%. Little or no vegetation scouring occurred and vegetation on inter-channel sandbars increased 3-fold from 1998-2000 (Vander Lee 2002).
    - Reduced flows during the drought years of 2000-2007 exposed additional sandbar habitat.
    - It has not been determined what magnitude and duration of flow would be needed to create new habitat.
41. **Can captive rearing positively affect terns and plovers?**
    - In 1995, due to high releases out of the dams and the filling of the reservoirs, least tern eggs and piping plover eggs and chicks were collected to prevent their loss from inundation. The collected eggs were hatched and chicks raised at a captive rearing facility operated by the Corps of Engineers. After fledging (able to fly) the fledglings were released into the wild. The captive rearing program then continued through the 2002 nesting season. From 1995-2002 523 piping plover eggs, 16 piping plover chicks and 478 least tern eggs were collected. Of these 443 piping plover eggs hatched (84.7% success) and 378 least tern eggs hatched (79.0% success). 411 piping plover chicks fledged (92.8% success) and 322 least tern chicks fledged (85.2% success) (USACE 2009).
    - Collection and incubation practices were refined during the program resulting in higher egg hatching success and lower mortality of chicks over time.
    - With the construction of a new captive rearing facility and flight pens in 1996, acclimation of juveniles for release into the wild was greatly improved.
    - A study in 2000 found the survival rate of post fledged captive reared plovers was the same as wild reared plovers (Niver 2000).
    - Captive reared piping plovers have been observed on the Missouri River every year from 1996 through 2010. A captive reared piping plover released in 1997 was observed in 2010. With an average life expectancy of 6-7 years, this 13 year old plover is extremely long lived (USACE 2009).

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O	Other

- The U.S. Fish & Wildlife Service indicated in the Biological Opinion (2003) that it no longer supported captive rearing by the Corps and the program was terminated. The rationale provided is as follows:
  - The Service is focused on restoring the Missouri River ecosystem, and does not think that diverting resources and time to captive rearing would allow the Corps to further that aim. Unlike the pallid sturgeon, the birds are able to reproduce in the wild, making such drastic measures unnecessary.
  - While piping plovers could be reared successfully (albeit, as research on the Great Lakes has shown, with a significantly lower return rate than their wild cohorts), least terns did not successfully make the transition to the wild and had a very low survival rate.
  - The Service is concerned about the potential for disease or genetic modification by selecting for birds in a captive environment.

42. **How does human disturbance affect tern and plovers?**
- A USGS study in 2006 on the Gavins Point Segment that assessed recreation and research disturbance of tern and plover nesting areas found very little recreation use of the monitored sandbars. The study found that 66% of the events monitored were classified recreational but only 3% of the recreational events resulted in a visit to a monitored sandbar. Research made up 34% of the events and 62% of these events resulted in a visit to a monitored sandbar. The study noted one instance where the presence of restriction signs seemed to redirect recreational users from a monitored sandbar (Stucker 2007).

43. **Can placement of restriction signs and public education positively affect terns and plovers?**
- Restriction signs are placed around nesting sites that contain 5 or more nests or in areas where there is a high probability of human disturbance.
- Information signs on the least tern, piping plover and pallid sturgeon have been placed at boat ramps along the Missouri River advising the public to be aware of the species and to release any sturgeon species caught while angling, and to avoid bird nesting areas.
- The Corps partially funds a USFWS special agent to provide law enforcement coverage throughout the nesting season.

XIII.What are the trends in habitat availability on the system?

Service Providers: ACE GS FWS NE SD U C O

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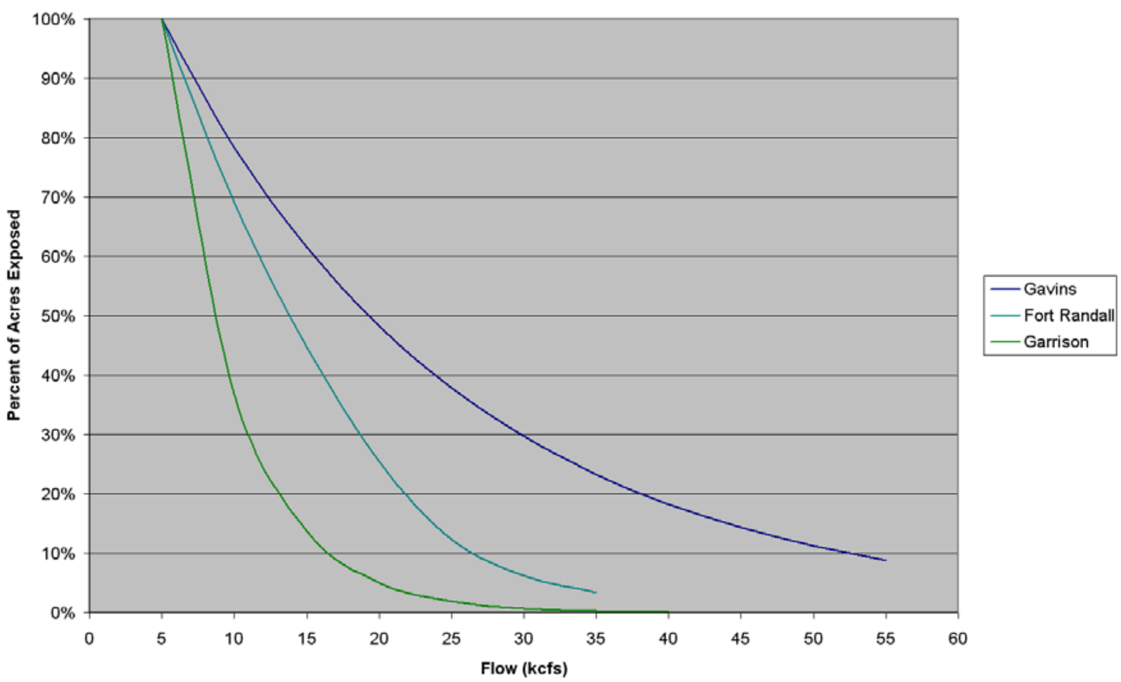
- A method to annually inventory and map emergent sandbars and land cover for the Missouri River using high-spatial resolution satellite imagery has been developed. Emergent sandbar habitat acreages are calculated every year and are reported in the Emergent Sandbar Habitat Annual Adaptive Management Report and the Corps Annual Report.

44. **What are the trends in flow events that create habitat (frequency/probability)?**
- Analysis of system conditions (inflows and outflows) from 1968 through 2013 indicate that in10 out of the 45 years, the potential existed to create sandbar habitat based on the criteria of 60,000 cfs for 60 days (however, this quantity and duration of flow is not known to create habitat).
- Seven of the nine years in which this potential existed appeared to be clumped together: 1969,1971,1972,1995,1996,1997,1999.
- The remaining two years were early in the period of analysis (1975 and 1978) indicating that two major events (1995-1999) and (2011) were the flow events capable of creating significant habitat since the listing of both species in 1986.

45. **What are the trends in erosion rates?**

- Erosion rates of sandbars over the period of 1998-2005 varied by segment and ranged from 5% (Lewis and Clark Lake) to 14% (Gavins Point River Segment) loss per year with an average rate of 10% loss per year.

46. **What are the trends in vegetation/ re-vegetation rates?**
    - Re-vegetation is widespread one year after tilling.
    - Vegetation rates of sandbars over the period of 1998-2005 varied by segment and ranged from 3% to 14% per year with an average rate of 6% per year.
47. **How does availability of ESH change due to water levels and dam releases?**
    - Draft curves have been developed to capture this relationship for three segments based on 2005 LiDAR (Gavins Point) and technical appendices to the Master Manual (Ft Randall and Garrison). While these represent an initial starting point, future investigations will be undertaken to update and refine these relationships. These curves can be used by taking a known acreage and discharge, for example 100 acres at 30,000 cfs in the Gavins Point segment, and adjusting it to a desired discharge, for example 15,000 cfs. In this example, 100 acres at 30,000 cfs (30% exposed) would correspond to approximately 217 acres of ESH at 15,000 cfs (65% exposed) ([100 acres/30%] * 65% = 217 acres).



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- The relationship of habitat availability to flow is complex. As flow is decreased, the area of exposed inter-channel sandbars and islands initially increases due to the lower river stage. However, as flow is further decreased inter-channel sandbars can become connected to islands and to floodplains which leads to a decrease in the amount of inter-channel sandbars depending upon the criteria and definitions used to define emergent sandbars.

XIV. What factors influence nest site selection, productivity and populations trends?

Service Providers: ACE FWS U

48. **How does breeding ground location and site selection affect tern and plover populations and productivity?**
    - The Missouri River Basin represents the northernmost breeding range of the interior population of the least tern. Under migration theory these terns would travel the furthest of all least terns with their wintering grounds being the southernmost of all least terns (southern Brazil and northern Argentina) (Newton

2007). This longer distance could mean a lower survival rate to and from the wintering grounds for Missouri River terns. It also means that survival should be higher for terns breeding on the lower Missouri at Gavins Point and Lewis & Clark Lake compared to those breeding on the upper Missouri below Fort Peck and Garrison Dams.

- The Platte, Niobrara and lower Missouri Rivers represent the southernmost breeding range for Northern Great Plains population of the piping plover. Under migration theory these plovers would travel the shortest distance to and from the wintering grounds on the Gulf and Atlantic Coasts (Newton 2007). These plovers would be anticipated to have a higher survival rate compared to plovers that have to migrate to North Dakota, Montana and Canada.
- Site selection on the Missouri River is an area that is being considered for further study.

49. **How does food availability affect piping plovers and least terns?**

- Plover chicks gained weight more rapidly in the alkali wetlands than on river segments (Le Fer 2006).
- Compared with cooler water river segments and reservoir segments, invertebrate numbers and biomass were higher in the wetlands and warm water (Gavins River) segment, but plover chick survival was lower on the warm water (Gavins River) segment; thus, piping plovers adapted to a variety of prey densities, and other factors, likely predation, reduced survival rates in the warm water (Gavins River) segment (Le Fer 2006).
- Prey availability plays a role in plover chick survival (heavier chicks were more likely to survive to fledging). However, other factors in addition to prey availability, such as predation pressures, also play a role in reproductive output in the Great Plains population (Le Fer 2006).
- Plover chicks that were larger at early stages (4-5 days and 8-9 days old) were more likely to survive to fledging. However, chick size at 4-5 days and 8-9 days did not vary among sites and, thus, did not explain differential survival among sites (Le Fer 2006).
- Water temperatures, variation in water temperature, less scouring flows, lack of daily water fluctuations, habitat, or food difference may explain the greater number of invertebrates in the warm water (Gavins River) Segment (Le Fer 2006).
- A separate study has been conducted on the availability of forage for least terns within the Gavins Point River segment. Results of this study are pending.

50. **How does density-dependence affect piping plovers?**

- Piping plovers are territorial and may exhibit aggressive behavior towards other adult and juvenile plovers using the same breeding area (Catlin 2009).
- Piping plover juvenile survival was negatively related to nesting density on the relatively densely populated engineered sandbars (Catlin 2009).
- On the less dense natural sandbars, survival was positively correlated with density (Catlin 2009).
- Adult survival did not appear to be related to density within the study (Catlin 2009).
- Juveniles from densely populated engineered sandbars were more likely to leave engineered habitat to nest on natural sandbars than were juveniles hatched on less densely populated engineered sandbars (Catlin 2009).
- It is possible that juveniles moved to natural habitats because they were unable to compete with adults for the more desirable engineered habitats (Catlin 2009).

51. **How does predation affect terns and plovers?**

ACE	USACE
LAB	USACE Labs
GS	USGS
FWS	USFWS
MT	MFWP
MO	MDC
NE	NGPC
SD	SDGFP
U	Universities
IA	IDNR
C	Contractors
O	Other

- While conducting research in 1991 and 1992, Kruse and others (1993) documented that raccoon and mink were responsible for most of the known nest predation (77.3%) and great horned owls were responsible for most of the known chick predation (68.2%).
- Of the depredated nests monitored by the Corps from 1993 through 2007 with a predator identified, raccoon and mink have been implicated 68.4% (214/313) of the time (USACE 2009-07).
- Of the nests monitored by the Corps in the last ten years (1999-2008) on both natural and constructed sandbars on the Missouri River, predators have been directly identified in the loss of 5.1% (292/5,716) of piping plover nests and 6.7% (336/5,052) of least tern nests. These estimates are conservative because they include only nests that were positively identified as being depredated through evidence left at the nest bowl, such as track trails, feces, and feathers (USACE 2009-07).
- Monitoring of least tern and piping plover breeding activities on sandbars constructed below Gavins Point Dam showed high productivity in the first nesting season after construction. In subsequent years densities increased and productivity for the three older sandbars dropped. However, apparent nest success for these sandbars remained high for 2004-2008 with 68% of plover nests and 70% of tern nests hatching out at least one egg. The reason for the low productivity on these older bars was due to high chick mortality. In the absence of evidence of chick losses due to weather events, the most likely causes of the recorded high chick mortality were likely predation (USACE 2009-07).
- USDA trappers have set pole traps on constructed sandbar complexes to remove great horned owls. Virginia Tech researchers have documented that after an owl is removed piping plover chicks have a higher survival rate.

52. **How do weather events affect terns and plovers?**

- Severe thunder storms and hail storms have been documented to be factors in nest destruction, chick and adult losses on the Missouri River. For example: On July 9, 2009 USGS technicians surveyed the constructed sandbar at RM 791.5 just hours after a severe thunderstorm had passed through the area. The storm was documented to have had high winds and large hail. The USGS crew found on the sandbar the following dead birds: 23 least tern chicks, 5 least tern fledglings, 6 least tern adults, 8 piping plover chicks, 3 piping plover adults. The crew also found a least tern chick and a least tern fledgling that were severely injured and likely did not survive (Sherfy 2009).

ACE	USACE
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MO	MDC
NE	NGPC
SD	SDGFP
U	Universities
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C	Contractors
O	Other

ISP Projects Addressing Questions:

- Inland Migration Stopovers Used by Piping Plover
- Piping Plover Population Dynamics on Natural and Engineered Sandbars on the Missouri River.
- Population Dynamics of Piping Plovers on the Missouri River, South Dakota
- Piping Plover Foraging Ecology in the Great Plains
- Least Tern and Piping Plover Productivity Monitoring
- A Muddy Question: Assessing Human Recreation and Research Disturbances on Missouri River Sandbars Managed for Endangered Birds
- Evaluation of procedures for Monitoring Productivity and Numbers of Piping Plovers & Least Terns on the Missouri River

XV. How are factors outside of the Missouri River affecting populations?

Service Providers: ACE GS FWS U O

53. **How does immigration/ emigration (use of other nesting habitats) affect Missouri River piping plover populations?**
   - Adults and juveniles emigrated from (left) the study area at a higher rate after the 2006 breeding season, a year when water discharge was higher, nesting densities were higher (as a result of reduced habitat availability), and reproductive success was lower (as a result of predation) than in the other years (Catlin 2009).
   - Based on population models for terns and plovers, it appears that immigration of birds from outside of the Missouri River contributed to the growth of the Missouri River populations seen between 1998 and 2007.
   - Researchers from the Virginia Polytechnic Institute have documented that piping plovers banded on the Missouri River below Gavins Point Dam have been re-sighted on the Missouri River below Fort Randall Dam, on Lewis & Clark Lake, on the Niobrara River, on the Platte River and at the Lake of the Woods Ontario Canada (Daniel Catlin, Joy Felio, Virginia Polytechnic Institute – personal communication).
   - Researchers from the Virginia Polytechnic Institute have documented that piping plovers banded on the Platte River as chicks in 2008, nested the following year on the constructed sandbar complex on Lewis & Clark Lake (Felio 2009).
54. **How does survival during migration affect Missouri River populations?**
   - Piping plover migration routes may be as short as 1,000 miles (Louisiana-Texas Gulf Coast) to as long as 2,000 miles (Bahamas) between the Missouri River breeding grounds and wintering grounds.
   - Piping plover migration duration in not known, but may be relatively quick with birds moving between the breeding and wintering grounds in less than two weeks (Pompei 2007).
   - There are no clear migration routes seen on the maps of stopover sites, and no inland sites were used consistently year after year, but it must be noted that shorebird habitat tends to be quite variable at interior sites (Pompei 2007).
   - Migrating plovers appear to be somewhat flexible in their stopover site choices, Piping plovers do not seem to stage during migration as many other shorebird species do. This makes them less vulnerable to the loss of important stopover sites (Pompei 2007).
   - Findings confirm previous observations that plovers do not migrate in flocks, and it was found that they stay at stopover sites for only a short time. Sites where large numbers of plovers were seen tended to be at or very close to known breeding and wintering sites (Pompei 2007).

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LAB USACE Labs
GS USGS
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MT MFWP
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U Universities
IA IDNR
C Contractors
O Other

- Piping plovers stop at both inland and coastal sites during migration (Pompei 2007).
- The predictability of habitat existence and quality during migration is low from year to year, and even within a single season (Pompei 2007).
- Least Tern nesting on the Missouri River represents the northernmost range of the interior population and therefore these terns would winter on the southernmost wintering grounds. This may mean a migration as short as 4,000 miles to the Pacific coast of Columbia and as far as 9,000 miles to the Atlantic coast of northern Argentina.
- Least tern migration routes in the interior United States are believed to follow major river routes to the Gulf of Mexico after which the route is unknown.
- The duration of least tern migration is unknown. The locations of least tern stopover sites during migration are unknown.
- Least terns may flock together before beginning migration to the wintering grounds.

55. **How does survival on the wintering grounds affect Missouri River populations?**

- Piping plovers may spend from 9 to 10 months each year on the wintering grounds.
- The piping plover wintering range includes the Gulf Coast from Mexico to Florida, the Atlantic Coast from Florida up to North Carolina, the Bahamas, and Caribbean islands.
- Threats to piping plover wintering grounds include recreation use, urban development, oil spills and dredging operations.
- Studies by Virginia Tech researchers show a year to year high survival rate of piping plover banded below Gavins Point Dam indicating that survival is not a problem on the wintering grounds (Felio 2009).
- Survival of piping plovers on the wintering grounds is less frequently monitored than on the breeding grounds.
- Least tern wintering grounds locations are only vaguely known to be on the Atlantic and Pacific coasts of South America.
- The time least terns spend on migration and on the wintering grounds is between 9 to 10 months, but how much time is spent on migration and how much time is spent on the wintering grounds is unknown.
- Wintering grounds threats to survival are largely unknown due to the lack of knowledge as to where the wintering grounds are located.

ACE	USACE
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GS	USGS
FWS	USFWS
MT	MFWP
MO	MDC
NE	NGPC
SD	SDGFP
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C	Contractors
O	Other

ISP Projects Addressing Questions:

- Inland Migration Stopovers Used by Piping Plover
- Population Dynamics of Piping Plovers on the Missouri River, South Dakota
- Piping Plover Population Dynamics on Natural and Engineered Sandbars on the Missouri River.
- International Plover Census

XVI. What are the effects of management actions on non-target resources?

Service Providers: ACE GS FWS SD U O

56. **How do management actions for terns and plovers affect sturgeon?**

- Steps have been taken to identify potential spawning sites for sturgeon near locations targeted for ESH restoration and avoid them. Some potential projects have been canceled due to this consideration.

57. **How do management actions terns and plovers affect riverbank erosion?**

- Monitoring of constructed sites at river miles 761.3 and 770 has not exhibited significant changes in bankline erosion trends following construction of ESH sites.

58. **How do management actions for terns and plovers affect water quality?**

- Post-construction water quality surveys were conducted at River Mile 826.5 in Lewis and Clark Lake, downstream of a constructed sandbar site. No significant adverse affects to water quality were found.

ISP Projects Addressing Questions:

- Missouri River Restoration Project Water Quality Monitoring Program
- Emergent Sandbar Habitat Evaluation and Monitoring
- Two-Dimensional Hydraulic Model of the Missouri River

ACE USACE
LAB USACE Labs
GS USGS
FWS USFWS
MT MFWP
MO MDC
NE NGPC
SD SDGFP
U Universities
IA IDNR
C Contractors
O Other

Literature Cited:

Allen, T.C., Q.E. Phelps, R.D. Davinroy, and D.M. Lamm. 2007. A laboratory examination of substrate, water depth, and light use at two water velocity levels by individual juvenile pallid (*Scaphirhynchus albus*) and shovelnose (*Scaphirhynchus platorynchus*) sturgeon. Journal of Applied Ichthyology 23: 375-381.

Arujo-Lima, C.A.R.M., and E.C. Oliveira. 2005. Transport of larval fish in the Amazon. Journal of Fish Biology 53: 297-306.

Bajer, P.G., and M.L. Wildhaber. 2007. Population viability analysis of Lower Missouri River shovelnose sturgeon with initial application to the pallid sturgeon. Journal of Applied Ichthyology 23: 457-464.

Bayley, P.B. 1988. Factors affecting growth rates of young tropical floodplain fishes: seasonality and density-dependence. Environmental Biology of Fishes 21: 127–142.

Bayley, P.B. 1995. Understanding large river-floodplain ecosystems. BioScience 45: 153-158.

Blevins, D.W. 2006. The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River. USGS Circular. Reston, VA. U.S. Geological Survey, 8 p. http://pubs.usgs.gov/circ/2006/1301/.

Braaten, P.J., D. B. Fuller, R. D. Lott, T. M. Haddix, L. D. Holt, R. H. Wilson, M. L. Bartron, J. A. Kalie, P. W. DeHaan, W. R. Ardren, R. J. Holm and M. E. Jaeger. 2012. Natural growth and diet of known-age pallid sturgeon (Scaphirhynchus albus) early life stages in the upper Missouri River basin, Montana and North Dakota. Journal of Applied Ichthyology 2012: 1-9.

Braaten, P.J., D.B. Fuller, R.D Lott, M.P. Ruggles, and R.J. Holm. 2010. Spatial distribution of drifting pallid sturgeon larvae in the Missouri River inferred from two net designs and multiple sampling locations. North American Journal of Fisheries Management 30: 1062-1074.

Braaten, P.J., D.B. Fuller, R.D. Lott, and G. Jordan. 2009. An estimate of the historic population size of adult pallid sturgeon in the upper Missouri River Basin, Montana and North Dakota. Journal of Applied Ichthyology 25: 2-7.

Braaten, P.J., D.B. Fuller, L.D. Holte, R.D. Lott, and W. Viste. 2008. Drift dynamics of larval pallid sturgeon and shovelnose sturgeon in a natural side channel of the upper Missouri River, Montana. North American Journal of Fisheries Management 28: 808-826.

Bramblett, R.G., and R.G. White. 2001. Habitat use and movements of pallid and shovelnose sturgeon in the Yellowstone and Missouri Rivers in Montana and North Dakota. Transactions of the American Fisheries Society 130: 1006–1025.

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

Catlin, D.H. 2009. Population Dynamics of Piping Plovers (*Charadrius melodus*) on the Missouri River. Virginia Polytechnic Institute. Blacksburg, Virginia. 93 p.

DeLonay, A.J., R.B. Jacobson, D.M. Papoulias, D.G. Simpkins, M.L. Wildhaber, J.M. Reuter, T.W. Bonnot, K.A. Chojnacki, C.E. Korschgen, G.E. Mestl, and M.J. Mac. 2009. Ecological requirements for pallid sturgeon reproduction and recruitment in the Lower Missouri River: A research synthesis 2005–08. U.S. Geological Survey Scientific Investigations Report 2009–5201. 59 p.

Dryer, M. and A. Sandvol. 1993. Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service Office, Billings, Montana. 55 p.

Elliot, C.M., J.M. Reuter, and R.B. Jacobson. 2009. Channel morphodynamics in four reaches of the lower Missouri River, 2006-07. U.S. Geological Survey Scientific Investigations Report 2009-5074. 258 p. http://pubs.usgs.gov/sir/2009/5074/.

Elliott-Smith, E., S.M. Haig, and B.M. Powers. 2009. Data from the 2006 International Piping Plover Census. U.S. Geological Survey Data Series 426. 332 p.

Felio, J.H., D.H. Catlin, and J.D. Fraser. 2010. Evaluating Piping Plover Population Dynamics and Engineered Sandbar Habitat Field Operations Report 2009. Virginia Polytechnic Institute. Blacksburg, Virginia. 16 p.

Ferland, C.L. and S.M. Haig. 2002. 2001 International Piping Plover Census, Report to U.S. Geological Survey, Biological Resources Division, Forest and Rangeland Ecosystem Science Center, Corvallis, Oregon. 293 p.

Fisher, S.G. 1983. Succession in streams. Pages 7-27 in J.R. Barnes and G.W. Minshall, eds. Stream Ecology: application and testing of general ecological theory. Plenum Press, New York.

French, W.E., B.D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2013. Vulnerability of age-0 pallid sturgeon *Scaphirhynchus albus* to predation; effects of predator type, turbidity, body size, and prey density. Environmental Biology of Fishes DOI 10.1007/s10641-013-0166-y.

Fuller, D. B. and T. M. Haddix. 2012. Examination of pallid sturgeon use, migrations and spawning in Milk River and Missouri River below Fort Peck Dam during 2011. Report prepared for the U. S. Geological Survey, Columbia Environmental Research Center. Montana Fish, Wildlife and Parks, Fort Peck, MT.

Galat, D.L., L.H. Fredrickson, D.D. Humburg, K.J. Bataille, J.R. Bodie, J.Dohrenwend, G.T. Garvey, J.E., Heist, E.J., Brooks, R.C., Herzog, D.P., Hrabik, R.A., Killgore, K.J., Hoover, J.J., and Murphy, C.E., 2009, Current status of the pallid sturgeon in the Middle Mississippi River: habitat, movement, and demographics. St. Louis, Missouri. U.S. Army Corps of Engineers. 353 p. (http://)fishdata.siu.edu/pallid.

Gelwicks, J.E. Havel, D.L. Helmers, J.B. Hooker, J.R. Jones, M.F. Knowlton, J. Kubisiak, J. Mazourek, A.C. McColpin, R.B. Renken, and R.D. Semlitsch. 1998. Flooding to restore connectivity of regulated, large-river wetlands. BioScience 48: 721-733.

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

Grohs, K.L., R.A. Klumb, S.R. Chipps, and G.A. Wanner. 2009. Ontogenetic patterns in prey use by pallid sturgeon in the Missouri River, South Dakota and Nebraska. Journal of Applied Ichthyology 25: 48-53.

Hadley, G.L. and J.J. Rotella. 2009. Upper basin pallid sturgeon survival estimation project. Final Report. 34 p.

Haig, S.M. and J.H. Plissner. 1992. 1991 International Piping Plover Census, Report to U.S. Wildlife Service Region 3, Division of Endangered Species, Ft. Snelling, Minnesota 148 p.

Hartfield, P. and E. Kuhajda. 2009. Threat assessment: hybridization between pallid sturgeon and shovelnose sturgeon in the Mississippi River. Report to the U.S. Army Corps of Engineers. 22 p.

Hedrick, R.P., T. Kurobe, T.S. McDowell, S.C. Yun, and E. MacConnell. 2009. Development of management tools for the pallid sturgeon iridovirus. Final Report to the U.S. Army Corps of Engineers. 20 p.

Heist, E., J. Eichelberger, A. Asher, S. Youngs, A. DeLonay and K. Chojnacki. 2014. Genetic Tools Indicate Low Pallid Sturgeon Recruitment and High Rates of Hybridization in the Lower

Missouri and Mississippi Rivers. 75th Annual Midwest Fish and Wildlife Conference, Quebec City, Quebec.

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

Jacobson, R.B., D.W. Blevins, and C.J. Bitner. 2009. Sediment regime constraints on river restoration – An example from the Lower Missouri River, *in* James, L.A., Rathburn, S.L., and Whittecar, G.R., eds., Management and restoration of fluvial systems with broad historical changes and human impacts. Denver, Colo. Geological Society of America Special Paper 451: 1-22.

Jacobson, R.B., H.E. Johnson III, and B.J. Dietsch. 2009. Hydrodynamic simulations of physical aquatic habitat availability for pallid sturgeon in the Lower Missouri River, at Yankton, South Dakota, Kenslers Bend, Nebraska, Little Sioux, Iowa, and Miami, Missouri, 2006-07. U.S. Geological Survey Scientific Investigations Report. Reston, VA. 67 p. http://pubs.usgs.gov/sir/2009/5058/.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood-pulse concept in river-floodplain systems. Canadian Special Publication of Fisheries and Aquatic Sciences 106: 110-127.

Kaplinski, L., E. Stevens, and T.L. Hoffnagle. 2001. The 1996 controlled flood in Grand Canyon: flow, sediment transport, and geomorphic changes. Ecological Applications 11: 657-671.

Kappenman, K.M., W.C. Fraser, M. Toner, J. Dean, and M.A.H. Webb. 2009. Effect of temperature on growth, condition, and survival of juvenile shovelnose sturgeon. Transactions of the American Fisheries Society 138: 927-937.

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

Kelly, B.P. 2006. Hydrologic interactions among rainfall, side-channel chutes, the Missouri River, and ground water at Overton Bottoms North, Missouri, 1998-2004, *in* Jacobson, R.B., ed., Science to Support Adaptive Habitat Management: Overton Bottoms North Unit, Big Muddy National Fish and Wildlife Refuge, Missouri. U.S. Geological Survey Scientific Investigations Report 2006-5086. p. 33–68.

Kelly, B.P. 2004. Simulation of ground-water flow, contributing recharge areas, and ground-water travel time in the Missouri River alluvial aquifer near Ft. Leavenworth, Kansas. U.S. Geological Survey Scientific Investigations Report 2004-5215. 76 p.

Kelly, B.P. 2000. Effects of alternative Missouri River management plans on ground-water levels in the lower Missouri River flood plain. U.S. Geological Survey Water-Resources Investigations Report 2000-4052. 128 p.

King, A.J., Z. Tonkin, and J. Mahoney. 2008. Environmental flow enhances native fish spawning and recruitment in the Murray River, Australia. River Research and Applications 25: 1205-1218.

Klungle, M.M. and M.W. Baxter. 2005. Lower Missouri and Yellowstone rivers pallid sturgeon study. Report submitted to Western Area Power Administration. Montana Department of Fish, Wildlife and Parks, Fort Peck, MT. 23p.

Kruse, C.D. 1993. Influence of Predation on Least Tern and Piping Plover Productivity along the Missouri River in South Dakota. South Dakota State University. Brookings, South Dakota. 80 p.

Le Fer, D. 2006. Piping Plover Foraging Ecology in the Great Plains. Virginia Polytechnic Institute. Blacksburg, Virginia. 151 p.

Lott, C.A. 2006 Distribution and Abundance of the Interior Population of the Least Tern (*Sternula antillarum*), 2005. U.S. Army Corps of Engineers, Engineer Research and Development Center. Vicksburg, Mississippi. 88 p.

McAllister, R.F. 2010. February. “Comparison of spring rise impacts on groundwater levels in 2008 and 2009”. Presentation as the Annual Missouri River Natural Resources Committee Conference and Biological Opinion Forum. March 2010. Nebraska City, NE.

Mead, R.H. and J.A. Moody. 2010. Causes for the decline of suspended-sediment discharge in the Mississippi River system, 1940-2007. Hydrological Processes 24: 35-49.

Murphy, R.K, I.M.G. Michard, D.R.C. Prescott, J.S. Ivan. 2003. Predation of Adult Piping Plovers at Predator Exclosure Cages. Waterbirds 26: 150-155.

Murray, C.J., K.J. Klett, Y.L. Xie, C.R. Vernon, E.W. Oldenburg and K.B. Larson. 2014. Geographic Distribution and Habitat Associations of Pallid Sturgeon in the Missouri River. Pacific Northwest National Laboratory, Richland, Washington, USA. 100 p.

Newton, I. 2007. Migration Ecology of Birds. Academic Press, San Diego, California. 984 p.

Niver R.A. 2000. An Evaluation of Captive Rearing as a Management Tool for Piping Plovers in the Great Plains. University of Wisconsin. Madison, Wisconsin. 72 p.

Pallid Sturgeon Population Assessment Team. 2002 – 2010. Pallid Sturgeon Population Assessment Annual Reports. Contact: [redacted]. Reports available online at: http://www.moriverrecovery.org/mrrp/f?p=136:153:491786418771577::NO:::.

Plissner, J.H. and S.M. Haig. 1997. 1996 International Piping Plover Census, Report to U.S. Geological Survey, Biological Resources Division, Forest and Rangeland Ecosystem Science Center. Corvallis, Oregon. 231 p.

Poff, N.F., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. The natural flow regime. BioScience 47: 769-784.

Pompei V.D. and F.J. Cuthbert. 2007. Spring and Fall Distribution of Piping Plovers in North America: Implications for Migration Stopover Conservation. University of Minnesota. St. Paul, Minnesota. 28 p.

Reuter, J.M., R.B. Jacobson, C.M. Elliott, and A.J. DeLonay. 2009. Assessment of Lower Missouri River physical aquatic habitat and its use by adult sturgeon (genus *Scaphirhynchus)* 2005-07: U.S. Geological Survey Scientific Investigations Report 2009-5121. Reston, Va. U.S. Geological Survey. 81 p. http://pubs.er.usgs.gov/usgspubs/sir/sir20095121.

Reuter, J.M., Jacobson, R.B., Elliott, C.M., Johnson, H.E., III, and DeLonay, A.J., 2008, Hydraulic and substrate maps of reaches used by sturgeon (Genus *Scaphirhynchus*) in the Lower Missouri River, 2005–07: Data Series Report 386. Reston, Va. U.S. Geological Survey. 442 p. http://pubs.usgs.gov/ds/386/.

Rotella, J. 2012. Upper basin pallid sturgeon survival estimation project 2012 update. Report prepared for Upper Basin Pallid Sturgeon Workgroup. Montana State University, Bozeman.

Sherfy, M.H. and M.J. Anteau, T.L. Shaffer, M.A. Sovoda, J.H. Stucker. 2009. Research, Monitoring and Assessment for Least Tern and Piping Plover Habitat and Productivity on the Missouri River, 2009 Progress Report. U.S. Geological Survey. Northern Prairie Research Center. Jamestown, North Dakota. 59 p.

Steffensen, K.D., L.A. Powell, and J.D. Koch. 2010. Assessment of hatchery-reared pallid sturgeon survival in the lower Missouri River. North American Journal of Fisheries Management 30: 671-678.

Steffensen, K.D., T.W. Huenemann, K.R. Winders, C.J. Ridenour, R. Wilson, S. Stukel, D.A. Shuman, T. Haddix, and T.L. Welker. 2014. Pallid Sturgeon *Scaphirhynchus albus*: Is there evidence of recruitment in the Missouri River? Pallid Sturgeon Population Assessment Project Technical Report to the U.S. Army Corps of Engineers. 10 p.

Stucker, J.H. and M.H. Sherfy. 2007. A Muddy Question: Assessing Human Recreation and Research Disturbance on Missouri River Sandbars Managed for Endangered Birds. U.S. Geological Survey. Northern Prairie Research Center. Jamestown, North Dakota. 21 p.

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

USACE. 2010. 2009 Annual Report for the Biological Opinion on the Operation of the Missouri River Main Stem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. U.S. Army Corps of Engineers – Omaha & Kansas City Districts. 55 p.

USACE. 2009. 2008 Annual Report for the Biological Opinion on the Operation of the Missouri River Main Stem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. U.S. Army Corps of Engineers – Omaha & Kansas City Districts. 70 p.

USACE, 2009, Tern & Plover Data Management System. U.S. Army Corps of Engineers, Omaha District, Threatened & Endangered Species Section. 1986-2009.

USACE. 2009-07. Predation Management Plan for Least Tern and Piping Plover Habitat along the Missouri River. U.S. Army Corps of Engineers, Omaha District, Threatened & Endangered Species Section. 46 p.

USACE. 2008. 2007 Annual Report for the Biological Opinion on the Operation of the Missouri River Main Stem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. U.S. Army Corps of Engineers – Omaha & Kansas City Districts. 58 p.

USACE. 2007. 2006 Annual Report for the Biological Opinion on the Operation of the Missouri River Main Stem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. U.S. Army Corps of Engineers – Omaha & Kansas City Districts. 76 p.

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

Vander Lee, B.A. 2002. Evaluation of Least Tern and Piping Plover Habitat on the Missouri River. U.S. Army Corps of Engineers, Omaha District, Threatened & Endangered Species Section. 4 p.

Ward, J.V., K. Tockner, and F. Schiemer. 1999. Biodiversity of floodplain river ecosystems: ecotones and connectivity. Regulated Rivers: Research and Management 15: 125-139.

Winders, K.R. and K.D. Steffensen. 2014. Population size of pallid sturgeon, *Scaphirhynchus albus* (Forbes and Richardson, 1905) in the lower Missouri River near Kansas City, Missouri, USA. Journal of Applied Ichthyology.

Wrasse, C.J., H.A. Meyer, C.J. Ridenour, W.J. Doyle, and T.D. Hill. 2013. 2012 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 13. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 132p.

Appendix C

Land Acquisitions for the MRRP/Mitigation Project

Total MRRP Acres: 69,495.14
Total Mitigation Acres: 66,280.23
Total Rec River Acres: 3,214.91

*Note: Currently, the distinction between Mitigation and Missouri National Recreational River (Rec River) acres in this report occurs at river mile 725.

	Fee (Acres)	Easement (Acres)	Authority
Iowa Total:	11,155.29	4,047.49	Mitigation
Kansas Total:	6,079.87	-	Mitigation
Missouri Total:	27,048.98	7,337.23	Mitigation
Nebraska Total:	10,125.93	485.44	Mitigation
Total:	54,410.07	11,870.16	Mitigation
Nebraska Total:	2,371.95	296.64	Rec River
South Dakota Total:	546.32	-	Rec River
Total:	2,918.27	296.64	Rec River
Total:	57,328.34	12,166.80	-

Missouri River Recovery Program and Mitigation Project
Current Acquisition by Site, **KANSAS CITY DISTRICT**
Acquisitions through 01-JUL-2015

State	Site; County, State	River Miles	Tract	Fee Acreages	Easement Acreages	Date Aquired	Site Managed By
Kansas	Benedictine Bottoms; Atchison, Kansas	424-428.2	200	1490.85	-	27-JAN-93	KDWP
			201	147.82	-	27-JAN-93	KDWP
			203	472.55	-	15-NOV-94	KDWP
	Burr Oak; Doniphan, Kansas	463.9-467.4	4001	79.4	-	02-NOV-10	KDWP
			4002	153.00	-	09-JUL-09	KDWP
			4006	13.28	-	17-MAY-11	KDWP
	Dalbey Bottoms; Atchison, Kansas	0-0	3900	502	-	08-NOV-07	KDWP
			3901	1065	-	16-OCT-07	KDWP
		415-420	3903	30.9	-	03-SEP-09	KDWP
	Elwood Bottoms; Doniphan, Kansas	0-0	4502	59.10	-	29-SEP-11	KDWP
			4505	208.84	-	02-AUG-12	KDWP
			4506	163.20	-	31-JUL-14	USACE
			4508	189.00	-	28-AUG-07	KDWP
			4509	50.00	-	22-MAR-07	KDWP
			4514	335.10	-	31-JUL-06	KDWP
		441-450	4515	485.00	-	29-JUN-06	KDWP
		0-0	4517	111.53	-	28-JAN-15	USACE
	Oak Mills; Leavenworth, Kansas	405.8-413	3809	214.3	-	18-DEC-12	KDWP
			3810	309.00	-	18-DEC-12	KDWP
Missouri	Aspinwall Bend; Atchison, Missouri	525-526.2	807	93.00	-	30-JUN-10	MDC
			808-1	180.4	-	21-OCT-11	MDC
			808-2	221.1	-	21-OCT-11	MDC
			810	171.21	-	15-SEP-06	MDC
			815	37.00	-	07-DEC-07	MDC
	Baltimore Bend; Lafayette, Missouri	301.4-302.3	509	42	-	18-MAY-07	USFWS
			510	115.16	-	12-JUN-07	USFWS
	Bean Lake; Platte, Missouri	413.3-415.1	5912	11.58	-	28-FEB-13	USACE
			5914	499.83	-	28-FEB-13	USACE
	Berger Bend; Franklin, Missouri	91.8-92.6	600	186.00	-	27-SEP-95	USFWS
			606	150.20	-	27-SEP-95	USFWS
			608	80.03	-	27-SEP-95	USFWS
			616	58.16	-	20-NOV-98	USFWS
	Bootlegger Bend; Lafayette/Ray, Missouri	317.6-320.5	6300	1410.00	-	30-AUG-11	USACE
	Bryan Island; St. Louis, Missouri	23.8-26.3	1303	612.00	-	06-MAR-15	USACE
	Cambridge Bend; Chariton, Missouri	229.2-231.5	3717	168.10	-	13-JUN-06	USACE
			3718	59.46	-	20-SEP-11	USACE
	Camden Bend; Lafayette, Missouri	325.2-326.5	6605	172.0	-	18-SEP-12	USACE
	Columbia Bottom; St. Louis, Missouri	.3-4.8	1700E-1	-	4482.15	24-JUN-02	MDC
			1700E-2	-	110.65	17-MAR-03	MDC
			1700E-3	-	7.19	17-MAR-03	MDC
	Confluence Point; St. Charles, Missouri	.6-2	4800	520.69	-	10-APR-07	MDNR
			4801E	-	247.64	01-NOV-07	MDNR
	Cora Island; St. Charles, Missouri	2-8	3600	1238.00	-	25-JUN-08	USFWS
	Corning; Atchison, Missouri	512-518	1409-1	123.98	-	12-JUL-02	MDC
	Corning; Holt, Missouri	0-0	1401	743.30	-	29-JUN-01	MDC
			1402	115.50	-	11-MAY-06	MDC

			1403	214.80	-	28-FEB-02	MDC	
			1404	328.86	-	26-OCT-01	MDC	
		512-518	1405	46.00	-	29-SEP-09	MDC	
		0-0	1409-2	250.57	-	04-OCT-00	MDC	
			1410	226.00	-	21-JUN-02	MDC	
	Cranberry Bend; Lafayette, Missouri	278-291	5116	25.15	-	01-MAR-13	USFWS	
	Cranberry Bend; Saline, Missouri	0-0	5106	207.50	-	01-JUL-14	USACE	
		278-291	5107	237	-	01-DEC-08	USFWS	
	Deroin Bend; Atchison/Holt, Missouri	516.2-520.7	1800E	-	1081.88	18-APR-01	MDC	
	Eagle Bluffs; Boone, Missouri	170.6-172.5	1500E	-	571.00	13-NOV-00	MDC	
		0-0	1500E-2	-	211.00	06-DEC-06	MDC	
	Grand Pass; Saline, Missouri	268.2-268.3	100E-1	-	.37	16-DEC-91	MDC	
		270.1-270.3	100E-2	-	4.19	16-DEC-91	MDC	
	Grand River Bend; Saline, Missouri	248-253	6105	290.00	-	13-OCT-09	USACE	
	Heckman Island; Montgomery, Missouri	0-0	5200	400.00	-	24-JUL-08	USACE	
		103-109	5200-1	143.00	-	24-JUL-08	USACE	
	J and O Hare Wildlife Area; Andrew, Missouri	464-466	2001	96.11	-	21-AUG-03	MDC	
	J and O Hare Wildlife Area; Holt, Missouri		2000	560.60	-	21-AUG-03	MDC	
	Kickapoo Island; Platte, Missouri	403-408	4702	244.00	-	23-MAR-07	USACE	
	Lower Hamburg Bend; Atchison, Missouri	0-0	903	940.84	-	01-JUL-98	MDC	
			904	240.00	-	09-OCT-98	MDC	
			905	130.37	-	09-OCT-98	MDC	
			907	613.00	-	29-AUG-96	MDC	
			908	230.00	-	29-AUG-96	MDC	
			909	111.00	-	29-FEB-96	MDC	
		545.9-546.9	910	200.00	-	28-JUN-07	MDC	
	Nishnabotna; Atchison, Missouri	0-0	1000	471.5	-	06-AUG-14	USACE	
		537-546	1001	558.33	-	17-MAR-00	MDC	
		0-0	1006E	-	1.01	17-MAR-00	MDC	
			1007E	-	.33	30-OCT-98	MDC	
			1008	500.00	-	12-OCT-06	MDC	
	Nishnabotna; Atchison/Nemaha, Missouri	537-546	1007	725.00	-	30-OCT-98	MDC	
		0-0	1009	651.00	-	12-OCT-06	MDC	
	Overton Bottoms; Cooper, Missouri		400-1	245.87	-	22-MAR-95	USFWS	
			400-2	1217.00	-	22-MAR-95	USFWS	
			401	292.32	-	16-JUN-94	USFWS	
			402	332.44	-	11-FEB-97	USFWS	
			403-1	298.50	-	29-DEC-95	USFWS	
		178-188	404	205.71	-	26-APR-96	USFWS	
		0-0	405-1	42.90	-	28-AUG-95	USFWS	
			405-2	238.00	-	28-AUG-95	USFWS	
			405-3	36.50	-	28-AUG-95	USFWS	
			406	216.27	-	26-JUN-95	USFWS	
			407	14.45	-	11-JUL-95	USFWS	
			411-1	43.85	-	19-JUL-96	USFWS	
			411-2	208.01	-	19-JUL-96	USFWS	
			412	108.00	-	26-APR-96	USFWS	
			415	131.30	-	26-APR-96	USFWS	
			416	2.16	-	26-APR-96	USFWS	
			419	0.52	-	26-APR-96	USFWS	
			422	15.70	-	29-OCT-99	USFWS	
	Overton Bottoms; Cooper/Moniteau, Missouri	178-188	403-2	437.76	-	29-DEC-95	USFWS	
		0-0	408	259.50	-	05-OCT-95	USFWS	
			409-1	154.00	-	17-NOV-95	USFWS	
	Overton Bottoms; Moniteau, Missouri		409-2	324.10	-	17-NOV-95	USFWS	
		178-188	414	35.15	-	18-SEP-06	USFWS	
		0-0	418	192.20	-	17-NOV-95	USFWS	
			423	70.00	-	13-MAR-07	USFWS	
			424	30.30	-	13-JUL-10	USFWS	
			424-1	49.02	-	13-JUL-10	USFWS	
	Providence Bend; Boone, Missouri	162-169	3508	579.00	-	22-OCT-07	USACE	
	Rocheport Cave; Boone, Missouri	182.7-183.1	2200E	-	23.00	23-APR-02	MDC	
	Rush Bottom Bend; Holt, Missouri	0-0	1900	187.95	-	22-SEP-99	MDC	
			1901	143.88	-	03-JUN-99	MDC	
			1902	111.08	-	07-JUN-99	MDC	
		498-503	1903	83.40	-	22-SEP-99	MDC	
		0-0	1904	80.30	-	02-AUG-96	MDC	
			1905	331.00	-	25-SEP-08	MDC	
			1906	37.20	-	25-JUN-96	MDC	
			1907	93.00	-	12-SEP-96	MDC	

			1908	21.49	-	16-APR-96	MDC
			1910	5.40	-	31-DEC-96	MDC
			1911	2.50	-	31-DEC-96	MDC
			1912	2.50	-	31-DEC-96	MDC
			1914	42.50	-	03-JUN-99	MDC
			1916	74.88	-	29-JUL-14	MDC
	Sni Bend; Lafayette, Missouri	319-323	6405	42.44	-	26-OCT-11	USACE
			6406	33.12	-	19-JUL-12	USACE
	Tamerlane Bend; Carroll, Missouri	0-0	4403	362	-	30-JUN-08	USACE
		271-281	4410	214	-	10-SEP-09	USACE
		0-0	4413	270	-	10-SEP-09	USACE
	Tate Island; Callaway, Missouri		700	403.00	-	13-OCT-94	MDC
		110-113	701	19.41	-	14-OCT-94	MDC
	Thurnau; Holt, Missouri	0-0	1101	293.51	-	28-JUN-02	MDC
			1102	49.54	-	18-FEB-00	MDC
			1105	634.38	-	11-OCT-02	MDC
			1109	172.50	-	05-FEB-99	MDC
			1111	205.70	-	25-AUG-00	MDC
			1112	16.01	-	31-AUG-01	MDC
			1115	55.30	-	26-JUL-11	MDC
			1116	108.00	-	08-FEB-12	MDC
			1117	230.10	-	08-FEB-12	MDC
			1119-1	68.40	-	24-JAN-14	MDC
		504-512	1119-2	52.48	-	24-JAN-14	MDC
		506-507	1120	115.81	-	23-SEP-14	MDC
		506-506	1121	28.00	-	24-JUN-14	MDC
	Weston Bend; Platte, Missouri	403-403	2800E	-	12.00	05-APR-04	MDNR
	Wolf Creek Bend; Holt, Missouri	0-0	2500	503.00	-	04-JUN-04	MDC
			2501	257.33	-	12-DEC-05	MDC
			2502	52.00	-	12-DEC-05	MDC
			2502-2	205.80	-	12-DEC-05	MDC
			2507	9.70	-	08-JUL-08	MDC
		477-483	2508	0.51	-	11-JUN-09	MDC
	Worthwine Island; Andrew, Missouri	456.1-460	1600E	-	584.82	04-SEP-01	MDC

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The acquired date in the detailed table may not necessarily reflect the actual fiscal year in which the funds were obligated.

Missouri River Recovery Program and Mitigation Project
Current Acquisition by Site, **OMAHA DISTRICT**
Acquisitions through 01-JUL-2015

State	Site; County, State	River Miles	Tract	Fee Acreage	Easement Acreage	Date Acquired	Site Managed By
Iowa	Auldon Bar; Fremont, Iowa	574.9-580.2	103	59.39	-	28-JUN-07	IDNR
			106	315.24	-	05-JUN-95	IDNR
			108	272.28	-	21-AUG-98	IDNR
			109	471.78	-	28-JUN-07	IDNR
			111	41.91	-	28-JUN-07	IDNR
			112	102	-	23-MAR-09	IDNR
			113	66.33	-	31-AUG-09	IDNR
	Blackbird Bend; Monona, Iowa	693.7-698	104	72.05	-	19-NOV-97	IDNR
			104-2	151.15	-	19-NOV-97	IDNR
			105E	-	799.24	23-MAY-00	IDNR
	California Bend; Harrison, Iowa	649.5-651.1	100E	-	420	01-APR-99	IDNR
	Civil Bend (IA); Fremont, Iowa	572.7-574.9	100	280.87	-	20-FEB-15	USACE
	Copeland Bend; Fremont, Iowa	560.3-572.7	101	37.54	-	28-JUN-07	IDNR
			102	2	-	03-AUG-95	IDNR
			104	40	-	15-AUG-95	IDNR
			105	18.06	-	28-AUG-98	IDNR
			110	162.01	-	28-JUN-07	IDNR
			111	192.1	-	02-FEB-99	IDNR
			113	55.76	-	27-AUG-04	IDNR
			115	217.57	-	31-JUL-95	IDNR
			117	43.85	-	15-AUG-95	IDNR
			118	166.06	-	08-JUL-04	IDNR
			119	689.975	-	22-JAN-07	IDNR
			120	84.24	-	27-MAY-08	IDNR
			200	139.08	-	25-JUN-01	IDNR
			200-2	7.9	-	27-NOV-06	IDNR
			200-3	0.1	-	27-NOV-06	IDNR

			201	1.49	-	27-NOV-06	IDNR
			202	122.66	-	25-JUN-01	IDNR
			202-2	1.48	-	27-NOV-06	IDNR
			203	293.71	-	25-JUN-01	IDNR
			205	22.92	-	26-JAN-02	IDNR
			206	39.47	-	30-AUG-06	IDNR
			207-2	84.41	-	19-MAR-10	IDNR
			207-3	160.36	-	19-MAR-10	IDNR
			208-1	125.34	-	23-MAR-09	IDNR
			208-2	8.76	-	23-MAR-09	IDNR
			209	11.28	-	27-MAY-08	IDNR
			211	230.86	-	12-NOV-14	USACE
			301	60.14	-	27-MAY-08	IDNR
	Council Bend; Pottawattamie, Iowa	616.7-617.8	100E	-	88.64	28-DEC-06	IDNR
	Fawn Island (Little Sioux); Harrison, Iowa	673.4-674.1	103E	-	16.68	19-JUN-09	IDNR
	Glovers Point Bend; Woodbury, Iowa	710.5-713.6	100E	-	18	07-OCT-04	IDNR
	Hamburg Bend; Fremont, Iowa	551.3-556.1	107	103.7	-	25-JUL-97	IDNR
			108	31.66	-	01-JUL-98	IDNR
			109	185.74	-	22-DEC-95	IDNR
	Little Sioux Bend; Harrison, Iowa	666.8-668.6	100	190.61	-	17-NOV-09	USACE
	Louisville Bend; Monona, Iowa	681.6-685.3	103-1	32.89	-	07-JUN-94	IDNR
			103-2	9.51	-	07-JUN-94	IDNR
			103-3	41.5	-	07-JUN-94	IDNR
			104E	-	1002.49	01-APR-94	IDNR
	Lower Dakota Bend; Woodbury, Iowa	722.1-722.4	100	21.4	-	01-FEB-07	IDNR
	M.U. Payne; Fremont, Iowa	556.7-558.7	100	214.96	-	24-MAY-13	USACE
			101	516.48	-	02-NOV-12	IDNR
			102	562.97	-	02-NOV-12	IDNR
	Middle Decatur Bend; Monona, Iowa	686.1-689.5	102E	-	324.33	23-MAY-00	IDNR
			109	183.74	-	29-MAY-15	USACE
	Noddleman Island; Mills, Iowa	582.4-586.9	101	214	-	17-OCT-13	USACE
			106	219.15	-	17-DEC-97	IDNR
			108	719.27	-	30-JUL-96	IDNR
			109	175.3	-	10-FEB-99	IDNR
			110	118	-	17-DEC-97	IDNR
	Sandy Point Bend; Harrison, Iowa	654.8-657.9	100	251.6	-	17-NOV-09	USACE
	St Marys Island; Mills, Iowa	595.4-598.4	100	273.88	-	10-SEP-04	IDNR
			101	184.45	-	27-MAR-09	IDNR
			105	212.64	-	10-SEP-04	IDNR
			106	436.11	-	10-SEP-04	IDNR
			107	401.69	-	08-SEP-04	IDNR
			111	496.62	-	28-DEC-05	IDNR
			112	413.85	-	28-SEP-09	IDNR
	Three Rivers (Little Sioux); Harrison, Iowa	669.4-670	101E	-	37.57	26-JUL-10	IDNR
	Tieville Bend; Monona, Iowa	691.4-693.7	201	91.44	-	27-SEP-96	IDNR
	Tyson Bend; Harrison, Iowa	653-656.1	101E	-	697.86	24-MAR-09	IDNR
	Upper Decatur Bend; Monona, Iowa	689.5-691.4	300E	-	639.58	23-MAY-00	IDNR
			301E	-	3.1	06-JUN-03	Private
Nebraska	Audubon Bend; Cedar, Nebraska	789.5-793.9	100	2371.95	-	16-NOV-09	USACE
	Blackbird Bend; Thurston, Nebraska	693.7-698	103	90	-	30-AUG-10	USACE
	Brownville Bend; Nemaha, Nebraska	533.2-534.6	100	94.12	-	21-SEP-11	NGPC
			101	89.96	-	30-JUN-08	NGPC
			102	92.25	-	09-JAN-12	NGPC
			103	185.89	-	11-SEP-13	USACE
			103-2	6.71	-	11-SEP-13	USACE
	Civil Bend (NE); Cass, Nebraska	568.6-573.6	200	134.03	-	16-OCT-14	USACE
			204	251.75	-	13-AUG-14	USACE
	Cottier Bend; Richardson, Nebraska	505.9-509	103	387.78	-	20-NOV-14	USACE
	Hamburg Bend; Otoe, Nebraska	551.3-556.1	101	9.9	-	24-FEB-94	NGPC
			102	117.2	-	25-MAY-94	NGPC
			103	1011.74	-	12-AUG-93	NGPC
			104	126.02	-	13-SEP-93	NGPC
			105	279.22	-	25-MAY-94	NGPC
			106	31.46	-	26-FEB-04	NGPC
	Hole in the Rock; Thurston, Nebraska	705.7-706.4	AE	-	52	09-DEC-04	Omaha Indian Tribe
	Indian Cave Bend; Richardson, Nebraska	516.9-521.2	101E	-	85.49	20-JUL-09	NGPC
			102E	-	27.2	14-JUN-11	NGPC
	Kansas Bend; Nemaha, Nebraska	544.1-547.2	101-2	110	-	21-DEC-93	NGPC
			102	161.47	-	06-JUL-95	NGPC
			103-1	69.1	-	07-JUN-12	NGPC

			103-2	49.96	-	07-JUN-12	NGPC
			110	86.89	-	21-DEC-93	NGPC
	Kansas Bend; Otoe, Nebraska		100	32.03	-	22-DEC-93	NGPC
			101-1	112.55	-	21-DEC-93	NGPC
	Langdon Bend; Nemaha, Nebraska	527.7-532.3	101	456.66	-	14-JUL-94	NGPC
			103	221.62	-	30-DEC-93	NGPC
			104	242.35	-	12-JUL-94	NGPC
			105	95.07	-	13-SEP-11	NGPC
			109	387	-	09-OCT-03	NGPC
			110	265.26	-	08-OCT-11	NGPC
			113	111.49	-	26-DEC-12	NGPC
	Middle Decatur Bend; Burt, Nebraska	686.1-689.5	100	622	-	08-AUG-96	USACE
			103	86.04	-	08-AUG-96	USACE
			104	108.38	-	01-MAY-97	USACE
			108	60.86	-	11-JUL-96	USACE
	Nishnabotna Bend; Nemaha, Nebraska	540.8-544.1	105	244.75	-	16-MAR-95	NGPC
			106	112.22	-	03-MAR-95	NGPC
			107	80.02	-	25-FEB-99	NGPC
			108	116.03	-	13-FEB-99	NGPC
	Plattsmouth Chute; Cass, Nebraska	591.5-594.5	100E	-	284.76	29-MAY-07	NGPC
			101E	-	35.99	05-AUG-08	NGPC
	Ponca State Park; Dixon, Nebraska	753.8-755.3	100E	-	296.64	23-FEB-10	NGPC
	Sonora Bend; Nemaha, Nebraska	536.4-540.7	101	189.63	-	13-JUN-13	USACE
			101-2	0.41	-	13-JUN-13	USACE
	Tieville Bend; Burt, Nebraska	691.4-693.7	200	1013.75	-	27-SEP-96	USACE
	Tobacco Island; Cass, Nebraska	585.6-589.9	100	967.66	-	29-MAR-94	NGPC
			102	5.25	-	24-MAR-98	NGPC
			103	4.61	-	08-DEC-94	NGPC
			104	351.54	-	10-DEC-98	NGPC
			105	62.5	-	04-MAY-95	NGPC
			106	210	-	31-AUG-94	NGPC
			108	2.07	-	04-MAY-95	NGPC
			109	45.08	-	19-DEC-11	NGPC
	Van Horns Bend; Cass, Nebraska	574-576.7	100	533.65	-	30-MAR-06	USACE
South Dakota	North Alabama Bend; Clay, South Dakota	778.5-779.7	100	546.32	-	25-JUN-09	USACE
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The acquired date in the detailed table may not necessarily reflect the actual fiscal year in which the funds were obligated.

New to this report and Appendix C are updates resulting from: programmatic changes in how sites are named and recorded (Table 1); separation of acreages by tract number (some were formerly combined by acquisition date) (Table 2); and correction of errors from previous reports (e.g. counties listed incorrectly) (Table 3).

Table 1. In FY14, the MRRP chartered its first Board of Geographic Names (BoGN) to decide on site names. Members from across the program discussed and agreed to rename certain sites that have had conflicting names across the program. While some names were decided in FY 2014, most were finalized in FY15.

Previous Name	State	New Name	Reason for Change
Brownsville Bend	NE	**Brownville Bend**	Name change approved by BoGN.
Civil Bend	IA NE	**Civil Bend (IA);** **Civil Bend (NE)**	Broken into two sites. Name change approved by BoGN.
Columbia Bottoms	MO	**Columbia Bottom**	Name change approved by BoGN.
Corning/Hemmies Bend	MO	**Corning**	Name change approved by BoGN. Hemmies Bend is used for another area.
Eagle Bluffs CA	MO	**Eagle Bluffs**	Name change approved by BoGN.
Frazers Bend	IA	**M.U. Payne**	Omaha District approved name change request from Payne family. Change meets BoGN's requirements.
Glover's	IA	**Glovers Point Bend**	Name change approved by BoGN.
Grand Pass CA	MO	**Grand Pass**	Name change approved by BoGN.
Hole-in-the-Rock	NE	**Hole in the Rock**	Name change approved by BoGN.
Kansas Bend (lower portion of site)	NE	**Nishnabotna Bend**	Name change approved by BoGN. Kansas Bend and Nishnabotna Bend are two separate sites. Nishnabotna Bend is also a separate site from Nishnabotna (site).
Little Sioux	IA	**Little Sioux Bend** **Deer Island (Little Sioux)** **Fawn Island (Little Sioux)** **Three Rivers (Little Sioux)**	Broken into four sites; no real estate interest in Deer Island. Name change approved by BoGN.
Lincoln Bend/Indian Cave	NE	**Indian Cave Bend**	Name change approved by BoGN.
Lower Hamburg Bend (Iowa portion only)	MO	**Hamburg Bend**	Name change approved by BoGN. Site areas managed by the NWO District were consolidated into one site.
Nottleman Island	IA	**Noddleman Island**	Name change approved by BoGN.
Sandy Point	IA	**Sandy Point Bend**	Name change approved by BoGN.
St. Mary's Island	IA	**St Marys Island**	Name change approved by BoGN.
Upper Dakota Bend	IA	**Lower Dakota Bend**	Name change approved by BoGN. The site does indeed lie along the Lower Dakota Bend, rather than Upper Dakota Bend.
Van Horn's Bend	NE	**Van Horns Bend**	Name is still in review; however diacritical marks are likely to be dropped.
Weston Bend State Park	MO	**Weston Bend**	Name change approved by BoGN.
Worthwine Island CA	MO	**Worthwine Island**	Name change approved by BoGN.

Table 2. The acreages for some sites were combined by acquisition date, but this was not uniformly applied to all acreages even within the acreage listings for the same site. To correct this, acreages are now listed individually by tract number.

Site Name	State	Combined Acreage	Tracts and Acreages	Further Notes
Aspinwall Bend	MO	401.5	Tract 808-1 – 180.4 Tract 808-2 – 221.1	
Berger Bend	MO	416.23	Tract 600 – 186.00 Tract 606 – 150.20 Tract 608 – 80.03	
Brownville Bend	NE	192.60	Tract 103 – 185.89 Tract 103-2 – 6.71	
Copeland Bend	IA	134.10	Tract 208-1 – 125.34 Tract 208-2 – 8.76	
	IA	*244.77 (corrected from 274.08)	Tract 207-2 – 84.41 Tract 207-3 – 160.36 Tract 207-4 – 0	*Tracts 207-2 and 207-3 add up to 244.77, rather than 274.08. Tract 207-2 includes acreage from tract 207-4, therefore tract 207-4 is NOT being added to the acquisition table.
Lower Hamburg Bend	MO	843.00	Tract 907 – 613.00 Tract 908 – 230.00	
Overton Bottoms	MO	1462.87	Tract 400-1 – 245.87 Tract 400-2 – 1217.00	
	MO	736.26	Tract 403-1 – 298.50 Tract 403-2 – 437.76	
	MO	317.40	Tract 405-1 – 42.90 Tract 405-2 – 238.00 Tract 405-3 – 36.50	
	MO	478.10	Tract 409-1 – 154.00 Tract 409-2 – 324.10	
	MO	251.86	Tract 411-1 – 43.85 Tract 411-2 – 208.01	
	MO	79.32	Tract 424 – 30.30 Tract 424-1 – 49.02	
Tamerlane Bend	MO	484.00	Tract 4410 – 214.00 Tract 4413 – 270.00	
Thurnau	MO	338.10	Tract 1116 – 108.00 Tract 1117 – 230.10	
	MO	120.88	Tract 1119-1 – 68.40 Tract 1119-2 – 52.48	
Wolf Creek Bend	MO	257.80	Tract 2502 – 52.00 Tract 2502-2 – 205.80	

Table 3. MRRP sites and their associated notations or corrections

Site	State	Tracts (and Acreages)	Notes*
Auldon Bar	IA	106 (315.24) 108 (272.28) 113 (66.33)	Date acquired corrected to 5 Jun 1995 from 30 Jun 1995. Date acquired corrected to 21 Aug 1998 from 28 Aug 1998. Date acquired corrected to 31 Aug 2009 from 21 Mar 2009.
Blackbird Bend	NE IA	103 (90) 105E (799.24)	Tract is in Thurston County, Nebraska, rather than Burt, and managed by USACE, but will be licensed to IDNR. Date acquired corrected to 23 May 2000 from 15 Jun 2000.
Brownville Bend	NE	100 (94.12) 103 &103-2 (combined 192.6)	Date acquired corrected to 21 Sep 2011 from 29 Sep 2011. Dates acquired corrected to 11 Sep 2013 from 19 Sep 2013; tracts not yet added to management license.
California Bend	IA	100E (420)	Date acquired corrected to 1 Apr 1999 from 7 Apr 1999.
Civil Bend (IA)	IA	100 (132.81*)	*Acreage was incorrectly listed as 132.81 when it should be 280.87. Still managed by USACE.
Civil Bend (NE)	NE	200 (134.03)	Date acquired corrected to 16 Oct 2014 from 17 Oct 2014.
Copeland Bend	IA	102 (2) 104 (40) 105 (18.06) 111 (192.1) 115 (217.57) 117 (43.85) 211 (230.86)	Date acquired corrected to 3 Aug 1995 from 31 Aug 1995. Date acquired corrected to 15 Aug 1995 from 10 May 1996. Date acquired corrected to 28 Aug 1998 from 29 Sep 1998. Date acquired corrected to 2 Feb 1999 from 12 Mar 1999. Date acquired corrected to 31 Jul 1995 from 19 Aug 1995. Date acquired corrected to 15 Aug 1995 from 10 May 1996. Date acquired corrected to 12 Nov 2014 from 11 Nov 2014.
Corning	MO	1409-1 (123.98)	County has been updated to Atchison from Holt.
Glovers Point Bend	IA	100E (18)	Acquired easement's county and state corrected from Thurston County, NE to Woodbury, Iowa. Date acquired corrected to 7 Oct 2004 from 15 Nov 2004. (Most current work in Thurston County, NE has been done under the concept of existing Federal ownership under Bureau of Indian Affairs.)
Hamburg Bend	NE	103 (1011.74)	Date acquired corrected to 12 Aug 1993 from 13 Aug 1993.
Hole in the Rock	NE	AE (52*)	This is the only tract at this site that should be noted; manager has been corrected to Omaha Indian Tribe. *Unknown why a 90-acre fee acquisition was noted in previous annual reports; that information is incorrect.
Indian Cave Bend (as Lincoln Bend/Indian Cave)	NE	101E (85.49)	Report incorrectly listed as fee acres. It also listed as both Richardson and Nemaha counties, but has been corrected to only Richardson County.
Kansas Bend	NE	All tracts combined 100 (32.03), 101-1 (112.55) 103-1 (69.1), 103-2 (49.96)	River miles updated because Kansas Bend was split into two sites. The county has been corrected to Otoe County from Nemaha. Dates acquired corrected to 7 Jun 2012 from 6 Jun 2012.
Langdon Bend	NE	104 (242.35) 109 (387) 110 (265.26) 113 (111.49)	Date acquired corrected to 12 Jul 1994 from 31 Aug 1994. The report incorrectly listed 387 acres twice Date acquired corrected to 8 Oct 2011 from 10 Oct 2011. Date acquired corrected to 26 Dec 2012 from 28 Dec 2013.
Little Sioux Bend	IA	100 (190.61)	Date acquired corrected to 17 Nov 2009 from 18 Nov 2009.
Louisville Bend	IA	104E (1002.49*)	Date acquired corrected to 1 Apr 1994 from 20 Sep 1993.
Middle Decatur Bend	IA/ NE	100 (622-NE), 103 (86.04-NE), 104 (108.38-NE), 108 (60.86-NE), 109	Site manager corrected to USACE from IDNR.

		(183.74-IA) 102E (324.33-IA) 108 (60.86-NE)	 Date acquired corrected to 23 May 2000 from 20 Jun 2000. Date acquired corrected to 11 Jul 1996 from 25 Jun 1996.
M.U. Payne (as Frazers Bend)	IA	100 (214.96) 101 (516.48) 102 (562.97)	Date acquired corrected to 24 May 2013 from 7 Jun 2013; tract has not yet been transferred to Iowa NDR. Date acquired corrected to 2 Nov 2012 from 26 Nov 2012. Date acquired corrected to 2 Nov 2012 from 10 Dec 2012.
Nishnabotna	MO	1007 (725.00), 1009 (651.00)	Tracts lie in Atchison/Nemaha counties
Nishnabotna Bend	NE	105 (244.75), 106 (112.22), 107 (80.02), 108 (116.03) 105 (244.75) 107 (80.02) 108 (116.03)	Tracts were originally listed as Kansas Bend. Date acquired corrected to 16 Mar 1995 from 27 Mar 1995. Date acquired corrected to 25 Feb 1999 from 2 Apr 1999. Date acquired corrected to 13 Feb 1999 from 26 Feb 1999.
Noddleman Island	IA	101 (214)	Site Manager corrected to USACE; tract not yet added to IDNR management license.
Oak Mills	KS	3809 (214.30), 3810 (309.00)	Listed as Atchison and Leavenworth counties when it is only in Leavenworth County
Overton Bottoms	MO	423 (75.00*)	*An error in the acreage was corrected to 70 from 75.00.
Plattsmouth Chute	NE	101E (35.99)	Date acquired corrected to 5 Aug 2008 from 8 Aug 2008.
Ponca State Park	NE	100E (296.64)	Added as a Missouri National Recreational Reach site.
Rush Bottom Bend	MO	100, 101, 102, 103, 104, 106, 107, 108, 110, 111, 112, 114	[Noted in data only.] Tracts were transferred from Omaha District to Kansas City District (NWK); tracts were then renamed by NWK.
Rush Bottom Bend	MO	1900 (187.95), 1902 (111.08), 1903 (83.40), 1904 (80.30), 1908 (21.49), 1910 (5.40), 1911 (2.50), 1912 (2.50), 1914 (42.50), 1916 (74.88)	Tracts were incorrectly listed wholly or partially in Richardson County, Nebraska; however, an agreement between Missouri and Nebraska changed all Nebraska land on the Missouri side of the river to Missouri lands. All of these tracts are now wholly in Holt county.
Rush Bottom Bend	MO	1916 (74.88)	Date acquired corrected to 29 July 2014 from 31 Jul 2014.
Sandy Point Bend	IA	100 (251.6)	Date acquired corrected to 17 Nov 2009 from 18 Nov 2009.
Sonora Bend	NE	101 (189.63), 101-2 (0.41)	Date acquired corrected to 13 Jun 2013 from 21 Jul 2013.
Three Rivers (Little Sioux)	IA	101E (37.57)	Date acquired corrected to 26 Jul 2010 from 19 Jun 2009; IDNR is the manager, not USACE.
Tieville Bend	NE	200 (1013.75)	Manager updated to USACE from IDNR.
Tobacco Island	NE	100 (967.66) 102 (5.25) 103 (4.61) 109 (45.08)	Date acquired corrected to 29 Mar 1994 from 30 Mar 1994. Date acquired corrected to 24 Mar 1998 from 31 Mar 1998. Date acquired corrected to 8 Dec 1994 from 21 Dec 1994. Date acquired corrected to 19 Dec 2011 from 20 Dec 2011.
Van Horns Bend	NE	100 (533.65)	Site Manager corrected to USACE from NGPC.
Upper Decatur Bend	IA	300E (639.58)	Date acquired corrected to 23 May 2000 from 15 Jun 2000.

*River Miles for some sites has been updated to be more exact, but is not listed individually here. Data can be compared to previous reports to see the updates. Updates to site managers are considered as routine; therefore they are not listed unless an error was noted.

Appendix D

MRRIC Summary of Actions and Recommendations

MRRIC - Summary of Actions and Recommendations

Consensus recommendations made on substantive issues require a two-step decision making process with a tentative recommendation made at an initial meeting and a final recommendation made no sooner than the next MRRIC meeting. The two-step process is intended to allow time between the tentative and final consensus recommendation determinations for members to deliberate and consult with their constituents on the recommendations.

In its seventh year of operation, the Committee made four substantive recommendations to the lead agencies. For complete information of substantive recommendations and agencies' responses, please visit *www.MRRIC.org*.

Recommendations:

1) Fiscal Year 2016 Missouri River Recovery Program Work Plan, August 2015

Recommendations:

- Recommend the Corps working with the USFWS develop a peer review process, in discussion with MRRIC, of all aspects of the pallid sturgeon propagation effort.
- Recommend maintaining full, consistent funding for ISP efforts directed at answering key pallid sturgeon questions to implement the Management Plan.
- Recommend restoring funding for the ambient water quality monitoring program and would like to see this budget item increased in the future depending on future effects analysis results
- Recommend maintaining or enhancing water quality monitoring to provide information necessary to evaluate water quality effects on pallid sturgeon
- Requests the USACE provide its plan for BSNP mitigation moving forward in the Mgt. Plan effort

2) Expedite Implementation of Reimbursing Travel Expense, February 2015

MRRIC recommended USACE expedite implementation of reimbursing Committee member travel expenses as stated in the Water Resources Reform Development Act of 2014, Section 4013.

3) Regular Attendance and Engagement of the Environmental Protection Agency, May 2015

Recommended the Environmental Protection Agency attend MRRIC meetings regularly.

4) Letter to ASA Jo Ellen Darcy Regarding Real Property Acquisition

Recommendation to prepare a letter to ASA Darcy requesting a meeting to discuss the Corps' approach for acquiring required real property in support of MRRP and the Bank Stabilization and Navigation Project.

Appendix E

Related Scientific Documents

Pallid Sturgeon Research

Science Publications

Refereed Publications

Andvik, R. T., VanDeHey, J. A., Fincel, M. J., French, W. E., Bertrand, K. N., Chipps, S. R., Klumb, R. A., Graeb, B. D. S. 2010. Application of non-lethal stable isotope analysis to assess feeding patterns of juvenile pallid sturgeon Scaphirhynchus albus: A comparison of tissue types and sample preservation methods. Journal of Applied Ichthyology, 26: 831 – 835.

Braaten, P. J., Fuller, D.B., Lott, R.D., Ruggles, M.P., Brandt, T.F., Legare, R.G., and Holm, R.J., 2012. An experimental test and models of drift and dispersal processes of pallid sturgeon (*Scaphirhynchus albus*) free embryos in the Missouri River. Environmental Biology of Fishes, 93:377-392.

Braaten, P.J., Fuller, D.B., Lott, R.D., Haddix, T.M., Holte, L.D., Wilson, R.H., Jaeger, M.E., Bartron, M.L., Kalie, J., DeHaan, P.W., Ardren, W.R., and Holm, R.J. 2012. Natural growth rates and diet components of known-age pallid sturgeon early life stages in the upper Missouri River, Montana and North Dakota. Journal of Applied Ichthyology, 28: 496-504.

Braaten, P.J., Fuller, D.B., Lott, R.D., and G.R. Jordan. 2009. An estimate of the historic population size of adult pallid sturgeon in the upper Missouri River basin, Montana and North Dakota. Journal of Applied Ichthyology: Conference Paper.

Braaten, P.J., Fuller, D.B., Holte, L.D., Lott, R.D., Viste, W., Brandt, T.F. and R.G. Legare. 2008. Drift dynamics of larval pallid sturgeon and shovelnose sturgeon in a natural side channel of the upper Missouri River, Montana. North American Journal of Fisheries Management, 28: 808-826.

Cade, B.S., J.W. Terrell, and B.C. Neely. 2011. Estimating geographic variation in allometric growth and body condition of blue suckers with quantile regression. Transactions of the American Fisheries Society 140:1657-1669.

Doyle, W., C. Paukert, A. Starostka, and T. Hill. 2008. A comparison of four types of sampling gear used to collect shovelnose sturgeon in the lower Missouri River. Journal of Applied Ichthyology 2008:1-6.

Dzialowski, A.R., J.L. Bonneau, and T.R. Gemeinhardt. 2012. Comparisons of zooplankton and phytoplankton in created shallow water habitats of the lower Missouri River: implications for native fish. Aquatic Ecology.

Eder, B.L., K.D. Steffensen, J.D. Haas, and J.D. Adams. 2015. Short-term survival and dispersal of hatchery-reared juvenile pallid sturgeon stocked in the channelized Missouri River. Journal of Applied Ichthyology DOI 10.1111/jai.12881

Eder, B.L. 2009. Use of Constructed Side Channels of the Missouri River (Nebraska) by Age-0 Blue Sucker *Cycleptus elongatus*. Journal of Freshwater Ecology 24:667-668.

Erwin, S.O., and Jacobson, R.B. 2014. Influence of channel morphology and flow regime on larval drift of pallid sturgeon in the Lower Missouri River: River Research and Applications.

French, W.E., B.D. S. Graeb, K.N. Bertrand, S.R. Chipps, and R.A. Klumb. 2013. Size-dependent trophic patterns of pallid sturgeon and shovelnose sturgeon in a large river system. Journal of

Fish and Wildlife Management.

French, W.E., B.D.S. Graeb, S.R. Chipps, R.A. Klumb. 2013. Vulnerability of age-0 pallid sturgeon Scaphirhynchus albus to predation: effects of predator type, turbidity, body size, and prey density. Environmental Biology of Fishes DOI 10.1007/s10641-013-0166-y.

Gosch, N. J. C., M. L. Miller, A. R. Dzialowski, D. M. Morris, T. R. Gemeinhardt, and J. L. Bonneau. 2014. Assessment of Missouri River floodplain invertebrates during historic inundation: implications for river restoration. Knowledge and Management of Aquatic Ecosystems 412: 05.

Gosch, N.J.C., D.M. Morris, T.R. Gemeinhardt, and J.L. Bonneau. 2013. Pre- and post-construction assessment of nutrient concentrations at shallow water habitat restoration sites on the lower Missouri River. Journal of Water Resource and Protection 5:249-258.

Grohs, K.L., R.A. Klumb, S.R. Chipps, and G.A. Wanner. 2009. Ontogenetic patterns in prey use by pallid sturgeon in the Missouri River, South Dakota and Nebraska. Journal of Applied Ichthyology 25 (Supplement 2):48-53. (Project crews collected pallid sturgeon diets)

Hamel, M. J., K.D. Steffensen, J. J. Hammen, and M. A. Pegg. 2013. Evaluation of passive integrated transponder tag retention from two tagging locations in juvenile pallid sturgeon. Journal of Applied Ichthyology 29:41-43.

Hamel, M.J., K.D. Steffensen, P.T. Horner, and S.M. Stukel. 2009. A comparison of fish catch rate with two different benthic trawls in the Missouri River. Journal of Freshwater Ecology 24:625-634.

Heimann, D.C., D.M. Morris, and T.R. Gemeinhardt. 2014. Nutrient Contributions from Alluvial Soils Associated with the Restoration of Shallow-Water Habitat in the Lower Missouri River. River Research and Application.

Huenemann, T.W., K.D. Steffensen, G.E. Mestl, D.A. Shuman, and S. Stukel. 2015. The Status of Fishes in the Missouri River, Nebraska: Emerald Shiner (*Notropis atherinoides*), Red Shiner (*Cyprinella lutrensis*), River Shiner (*N. blennius*), Sand Shiner *N. stramineus*), Spotfin Shiner (*C. spiloptera*). Transaction of the Nebraska Academy of Science 35: 15-33.

Koch, J.D., K.D. Steffensen, and M.A. Pegg. 2011. Validation of age estimates obtained from juvenile pallid sturgeon *Scaphirhynchus albus* pectoral fin spines. Journal of Applied Ichthyology 27:209-212.

LaBay, S.R., J.G. Kral, S.M. Stukel. 2011. Precision of age estimates from scales and pectoral fin rays of blue sucker. Fisheries Management and Ecology 18:424-430.

McElroy, B., DeLonay, A.J., and Jacobson, R.B. 2012. Optimum swimming pathways of fish spawning migrations in rivers. Ecology 93(1): 29-34.

Morris, D.M., T.R. Gemeinhardt, N.J.C. Gosch, and D.E. Jensen. 2013. Water Quality During Two High Flow Years on the Lower Missouri River: The Effects of Reservoir and Tributary Contributions. River Research and Application DOI: 10.1002/rra.2693.

Murphy, B.R., D.W. Willis, M.D. Klopfer, and B.D.S. Graeb. 2010. Case 19. Size structure assessment of pallid sturgeon. Pages 155-159 *in* Case studies in fisheries management: applied critical thinking and problem solving. American Fisheries Society, Bethesda, Maryland. (Used data from Shuman et al. 2006)

Neely, B.C., M.J. Hamel, and K.D. Steffensen. 2008. A proposed standard weight equation for blue suckers. North American Journal of Fisheries Management 28:1450-1452.

Neely, B.C., K.D. Steffensen, and M.A. Pegg. 2009. A comparison of gastrically and surgically implanted telemetry transmitters in shovelnose sturgeon. Fisheries Management and Ecology 16:323-328.

Neely, B.C., M.A. Pegg, and B.L Eder. 2010. Determining detection requirements for individuals used in categorical resource selection analyses. Journal of Freshwater Ecology 25:163-168.

Papoulias, D.M., DeLonay, A.J., Annis, M.L., Wildhaber, M.L., Tillitt, D.E. 2011. Characterization of environmental cues for initiation of reproductive cycling and spawning in shovelnose sturgeon S*caphirhynchus platorynchus* in the Lower Missouri River, USA. Journal of Applied Ichtyhology, 27(2): 335-342.

Rapp, T., D.A. Shuman, B.D.S. Graeb, S.R. Chipps, E.J. Peters. 2011. Diet composition and feeding patterns of adult shovelnose sturgeon (*Scaphirhynchus platorynchus*) in the lower Platte River, Nebraska, U.S.A. Journal of Applied Ichthyology 27:351-355.

Ridenour, C.J., W.J. Doyle, and T.D. Hill. 2011. Habitats of age-0 sturgeon in the lower Missouri River. Transactions of the American Fisheries Society 140:1351-1358.

Schloesser, J.T., C.P. Paukert, W. J. Doyle, T.D. Hill, K.D. Steffensen, and V. Travnichek. 2011. Fish assemblages at engineered and natural channel structures in the lower Missouri River: implications for modified dike structures. River Research and Applications DOI: 10.1002/rra.1578.

Schloesser, J.T., C.P. Paukert, W. J. Doyle, T.D. Hill, K.D. Steffensen, and V. Travnichek. 2012. Heterogeneous detection probabilities for imperiled Missouri River fishes: implications for large river monitoring programs. Endangered Species Research 16:211-224.

Shuman, D.A., D.W. Willis, and S.C. Krentz. 2006. Application of a length-categorization system for pallid sturgeon (*Scaphirhynchus albus*). Journal of Freshwater Ecology 21(1):71-76.

Shuman, D.A., R.A. Klumb, R.Wilson, M. Jaeger, T. Haddix, B. Gardner, W. Doyle, P. Horner, M. Ruggles, K. Steffensen, S. Stukel, and G.A. Wanner. 2011. Pallid sturgeon growth, condition, and size structure within the Missouri River basin. Journal of Applied Ichthyology 27:269-281.

Spindler, B.D., S.R. Chipps., R.A. Klumb, B.D.S. Graeb, and M.C. Wimberly. 2012. Habitat and prey availability attributes associated with juvenile and early adult pallid sturgeon occurrence in the Missouri River. Endangered Species Research 16:225-234.

Spindler, B.D., S.R. Chipps., R.A. Klumb, and M.C. Wimberly. 2009. Spatial analysis of pallid sturgeon *Scaphirhynchus albus* distribution in the Missouri River, South Dakota. Journal of Applied Ichthyology 25 (Supplement 2): 8-13.

Steffensen, K.D., L.A. Powell, S.M. Stukel, K.R. Winders and W.J. Doyle. 2015. Updated assessment of hatchery-reared pallid sturgeon (Forbes & Richardson,1905) survival in the lower Missouri River. Journal of Applied Ichthyology (2015) 31: 1-8.

Steffensen, K.D., J.J. Wilhelm, J.D. Haas, and J.D. Adams. 2015. Conditional capture probability of Pallid Sturgeon in benthic trawls. North American Journal of Fisheries Management 35(4):626-631.

Steffensen, K.D., S.A. Lundgren, and T.W. Huenemann. 2015. Documented predation of pallid sturgeon *Scaphirhynchus albus* (Forbes & Richardson, 1905) by flathead catfish *Pylodictis olivaris* (Rafinesque, 1818). Journal of Applied Ichthyology 31(5)843-845.

Steffensen, K.D., S. Stukel, and D.A. Shuman. 2015. The status of fishes in the Missouri River, Nebraska: Blue Sucker. Transactions of the Nebraska Academy of Sciences 35:1-11.

Steffensen, K. D.; S. Stukel, and D. A. Shuman. 2014. The Status of Fishes in the Missouri River, Nebraska: Sauger (*Sander canadensis*). Transactions of the Nebraska Academy of Sciences and Affiliated Societies. Paper 471.

Steffensen, K. D., S. Stukel, and D. A. Shuman. 2014. The Status of Fishes in the Missouri River, Nebraska: Lake Sturgeon *(Acipenser fulvescens).* Transactions of the Nebraska Academy of Sciences and Affiliated Societies. Paper 468.

Steffensen, K. D., D. A. Shuman, and S. Stukel. 2014. The Status of Fishes in the Missouri River, Nebraska: Shoal Chub (*Macrhybopsis hyostoma*), Sturgeon Chub (*M. gelida*), Sicklefin Chub (*M. meeki*), Silver Chub (*M. storeriana*), Flathead Chub (*Platygobio gracilis*), Plains Minnow (*Hybognathus placitus*), Western Silvery Minnow (*H. argyritis*), and Brassy Minnow (*H. hankinsoni*). Transactions of the Nebraska Academy of Sciences and Affiliated Societies. Paper 470.

Steffensen, K.D., L.A. Powell, and M.A. Pegg. 2012. Population size of hatchery-reared and wild pallid sturgeon in the lower Missouri River. North American Journal of Fisheries Management 32:159-166.

Steffensen, K.D., B.L. Eder, and M.A. Pegg. 2011. Using Lindgren-Pitman hook timers to understand the dynamics of trotlines catches in a large river. North American Journal of Fisheries Management 31:980-985.

Steffensen, K.D., L.A. Powell, J.D. Koch. 2010. Assessment of Hatchery-Reared Pallid Sturgeon Survival in the Lower Missouri River. North American Journal of Fisheries Management 30:671-678.

Wanner, G.A., K.L. Grohs, and R.A. Klumb. 2011. Influence of abiotic factors on larval fish catches in the lower Niobrara River, Nebraska. Journal of Fish and Wildlife Management. (PSPAP data entry for this project)

Wanner, G.A., D.A. Shuman, R.A. Klumb, K. Steffensen, S. Stukel, and N. J. Utrup. 2010. Comparison of white and green mesh trammel and gill nets to assess the fish community in the Missouri River. North American Journal of Fisheries Management 30:12-25.

Wanner, G.A., and R.A. Klumb. 2009. Length-weight relationships for three Asian carp species in the Missouri River. Journal of Freshwater Ecology 24:489-495. (used PSPAP data)

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

Wanner, G.A., D.A. Shuman, M.L. Brown, and D.W. Willis. 2007. An initial assessment of sampling procedures for juvenile pallid sturgeon in the Missouri River downstream of Fort Randall Dam, South Dakota and Nebraska. Journal of Applied Ichthyology 23:529-538.

Whiteman, K.W., V.H. Travnichek, D.L. Garner, B.L. Eder, and K.D. Steffensen. 2012. Comparison of fish communities in recently constructed side-channel chutes with the main stem Missouri River. Prairie Naturalist 43:100-109.

Wildhaber, M.L., S.H. Holan, J.L. Bryan, D.W. Gladish, and M. Ellersieck. 2011. Assessing power of large river fish monitoring programs to detect population changes: the Missouri river sturgeon example. Journal of Applied Ichthyology 27:282-290.

Wildhaber, M.L., DeLonay, A.J., Papoulias, D.M., Galat, D.L., Jacobson, R.B., Simpkins, D.G., Braaten, P.J., Korschgen, C.E., and Mac, M.J. 2011. Identifying structural elements needed for development of a predictive life-history model for pallid and shovelnose sturgeons. Journal of Applied Ichtyhology, 27(2): 462-469.

Williamson, C.W., and R.R. Dirnberger. 2010. A comparison of techniques using dorsal spines to estimate sauger age. North American Journal of Fisheries Management 30:1016-1019.

Technical Reports/Grey Literature:

Bryan, J.L., M.L. Wildhaber, D.W. Gladish, S.H. Holan, M.R. Ellerseick. 2010. Power to detect trends in Missouri River fish populations within the Pallid Sturgeon Population Assessment Program. USGS, OFR 2010-1020. U.S. Geological Survey, Columbia, Missouri. 141p.

Dattilo, J.E., R.R. Dirnberger, P.T. Horner, D.J. Niswonger, M.L. Miller, and V.H. Travinchek. 2008. Three-year summary age and growth report for plains minnow, western silvery minnow, and brassy minnow (*Hybognathus spp*.). Report to the U.S. Army Corps of Engineers-Northwest Division. Missouri Department of Conservation, Chillicothe, Missouri. 67p.

Dattilo, J.E., R.R. Dirnberger, P.T. Horner, D.J. Niswonger, M.L. Miller, and V.H. Travinchek. 2008. Three-year summary age and growth report for sand shiner (*Notropis stamineus*). Report to the U.S. Army Corps of Engineers-Northwest Division. Missouri Department of Conservation, Chillicothe, Missouri. 63p.

Dattilo, J.E., R.R. Dirnberger, P.T. Horner, D.J. Niswonger, M.L. Miller, and V.H. Travinchek. 2008. Three-year summary age and growth report for sauger (*Sauger canadensis*). Report to the U.S. Army Corps of Engineers-Northwest Division. Missouri Department of Conservation, Chillicothe, Missouri . 79p.

Doyle, W., and C. Ridenour. 2008. Evidence for inlet control structure modification needs on chute projects in the lower Missouri River. Report to the U.S. Army Corps of Engineers. 2p.

Doyle, W.J., and C.J. Ridenour. 2009. Estimate of sample-size required to describe shovelnose sturgeon length-weight relationship. U.S. Fish and Wildlife Service, Columbia, Missouri. 13p.

Herman, P., A. Plauck, N. Utrup, and T. Hill. 2008. Three-year summary age and growth report for sicklefin chub (*Macrhybopsis meeki*). Report to the U.S. Army Corps of Engineers-Northwest Division. U.S. Fish and Wildlife Service, Columbia, Missouri. 64p.

Herman, P., A. Plauck, N. Utrup, and T. Hill. 2008. Three-year summary age and growth report for sturgeon chub (*Macrhybopsis gelida*). Report to the U.S. Army Corps of Engineers-Northwest Division. U.S. Fish and Wildlife Service, Columbia, Missouri. 63p.

Herman, P., A. Plauck, N. Utrup, and T. Hill. 2008. Three-year summary age and growth report for speckled chub (*Macrhybopsis aestivalis*). Report to the U.S. Army Corps of Engineers-Northwest Division. U.S. Fish and Wildlife Service, Columbia, Missouri. 63p.

Huenemann, T.W. (editor). 2013. Central Lowlands and Interior Highlands Pallid Sturgeon Spawning and Stocking Summary. Report for the Middle Basin Pallid Sturgeon Workgroup. Nebraska Game and Parks Commission, Lincoln, Nebraska. 98p.

Hunziker, J., L. Holte, and T. Haddix. 2007. Summary age and growth report for sturgeon chub (*Macrhybopsis gelida*), sickelfin chub (*Macrhybopsis meeki*), and speckled shub (*Macrhybopsis aestivalis*). Report to the U.S. Army Corps of Engineers-Northwest Division. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana.

Jaeger, M., H. Bollig, B. Gardner, R. Holm, K. Kappenman, R. Klumb, S. Krentz, and R. Wilson. 2007. Protocols for tagging and marking hatchery reared pallid sturgeon in Recovery Priority Management Areas 1, 2, and 3. Upper Basin Pallid Sturgeon Workgroup Tagging Committee. March 2007. (Incorporates Project data for retention rates)

King, W.L., and R.H. Wilson. 2003. Movements and habitat preferences of adult post-spawn pallid sturgeon. 2002 Progress Report. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 34p.

Klumb, R.A., D.A. Shuman, D.A. James, and K.L. Grohs. 2011. Movement patterns of age-1 and age-7 pallid sturgeon within the Missouri River during record 2011 discharges downstream of Fort Randall Dam. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. 2010 Progress Report Prepared for Western Area Power Administration, Billings, Montana and the Upper Basin Pallid Sturgeon Workgroup.

Koch, J., and K. Steffensen. 2009. Two-year summary age and growth report for shovelnose sturgeon. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 72p.

Kueter, T.K., K.D. Steffensen, and M.J. Hamel. 2007. Comparison between two different mesh sizes in trammel nets on the Missouri River. Nebraska Game and Parks Commission, Lincoln, Nebraska. 25p.

Labay, S., J. Kral, and S. Stukel. 2008. Three-year summary age and growth report for blue sucker (*Cycleptus elongatus*). Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 93p.

Ridenour, C.J., J.M. Finley, and T.D. Hill. 2008. Long-term trends in gizzard shad population abundance and body condition from side-channel chutes in Missouri River, 1997-2006. U.S. Fish and Wildlife Service, Region 3 Fisheries Data Series: FDS-2008-3. U.S. Fish and Wildlife Service, Columbia, Missouri. (Used Project Data)

Ridenour, C.J., J.A. McMullen, and T.D. Hill. 2009. Assessment of Connected side-channel chutes as habitat restoration for age-0 sturgeons in lower Missouri River. U.S. Fish and Wildlife Service, Region 3 Fisheries Data Series: FDS-2009-1. U.S. Fish and Wildlife Service, Columbia, Missouri. (Used Project Data)

Ridenour, C.J., C.J. Wrasse, H.A. Meyer, W.J. Doyle, and T.D. Hill. 2012. 2011 contingency sampling report-Variation in fish assemblages among four habitat complexes during a summer flood: implications for flow refuge. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 39p.

Shuman, D.A., R.A. Klumb, K.L. Grohs, and D.A. James. 2013. Floodplain sampling report for the fish community in the Missouri River: Segments 5 &6. U. S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. 2011 Annual Report for U.S. Army Corps of Engineers-Northwest Division.

Steffensen, K.D. 2010. Pallid sturgeon population assessment program trotline evaluation. Nebraska Game and Parks Commission, Lincoln, Nebraska. 45p.

Steffensen, K.D., and J.D. Koch. 2008. Water temperature effects on trotline catch rates for pallid sturgeon, shovelnose sturgeon and by-catch. Nebraska Game and Parks Commission, Lincoln, Nebraska. 35p.

Steffensen, K.D., and M.J. Hamel. 2007. Evaluation of the OT01 and OT16 otter trawls in the Missouri River. Nebraska Game and Parks Commission, Lincoln, Nebraska. 26p.

Steffensen, K.D., and M.J. Hamel. 2007. Comparison of stern versus bow otter trawling in the Missouri River. Nebraska Game and Parks Commission, Lincoln, Nebraska. 5p.

Steffensen, K., and M. Hamel. 2008. Four-year summary age and growth report for shovelnose sturgeon (*Schaphirhynchus platorynchus*). Report to the U.S. Army Corps of Engineers-Northwest Division. Nebraska Game and Parks Commission, Lincoln, Nebraska. 88p.

Steffensen, K.D., and M.J. Hamel. 2008. Water temperature effects on gill net catch rates. Nebraska Game and Parks Commission, Lincoln, Nebraska. 25p.

Steffensen, K., R. Klumb, and W. Doyle. 2008. Protocols for tagging and marking hatchery reared pallid sturgeon in Recovery Priority Management Area 4. Middle Basin Pallid Sturgeon Workgroup Tagging Committee. (Incorporates Project data for retention rates)

Steffensen, K.D., J.J. Wilhelm, T.W. Huenemann, D.M. Pauley, B.L. Eder, and G.E. Mestl. 2012. 2011 High Water Contingency Report for the Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 68p.

Stukel, S., J. Kral, and S. LaBay. 2010. Monitoring the fish community of an engineered backwater of the Missouri River. Final report submitted to South Dakota Game and Fish Department. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 42p.

Stukel, S., J. Kral, N. Loecker, and S. Labay. 2012. 2011 high-water report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 125p

Wanner, G.A., K.L. Grohs, and R.A. Klumb. 2010. Spatial and temporal patterns of larval fish in the lower Niobrara River. STAGES - newsletter of the Early Life History Section of the American Fisheries Society 31(1):4. (PSPAP data entry by MDC)

Wanner, G.A., and R.A. Klumb. 2009. Asian carp in the Missouri River: Analysis from multiple Missouri River habitat and fisheries programs. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. Prepared for the Aquatic Nuisance Species Coordinator, U. S. Fish and Wildlife Service – Region 6, 134 Union Boulevard, Lakewood, Colorado. U.S. Fish and Wildlife Service, Pierre, South Dakota. (Used Project data)

Wanner, G.A., and R.A. Klumb. 2011. Fish assemblages in Verdigre Creek and the lower Niobrara River, Nebraska. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. Prepared for the National Park Service, Missouri National Recreational River Office, Yankton, South Dakota. August 2011. (PSPAP data entry by MDC)

Wanner, G.A., M.A. Pegg, S. Schainost, R.A. Klumb, and D.A. Shuman. 2011. River geomorphology and fish barriers affect on spatial and temporal patterns of fish assemblages in the Niobrara River, Nebraska. U.S. Fish and Wildlife Service, Pierre, South Dakota.

Wanner, G.A., M.A. Pegg, S. Schainost, R.A. Klumb, and D.A. Shuman. 2011. River geomorphology and fish barriers affect on spatial and temporal patterns of fish assemblages in the Niobrara River, Nebraska. U.S. Fish and Wildlife Service, Pierre, South Dakota. Feb 2011. (PSPAP data entry by MDC)

Wanner, G.A., D.A. Shuman, K.L. Grohs, and R.A. Klumb. 2010. Population characteristics of sturgeon and Asian carp in the Niobrara River downstream of Spencer Dam, Nebraska in 2008 and 2009. Prepared for Nebraska Public Power District - Columbus, Nebraska. U.S. Fish and Wildlife Service, Pierre, South Dakota. (Project performed data QA/QC and entry into database)

Wanner, G.A., M.A. Pegg, D.A. Shuman, and R.A. Klumb. 2009. Niobrara River fish community downstream of Spencer Dam, Nebraska 2008 progress report. U.S. Fish and Wildlife Service Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. (Project performed data QA/QC and entry into database)

Wilhelm, J.J., and T.W. Huenemann. 2011. Fish presence in floodplain habitats in the upper channelized Missouri River. Nebraska Game and Parks Commission, Lincoln, Nebraska. 11p.

Theses and Dissertations:

Bessert, M.L. 2006. Molecular systematics and population structure in the North American endemic fish genus *Cycleptus* (Teleostei: Catostomidae). Doctoral dissertation. University of Nebraska, Lincoln. 219p. (Project crews collected blue sucker tissue samples for genetics)

French, W.E. 2010. Predation vulnerability and trophic interactions of pallid sturgeon *Scaphirhynchus albus.* MS thesis. South Dakota State University, Brookings. 70p. (Project crews in North Dakota, South Dakota, & Nebraska collected tissue samples for stable isotopes)

Grohs, K.L. 2008. Macroinvertebrate composition and patterns of prey use by juvenile pallid sturgeon (*Scaphirhynchus albus*) in the Missouri River. South Dakota and Nebraska. MS thesis. South Dakota State University, Brookings. 226p. (Project crews collected pallid sturgeon diets)

Meyer, H.A. 2011. Influence of diet and environmental variation on physiological responses of juvenile pallid sturgeon (*Scaphirhynchus albus*). MS thesis. South Dakota State University, Brookings. 78 p. (PSAP crews collected broodstock for fish used in this study).

Schloesser, J.T. 2008. Large river fish community sampling strategies and fish associations to engineered and natural river channel structures. MS thesis. Kansas State University, Manhattan. 76 p.

Spindler, B.D. 2008. Modeling spatial distribution and habitat associations for juvenile pallid sturgeon (*Scaphirhynchus albus*) in the Missouri River. MS thesis. South Dakota State University, Brookings. 110p. (Used Project data)

Steffensen, K.D. 2012. Population Characteristics, Development of a Population Viability Model, and Catch Dynamics of Pallid Sturgeon in the Lower Missouri River. MS thesis. University of Nebraska-Lincoln, Lincoln, Nebraska. 120p.

Wanner, G.A. 2006. Sampling techniques for juvenile pallid sturgeon and the condition and food habits of sturgeon in the Missouri River below Fort Randall Dam, South Dakota. MS thesis. South Dakota State University, Brookings. 175p. (Used Project data)

Wanner, G.A., M.A. Pegg, R.A. Klumb, S. Schainost, and D.A. Shuman. 2011. River geomorphology and fish barriers affect on spatial and temporal patterns fish assemblages in Niobrara River, Nebraska. US Fish & Wildlife Service Technical Report.

Synthesis Reports and Science Reviews:

Bryan, J.L., M.L. Wildhaber, D. Gladish, S. Holan, and M. Ellerseick. 2009. The power to detect trends in Missouri River fish populations within the Pallid Sturgeon Population Assessment Program. Final report to the Army Corp of Engineers. 419p.

Hadley, G.L., and J.J. Rotella. 2009. Upper basin pallid sturgeon survival estimation project. Montana State University. Final Report. 34p. (Used Project data)

Oldenburg, E.W., B.J. Goodman, J.W. Boyd, and T.P. Hanrahan. 2010. 2007–2008 Annual Synthesis Report - Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River. Prepared for the Missouri River Integrated Science Program, U.S. Army Corps of Engineers, Yankton, South Dakota. 224p.

Oldenburg, E.W., B.J. Goodman, J.W. Boyd, and T.P. Hanrahan. 2010. Summary of the 2007–2008 Annual Synthesis Report - Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River. Prepared for the Missouri River Integrated Science Program, U.S. Army Corps of Engineers, Yankton, South Dakota. 24p.

Oldenburg, E., T. Hanrahan, R. Harnish, B. Bellgraph, J. Duncan, and C. Allwardt. 2008. 2005 annual synthesis report- Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River. Prepared for the Missouri River Integrated Science Program, U.S. Army Corps of Engineers, Yankton, South Dakota. 113p.

Oldenburg, E., T. Hanrahan, R. Harnish, B. Bellgraph, J. Duncan, and C. Allwardt. 2008. 2006 annual synthesis report- Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River. Prepared for the Missouri River Integrated Science Program, U.S. Army Corps of Engineers, Yankton, South Dakota. 306p.

Oldenburg, E., T. Hanrahan, R. Harnish, B. Bellgraph, J. Duncan, and C. Allwardt. 2008. Summary of the 2006 annual synthesis report- Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River. Prepared for the Missouri River Integrated Science Program, U.S. Army Corps of Engineers, Yankton, South Dakota. 14p.

Peery, M.Z. 2004. Power to Detect Trends in Pallid and Shovelnose Sturgeon Populations in the Missouri River. Sustainable Ecosystems Institute, Portland, Oregon. Report to the U.S. Army Corps of Engineers. 27p.

Rotella, J. J. 2012. Upper basin pallid sturgeon survival estimation project. 2010 Update. Report prepared for Upper Basin Pallid Sturgeon Workgroup. Montana State University, Bozeman. 39p. (Used Population Assessment Data)

Schapaugh A., and A. Tyre. 2011. Power Analysis for the Pallid Sturgeon Population Assessment Program. University of Nebraska - Lincoln. Prepared for the U.S. Army Corps of Engineers. 42p.

Sustainable Ecosystems Institute. 2004. Independent Science Review of the Pallid Sturgeon Population Assessment Program: Final Report. Sustainable Ecosystems Institute, Portland, Oregon. Report to the U.S. Army Corps of Engineers. 81p.

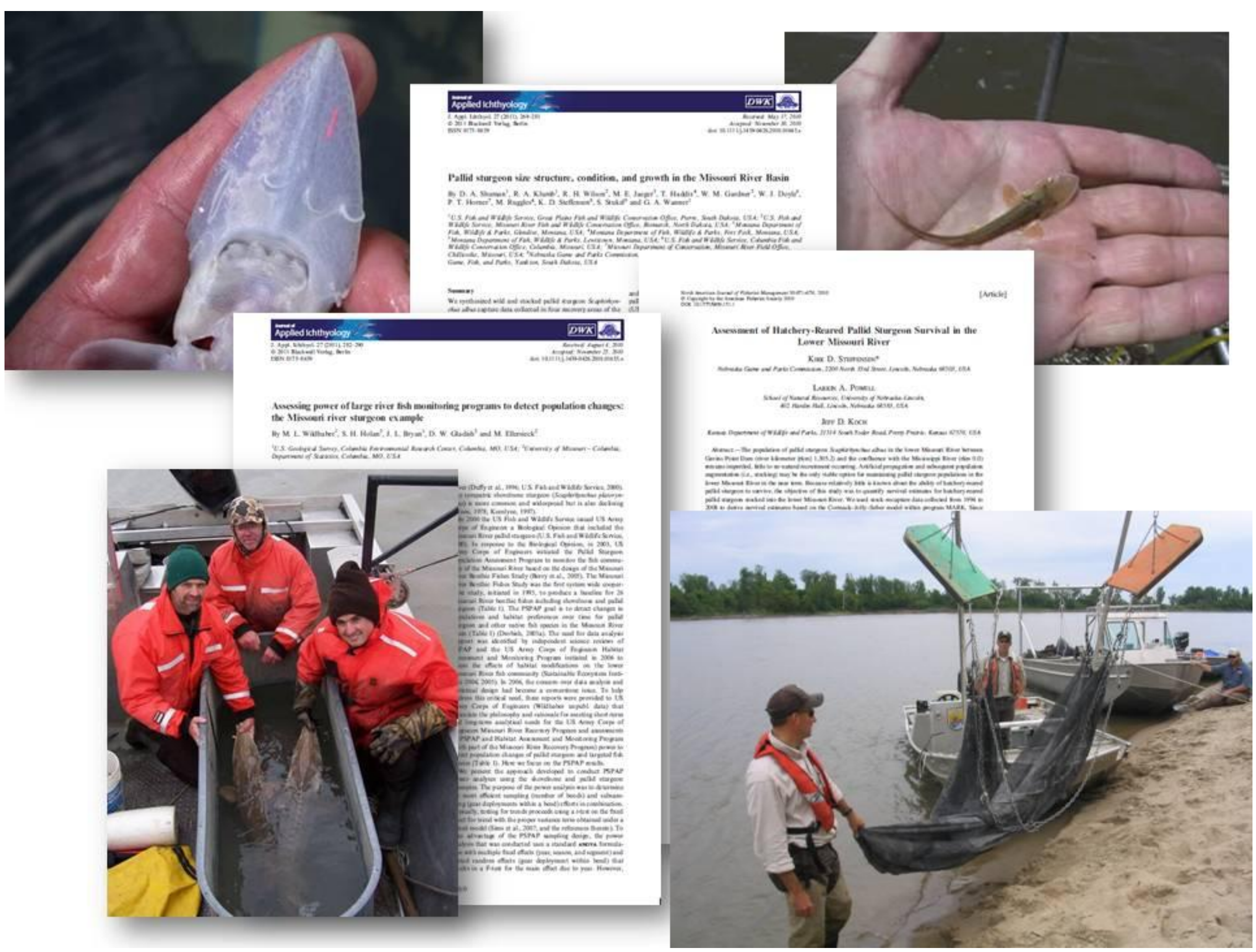
Appendix 1.

Pallid Sturgeon Population Assessment Project

Science Products

Pallid Sturgeon Population Assessment Product Delivery Team

11/18/2015



Overview

Pallid sturgeon, listed as endangered by the U.S. Fish & Wildlife Service (Service) in 1990, have been characterized by an aging and declining wild population and a lack of recent, natural recruitment throughout much of the Missouri River basin. The U.S. Army Corps of Engineers (Corps), as the water management entity responsible for the Missouri River mainstem from Fort Peck Dam to the Mississippi River, consulted with the Service regarding the conservation of the pallid sturgeon (Corps 1999). In 2000, the Service issued the Corps the 2000 Missouri River Biological Opinion (2000 Opinion; USFWS 2000) on the operations of the Missouri River Mainstem Reservoir System, the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. The 2000 Opinion addresses four species listed at the time as threatened or endangered, including the pallid sturgeon *Scaphirhynchus albus*. In 2003, the Service provided the Corps with an Amendment to the 2000 Opinion (2003 Amendment; USFWS 2003).

The 2000 Opinion and the 2003 Amendment list several Reasonable and Prudent Alternative (RPA) elements, Reasonable and Prudent Measures, and Conservation Measures that address the pallid sturgeon and habitat restoration issues. RPA element VI A (Pallid Sturgeon Propagation and Augmentation, p. 250, 2000 Opinion) and RPA element VI B (Pallid Sturgeon Population Assessment, p. 252, 2000 Opinion) address the pallid sturgeon's inability to naturally reproduce and the need to detect changes in populations and ecosystem trends.

The Pallid Sturgeon Population Assessment Project (Project) was developed to provide the data needed to evaluate the two sturgeon RPA elements and to measure the benefits of the various management actions for pallid sturgeon identified in the 2000 Opinion. The Project utilizes a comprehensive monitoring plan to assess survival, movement, distribution, habitat use, and habitat characteristics of wild and hatchery-reared (stocked) pallid sturgeon. A series of native Missouri River fish species were also identified and incorporated into the Project. An evaluation of these native species in addition to the pallid sturgeon provides a more comprehensive assessment of the overall changes in the ecosystem (i.e., form and function through habitat development and flow modification) rather than assessing a single endangered species.

The Corps engaged a core group of scientists (Pallid Sturgeon Population Assessment Team (Team); Appendix 2) comprised of representatives from state and federal natural resource agencies and universities affiliated with Missouri River fisheries projects and/or pallid sturgeon projects to develop the monitoring design, protocols, and guidance language that make up the Project. The Team identifies and utilizes the best available science to adjust the design and protocols to accomplish the overall objectives of the Project. The monitoring effort is focused on Missouri River action areas ranked as "high" (under the Biological Opinion) regarding management action priorities for pallid sturgeon (Appendix 3; Project Area, Segments 1-14) and works to integrate with other monitoring and research efforts along the Missouri River.

Ultimately, the Project is designed to provide the data necessary to evaluate the Pallid Sturgeon Population Augmentation RPA element (i.e., VI A) and to deliver the information necessary to quantify population trends for pallid sturgeon and other native fishes (e.g., abundance, survival, population structure). Assessment of fish population metrics at large spatial scales gives a system-level evaluation of the impacts of management actions on pallid sturgeon and other native species. However, the Project provides more than is required to meet BiOp and Project objectives. Team members work cooperatively with other agencies and researchers to collect biological information for a variety of research projects, lead or support pallid sturgeon broodstock collection efforts throughout the basin, provide Missouri River fish and habitat data to a number of natural resource agencies and research institutions upon request, and share monitoring and research findings with stakeholders, resource agencies, and other scientists at a variety of public meetings and conferences.

This summary report is a living document and serves as a record of the science products and data/information sharing accomplished through the Project since its inception. Individual Team members listed in Appendix 2 may be contacted to request copies of any science product or to discuss its content.

Pallid Sturgeon Population Assessment Project – Science Products

SOPs and Guiding Documents

Welker, T.L., and M.R. Drobish (editors). 2012. Missouri River Standard Operating Procedures for Fish Sampling and Data Collection, Volume 1.7. U.S. Army Corps of Engineers, Omaha District, Yankton, South Dakota. 215p.

Welker, T.L., and M.R. Drobish (editors). 2012. Pallid Sturgeon Population Assessment Project, Volume 1.7. U.S. Army Corps of Engineers, Omaha District, Yankton, South Dakota. 60p.

Annual Reports

2002

Steffensen, K.D., and G.E. Mestl. 2002. 2002 preliminary report: pallid sturgeon population and habitat survey - Segment 9. Draft Performance Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 50p.

Doyle, W., and A. Starostka. 2003. 2002 preliminary report: lower Missouri River Pallid Sturgeon Monitoring and Population Assessment Project - Segments 13 and 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 74p.

2003

Steffensen, K.D., and G.E. Mestl. 2004. Pallid Sturgeon Population Assessment Program 2003 - Segment 9. Annual Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 46p.

U. S. Fish and Wildlife Service (USFWS). 2004. Pallid Sturgeon Population Assessment Program 2003 annual report Segments 5 and 6. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. 2003 Annual Report for U.S. Army Corps of Engineers-Northwest Division. 72p.

Doyle, W., and A. Starostka. 2004. Pallid Sturgeon Population Assessment Program 2003 – Segments 13 and 14. Annual Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 74p.

2004

Shuman, D.A., R.A. Klumb, and S.T. McAlpin. 2005. 2004 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Pierre, South Dakota. 129p.

Steffensen, K., and G. Mestl. 2005. 2004 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 9. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 161p.

Doyle, W., N. Frohnauer, C. Lee, A. Plauck, N. Utrup, and T. Hill. 2005. 2004 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 13 and 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 246p.

2005

Wilson, R., Z. Sandness, E. Nelson, and S. Krentz. 2006. 2005 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 171p.

Shuman, D.A., W.A. Wanner, R.A. Klumb, and W.A. Stancill. 2006. 2005 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Pierre, South Dakota. 191p.

Stukel, S., J. Kral, and S. Labay. 2006. 2005 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 171p.

Barada, T., and K. Steffensen. 2006. 2005 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 8. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 126p.

Steffensen, K., and T. Barada. 2006. 2005 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 9. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 178p.

Kennedy, A.J., P.T. Horner, and V.H. Travnichek. 2006. 2005 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 201p.

Utrup, N., W. Doyle, C. Lee, and T. Hill. 2006. 2005 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 13. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 187p.

Utrup, N., W. Doyle, C. Lee, and T. Hill. 2006. 2005 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 189p.

2006

Haddix, T., L. Holte, and C. Sampson. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 45p.

Haddix, T., L. Holte, and C. Sampson. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 153p.

Haddix, T., L. Holte, and C. Sampson. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 147p.

Wilson, R., Z. Sandness, E. Nelson, and S. Krentz. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 162p.

Shuman, D.A., W.A. Wanner, R.A. Klumb, and W.A. Stancill. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Pierre, South Dakota. 116p.

Stukel, S., J. Kral, and S. Labay. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 129p.

Hamel, M., and K. Steffensen. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 8. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 131p.

Steffensen, K., and M. Hamel. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 9. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 150p.

Caton, D.J., P.T. Horner, and V.H. Travnichek. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 155p.

Caton, D.J., P.T. Horner, and V.H. Travnichek. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 117p.

Plauck, A., N. Utrup, W. Doyle, P. Herman, and T. Hill. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 13. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 162p.

Utrup, N., A. Plauck, W. Doyle, P. Herman, and T. Hill. 2007. 2006 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 165p.

2007

Haddix, T., L. Holte, and C. Lott. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 44p.

Haddix, T., L. Holte, and C. Lott. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 146p.

Haddix, T., L. Holte, and C. Lott. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 148p.

Wilson, R., Z. Sandness, E. Nelson, and S. Krentz. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 155p.

Shuman, D.A., W.A. Wanner, and R.A. Klumb. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Pierre, South Dakota. 132p.

Stukel, S., J. Kral, and S. Labay. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 167p.

Hamel, M., and K. Steffensen. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 8. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 136p.

Steffensen, K., and M. Hamel. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 9. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 152p.

Niswonger, D.J., P.T. Horner, and V.H. Travnichek. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 171p.

Niswonger, D.J., P.T. Horner, and V.H. Travnichek. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 158p.

Plauck, A., N. Utrup, W. Doyle, P. Herman, and T. Hill. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 13. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 161p.

Utrup, N., A. Plauck, W. Doyle, P. Herman, and T. Hill. 2008. 2007 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 171p.

2008

Haddix, T., L. Holte, and J. Hunziker. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 47p.

Haddix, T., L. Holte, and J. Hunziker. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 154p.

Haddix, T., L. Holte, and J. Hunziker. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 155p.

Wilson, R., E. Nelson, and Z. Sandness. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 155p.

Shuman, D.A., R.A. Klumb, and W.A. Wanner. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Pierre, South Dakota. 132p.

Stukel, S., J. Kral, and S. Labay. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 148p.

Koch, J.D., and K.D. Steffensen. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 8. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 134p.

Steffensen, K., and J. Koch. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 9. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 157p.

Niswonger, D.J., P.T. Horner, M. Miller, and V.H. Travnichek. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 205p.

Horner, P.T., D.J. Niswonger, M. Miller, and V.H. Travnichek. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 150p.

Plauck, A., P. Herman, W. Doyle, and T. Hill. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 13.

Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 171p.

Herman, P., A. Plauck, W. Doyle, and T. Hill. 2009. 2008 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 175p.

2009

Haddix, T., L. Holte, and J. Hunziker. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 51p.

Haddix, T., L. Holte, and J. Hunziker. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 115p.

Haddix, T., L. Holte, and J. Hunziker. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 116p.

Wilson, R., E. Nelson, and Z. Sandness. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 121p.

Shuman, D.A., R.A. Klumb, K.L. Grohs, and W.A. Wanner. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Pierre, South Dakota. 133p.

Stukel, S., J. Kral, and S. Labay. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 126p.

Eder, B., and K. Steffensen. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 8. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 113p.

Steffensen, K. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 9. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 123p.

Horner, P.T., D.J. Niswonger, and K.W. Whiteman. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 130p.

Niswonger, D.J., K.W. Whiteman, P.T. Horner, and V.H. Travnichek. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 116p.

Plauck, A., P. Herman, W. Doyle, and T. Hill. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 13. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 137p.

Herman, P., A. Plauck, W. Doyle, and T. Hill. 2010. 2009 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 140p.

2010

Haddix, T., L. Holte, and J. Hunziker. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 51p.

Haddix, T., L. Holte, and J. Hunziker. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 113p.

Haddix, T., L. Holte, and J. Hunziker. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 112p.

Wilson, R., E. Nelson, and Z. Sandness. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 118p.

Shuman, D.A., R.A. Klumb, W.A. Wanner, and K.L. Grohs. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Pierre, South Dakota. 139p.

Stukel, S., J. Kral, N. Loecker, and S. Labay. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 125p.

Eder, B., and K. Steffensen. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 8. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 114p.

Steffensen, K. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 9. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 121p.

Niswonger, D.J., K.R. Winders, and K.W. Whiteman. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 133p.

Winders, K.R., D.J. Niswonger, and K.W. Whiteman. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 120p.

Ridenour, C.J., W.J. Doyle, C. Wrasse, and T.D. Hill. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 13. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 114p.

Ridenour, C.J., W.J. Doyle, C. Wrasse, and T.D. Hill. 2011. 2010 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 118p.

2011

Haddix, T., L. Holte, and J. Hunziker. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 51p.

Haddix, T., L. Holte, and J. Hunziker. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 113p.

Haddix, T., L. Holte, and J. Hunziker. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 118p.

Wilson, R., T. Berger, E. Nelson, and Z. Sandness. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 92p.

Shuman, D.A., and R.A. Klumb. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. 138p.

Stukel, S., J. Kral, and N. Loecker. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 114p.

Steffensen, K.D. and T.W. Huenemann. 2011. 2012 Annual Report: Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River, Segment 8. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 95p.

Steffensen, K.D. and T.W. Huenemann. 2011. 2012 Annual Report: Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River, Segment 9. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 113p.

Niswonger, D.J., K.R. Winders, and K.W. Whiteman. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 133p.

Whiteman, K.W., D.J. Niswonger, and K.R. Winders. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 147p.

Ridenour, C.J., H.A. Meyer, C.J. Wrasse, W.J. Doyle, and T.D. Hill. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 13. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 128p.

Meyer, H.A., C.J. Wrasse, C.J. Ridenour, W.J. Doyle, and T.D. Hill. 2012. 2011 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 14. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 121p.

2012

Haddix, T., L. Holte, J. Hunziker and R. Lott. 2013. 2012 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 52p.

Haddix, T., L. Holte, J. Hunziker and R. Lott. 2013. 2012 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 124p.

Haddix, T., L. Holte, J. Hunziker and R. Lott. 2013. 2012 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 124p.

Huenemann, T.W., and K.D. Steffensen. 2013. 2012 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 8. Nebraska Game and Parks Commission, Lincoln, NE. 117p.

Meyer, H.A., C.J. Wrasse, C.J. Ridenhour, W.J. Doyle and T.D. Hill. 2013. 2012 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 14. USFWS, Columbia Fish and Wildlife Conservation Office. 146p.

Niswonger, D.J., K. Winders and K.W. Whiteman. 2013. 2012 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 137p.

Shuman, D. A., R.A. Klumb, D.A. James, and K. L. Grohs. 2013. 2012 Annual Report. Pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. Prepared for the U.S. Army Corps of Engineers – Missouri River Recovery Program. April 2015. 165p.

Steffensen, K. D., and T. W. Huenemann. 2013. 2012 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 9. Nebraska Game and Parks Commission, Lincoln, NE. 127p.

Steffensen, K. D. 2012. 2012 Nebraska Game and Parks Commission Intensive Pallid Sturgeon Broodstock Collection Summary Newsletter. Nebraska Game and Parks Commission, Lincoln, NE.

Stukel, S., J. Kral, and N. Loecker. 2013. 2012 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 126p.

Whiteman, K.W., K.W. Winders, D.J. Niswonger, and V.H. Travnichek. 2013. 2012 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 122p.

Wilson, R., T. Berger, E. Nelson, and Z. Sandness. 2013. 2012 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 118p.

Wrasse, C., C. Ridenour, W. Doyle and T. Hill. 2013. 2012 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 14. USFWS, Columbia Fish and Wildlife Conservation Office. 144p.

2013

Haddix, T., L. Holte, and J. Hunziker. 2014. 2013 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 54p.

Haddix, T., L. Holte, and J. Hunziker. 2014. 2013 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 120p.

Haddix, T., L. Holte, J. Hunziker and R. Lott. 2014. 2013 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3.

Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 125p.

Herman, P, C. Wrasse and A. McDaniel. 2014. 2013 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 14. USFWS, Columbia Fish and Wildlife Conservation Office. 147p.

Huenemann, T.W., and K.D. Steffensen. 2014. 2013 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 8. Nebraska Game and Parks Commission, Lincoln, NE. 123p.

Garner, D.L., K.W. Winders, D.J. Niswonger, and K.W. Whiteman. 2014. 2013 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 129p.

Niswonger, D.J. and K. Winers. 2014. 2013 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 147p.

Pierce, L. L., D. A. Shuman, R.A. Klumb, D. A. James, and K. L. Grohs. 2014. 2013 Annual Report. Pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. Prepared for the U.S. Army Corps of Engineers – Missouri River Recovery Program. April 2015. 144p.

Steffensen, K. D., and T. W. Huenemann. 2014. 2013 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 9. Nebraska Game and Parks Commission, Lincoln, NE. 127p.

Steffensen, K. D. 2013. 2013 Nebraska Game and Parks Commission Intensive Pallid Sturgeon Broodstock Collection Summary Newsletter. Nebraska Game and Parks Commission, Lincoln, NE.

Stukel, S., N. Loecker and J. Kral. 2014. 2013 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 125p.

Wilson, R., T. Berger, E. Nelson, and Z. Sandness. 2014. 2013 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 118p.

Wilson, R., T. Berger, E. Nelson, and Z. Sandness. 2014. 2013 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 15.

Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 60p.

Winders, K. 2014. 2013 Database Management for Missouri River Recovery Program Projects. Missouri Department of Conservation. 21p.

Wrasse, C., P. Herman and C. Ridenour. 2014. 2013 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 13. USFWS, Columbia Fish and Wildlife Conservation Office. 142p.

2014

Haddix, T., L. Holte, and J. Hunziker. 2015. 2014 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 1. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 54p.

Haddix, T., L. Holte, and J. Hunziker. 2015. 2014 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 2. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 130p.

Haddix, T., L. Holte, and J. Hunziker. 2015. 2014 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 3. Report to the U.S. Army Corps of Engineers. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana. 129p.

Herman, P. and C. Wrasse. 2015. 2014 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 14. USFWS, Columbia Fish and Wildlife Conservation Office. 147 p.

Huenemann, T.W., and K.D. Steffensen. 2015. 2014 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 8. Nebraska Game and Parks Commission, Lincoln, NE. 123p.

Jacobson, R.B., Parsley, M.J., Annis, M.L., Colvin, M.E., Welker, T.L., and James, D.A., 2014, Development of conceptual ecological models linking management of the Missouri River to pallid sturgeon population dynamics: U.S. Geological Survey Open-File Report 2015–1038, 47 p., http://dx.doi.org/10.3133/ofr20151038.

McDaniel, A.J., D.J. Niswonger, K.W. Winders, D.L. Garner, and K.W. Whiteman. 2015. 2014 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 11. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 138p.

Niswonger, D.J., A.J. McDaniel and K.W. Whiteman. 2015. 2014 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 10. Report to the U.S. Army Corps of Engineers. Missouri Department of Conservation, Chillicothe, Missouri. 141p.

Pierce, L. L., D. A. Shuman, D. A. James, and K. L. Grohs. 2015. 2014 Annual Report. Pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segments 5 and 6. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. Prepared for the U.S. Army Corps of Engineers – Missouri River Recovery Program. April 2015.

Steffensen, K. D., and T. W. Huenemann. 2015. 2014 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 9. Nebraska Game and Parks Commission, Lincoln, NE. 128p.

Steffensen, K. D. 2014. 2014 Nebraska Game and Parks Commission Intensive Pallid Sturgeon Broodstock Collection Summary Newsletter. Nebraska Game and Parks Commission, Lincoln, NE.

Stukel, S., J. Kral, and N. Loecker. 2015. 2014 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 125p.

Wilson, R., T. Berger, E. Nelson, and Z. Sandness. 2015. 2014 annual report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 4. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 118p.

Winders, K. 2015. 2014 Database Management for Missouri River Recovery Program Projects. Missouri Department of Conservation. 21p.

Wrasse, C., P. Herman, J. Smith, A. Masters, C. Yonce and J. Henry. 2015. 2014 Annual Report, Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 14. USFWS, Columbia Fish and Wildlife Conservation Office. 138 p.

2015

Steffensen, K. D. 2015. 2015 Nebraska Game and Parks Commission Intensive Pallid Sturgeon Broodstock Collection Summary Newsletter. Nebraska Game and Parks Commission, Lincoln, NE.

Technical Reports/Grey Literature

Bryan, J.L., M.L. Wildhaber, D.W. Gladish, S.H. Holan, M.R. Ellerseick. 2010. Power to detect trends in Missouri River fish populations within the Pallid Sturgeon Population Assessment Program. USGS, OFR 2010-1020. U.S. Geological Survey, Columbia, Missouri. 141p.

Dattilo, J.E., R.R. Dirnberger, P.T. Horner, D.J. Niswonger, M.L. Miller, and V.H. Travinchek. 2008. Three-year summary age and growth report for plains minnow, western silvery minnow, and brassy minnow (*Hybognathus spp*.). Report to the U.S. Army Corps of Engineers-Northwest Division. Missouri Department of Conservation, Chillicothe, Missouri. 67p.

Dattilo, J.E., R.R. Dirnberger, P.T. Horner, D.J. Niswonger, M.L. Miller, and V.H. Travinchek. 2008. Three-year summary age and growth report for sand shiner (*Notropis stamineus*). Report to the U.S. Army Corps of Engineers-Northwest Division. Missouri Department of Conservation, Chillicothe, Missouri. 63p.

Dattilo, J.E., R.R. Dirnberger, P.T. Horner, D.J. Niswonger, M.L. Miller, and V.H. Travinchek. 2008. Three-year summary age and growth report for sauger (*Sauger canadensis*). Report to the U.S. Army Corps of Engineers-Northwest Division. Missouri Department of Conservation, Chillicothe, Missouri . 79p.

Doyle, W., and C. Ridenour. 2008. Evidence for inlet control structure modification needs on chute projects in the lower Missouri River. Report to the U.S. Army Corps of Engineers. 2p.

Doyle, W.J., and C.J. Ridenour. 2009. Estimate of sample-size required to describe shovelnose sturgeon length-weight relationship. U.S. Fish and Wildlife Service, Columbia, Missouri. 13p.

Herman, P., A. Plauck, N. Utrup, and T. Hill. 2008. Three-year summary age and growth report for sicklefin chub (*Macrhybopsis meeki*). Report to the U.S. Army Corps of Engineers-Northwest Division. U.S. Fish and Wildlife Service, Columbia, Missouri. 64p.

Herman, P., A. Plauck, N. Utrup, and T. Hill. 2008. Three-year summary age and growth report for sturgeon chub (*Macrhybopsis gelida*). Report to the U.S. Army Corps of Engineers-Northwest Division. U.S. Fish and Wildlife Service, Columbia, Missouri. 63p.

Herman, P., A. Plauck, N. Utrup, and T. Hill. 2008. Three-year summary age and growth report for speckled chub (*Macrhybopsis aestivalis*). Report to the U.S. Army Corps of Engineers-Northwest Division. U.S. Fish and Wildlife Service, Columbia, Missouri. 63p.

Huenemann, T.W. (editor). 2013. Central Lowlands and Interior Highlands Pallid Sturgeon Spawning and Stocking Summary. Report for the Middle Basin Pallid Sturgeon Workgroup. Nebraska Game and Parks Commission, Lincoln, Nebraska. 98p.

Hunziker, J., L. Holte, and T. Haddix. 2007. Summary age and growth report for sturgeon chub (*Macrhybopsis gelida*), sickelfin chub (*Macrhybopsis meeki*), and speckled shub (*Macrhybopsis aestivalis*). Report to the U.S. Army Corps of Engineers-Northwest Division. Montana Department of Fish, Wildlife, and Parks, Fort Peck, Montana.

Jaeger, M., H. Bollig, B. Gardner, R. Holm, K. Kappenman, R. Klumb, S. Krentz, and R. Wilson. 2007. Protocols for tagging and marking hatchery reared pallid sturgeon in Recovery Priority Management Areas 1, 2, and 3. Upper Basin Pallid Sturgeon Workgroup Tagging Committee. March 2007. (Incorporates Project data for retention rates)

King, W.L., and R.H. Wilson. 2003. Movements and habitat preferences of adult post-spawn pallid sturgeon. 2002 Progress Report. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 34p.

Klumb, R.A., D.A. Shuman, D.A. James, and K.L. Grohs. 2011. Movement patterns of age-1 and age-7 pallid sturgeon within the Missouri River during record 2011 discharges downstream of Fort Randall Dam. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. 2010 Progress Report Prepared for Western Area Power Administration, Billings, Montana and the Upper Basin Pallid Sturgeon Workgroup.

Koch, J., and K. Steffensen. 2009. Two-year summary age and growth report for shovelnose sturgeon. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 72p.

Kueter, T.K., K.D. Steffensen, and M.J. Hamel. 2007. Comparison between two different mesh sizes in trammel nets on the Missouri River. Nebraska Game and Parks Commission, Lincoln, Nebraska. 25p.

Labay, S., J. Kral, and S. Stukel. 2008. Three-year summary age and growth report for blue sucker (*Cycleptus elongatus*). Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 93p.

Ridenour, C.J., J.M. Finley, and T.D. Hill. 2008. Long-term trends in gizzard shad population abundance and body condition from side-channel chutes in Missouri River, 1997-2006. U.S. Fish and Wildlife Service, Region 3 Fisheries Data Series: FDS-2008-3. U.S. Fish and Wildlife Service, Columbia, Missouri. (Used Project Data)

Ridenour, C.J., J.A. McMullen, and T.D. Hill. 2009. Assessment of Connected side-channel chutes as habitat restoration for age-0 sturgeons in lower Missouri River. U.S. Fish and Wildlife Service, Region 3 Fisheries Data Series: FDS-2009-1. U.S. Fish and Wildlife Service, Columbia, Missouri. (Used Project Data)

Ridenour, C.J., C.J. Wrasse, H.A. Meyer, W.J. Doyle, and T.D. Hill. 2012. 2011 contingency sampling report- Variation in fish assemblages among four habitat complexes during a summer flood: implications for flow refuge. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 39p.

Shuman, D.A., R.A. Klumb, K.L. Grohs, and D.A. James. 2013. Floodplain sampling report for the fish community in the Missouri River: Segments 5 &6. U. S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. 2011 Annual Report for U.S. Army Corps of Engineers-Northwest Division.

Steffensen, K.D. 2010. Pallid sturgeon population assessment program trotline evaluation. Nebraska Game and Parks Commission, Lincoln, Nebraska. 45p.

Steffensen, K.D., and J.D. Koch. 2008. Water temperature effects on trotline catch rates for pallid sturgeon, shovelnose sturgeon and by-catch. Nebraska Game and Parks Commission, Lincoln, Nebraska. 35p.

Steffensen, K.D., and M.J. Hamel. 2007. Evaluation of the OT01 and OT16 otter trawls in the Missouri River. Nebraska Game and Parks Commission, Lincoln, Nebraska. 26p.

Steffensen, K.D., and M.J. Hamel. 2007. Comparison of stern versus bow otter trawling in the Missouri River. Nebraska Game and Parks Commission, Lincoln, Nebraska. 5p.

Steffensen, K., and M. Hamel. 2008. Four-year summary age and growth report for shovelnose sturgeon (*Schaphirhynchus platorynchus*). Report to the U.S. Army Corps of Engineers-Northwest Division. Nebraska Game and Parks Commission, Lincoln, Nebraska. 88p.

Steffensen, K.D., and M.J. Hamel. 2008. Water temperature effects on gill net catch rates. Nebraska Game and Parks Commission, Lincoln, Nebraska. 25p.

Steffensen, K., R. Klumb, and W. Doyle. 2008. Protocols for tagging and marking hatchery reared pallid sturgeon in Recovery Priority Management Area 4. Middle Basin Pallid Sturgeon Workgroup Tagging Committee. (Incorporates Project data for retention rates)

Steffensen, K.D., J.J. Wilhelm, T.W. Huenemann, D.M. Pauley, B.L. Eder, and G.E. Mestl. 2012. 2011 High Water Contingency Report for the Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River. Report to the U.S. Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. 68p.

Stukel, S., J. Kral, and S. LaBay. 2010. Monitoring the fish community of an engineered backwater of the Missouri River. Final report submitted to South Dakota Game and Fish Department. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 42p.

Stukel, S., J. Kral, N. Loecker, and S. Labay. 2012. 2011 high-water report - pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: Segment 7. Report to the U.S. Army Corps of Engineers. South Dakota Department of Game, Fish, and Parks, Yankton, South Dakota. 125p

Wanner, G.A., K.L. Grohs, and R.A. Klumb. 2010. Spatial and temporal patterns of larval fish in the lower Niobrara River. STAGES - newsletter of the Early Life History Section of the American Fisheries Society 31(1):4. (PSPAP data entry by MDC)

Wanner, G.A., and R.A. Klumb. 2009. Asian carp in the Missouri River: Analysis from multiple Missouri River habitat and fisheries programs. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. Prepared for the Aquatic Nuisance Species

Coordinator, U. S. Fish and Wildlife Service – Region 6, 134 Union Boulevard, Lakewood, Colorado. U.S. Fish and Wildlife Service, Pierre, South Dakota. (Used Project data)

Wanner, G.A., and R.A. Klumb. 2011. Fish assemblages in Verdigre Creek and the lower Niobrara River, Nebraska. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. Prepared for the National Park Service, Missouri National Recreational River Office, Yankton, South Dakota. August 2011. (PSPAP data entry by MDC)

Wanner, G.A., M.A. Pegg, S. Schainost, R.A. Klumb, and D.A. Shuman. 2011. River geomorphology and fish barriers affect on spatial and temporal patterns of fish assemblages in the Niobrara River, Nebraska. U.S. Fish and Wildlife Service, Pierre, South Dakota.

Wanner, G.A., M.A. Pegg, S. Schainost, R.A. Klumb, and D.A. Shuman. 2011. River geomorphology and fish barriers affect on spatial and temporal patterns of fish assemblages in the Niobrara River, Nebraska. U.S. Fish and Wildlife Service, Pierre, South Dakota. Feb 2011. (PSPAP data entry by MDC)

Wanner, G.A., D.A. Shuman, K.L. Grohs, and R.A. Klumb. 2010. Population characteristics of sturgeon and Asian carp in the Niobrara River downstream of Spencer Dam, Nebraska in 2008 and 2009. Prepared for Nebraska Public Power District - Columbus, Nebraska. U.S. Fish and Wildlife Service, Pierre, South Dakota. (Project performed data QA/QC and entry into database)

Wanner, G.A., M.A. Pegg, D.A. Shuman, and R.A. Klumb. 2009. Niobrara River fish community downstream of Spencer Dam, Nebraska 2008 progress report. U.S. Fish and Wildlife Service Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota. (Project performed data QA/QC and entry into database)

Wilhelm, J.J., and T.W. Huenemann. 2011. Fish presence in floodplain habitats in the upper channelized Missouri River. Nebraska Game and Parks Commission, Lincoln, Nebraska. 11p.

Data Requests

Format: Requesting Individual(s) (Affiliation). Year. Purpose of Data Request:

Cade, B., and B. Neely (U.S. Geological Survey, Fort Collins Science Center; and Texas Parks and Wildlife Department). 2009. Purpose of Data Request: Obtained length and weight data for blue suckers which were used to develop quantile regression approaches for estimating and comparing fish body condition at a distribution-wide scale.

Clark-Kolaks, S., and A. Delonay (U.S. Geological Survey, Columbia Environmental Research Center). 2007. Purpose of Data Request: Conduct a collaborative analysis to evaluate the effectiveness of fish collection procedures under the Population Assessment Program by using available GIS coverages and expertise of Population Assessment Crew members.

Cooperating for Recovery (CORE) Aquatic Habitat Workgroup. 2009. Purpose of Data Request: To assess progress to-date and review physical metrics for overall utility for shallow water habitat creation efforts.

Cox, O. (Nebraska Game and Parks Commission). 2007. Purpose of Data Request: To summarize habitat data collected by the Pallid Sturgeon Population Assessment Project and the Habitat Assessment and Monitoring Project.

Datillo, J. (Missouri Department of Conservation). 2009. Purpose for Data Request: To assess young-of-year annual catch differences in the lower Missouri River.

Doyle, W. (U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2008. Purpose for Data Request: To obtain pallid capture data to develop protocols for tagging and marking hatchery-reared pallid sturgeon in RPMA 4 and the pallid sturgeon range-wide stocking and augmentation plan.

Doyle, W. (U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2009. Purpose for Data Request: To explain absence of YOY sturgeon <120mm in Lisbon chute relative to their ability to maintain position in river, choice of habitat, and constraints of lower closing, 2) Identify priority habitat rehabilitation areas for YOY sturgeon relative to emergence from drift phase and habitat use, 3) Summarize pallid sturgeon continued use and growth in transition areas to identify locomotion ability and affinity for habitat types, and 4) Evaluate juvenile pallid sturgeon migration back to upper reaches of the lower river and comparative densities to lower river in first 3 years of life relative to annual hydrologic events and first emergence from drift.

Drobish, M. (USACE, , Omaha District, Threatened and Endangered Species Section). 2007. Purpose of Data Request: To report wild and hatchery numbers of pallid sturgeon captured by year.

Duncan, M. (Montana State University, Montana Cooperative Fishery Research Unit). 2008. Purpose of Data Request: To compare catch of fishes between Missouri and Yellowstone rivers. (Dissertation)

Duncan, M. (Montana State University, Montana Cooperative Fishery Research Unit). 2010a. Purpose of Data Request: Compare catch of fishes between Missouri and Yellowstone rivers. (Dissertation)

Duncan, M. (Montana State University, Montana Cooperative Fishery Research Unit). 2010b. Purpose of Data Request: To compare catch of fishes between Missouri and Yellowstone rivers. (Dissertation)

Echelle, A. (Oklahoma State University). 2009. Purpose of Data Request: To use data (i.e., specimens) in a systematic analysis to determine relationships amongst *Macrhybopsis* species.

Flash, S. (USACE, Omaha District). 2009. Purpose of Data Request: To incorporate pallid sturgeon capture data from the Missouri River segments; Ft. Peck to the headwaters of Lake Sakakawea, Ft. Randall Dam to headwaters of Lewis and Clark Lake, Lewis and Clark Lake and downstream of

Gavins Point to Ponca, NE into the Emergent Sandbar Habitat and Evaluation Ranking System (ESHER).

Fleming, C. (USACE, Omaha District, Threatened and Endangered Species Section). 2007. Purpose of Data Request: To quantify statistical power to guide gear selection and sampling intensity within HAMP.

Garvey, B. (Nebraska Game and Parks Commission). 2009. Purpose of Data Request: To summarize all broodstock data for RPMA 4 in a single database to be updated and maintained annually.

Gemeinhardt, T., and T. Welker (USACE Kansas City District; USACE, Omaha District, Threatened and Endangered Species Section). Purpose of Data Request: Exploratory analysis of the relationship between shallow water habitat creation and *Scaphirhynchus* sturgeon (less than 75mm) CPUE.

Hadley, G. (Montana State University). 2008. Purpose of Data Request: To estimate survival of hatchery stocked pallid sturgeon in the upper Missouri River.

Hall, J. (Nebraska Game and Parks Commission). 2010. Purpose of Data Request: To assess blue sucker habitat use in relation to environmental variables in the lower Missouri River.

Hanrahan, T. (Pacific Northwest National Laboratory). 2007. Purpose of Data Request: 2005 and 2006 synthesis analyses and reports for the Pallid Sturgeon Population Assessment Project.

Herzog, D., B. Todd, and V. Travnichek (Missouri Department of Conservation). 2008. Purpose of Data Request: Lower Missouri River lake sturgeon captures and associated fish species were utilized as supporting information to expand sampling for evaluating the State of Missouri stocking program for lake sturgeon in the Missouri River.

Hoover, D*., T*. Gemeinhardt, and T. Welker (*USACE, Kansas City District; USACE, Omaha District, Threatened and Endangered Species Section). 2012. Pallid count information for public meetings associated with the Benedictine Bottoms mitigation site.

Horner, P., and D. Niswonger (Missouri Department of Conservation). 2008. Purpose of Data Request: Evaluation of dispersal, recapture rates and growth and condition for shovelnose sturgeon in the Missouri River based on the floy tag mark-recapture study (U.S. Geological Survey-Columbia Environmental Research Center).

Horner, P., and D. Niswonger (Missouri Department of Conservation). 2009. Purpose of Data Request: To assess changes in species composition and abundance spatially and temporally using catch of small fishes from standard mini-fyke and otter trawl sampling in the lower Missouri River.

Jackson, Z. (Iowa State University, Department of Natural Resource Ecology and Management). 2006. Purpose of Data Request: Develop growth standards for 27 fish species. Standards were used to make regional and national comparisons of growth and will facilitate better communication among biologists and provide an additional tool for describing growth of fishes.

Jaeger, M. (Montana Fish, Wildlife, and Parks Department). 2008. Purpose of Data Request: To provide a second line of inference to estimate emigration of pallid sturgeon stocked in the Yellowstone River for the purpose of adjusting survival estimates of pallid sturgeon in the Yellowstone River.

Jaeger, M., and G. Jordan (Montana Fish, Wildlife, and Parks Department; and U.S. Fish and Wildlife Service, Pallid Sturgeon Recovery Coordinator). 2007. Purpose of Data Request: To determine survival rates of stocked juvenile pallid sturgeon in the Upper Basin of the Missouri River (RPMAs 1 – 3).

Jarnot, C. (Bemidji State University). 2007. Purpose of Data Request: To determine correlations between fish species abundance and physio-chemical parameters. (Statistics course)

Jenkins, J., and J. Dean (U.S. Geological Survey, National Wetlands Research Center, Lafayette, Louisiana; and Natchitoches National Fish Hatchery). 2008. Purpose of Data Request: Differentiation of pallid sturgeon (*Scaphirhynchus albus)* from shovelnose sturgeon (*S. platorynchus*): evaluation of a flow cytometric method based on DNA content difference.

Johnson, J. (University of Missouri-Columbia). 2007. Purpose of Data Request: Examine "Reproductive Development of *Macrhybopsis* Chubs in Relation to Environmental Variables in the Lower Missouri River". (MS Thesis)

Jordan, G. (U.S. Fish and Wildlife Service, Pallid Sturgeon Recovery Coordinator). 2007. Purpose of Data Request: To use tissue samples from RPMA 1 and 2 to estimate the effective population size (Ne) of the pallid sturgeon parental population.

Klumb, R. (U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office). 2008. Purpose of Data Request: To expand comparisons of minnow and predator relative abundance and size structure between Fort Randall and Gavins Point reaches during 2003-2004 to include 2005-2006.

Klumb, R. (U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office). 2009. Purpose of Data Request: To compare size ranges of sturgeon captured with standard and non-standard gears.

Klumb, R. (U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office). 2009. Purpose of Data Request: To incorporate data into a general presentation for a sturgeon symposium at the Minnesota-Wisconsin-Ontario American Fisheries Society meeting.

Klumb, R., and S. Stukel (U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office; and South Dakota Game, Fish and Parks Department). 2011. Purpose of Data Request: To create geographic information system (GIS) coverages with associated metadata for pallid sturgeon and native fish distributions within Segments 5 – 7. The data will be used for planning purposes for multiple agencies within the Missouri National Recreational River.

Klumb, R., D. Chapman, and K. Irons (U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office; U.S. Geological Survey, Columbia Environmental Research Center; Illinois natural History Survey). 2009. Purpose of Data Request: To expand Asian carp data presented in FWS report on Asian carp in the Missouri River using data collected from multiple habitat and fisheries programs to assess condition of Bighead and Silver carps throughout the Mississippi River basin.

Miller, M. (Missouri Depart of Conservation). 2009. Purpose of Data Request: Evaluation of pallid sturgeon catch rates for different hook types/sizes used throughout the Missouri River.

Neely, B., and B. Cade (Texas Parks and Wildlife Department; and U.S. Geological Survey, Fort Collins Science Center). 2009. Purpose of Data Request: Develop quantile regression approaches for estimating and comparing blue sucker body condition at a distribution-wide scale.

Niswonger, D. (Missouri Department of Conservation). 2008. Purpose of Data Request: To test for differences in small fish abundance between flood and non-flood areas in the lower Missouri River.

Niswonger, D. (Missouri Department of Conservation). 2012. Purpose of Data Request: To map Asian carp distribution for development of future actions that address their spread.

Oldenburg, E. (Pacific Northwest National Laboratory). 2010. Purpose of Data Request: To develop length-specific gear analysis for target native fishes sampled through the Pallid Sturgeon Population Assessment Project.

Oldenburg, E., and T. Welker (Pacific Northwest National Laboratory; and USACE, Omaha District, Threatened and Endangered Species Section). 2011. Purpose of Data Request: Assessment of pallid sturgeon geographic distribution and habitat association in the Missouri River from Fort Peck Dam to the Missouri River mouth.

Papoulias, D. (U.S. Geological Survey, Columbia Environmental Research Center). 2012. Purpose of Data Request: To obtain a large data set on pallid sturgeon to determine the feasibility of using weight or length at age to tentatively ID sex.

Paukert, C., and J. Schloesser (Kansas State University). 2008. Purpose of Data Request: To analyze fish community difference in push trawls, mini fyke nets, and otter trawls.

Plauck, A. (U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2009. Purpose of Data Request: To examine dispersal trends in stocked pallid sturgeon in the lower Missouri River.

Rapp, T. (South Dakota State University). 2012. Purpose of Data Request: Pallid sturgeon length (mm), weight (g), and capture site water temperature (C) will be combined with blood samples data to assess stress levels in pallid sturgeon captured at various water temperatures.

Schloesser, J., C. Paukert, and W. Doyle (Kansas State University; and U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2007. Purpose of Data Request: To assess Missouri River fish sampling and species associations at micro-habitats along a latitudinal gradient. (MS Thesis)

Schloesser, J. (U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2008. Purpose of Data Request: To incorporate MDC trotline data into probability models for calculating the effort needed to capture a pallid sturgeon.

Simpkins, D., J. Stucker, and S. Stukel (U.S. Geological Survey, Columbia Environmental Research Center; U.S. Geological Survey-Northern Prairie Wildlife Research Center; and South Dakota Game, Fish, and Parks). 2007. Purpose of Data Request: To compare the effectiveness of common gears used to sample young-of-the-year sturgeon and other small bodied fishes potentially used as forage by pallid sturgeon and least terns in the Recreational River Reach of the Missouri River below Gavins Point Dam.

Sparks, K. (USACE, Kansas City District). 2012. Purpose of Data Request: To assess the feasibility of using Pallid Sturgeon Population Assessment Project data for examining long-term trends in Missouri River fishes in relation to current USACE operations.

Starostka, A. (U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2008. Purpose of Data Request: To assess age and Growth of *Macrhybopsis* Chubs in Missouri River.

Steffensen, K. (Nebraska Game and Parks Commission). 2008. Purpose of Data Request: To quantify survival of hatchery-reared pallid sturgeon in RPMA 4.

Steffensen, K. (Nebraska Game and Parks Commission). 2010. Purpose of Data Request: To investigate the benefits/redundancy of trot lines compared to other standard gear of the Population Assessment Program.

Steffensen, K. (Nebraska Game and Parks Commission). 2011. Purpose of Data Request: To examine the spatial variation in native fish populations in the Missouri River below Gavins Point Dam.

Steffensen, K., and M. Hamel (Nebraska Game and Parks Commission). 2007. Purpose of Data Request: To compare CPUE of fish species collected in two types of otter trawls (OT01 and OT16) and compare CPUE differences between stern and bow trawling.

Steffensen, K., and M. Hamel (Nebraska Game and Parks Commission). 2008. Purpose of Data Request: To compare temperature effects on catch-per-unit-effort of passive gill nets to determine when gill nets are most effective for sampling target species.

Steffensen, K., M. Hamel, and B. Neely (Nebraska Game and Parks Commission). 2007. Purpose of Data Request: To develop a standard weight (Ws) equation for use in the computation of relative weight (Wr) for blue sucker.

Steffensen, K., and M. J. Koch (Nebraska Game and Parks Commission). 2009. Purpose of Data Request: To conduct a preliminary analysis on the effects of temperature on pallid sturgeon catch and on by-catch for trotlines in the Missouri River.

Sterner, V. (Iowa Department of Natural Resources). 2010. Purpose of Data Request: To assess recreational fisheries management and update distribution maps of Iowa native fish species.

Travnichek, V., and I. Vining (Missouri Department of Conservation). 2011. Purpose of Data Request: Evaluation of tag retention for shovelnose sturgeon in the Missouri River based on t-bar tag mark-recapture study. Percent retained will be used as a covariate in MARK for a population estimate and survival rate study currently being analyzed using MDC sturgeon study data.

Tyre, A., and A. Schapaugh (University of Nebraska-Lincoln). 2010. Purpose of Data Request: To determine the extent of differences in the relative abundance of pallid and shovelnose sturgeon and associated forage fishes among bends of different types in the lower Missouri River (HAMP data).

Utrup, N. (U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2008. Purpose of Data Request: Evaluation of dispersal and recapture rates for hatchery-reared pallid sturgeon in the Missouri River below Gavins Point Dam.

Utrup, N., and W. Doyle (U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2008. Purpose of Data Request: Evaluation of the POT02 “Push” Otter Trawl in the Missouri River.

Wanner, G., and R. Klumb (U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office). 2007. Purpose of Data Request: To summarize data for Asian carp in the Missouri River – Report to U.S. Fish and Wildlife Service Region 6 Aquatic Nuisance Species Coordinator.

Wanner, G. (U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office). 2007. Purpose of Data Request: To assess the effect of green and white mesh trammel and gill nets on catch of Missouri River fishes.

Welker, T. (USACE, Omaha District, Threatened and Endangered Species Section). 2010. Purpose of Data Request: To develop a presentation of pallid catch data for a joint Corps NW Division/Mississippi Valley Division Pallid Meeting and the Platte River Recovery Implementation Program.

Welker, T. (USACE, Omaha District, Threatened and Endangered Species Section). 2011. Purpose of Data Request: To update pallid length frequency and capture data for numerous presentations.

Welker, T., and A. Tyre (USACE, Omaha District, Threatened and Endangered Species Section; and University of Nebraska-Lincoln). 2011. Purpose of Data Request: To calculate the power to detect long-term trends in abundance of pallid sturgeon.

Welker, T., and M. Wildhaber (USACE, Omaha District, Threatened and Endangered Species Section; and U.S. Geological Survey, Columbia Environmental Research Center). 2011. Purpose of Data Request: To develop a Project Synthesis Report (Pallid Sturgeon Population Assessment Project) that assesses abundance trends of pallid sturgeon and other native fish species and quantifies survival and population size for pallid sturgeon in the lower Missouri River basin.

Welker, T., and M. Wildhaber (USACE, Omaha District, Threatened and Endangered Species Section; and U.S. Geological Survey, Columbia Environmental Research Center). 2012. Purpose of Data Request: To develop length-frequency distributions of pallid sturgeon origins (i.e., hatchery, wild, hybrid, unknown) for the BiOp Annual Report.

Whiteman, K. (Missouri Department of Conservation). 2009. Purpose of Data Request: Compare Missouri River main-channel fish communities to those in chutes.

Wildhaber, M. (U.S. Geological Survey, Columbia Environmental Research Center). 2006. Purpose of Data Request: To apply multiple-gear analytical method to the Pallid Sturgeon Assessment Program (PSAP) data. The method developed is designed to provide a more comprehensive approach than is classically used to assess fish catch data.

Wildhaber, M. (U.S. Geological Survey, Columbia Environmental Research Center). 2006. Purpose of Data Request: To conduct Power Analysis for the Population Assessment Program to guide sampling efforts (e.g., statistical significance, confidence).

Wildhaber, M. (U.S. Geological Survey, Columbia Environmental Research Center). 2009. Purpose of Data Request: Development of population and survival estimates for pallid sturgeon in the lower Missouri River.

Wildhaber, M. (U.S. Geological Survey, Columbia Environmental Research Center). 2011. Purpose of Data Request: Development of population and survival estimates for pallid sturgeon in the lower Missouri River (update to the 2009 request).

Williamson, C. (Missouri Department of Conservation). 2009. Purpose of Data Request: To obtain sauger spine information to update sauger age and growth report.

Wilson, C. (Missouri Department of Conservation). 2011. Purpose of Data Request: Evaluation of Macro/Meso/Micro habitat selections of pallid sturgeon on the Lower Missouri River.

Wilson, C. (Missouri Department of Conservation). 2012. Purpose of Data Request: Analyze the effects of stocking variables (boat vs. habitat stocking, season, age) on pallid sturgeon dispersal in the lower Missouri River.

Wilson, R. (U.S. Fish and Wildlife Service, Missouri River Fish and Wildlife Management Assistance Office). 2007. Purpose for Data Request: To update the U.S. Fish and Wildlife Service national pallid sturgeon capture database with 2006 pallid capture information in accordance with the requirements in section 10 collection permits.

Wilson, R. (U.S. Fish and Wildlife Service, Missouri River Fish and Wildlife Management Assistance Office). 2008. Purpose for Data Request: To update the U.S. Fish and Wildlife Service national pallid sturgeon capture database with 2007 pallid capture information in accordance with the requirements in section 10 collection permits.

Wilson, R. (U.S. Fish and Wildlife Service, Missouri River Fish and Wildlife Management Assistance Office). 2009. Purpose for Data Request: To update the U.S. Fish and Wildlife Service national pallid sturgeon capture database with 2008 pallid capture information in accordance with the requirements in section 10 collection permits.

Winders, K. (Missouri Department of Conservation). 2010. Purpose of Data Request: To update the Missouri Natural Heritage Program database for the state of Missouri.

Winders, K. (Missouri Department of Conservation). 2011. Purpose of Data Request: To update the Missouri Natural Heritage Program database for the state of Missouri.

Winders, K. (Missouri Department of Conservation). 2011. Purpose of Data Request: To assess the longitudinal variation in community richness in the Missouri River main stem.

Winders, K. (Missouri Department of Conservation). 2012. Purpose of Data Request: Evaluate t-bar tag retention rates for shovelnose sturgeon.

Wilson, C., and K. Winders (Missouri Department of Conservation). 2010. Purpose of Data Request: To evaluate season and discharge effects on probability of capture of blue catfish with trot lines in both flowing and non-flowing pools on the lower Missouri River.

Wrasse, C. (U.S. Fish and Wildlife Service, Columbia National Fish and Wildlife Conservation Office). 2008. Purpose of Data Request: To assess relative abundance of young-of-year sturgeon in the lower Missouri River.

Yeager, L., and S. Stukel (National Park Service; and South Dakota Game, Fish and Parks Department). 2012. Purpose of Data Request: To obtain a summary of fish community data collected on NPS Bow Creek property during flood of 2011.

Data Collected for Non-project Use

Format: Requesting individual; agency; year(s) data collected; location in MR; purpose of data collection

Bessert, M.; University of Nebraska-Lincoln; 2004-2005; Segments 4, 5, 6, 9, 13, and 14; Collected tissue samples from blue sucker for development of a range-wide genetic baseline for the species. (Ph.D. dissertation)

Borden, C.; University of Nebraska-Lincoln; 2008-2009; Segments 1-14; Collected tissue samples from three chub species (sicklefin chub, *Macrhybopsis meeki*; sturgeon chub, *Macrhybopsis gelida*; and shoal chub (formerly speckled chub), *Macrhybopsis hyostoma*) for development of a range-wide genetic baseline for the three species.

Gross, J.; U.S. Geological Survey-Northern Rocky Mountain Science Center, Fort Collins, Colorado; 2010; Segment 4; Assisted with the study "The effects of oil exploration on the survival of juvenile endangered pallid sturgeon". The study was designed to assess the effects of water seismic surveys on pallid sturgeon and other native fish species.

Papoulias, D.; U.S. Geological Survey-Columbia Environmental Research Center, Columbia, Missouri; 2005; Segments 7-14; Blood and egg samples were collected from shovelnose sturgeon to develop a model that would allow estimates of reproductive readiness (how far advanced the oocytes were, or whether they had been spawned or reabsorbed) based on blood reproductive hormone measurements.

Stagmiller, K.; Montana Fish, Wildlife and Parks, Helena, Montana; 2010; U.S. Fish and Wildlife Service-Great Plains FWCO collected tissue samples from pallid sturgeon and shovelnose sturgeon in Segments 5 and 6 for iridovirus PCR research.

Webb, M.; U.S. Fish and Wildlife Service-Bozeman Fish Technology Center, Bozeman, Montana; 2010 to present; Segments 1-4; Collected blood samples from hatchery-released pallid sturgeon to determine age at sexual maturation.

Wildhaber, M.; U.S. Geological Survey-Columbia Environmental Research Center, Columbia, Missouri; 2006-Present; Segments 7-14; Tagged shovelnose sturgeon with floy tags and reported recapture data to U.S. Geological Survey. Recapture data were used to develop population and survival estimate models for shovelnose sturgeon which aided in the development of models for the rarer pallid sturgeon.

Posters

Berg, K.L., R.A. Klumb, and S.R. Chipps. 2007. Diets of juvenile pallid sturgeon and macroinvertebrate composition in the Fort Randall reach of the Missouri River. 137th Annual Meeting of the American Fisheries Society, San Francisco, California.

Bonneau, J.L., T.M. Fleeger, and T.R. Gemeinhardt. 2012. Evaluating Shallow Water Habitat Creation Efforts - How Do We Measure Success? Missouri River Natural Resources Committee Conference.

Bryan, J.L., M. L. Wildhaber, M.Z. Peery, V.H. Travnichek, G.E. Mestl, T.D. Hill, and M.R. Drobish. 2007. Power to detect trends in pallid sturgeon populations in the Lower Missouri River. Missouri River Natural Resources Conference and Biological Opinion Forum: Adapting to Adaptive Management, Nebraska City, Nebraska.

Clark-Kolaks, S.J., D.W. Everitt, P.T. Horner, K.D. Steffensen, N.J. Utrup, and A.J. DeLonay. 2007. Evaluation of Sampling Procedures for the Pallid Sturgeon Monitoring and Assessment Program on the Lower Missouri River. 137th Annual Meeting of the American Fisheries , San Francisco, California.

Clark-Kolaks, S.J., D.W. Everitt, P.T. Horner, K.D. Steffensen, N.J. Utrup, and A.J. DeLonay. 2008. Pallid Sturgeon Assessment Program on the Lower Missouri River. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Dattilo, J.E. 2010. Identifying characteristcs of young of year chubs (*Macrhybopsis spp.*) of the Missouri River. 14th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Dattilo, J.E., P.T. Horner, D.J. Niswonger, M.L. Miller, and E.A. Windmeyer. 2009. Population trends among select *Macrhybopsis spp.* in the lower Missouri River. 13th Missouri River Natural Resources Conference and BiOp Forum, Billings Montana.

Drobish, M., and R. Vander Lee. 2003. The pulse rate of the pallid sturgeon and associated fish community on the Missouri River. 7th Missouri River Natural Resources Conference and BiOP Forum, Atchison, Kansas.

French, W.B. D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2009. Prey selection by juvenile pallid sturgeon. 46th Annual Meeting of the Dakota Chapter American Fisheries Society, Bismarck, North Dakota.

Garvey Jr., W.K. 2009. 2008 Middle basin pallid sturgeon broodstock collection. 13th Missouri River Natural Resource Conference and BiOp Forum, Billings, Montana.

Gemeinhardt, T.R., and J.L. Bonneau. 2012. An Evaluation of Potential Impacts to Water Quality of the Missouri River from Shallow Water Habitat Creation. Missouri River Natural Resources Committee Conference.

Gosch, N.J.C., and M.L. Miller. 2012. Assessment of floodplain benthic invertivores on the Missouri River. Missouri River Natural Resources Committee Conference.

Gosch, N.J.C., and M.L. Miller. 2012. Entrapment: floodplain habitat use by Missouri River fishes. Missouri River Natural Resources Committee Conference

Gosch, N.J.C., and M.L. Miller. 2012. Floodplain habitat use by Missouri River fishes. Missouri Natural Resources Conference.

Hamel, M.J., K.D. Steffensen, S.M. Stukel, W.J. Doyle, P.T. Horner, and D.A. Shuman. 2008. Influence of mesh size and trawling techniques on catch of benthic fish species of the Missouri River. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Henry, J., J. Yonce and C. Wrasse. Distribution of Lake Sturgeon Captures within the lower 250 miles of the Missouri River. Poster Presentation: Missouri River Natural Resources Conference; March

2015; Nebraska City, NE.

Holte, L., J. Hunziker, and T. Haddix. 2011. Pallid Sturgeon Population Assessment Program on the Missouri River below Fort Peck Dam. Montana Chapter of the American Fisheries Society, Great Falls, Montana.

Holte, L., J. Hunziker, T. Haddix and R. Wilson. 2009. Evaluation of trotlines for sampling pallid and shovelnose sturgeon in the Missouri River downstream of Fort Peck Dam, Montana and North Dakota. 13th Missouri River Natural Resource Conference and BiOp Forum, Billings, Montana.

Horner, P.T., D.J. Niswonger, E.M. Gilmore, M.J. Allen, K.D. Steffensen, and W.J. Doyle. 2008. Comparison of young-of-year fish catch between flood year and non-flood years on the Missouri River. 12th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Huffmon, T.R., J.E. Dattilo, and K.R. Winders. Fish community in the Kansas River: detectability above and below the weir. 15th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Kennedy, A.J., P.T. Horner, and V.H. Travnichek. 2006. Comparison of fish communities captured with bag seines and mini-fyke nets in the lower Missouri River. 67th Annual Midwest Fish and Wildlife Conference, Omaha, Nebraska.

Kennedy, T., P. Horner, and V. Travnichek. 2007. Comparison of fish communities captured with bag seines and mini-fyke nets in the lower Missouri River. Missouri Natural Resources Conference, Lake of the Ozarks, Missouri.

McDaniel, Adam. 2015**.** Effects of Seasonal Water Temperatures on Catch Rates and Habitat Associations of Pallid Sturgeon. Missouri Natural Resources Conference, Osage Beach, MO.

McDaniel, Adam. 2015**.** Effects of Seasonal Water Temperatures on Catch Rates and Habitat Associations of Pallid Sturgeon. 75th Annual Midwest Fish and Wildlife Conference. Indianapolis, IN.

McDaniel, A.J., C.J. Ridenour, W.J. Doyle, and T.D. Hill. 2012. Distribution of sauger in lower Missouri River relative to a range of hydrographs. Missouri Natural Resources Conference, Osage Beach, Missouri.

McMullen, J.A., C.J. Ridenour, and T.D. Hill. 2008. Assessment of Connected side-channel chutes as habitat restoration for age-0 sturgeons in lower Missouri River. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Meyer, H.A., S.R. Chipps, B.D.S. Graeb, and R.A. Klumb. 2011. Growth, food consumption and energy status of age-0 pallid sturgeon (*Scaphirhynchus albus*) fed commercial or invertebrate diet. 141st

Annual Meeting of the American Fisheries Society, Seattle, Washington. (PSAP crews collected broodstock for fish used in this study).

Meyer, H.A., S.R. Chipps, B.D.S. Graeb, and R.A. Klumb. 2012. Evidence for countergradient variation in pallid sturgeon physiology 16th Annual Missouri River Natural Resources Conference, Pierre, South Dakota. March 2012. (PSAP crews collected broodstock for fish used in this study).

Meyer, H.A., S.R. Chipps, B.D.S. Graeb, and R.A. Klumb. 2012. Evidence for countergradient variation in pallid sturgeon physiology 47th Annual Meeting of the Dakota Chapter American Fisheries Society, Chamberlain, South Dakota. February 2012. (PSAP crews collected broodstock for fish used in this study).

Meyer, H.A., C.J. Ridenour, and T.D. Hill. 2012. Seasonal resource selection by blue suckers in the lower Missouri River. Missouri River Natural Resources Committee Conference, Pierre, South Dakota.

Miller, M.L., J.E. Dattilo, and P.A. Herman. 2008. Sturcture preparation methods for determining age of selected Missouri River fishes. 12th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Miller, M.L., K.D. Steffensen, W.J. Doyle, and S.M. Stukel. 2009. Trotline hook evaluation for pallid sturgeon (*Scaphirhynchus albus*) on the Lower Missouri River; Gavins Point Dam to the Mouth. 13th Missouri River Natural Resources Conference and BiOp Forum, Billings Montana.

Miller, M.L., and N.J.C. Gosch. 2012. Benthic Macro Fauna Colonization on Inundated Floodplain Sites Along the Lower Missouri River. Missouri River Natural Resources Committee Conference.

Morris, D.M., T.R. Gemeinhardt, and D.E. Jensen. 2012. Comparison of Multiple Water Quality Parameters During High Flow Events on the Lower Missouri River. Missouri River Natural Resources Committee Conference.

Neely, B.C., K.D. Steffensen, and M.A. Pegg. 2008. A Comparison of Two Transmitter Implantation Techniques in Shovelnose Sturgeon. 138th Annual Meeting of the American Fisheries Society, Ottawa, Canada.

Niswonger, Darby N, A. McDaniel, and K. R. Winders. 2015.Geographic distribution and abundance of pallid sturgeon x shovelnose sturgeon hybrids in the Missouri River. Missouri River Natural Resources Conference, Nebraska City, NE.

Niswonger, D.J., T.R. Huffmon, and K.R. Winders. 2012. Fish production in Missouri tributaries: flood vs. drought. 73rd Annual Midwest Fish and Wildlife Conference, Wichita, Kansas.

Plauck, A.T., W.J. Doyle, and T.D. Hill. 2009. Dispersal and recapture success of hatchery reared pallid sturgeon in the lower Missouri River. 13th Missouri River Natural Resources Conference and BiOP Forum, Billings, Montana.

Rapp, T., B.D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2012. Ontogenetic prey preferences of pallid sturgeon. 47th Annual Meeting of the Dakota Chapter American Fisheries Society, Chamberlain, South Dakota, February 2012. (PSAP crews collected broodstock for fish used in this study).

Rapp, T., B.D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2012. Ontogenetic prey preferences of pallid sturgeon. 16th Annual Missouri River Natural Resources Conference, Pierre, South Dakota. March 2012. (Second place, best student poster). (PSAP crews collected broodstock for fish used in this study).

Ridenour, C.J., J.L. Johnson, L. Erikson, and T.D. Hill. 2008. Age and Growth of *Macrhybopsis* chubs in Missouri River. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Ridenour, C.J., A.J. McDaniel, and T.D. Hill. 2012. Role of hydrology on the distribution and population structure of sauger in lower Missouri River. 142nd Annual Meeting of the American Fisheries Society, St. Paul, Minnesota.

Ridenour, C.J., A.J. McDaniel, W.J. Doyle, and T.D. Hill. 2012. Variation in age-0 sauger habitat use and abundance with river flow in lower Missouri River. Missouri River Natural Resources Committee Conference, Pierre, South Dakota.

Ridenour, C.J., J.A. McMullen, and T.D. Hill. 2009. Assessment of shallow-water habitat for young sturgeon in lower Missouri River. 139th Annual Meeting of the American Fisheries Society, Nashville, Tennessee.

Ridenour, C.J., J.A. McMullen, and T.D. Hill. 2009. Habitat used by young sturgeons in the channelized lower Missouri River. 13th Missouri River Natural Resources Conference and BiOP Forum, Billings, Montana.

Ridenour, C.J., J.J. Spurgeon and T.D. Hill. 2010. Assessment of natural flow for early life history survival of *Scaphirhynchus* sturgeon in the contemporary lower Missouri River. 14th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraksa.

Ridenour, C.J., C.J. Wrasse and T.D. Hill. 2010. Implications of river restoration for nursery habitat of blue and channel catfish. Conservation, Ecology, and Management of Catfish: the Second International Symposium, St. Louis, Missouri.

Shuman, D.A., R.A. Klumb, G.A. Wanner, K. Steffensen, W. Doyle, B. Gardner, M. Jaeger, M. Ruggles, T. Haddix, P. Horner, S. Stukel, and R. Wilson. 2009. Pallid sturgeon growth, condition, and size structure within the Missouri River Basin. 139th Annual Meeting of the American Fisheries Society, Nashville, Tennessee.

Shuman, D.A., R.A. Klumb, G.A. Wanner, K. Steffensen, W. Doyle, B. Gardner, M. Jaeger, M. Ruggles, T. Haddix, P. Horner, S. Stukel, and R. Wilson. 2009. Pallid sturgeon growth, condition, and size structure within the Missouri River Basin. 13th Annual Misouri River Natural Resources Conference, Billings, Montana.

Spindler, B.D., S.R. Chipps, and R.A. Klumb. 2007. Distribution and habitat use of juvenile pallid sturgeon in the Fort Randall reach of the Missouri River. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Spindler, B.D., S.R. Chipps, and R.A. Klumb. 2007. Distribution and habitat use of juvenile pallid sturgeon in the Fort Randall reach of the Missouri River. 68th Annual Midwest Fish and Wildlife Conference, Madison, Wisconsin.

Spindler, B.D., S.R. Chipps, R.A. Klumb, and M.C. Wimberly. 2007. Distribution and habitat use of juvenile pallid sturgeon in the Fort Randall reach of the Missouri River. 137th Annual Meeting American Fisheries Society, San Francisco, California.

Spurgeon, J.J., C.J. Ridenour, and T.D. Hill. 2009. Impact of mean annual flow on early life history survival of *Scaphirhynchus* sturgeon in lower Missouri River. 70th Annual Midwest Fish and Wildlife Conference, Springfield, Illinois.

Steffensen, K.D., and A.J. Barada. 2006. Pallid sturgeon sampling in the upper channelized reach of RPMA # 4. 67th Annual Midwest Fish and Wildlife Conference, Omaha, Nebraksa.

Steffensen, K.D., and G.E. Mestl. 2002. Reducing the field handling time of sturgeon. 6th Missouri River Natural Resources Conference and BiOp Forum, South Sioux City, Nebraska.

Steffensen, K.D., J.D. Koch, and G.E. Mestl. 2005. Pallid and shovelnose sturgeon winter population assessment in the upper channelized Missouri River. *Scaphirhynchus* Conference, St. Louis, Missouri.

Wanner, G.A., D.A. Shuman, R.A. Klumb, K. Steffensen, S. Stukel, and N.J.Utrup. 2007. Comparisons of white and green mesh trammel and gill nets to assess the fish community in the Missouri River. 68th Annual Midwest Fish and Wildlife Conference, Madison, Wisconsin.

Wanner, G. A., D. A. Shuman, R. A. Klumb, K. Steffensen, S. Stukel, and N. J. Utrup. 2008. Comparisons of White and Green Mesh Trammel and Gill Nets to Assess the Fish Community in the Missouri River. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Welker, T.L., G.A. Williams, and C.D. Kruse. 2011. Pallid sturgeon population assessment and monitoring on the Missouri River. 141st Annual Meeting of the American Fisheries Society, Seattle, Washington.

Williamson, L. 2008. Data collection and database management for a Missouri River Monitoring Program. Organization of Fish and Wildlife Information Managers, Albuquerque, New Mexico.

Williamson, C.W., and R.R. Dirnberger. 2009. A comparison of methods using dorsal spines to estimate sauger age. 13th Missouri River Natural Resources Conference and BiOp Forum, Billings Montana.

Wilson, C.D., and K.R. Winders. 2011. Optimizing potential for blue catfish trotlining success. 15th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Wilson, C.D., and K.R. Winders. 2013. Habitat association of pallid sturgeon in the lower Missouri River. Missouri Natural Resources Conference, Osage Beach, Missouri.

Wilson, R., and S. Krentz. 2008. Pallid sturgeon monitoring in the Missouri and Yellowstone rivers in North Dakota. 12th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Wrasse, C., A. Masters, S. Ettinger-Dietzel and W. Bouska. Capture of age-0 Hatchery Reared Pallid Sturgeon – Clues to Dispersal and Habitat Use. Poster Presentation: Missouri River Natural Resources Conference; March 2015; Nebraska City, NE.

Wrasse, C., A. Starostka, W. Doyle, and T. Hill. 2008. Role of environmental variables in shovelnose sturgeon reproduction. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Presentations

Adams, J.D. and T.W. Huenemann. 2015. A comparison of stomach content collection methods and food habits of Shovelnose Sturgeon during and after a severe flood event. Missouri River Natural Resource Conference. Nebraska City, NE.

Barada, A.J., G.E. Mestl and K.D. Steffensen. 2007. Native fish distribution and abundance in the upper channelized Missouri River. 11th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Barada, A.J., and K.D. Steffensen. 2007. Native fish distribution and abundance in the upper channelized Missouri River. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Tri-State Meeting, Council Bluffs, Iowa.

Berg, K.L., S. Chipps, R. Klumb. 2007. Relative prey use by juvenile pallid sturgeon, compared to the Missouri River macroinvertebrate assemblage below Fort Randall Dam. 44th Annual Meeting of the Dakota Chapter American Fisheries Society, Bismarck, North Dakota.

Berg, K.L., S. Chipps, R. Klumb. 2006. Relative prey use by juvenile pallid sturgeon, compared to the macroinvertebrate assemblage in the Missouri River below Fort Randall Dam. 67th Annual Midwest Fish and Wildlife Conference, Omaha, Nebraska.

Bryan, J.L., M.L. Wildhaber, S.H. Holan, D.W. Gladish, and M. Ellerseick. 2009. Evaluating power of the Missouri River Pallid Sturgeon Populations Assessment Program to detect population changes. The 6th International Symposium on Sturgeon, Wuhan, Hubei Province, China.

Bryan, J.L.. M.L. Wildhaber, M.Z. Peery, V.H. Travnichek, G.E. Mestl, T.D. Hill, and M.R. Drobish 2007. Power to detect trends in shovelnose and pallid sturgeon populations in the Lower Missouri River. American Fisheries Society, San Francisco, California.

Bryan, J.L., M.L. Wildhaber, M.Z. Peery, V.H. Travnichek, G.E. Mestl, T.D. Hill, and M.R. Drobish. 2007. Power to detect trends in pallid sturgeon populations in the lower Missouri River. 11th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Civiello, A.P., and J.M. Long. 2015. Influence of habitat on young-of-year shovelnose sturgeon prey use. 145nd Annual Meeting of the American Fisheries Society.

Columbo, R., J. Garvey, K.J. Kilgore, J. Koch, M. Pegg, M. Quist, A. Schery, T. Sutton, V. Travnichek, C.S. Guy, R. Klumb, N. Caswell, S. Hale, Q. Phelps, and B. Gardner. 2009. Distribution, life history, and population status of the shovelnose sturgeon. 139th Annual Meeting of the American Fisheries Society, Nashville, Tennessee.

Cox, O.N., P.T. Horner, A. Starostka, S.M. Stukel, N.J. Utrup, K.D. Steffensen, S.J. Sampson and G.E. Mestl. 2007. Habitat Use by Missouri River Pallid Sturgeon. 11th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Drobish, M. 2003. Pallid sturgeon population assessment and related activities in the Missouri River from Fort Peck Dam to the mouth near St. Louis. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Gretna, Nebraska.

Drobish, M. 2004. Pallid Sturgeon Population Assessment Program. Independent Science Review Panel-Sustainable Ecosystems Institute, Sioux Falls, South Dakota.

Drobish, M. 2004. Vision for success: partnering agencies working together for the pallid sturgeon. 134th Annual Meeting of the American Fisheries Society, Madison, Wisconsin.

Drobish, M. 2005. Pallid sturgeon program update. South Dakota Game and Fish Department winter fisheries meeting.

Drobish, M. 2007. Pallid sturgeon research, monitoring, propagation, and habitat creation. Joint meeting of U.S. Army Corps of Engineers Northwest and Mississippi Valley Divisions, St. Louis, Missouri.

Dzialowski, A.R., T.R. Gemeinhardt, and J.L.Bonneau. 2012. Comparisons of phytoplankton and zooplankton communities in lower Missouri River mainstem and floodplain sites in 2011. 142nd Annual Meeting of the American Fisheries Society.

Fleming, C., J. Bonneau, G. Pavelka, T. Welker, and G. Williams. 2011. Missouri River Recovery Program: endangered species monitoring and research. Presentation to the U.S. Army Corps Chief of Engineers' Environmental Advisory Board, Yankton, South Dakota.

French, W., B. Graeb, K. Bertrand, S. Chipps, and R. Klumb. 2009. Isotope analysis of sturgeon diets. 70th Annual Midwest Fish and Wildlife Conference, Springfield, Illinois.

French, W.E., B.D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2009. Vulnerability of age-0 pallid sturgeon to predation. Annual Meeting of the Wisconsin, Minnesota, and Ontario Chapters American Fisheries Society, Duluth, Minnesota.

French, W., S. Chipps, B. Graeb, and R. Klumb. 2009. Prey selection and vulnerability to predation in juvenile pallid sturgeon. 139th Annual Meeting of the American Fisheries Society, Nashville, Tennessee.

Garvey Jr., W.K. 2007. Pallid Sturgeon Population Assessment Program status update. Nebraska Game and Parks Fisheries Division Meeting, Gretna, Nebraska.

Garvey Jr., W.K. 2009. 2008 Nebraska Game and Parks broodstock collection effort. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Gretna, Nebraska.

Garvey Jr., W.K., and K.D. Steffensen. 2011. The population structure of pallid sturgeon in an intensively sampled reach of the Missouri River. 72nd Annual Midwest Fish and Wildlife Conference, Des Moines, Iowa.

Gemeinhardt, T.R., D.M. Morris, and B. Johnson. 2015. Shallow Water Habitat Check-In and Habitat Distribution on the Lower Missouri River. Missouri River Natural Resources Committee Conference.

Gemeinhardt, T.R., N.J.C. Gosch, M.L. Miller, and S. Sampson. 2014. Chute Accessibility of Age-0 Sturgeon in the Lower Missouri River. Missouri River Natural Resources Committee Conference.

Gosch, N.J.C., T.R. Gemeinhardt, D.M. Morris, M.L. Miller, T.L. Welker, and J.L. Bonneau. 2015. Is shallow water a suitable surrogate for assessing efforts to address pallid sturgeon population declines? Missouri River Natural Resources Committee Conference.

Gosch, N.J.C., and M.L. Miller. 2012. Assessment of floodplain benthic invertebrates and invertivores on the Missouri River. 142nd Annual Meeting of the American Fisheries Society.

Haas, J.D., B.L. Eder, K.D. Steffensen, and J.D. Adams. 2015. Short-term survival and dispersal of hatchery-reared juvenile Pallid Sturgeon stocked in the channelized Missouri River. Missouri River Natural Resource Conference. Nebraska City, NE.

Haddix, T. M., Holte, L. and J. Hunziker 2015. 2014 Montana pallid sturgeon population assessment brief overview. Upper Basin Pallid Sturgeon Workgroup Annual Meeting. Miles City, MT.

Haddix, T., D. Fuller, L. Holte, J. Hunziker, and R. Lott. 2011. Influence of the Milk River on the fishes of the lower Missouri River downstream of Fort Peck Dam. Annual Meeting of the Montana Chapter of the American Fisheries Society, Great Falls, Montana.

Haddix, T., L. Holte, J. Hunziker and D. Fuller. 2011. Burbot *Lota lota* recruitment in the lower Missouri River during the historic flows of 2011. Annual Meeting of the Montana Chapter of the American Fisheries Society, Helena, Montana.

Hamel, M.J., and K.D. Steffensen. 2007. Influence of mesh size and trawling techniques on catch of benthic fish species of the Missouri River. 68th Annual Midwest Fish and Wildlife Conference, Madison, Wisconsin.

Hamel, M.J., and K.D. Steffensen. 2008. Age and growth of shovelnose sturgeon in the Missouri River. 138th Annual Meeting of the American Fisheries Society, Ottawa, Canada.

Holte, L. H., Rugg, M. and R. Wilson. 2015. A look into the future for pallid sturgeon downstream of Fort Peck Dam, MT. Great Plains Fisheries Workers Association annual meeting in Helena, MT.

Holte, L., T. Haddix, and J. Hunziker. 2012. Burbot *Lota lota* recruitment in the lower Missouri River during historic flows of 2011. 15th Missouri River Natural Resources Conference and BiOp Forum, Pierre, South Dakota.

Holte, L., T. Haddix, and J. Hunziker. 2010. Trotline use to improve confidence of survival estimates in the upper Missouri River. 14th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Holte, L., T. Haddix, and J. Hunziker. 2009. Pallid Sturgeon Population Assessment Project overview. Great Plains Fishery Workers Annual Meeting, Lethbridge, Alberta, Canada.

Hong, Y. 2008. The database management system (DBS) of the Missouri River pallid sturgeon recovery program (MRPSRP). Organization of Fish and Wildlife Information Managers, Albuquerque, New Mexico.

Hong, Y. 2009. A clearinghouse for pallid sturgeon data. Organization of Fish and Wildlife Information Managers, Seattle, Washington.

Horner, P.H., and D.J. Niswonger. 2009. Assessment of shovelnose sturgeon mark-recapture efforts on the Missouri River. 13th Missouri River Natural Resources Conference and BiOp Forum, Billings Montana.

Huenemann, T.W. 2015. Spatiotemporal patterns of native species in the lower Missouri River. 145th Annual Meeting of the American Fisheries Society, Portland, OR.

Huenemann, T.W. 2015. Missouri River pallid sturgeon and fish community monitoring program. 145th Annual Meeting of the American Fisheries Society, Portland, OR.

Huenemann, T.W. 2012. Fish use of the floodplain during the 2011 flood. Central Mountains and Plains Section of the Wildlife Society, 2012 Conference. Bismarck, North Dakota.

Huenemann, T.W., D.M. Pauley, and K.D. Steffensen. 2012. Assessment of fish presence and distribution in floodplains during a high water Event on the Missouri River. 16th Missouri River Natural Resources Conference and BiOp Forum, Pierre, South Dakota.

Huenemann, T.W., K.D. Steffensen, B.L. Eder, and G.E. Mestl. 2011. Assessment of fish presence and distribution in floodplains during a high water event on the Missouri River. 72nd Annual Midwest Fish and Wildlife Conference, Des Moines, Iowa.

Hunziker, J. T. Haddix, and L. Holte. 2009. The sampling gears of the Missouri River Pallid Sturgeon Population Assessment Program. Great Plains Fisheries Workers Association Annual Meeting, Lethbridge, Alberta, Canada.

James, D. A., L. L. Pierce, M. L. Annis, M. E. Colvin, R. B. Jacobson, M. Randall, and T. L. Welker. 2015. Association of native prey-fish abundance to pallid sturgeon condition. Contributed paper. 145th Annual meeting of the American Fisheries Society. Portland, OR.

James, D. A., L. L. Pierce, M. L. Annis, M. E. Colvin, R. B. Jacobson, M. Randall, and T. L. Welker. 2015. Association of native prey-fish abundance to pallid sturgeon condition. Contributed paper. 50th Annual Meeting, Dakota Chapter of American Fisheries Society, Bismarck, ND.

James, D. A., L. L. Pierce, M. L. Annis, M. E. Colvin, R. B. Jacobson, M. Randall, and T. L. Welker. 2015. Association of native prey-fish abundance to pallid sturgeon condition. Contributed paper. 2015 Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, NE.

Klumb, R.A. 2007. Relative abundance of shallow water fishes in the Missouri River downstream of Fort Randall and Gavins Point dams, South Dakota and Nebraska. 68th Annual Midwest Fish and Wildlife conference, Madison, Wisconsin.

Klumb, R.A., D.A. James, D.A. Shuman, and K.L. Grohs. 2012. The influence of record discharge on the small-bodied fish community in a portion of the Missouri River. 142nd Annual Meeting of the American Fisheries Society, St. Paul, Minnesota.

Klumb, R., D. Shuman, and S. Stukel. 2008. Relative abundance of shallow water fishes in the Missouri River downstream of Fort Randall and Gavins Point dams, South Dakota and Nebraska. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Klumb, R.A., D. Shuman, and S. Stukel. 2008. Relative abundance of shallow water fishes in the Missouri River downstream of Fort Randall and Gavins Point dams, South Dakota and Nebraska. Annual Meeting of the Dakota and Iowa Chapters American Fisheries Society, Sioux Falls, South Dakota.

Klumb, R.A. C. Kruse, M. Drobish, T. Welker, M. Ruggles, T. Haddix, S. Krentz, R. Wilson, D. Shuman, S. Stukel, S. LaBay, J. Kral, K. Steffensen, G. Mestl, P. Horner, D. Niswonger, W. Doyle, A. Plauck, T. Hill, and M.L. Wildhaber. 2009. Standardized pallid sturgeon and fish community monitoring in the Missouri River basin. Annual Meeting of the Wisconsin, Minnesota, and Ontario Chapters American Fisheries Society, Duluth, Minnesota.

McDaniel, A., K.R. Winders. 2015**.** Effects of Seasonal Water Temperatures on Catch Rates and Habitat Selectivity of Pallid Sturgeon. Missouri River Natural Resources Conference, Nebraska City, NE.

Meyer, H.A., S.R. Chipps, R.A. Klumb, and B.D.S. Graeb. 2010. Growth, metabolism, and energy density of juvenile pallid sturgeon fed commercial and natural diets. 3rd Annual Meeting of the North American Chapter of the World Sturgeon Conservation Society, Bozeman, Montana.

Meyer, H., S. Chipps, B. Graeb, and R. Klumb. 2011. Growth, metabolism, and energy density of juvenile pallid sturgeon fed commercial and natural diets. 48th Annual Meeting of the Dakota Chapter American Fisheries Society, Bismarck, North Dakota.

Meyer, H.A., S.R. Chipps, B.D.S. Graeb, and R.A. Klumb. 2011. Latitudinal variation in pallid sturgeon physiology. 4th Annual Meeting of the North American Chapter of the World Sturgeon Conservation Society, Nanaimo, British Columbia, Canada.

Meyer, H.A., S.R. Chipps, B.D.S. Graeb, and R.A. Klumb. 2011. Latitudinal variation in juvenile pallid sturgeon (*Scaphirhynchus albus*) physiology. 141st Annual Meeting of the American Fisheries Society, Seattle, Washington.

Meyer, H.A., C.J. Ridenour, W.J. Doyle and T.D. Hill. 2012. Influence of flow regime on the condition of blue suckers in the lower Missouri River. 142nd Annual Meeting of the American Fisheries Society, St. Paul, Minnesota.

Meyer, H.A., C.J. Ridenour and T.D. Hill. 2012. Influence of flow regime on the condition of native fluvial specialists in the lower Missouri River. 73rd Annual Midwest Fish and Wildlife Conference, Wichita, Kansas.

Milller, M.L. 2009. Trotline use within the pallid sturgeon population assessment program. Missouri Natural Resources Conference, Osage Beach, Missouri.

Morris, D.M. 2012. Comparison of Water Quality During Two High Year flows on the Lower Missouri River. 142nd Annual Meeting of the American Fisheries Society.

Morris, D.M., T.R. Gemeinhardt, M.L. Miller, N.J.C. Gosch, W.W. Bouska. 2015. Identification and Assessment of High-Density Capture Locations of Age-0 Sturgeon. Missouri River Natural Resources Committee Conference.

Neely, B.C., and J.J. Wilhelm. 2009. Use distributions, movements, and resource selection of blue suckers in the middle Missouri River. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Gretna, Nebraska

Neely, B.C., and J.J. Wilhelm. 2009. Use distributions, movements, and resource selection of blue suckers in the middle Missouri River. 13th Missouri River Natural Resource Conference and BiOp Forum, Billings, Montana.

Niswonger, Darby N. 2015. Pallid sturgeon broodstock efforts on the Missouri River. Missouri Natural Resources Conference, Osage Beach, MO.

Niswonger, D.J. and T. Huenemann. 2015. Missouri River Pallid Sturgeon and Fish Community Monitoring Program. American Fisheries Society 145th Annual Meeting, August 16-20th, Portland, OR.

Niswonger, D.J. 2012. Pallid sturgeon and other fish of the Missouri River. Greenway Network River Soundings Conference, St. Louis, Missouri.

Niswonger, D.J., and P.T. Horner. 2008. Assessment of shovelnose sturgeon mark/ recapture efforts on the Missouri River. 12th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Niswonger, D.J., and P.H. Horner. 2010. Pallid sturgeon monitoring in the Kansas and Missouri Rivers. Kansas Natural Resources Conference, Wichita, Kansas.

Niswonger, D.J., P.T. Horner, and V.H. Travnichek. 2008. Comparison of young-of-the-year catch of fishes between flood years and non flood years on the Missouri River. Missouri Natural Resources Conference, Lake of the Ozarks, Missouri.

Niswonger, D.J., P.T. Horner, and V.H. Travnichek. 2008. Missouri River monitoring program. Missouri Natural Resources Conference, Lake of the Ozarks, Missouri.

Pauley D.M. 2015. Missouri River paddlefish update. 2015 Nebraska Chapter of the American Fisheries Society Annual Meeting, Nebraska, NE.

Pauley, D.M. 2011. Age-0 fish usage of the floodplain on the channelized Missouri River. 72nd Annual Midwest Fish and Wildlife Conference, Des Moines, Iowa.

Pauley, D.M., T.W. Huenemann, and K.D. Steffensen. 2012. Assessment of fish presence and distribution in floodplains during a high water event on the Missouri River. 16th Missouri River Natural Resource Conference and BiOp Forum, Pierre, South Dakota.

Pegg, M.A., B.C. Neely, and K.D. Steffensen. 2008. Young-of-year fish community structure and habitat use along the upper channelized reach of the Missouri River. 138th Annual Meeting of the American Fisheries Society, Ottawa, Canada.

Pierce, L. L., D. A. James, and D. A. Shuman. 2015. Differences in capture probability of an endangered species (Pallid Sturgeon) among four sampling gears. Contributed poster. 50th Annual Meeting, Dakota Chapter of American Fisheries Society, Bismarck, ND.

Pierce, L. L., D. A. James, and D. A. Shuman. 2015. Differences in capture probability of an endangered species (Pallid Sturgeon) among four sampling gears. Contributed poster. 2015 Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, NE.

Rapp, T., W.E. French, B.D.S. Graeb, S.R. Chipps, and R. Klumb. 2011. Ontogenetic prey preferences of pallid sturgeon. 141st Annual Meeting of the American Fisheries Society, Seattle, Washington.

Rapp, T., B.D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2010. Influence of predation on habitat selection by juvenile pallid sturgeon. 3rd Annual Meeting of the North American Chapter World Sturgeon Conservation Society, Bozeman, Montana.

Rapp, T., B.D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2010. Laboratory examination of juvenile pallid sturgeon habitat preferences with focus on predation. 14th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Rapp, T., B.D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2010. Laboratory examination of juvenile pallid sturgeon habitat preferences with focus on predation. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, Pennsylvania.

Rapp, T., B.D.S. Graeb, S.R. Chipps, and R.A. Klumb. 2010. Laboratory examination of habitat preferences by juvenile pallid sturgeon with focus on predation. 47th Annual Meeting of the Dakota Chapter American Fisheries Society, Spearfish, South Dakota.

Ridenour, C.J. 2008. Management implications for channel modifying structures used by native chubs in a regulated river. 69th Annual Midwest Fish and Wildlife Conference, Columbus, Ohio.

Ridenour, C.J. 2008. Habitat used by *Macrhybopsis* chubs associated with channel modifying structures in a large regulated river: implications for river management. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Ridenour, C.J., and T.D. Hill. 2012. Effects of flood flows on habitat use by benthic Missouri River fishes: toward improving capacity for recovery. 142nd Annual Meeting of the American Fisheries Society, St. Paul, Minnesota.

Ridenour, C.J., W.J. Doyle, and T.D. Hill (H.A. Meyer, Presenter). 2012. Lateral distribution of *Scaphirhynchus* sturgeon during overbank flood flows in lower Missouri River. MICRA Paddlefish-Sturgeon Winter Committee Meeting, St. Louis, Missouri.

Ridenour, C.J., W.J. Doyle and T.D. Hill (H.A. Meyer, Presenter). 2012. Lateral distribution of *Scaphirhynchus* sturgeon during flood flows in the lower Missouri River: 2010 case study. Mississippi Interstate Cooperative Resource Association Sturgeon and Paddlefish Committee Annual Meeting, Kirkwood, Missouri.

Ridenour, C.J., W.J. Doyle, and T.D. Hill. 2010. Habitats used by age-0 *Scaphirhynchus* sturgeon in the lower Missouri River. 71st Annual Midwest Fish and Wildlife Conference, Minneapolis, Minnesota.

Ridenour, C.J., W.J. Doyle, and T.D. Hill. 2011. Habitats of age-0 *Scaphirhynchus* sturgeon in the lower Missouri River. 14th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Ridenour, C.J., W.J. Doyle, and T.D. Hill. 2011. Lateral distribution of *Scaphirhynchus* sturgeon during flood flows in lower Missouri River. 14th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Ridenour, C.J., W.J. Doyle, and T.D. Hill. 2011. Lateral distribution of *Scaphirhynchus* sturgeon during overbank flood flows in lower Missouri River. 72nd Annual Midwest Fish and Wildlife Conference, Des Moines, Iowa.

Schloesser, J., C. Paukert, W. Doyle, and T. Hill. 2008. Detection probabilities for monitoring Missouri River fishes. 138th Annual Meeting of the American Fisheries Society, Ottawa, Canada.

Schloesser, J., C. Paukert, W. Doyle, T. Hill, G. Mestl, and V. Travnichek. 2007. Probability of detection and catch rate variability by gear type for Missouri River fishes. 68th Midwest Fish and Wildlife Conference, Madison, Wisconsin.

Shuman, D.A. 2005. What do we know and what have learned: growth, survival, and distribution of pallid sturgeon. Carnival of Communication. 2005 Biological Opinion review of the Missouri, Omaha, Nebraska.

Shuman, D.A. 2010. Pallid sturgeon in the Missouri River – Monitoring progress towards recovery. U.S. Fish and Wildlife Service, Arlington, Virginia.

Shuman, D.A., R.A. Klumb, D.A. James, and K.L. Grohs. 2012. Movement patterns of age-1 and age-7 pallid sturgeon during record discharges within the Missouri River. 142nd Annual Meeting of the American Fisheries Society, St. Paul, Minnesota.

Shuman, D.A., R.A. Klumb, D.A. James, and K.L. Grohs. 2012. Movement patterns of age-1 and age-7 pallid sturgeon during record discharges within the Missouri River. 16th Annual Missouri River Natural Resource Committee Conference, Pierre, South Dakota.

Shuman, D., R. Klumb, and G. Wanner. 2006. Evaluation of hatchery stocked pallid sturgeon below Fort Randall Dam, South Dakota and Nebraska. 10th Missouri River Natural Resources Conference and BiOp Forum, South Sioux City, Nebraska.

Shuman, D., R. Klumb, and G. Wanner. 2006. Evaluation of hatchery stocked pallid sturgeon below Fort Randall Dam, South Dakota and Nebraska. 43rd Annual Meeting of the Dakota Chapter American Fisheries Society, Chamberlain, South Dakota.

Shuman, D.A., R.A. Klumb, and G.A. Wanner. 2009. Status of hatchery reared pallid sturgeon downstream of Fort Randall Dam. 46th Annual Meeting of the Dakota Chapter American Fisheries Society, Bismarck, North Dakota.

Shuman, D.A., R.A. Klumb, and G.A. Wanner. 2009. A big fish in a bigger river: monitoring pallid sturgeon in the Missouri River downstream of Fort Randall Dam, South Dakota 2003-2008. Annual Meeting of the Wisconsin, Minnesota, and Ontario Chapters American Fisheries Society, Duluth, Minnesota.

Shuman, D.A., R.A. Klumb, and G.A. Wanner. 2009. Missouri River pallid sturgeon assessment and research activities. Middle Basin Pallid Sturgeon Workgroup Meeting, Blue Springs, Missouri.

Shuman, D., R. Klumb, and G. Wanner. 2011. A comparison of fall and spring gill netting in an inter-reservoir reach of the Missouri River, South Dakota and Nebraska. 15th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Shuman, D., R. Klumb, and G. Wanner. 2011. A seasonal comparison of gill net effectiveness in the Missouri River, South Dakota and Nebraska. 48th Annual Meeting of the Dakota Chapter American Fisheries Society, Bismarck, North Dakota.

Shuman, D.A., G.A. Wanner, R.A. Klumb, K. Steffensen, W. Doyle, B. Gardner, T. Haddix, P. Horner, S. Stukel, and R. Wilson. 2007. Pallid sturgeon population augmentation in the Missouri River: A basin wide look at the condition, growth, and population structure. 44th Annual Meeting of the Dakota Chapter American Fisheries Society, Bismarck, North Dakota.

Shuman, D.A., G.A. Wanner, R.A. Klumb, K. Steffensen, W. Doyle, W. Gardner, T. Haddix, P. Horner, S. Stukel, and R. Wilson 2007. Pallid sturgeon in the Missouri River: a basin wide assessment of the condition, growth, and population structure. 11th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Shuman, D.A., G.A. Wanner, R.A. Klumb, K. Steffensen, W. Doyle, W. Gardner, T. Haddix, P. Horner, S. Stukel, and R. Wilson. 2008. A basin wide assessment of condition, growth, and stock structure of pallid sturgeon in the Missouri River. 12th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Spindler, B.D., S. Chipps, R. Klumb, and M. Wimberly. 2006. Identification of habitat areas for juvenile pallid sturgeon in the Fort Randall reach of the Missouri River. 67th Annual Midwest Fish and Wildlife Conference, Omaha, Nebraska.

Spindler, B.D., S. Chipps, R. Klumb, and M. Wimberly. 2007. Identification and hydrological attributes of habitat areas for juvenile pallid sturgeon in the Fort Randall reach of the Missouri River. 44th Annual Meeting of the Dakota Chapter American Fisheries Society, Bismarck, North Dakota.

Steffensen, K.D. 2003. Pallid sturgeon sampling on the lower channelized Missouri River. Platte River Pallid Sturgeon and Sturgeon Chub Task Force Meeting, Ponca, Nebraska.

Steffensen, K.D. 2006. Summary of pallid sturgeon stocking and sampling in RPMA #4. Annual Meeting of the Nebraska Chapter of the America Fisheries Society, Gretna, NE.

Steffensen, K.D. 2007. Evaluation of hatchery stocked pallid sturgeon in the upper channelized Missouri River. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Council Bluffs, Iowa.

Steffensen, K.D. 2012. Population Characteristics, Development of a Population Viability Model, and Catch Dynamics of Pallid Sturgeon in the Lower Missouri River. Thesis Seminar, University of Nebraska-Lincoln, Lincoln, Nebraska.

Steffensen, K.D., and T.J. Barada. 2006. Pallid sturgeon *Scaphirhynchus albus* sampling in the upper channelized reach of RPMA #4. 67th Annual Midwest Fish and Wildlife Conference, Omaha, NE.

Steffensen, K.D., B.L. Eder, and M.A. Pegg. 2011. Using LP hook timers to understand the dynamics of trotline catches in a large river. 72nd Annual Midwest Fish and Wildlife Conference, Des Moines, Iowa.

Steffensen, K.D., B.L. Eder, and M.A. Pegg. 2012. Using LP hook timers to understand the dynamics of trotline catches in a large river. 16th Missouri River Natural Resources Conference and BiOp Forum, Pierre, South Dakota.

Steffensen, K.D., B.L. Eder, and M.A. Pegg. 2012. Using LP hook timers to understand the dynamics of trotline catches in a large river. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Gretna, NE.

Steffensen, K.D., and G.E. Mestl. 2004. Pallid sturgeon and associated fish community sampling on the channelized Missouri River. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Gretna, Nebraska.

Steffensen, K.D. and G.E. Mestl. 2007. Nebraska's pallid sturgeon stocking program. Nebraska Game and Parks Commission, Fisheries Division Meeting, Gretna, Nebraska.

Steffensen, K.D., G.E. Mestl, B.L. Eder, T.W. Huenemann, D.M. Pauley, and J.J. Wilhelm. 2012. Floodplain use by fish during the 2011 Missouri River flood. 141st National American Fisheries Society Annual Meeting, St. Paul, Minnesota.

Steffensen, K.D., G.E. Mestl, and J.D. Koch. 2005. Pallid sturgeon population assessment program. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Gretna, Nebraska.

Steffensen, K.D., L.A. Powell, and J.D. Koch. 2009. Assessment of hatchery reared pallid sturgeon survival in the lower Missouri River. 139th Annual Meeting of the American Fisheries Society, Nashville, Tennessee.

Steffensen, K.D., L.A. Powell, and J.D. Koch. 2009. Assessment of hatchery reared pallid sturgeon survival in the lower Missouri River. 13th Missouri River Natural Resources Conference and BiOp Forum, Billings, Montana.

Steffensen, K.D., L.A. Powell, and J.D. Koch. 2009. Assessment of hatchery reared pallid sturgeon survival in the lower Missouri River. Annual Meeting of the Nebraska Chapter of the American Fisheries Society, Gretna, Nebraska.

Steffensen, K.D., L.A. Powell, and M.A. Pegg. 2010. Using mark-recapture to estimate the population size of pallid sturgeon in the upper channelized Missouri River. 71st Annual Midwest Fish and Wildlife Conference, Minneapolis, Minnesota.

Steffensen, K.D., L.A. Powell, and M.A. Pegg. 2011. Using mark-recapture to estimate the population size of pallid sturgeon in the upper channelized Missouri River. 15th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Steffensen, K.D., L.A. Powell, and M.A. Pegg. 2011. Using mark-recapture to estimate the population size of pallid sturgeon in the upper channelized Missouri River. Joint Meeting of the Middle and Lower Basin Pallid Sturgeon Workgroups, St. Louis, Missouri.

Steffensen, K.D., J.J. Wilhelm, T.W. Huenemann, D.M. Pauley, B.L. Eder, and G.E. Mestl. 2012. Fish use of the floodplain during the 2011 flood. Missouri River Institute Research Symposium, Vermillion, South Dakota.

Travnichek, V. 2008. Aquatic habitat restoration efforts in the Missouri River floodplain: can ecosystem recovery and floodplain development coexist? Symposium on Finding the Balance Between Floods, Flood Protection, and River Navigation, St. Louis, Missouri.

Travnichek, V.H. 2011. The Missouri River: from the “Voyage of Discovery” to the road of recovery. Organization of Fish and Wildlife Information Managers, St Louis, Missouri.

Utrup, N., W. Doyle, T. Hill, P. Horner, K. Steffensen, and S. Stukel. 2007. Population characteristics of shovelnose sturgeon in the lower Missouri River. 11th Missouri River Natural Resources Conference and BiOP Forum, Nebraska City, Nebraska.

Utrup, N., W. Doyle, A. Plauck, T. Hill, K. Steffensen, G. Mestl, P. Horner, V. Travnichek, and S. Stukel. 2007. Dispersal of hatchery reared pallid sturgeon in the lower Missouri River. 137th Annual Meeting of the American Fisheries Society, San Francisco, California.

Wanner, G.A., K.L. Grohs, and R.A. Klumb. 2010. Spatial and temporal patterns of larval fish catches in the lower Niobrara River. 34th Annual Larval Fish Conference, Santa Fe, New Mexico.

Wanner, G., and R. Klumb. 2010. Asian carp in the Missouri River: Analysis from multiple Missouri River habitat and fisheries programs. 14th Annual Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Wanner, G., M. Pegg, D. Shuman, and R. Klumb. 2009. Spatial and temporal patterns in the Niobrara River fish community downstream of Spencer Dam. 139th Annual Meeting of the American Fisheries Society, Nashville, Tennessee.

Wanner, G.A., M.A. Pegg, D.A. Shuman, and R.A. Klumb. 2009. Spatial and temporal patterns in the Niobrara River fish community downstream of Spencer Dam, Nebraska. 13th Missouri River Natural Resources Conference and BiOP Forum, Billings, Montana.

Wanner, G.A., M.A. Pegg, S. Schainost, D.A. Shuman, and R.A. Klumb. 2010. Spatial and temporal patterns in the Niobrara River fish community. Niobrara River Environmental Flows Workshop, Lincoln, Nebraska.

Wanner, G.A., M.A. Pegg, S. Schainost, D.A. Shuman, and R.A. Klumb. 2010. Spatial and temporal patterns in the Niobrara River fish community. Annual Valentine NWR Fisheries Meeting, Valentine, Nebraska.

Wanner, G.A., M.A. Pegg, S. Schainost, R.A. Klumb, and D.A. Shuman. 2010. Spatial and temporal patterns in the Niobrara River fish community. 47th Annual Meeting of the Dakota Chapter American Fisheries Society, Spearfish, South Dakota.

Welker, T.L. 2009. Pallid sturgeon program. Missouri River Futures Annual Full-Group Meeting, Ponca State Park, Ponca, Nebraska.

Welker, T.L. 2011. Pallid Sturgeon Population Assessment Project. Independent Science Advisory Panel briefing: spring pulse management action, Kansas City, Kansas.

Welker, T., C. Fleming, and J. Bonneau (Presenters). 2010. Missouri River Recovery Program: pallid sturgeon coordination. Joint meeting of U.S. Army Corps of Engineers Northwest and Mississippi Valley Divisions, Alton, Illinois.

Welker, T., C. Kruse, and M. Drobish. 2010. Partnering for pallid sturgeon: implementing a long-term population assessment and monitoring program on the Missouri River. Missouri River Implementation Committee: Science and Adaptive Management Workgroup Meeting, Omaha, Nebraska.

Welker, T., C. Kruse, M. Drobish, T. Haddix, M. Ruggles, S. Krentz, R. Wilson, R. Klumb, D. Shuman, S. Stukel, S. LaBay, J. Kral, K. Steffensen, G. Mestl, P. Horner, D. Niswonger, V. Travnichek, W. Doyle, A. Plauck, T. Hill, and M. Wildhaber. 2009. Partnering for pallid sturgeon: implementing a long-term population assessment and monitoring program on the Missouri River. 139th Annual Meeting of the American Fisheries Society, Nashville, Tennessee.

Welker, T.L., and G.A. Williams. 2010. Missouri River Recovery Program: pallid sturgeon research and monitoring. Platte River Recovery Implementation Program: Governance Committee Meeting, Denver, Colorado.

Whiteman, K.W. 2010. Comparison of fish communities in recently constructed side-channel chutes with the main channel Missouri River. 14th Missouri River Natural Resources Conference and BiOpForum, Nebraska City, Nebraska.

Wilhelm J.J. 2015. Biological responses of large-river fishes to hydrological conditions on the Missouri River. 145th Annual Meeting of the American Fisheries Society, Portland, OR.

Wilhelm J.J. 2015. Benthic fish condition response to high water events on the Missouri River. 2015 Missouri River Natural Resource Conference, Nebraska City, NE.

Wilhelm J.J. 2015. Benthic fish condition response to high water events on the Missouri River. 2015 Nebraska Chapter of the American Fisheries Society Annual Meeting, Nebraska, NE.

Wilhelm, J.J., and T.W. Huenemann. 2011. A survey of fish presence in floodplain mitigation sites. Nebraska Chapter American Fisheries Society Meeting. Gretna, Nebraska.

Wilhelm, J.J., and T.W. Huenemann. 2011. A survey of fish presence in floodplain mitigation sites. 15th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Wilhelm, J.J., K.D. Steffensen, B.L. Eder, and T.W. Hunemann. 2011. A comparison between high water events in 2010 and 2011 at Schilling Wildlife Management Area. 72nd Annual Midwest Fish and Wildlife Conference, Des Moines, Iowa.

Wilhelm, J.J., K.D. Steffensen, B.L. Eder, and T.W. Hunemann. 2012. A comparison between high water events in 2010 and 2011 at Schilling Wildlife Management Area. Annual Meeting of the Nebraska Chapter American Fisheries Society Meeting, Gretna, Nebraska.

Wilhelm, J.J., K.D. Steffensen, B.L. Eder, and T.W. Hunemann. 2012. A comparison between high water events in 2010 and 2011 at Schilling Wildlife Management Area. 16th Missouri River Natural Resources Conference and BiOp Forum, Pierre, South Dakota.

Wilhelm, J.J., K.D. Steffensen, B.L. Eder, T.W. Huenemann, and D.M. Pauley. 2012. Fish communities in the Missouri River floodplain lakes after the 2011 flood. 73rd Midwest Fish and Wildlife Conference. Wichita, Kansas.

Wilson, R., E. Nelson, and Z. Sandness. 2011. Pallid Sturgeon in the Headwaters of Lake Sakakawea. 15th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Wilson, R., E. Nelson, and Z. Sandness. 2011. Pallid Sturgeon in the Headwaters of Lake Sakakawea. 48th Annual Meeting of the Dakota Chapter American Fisheries Society, Bismarck, North Dakota.

Winders, K.W. 2011. Fish community in the Kansas River: comparison of occupancy modeling estimates using program PRESENCE and MARK. 15th Missouri River Natural Resources Conference and BiOp Forum, Nebraska City, Nebraska.

Winders, K.W. 2012. The Disturbed-disturbance hypothesis. 73rd Annual Midwest Fish and Wildlife Conference, Wichita, Kansas.

Winders, K.W. 2013. Using short-duration trotlines to assess spatial heterogeneity in fish populations. Missouri Natural Resources Conference, Osage Beach, Missouri.

Winders, K.W., and M.L. Miller. The effects of Missouri River floodplain inundation on the recruitment of native fishes. 2012. 142nd Annual Meeting of the American Fisheries Society, Minneapolis –St. Paul, Minnesota.

Wrasse, C. and J Yonce. Using Short-lived Cyprinid Species to Detect Change in a Long Term Sturgeon Monitoring Program. Oral Presentation: 145th Annual Meeting of the American Fisheries Society; August 2015: Portland, OR.

Wrasse, C. Fluctuations in *Macrhybopsis* Chub Populations– Did the 2011 Flood Have an Effect? Oral Presentation: Missouri River Natural Resources Conference; March 2015; Nebraska City, NE.

Appendix 1.

Literature Cited

Corps. 1999. 1999 Biological Assessment on the Effects of Missouri River Main Stem System Operations on the: Pallid Sturgeon, Piping Plover, Interior Least Tern, and Bald Eagle. 156p.

USFWS. 2000. 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. 385p.

USFWS. 2003. 2003 Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. 308p.

Appendix 2.

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Appendix 2.

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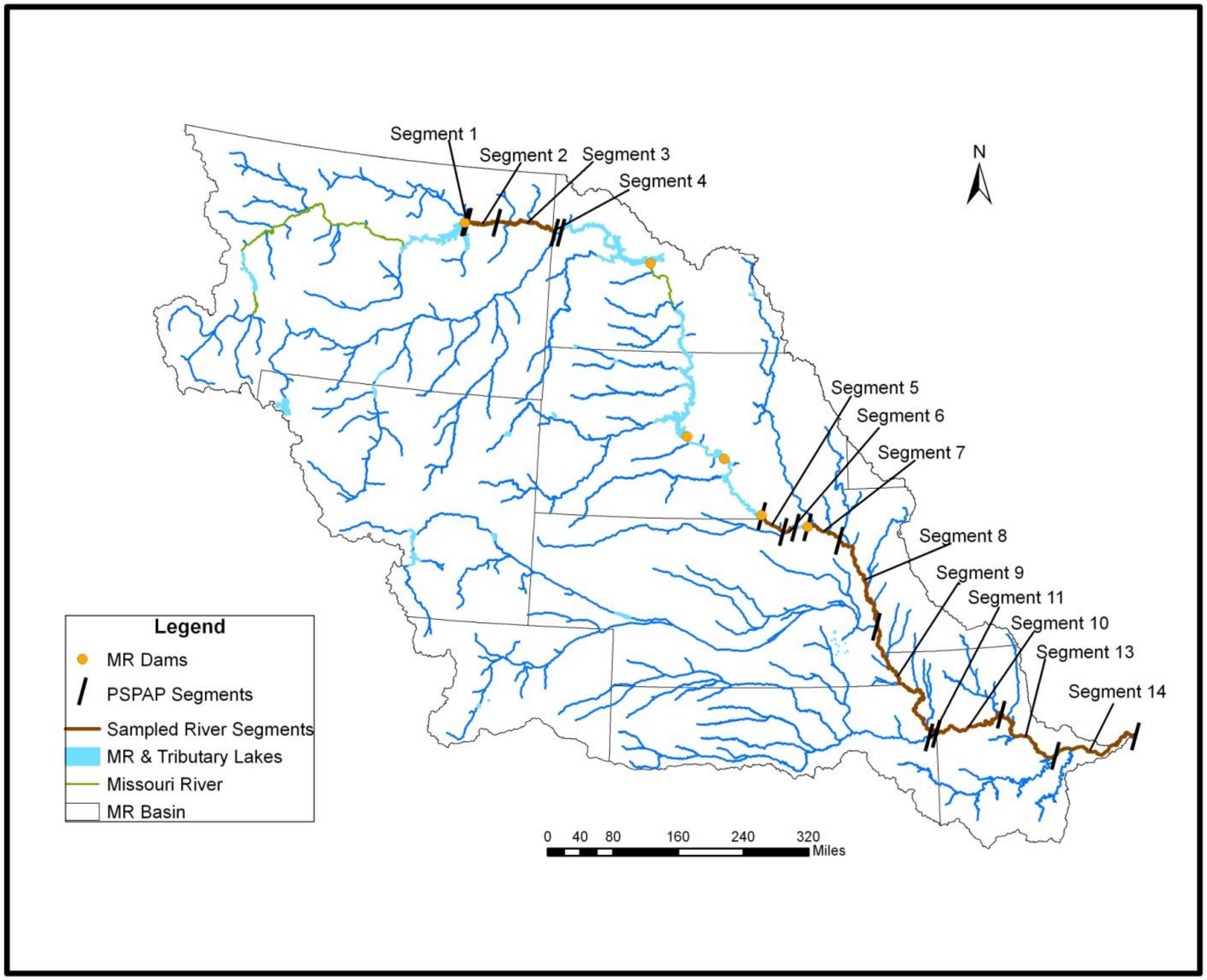
Appendix 3.



Map containing high priority segments of the Missouri River sampled through the Pallid Sturgeon Population Assessment Project.

U.S. Army Corps of Engineers Summary

Evaluating the Effects of Shallow Water Habitat Implementation on Scaphirhynchus sp. (Partners include USFWS-FWCO)

During 2014, USACE and USFWS staff conducted a total of 2,833 randomly-selected trawls, which captured 1,323 age-0 sturgeon. We are still awaiting genetic analysis for many of the age-0 sturgeon captured during 2014 but one of the individuals captured has been identified as a pallid sturgeon thus far. Preliminary analysis found no statistical differences in mean catch-per-unit-effort (CPUE) of age-0 sturgeon among the 5 study reaches. Although not statistically different, it is interesting that the highest observed mean CPUE values were found in the reaches with the lowest availability of shallow water (reaches 4 and 1).

As for the habitat analysis (using the habitat classification system from the Pallid Sturgeon Population Assessment Program), no statistical testing has been conducted yet. However, preliminary analysis of the macro-meso habitats (with at least 15 trawls conducted) found that the highest observed mean CPUE of age-0 sturgeon occurred in the inside bend-channel border habitat. Mean CPUE in the channel crossover-channel border habitat was also relatively high. Within both of these macro-meso habitats, the preliminary microcode habitat analysis found the highest observed mean CPUE occurred at wing dike structures.

It is important to note that these results are preliminary. Data analysis techniques may change and data from 2015 sampling efforts may be incorporated in the future. Expected completion of the study is May 2016.

U.S. Army Corps of Engineers

Age-0 Shovelnose Sturgeon Prey Consumption in the Lower Missouri River

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ABSTRACT

A lack of nutritious food during the first year of life is a hypothesized factor that may limit survival of endangered pallid sturgeon *Scaphirhynchus albus* in the lower Missouri River (LMOR). Unfortunately, information for age-0 pallid sturgeon diets remains limited but diet analyses for age-0 *Scaphirhynchus* spp. (sturgeon hereafter) have occurred. Little information, however, exists on age-0 sturgeon diets in the LMOR; thus, our primary objective was to document age-0 sturgeon diets in this system. We examined guts contents from 30 individuals, which were genetically identified as shovelnose sturgeon *Scaphirhynchus platorynchus*, and three stomachs were empty. The remaining age-0 shovelnose sturgeon consumed chironomid larvae almost exclusively (> 98% of prey items consumed). Our results were similar to studies conducted in other systems and it appears unlikely that a lack of nutritious food was a major factor affecting the individuals captured during this study. This effort provides important information to help guide ongoing adaptive management efforts in the LMOR.

INTRODUCTION

A lack of nutritious food for young pallid sturgeon as they settle from the drift and transition to exogenous feeding is a hypothesized factor that may limit survival of endangered pallid sturgeon *Scaphirhynchus albus* in the lower Missouri River (LMOR; Gavins Point Dam, South Dakota downstream to the confluence of the Mississippi River at St. Louis, Missouri). Unfortunately, information for wild age-0 pallid sturgeon is limited, but diet analyses for age-0 shovelnose sturgeon *Scaphirhynchus platorynchus* in the upper Missouri River (Braaten *et al.*, 2007) and age-0 *Scaphirhynchus* spp. (sturgeon hereafter) in the middle (Sechler *et al.*, 2012, 2013) and lower Mississippi River (Harrison *et al.*, 2014) have occurred recently. Although the use of surrogates should be approached cautiously (Murphy *et al.*, 2011), there is some evidence suggesting that age-0 shovelnose sturgeon may be an adequate surrogate, in terms of diet, for age-0 pallid sturgeon. In the upper Missouri River, age-0 shovelnose and pallid sturgeon had similar diets as both species exclusively consumed dipterans and ephemeropterans, although this included only six pallid sturgeon individuals (Braaten *et al.*, 2007, 2012). Additionally, Sechler *et al*. (2012) found that middle Mississippi River age-0 sturgeon (that were likely dominated by shovelnose individuals) consistently preferred chironomids and often positively selected for ephemeropterans as well, which was nearly identical to age-0 pallid sturgeon laboratory experiments (Rapp, 2014). Despite the need to better understand potential food limitations in the LMOR, little information exists on either age-0 shovelnose or pallid sturgeon diets in this system. Thus, the primary objective was to use age-0 shovelnose sturgeon collected during a previous study (Gosch *et al.*, 2015) to provide information on diet composition in the LMOR to support ongoing adaptive management efforts for pallid sturgeon recovery.

METHODS

Age-0 shovelnose sturgeon were collected with a variety of gears (including benthic otter trawls and boat- and sled-mounted plankton nets) as part of a previous study from May through September 2012 at side-channel and adjacent main-stem sites: Lisbon (river kilometer [RKM] 351), Jameson (RKM 344), Overton (RKM 301) and Pelican (RKM 26). See Gosch *et al.* (2015) for a more detailed description of the study sites, sampling design, and gears. Depth was measured at the beginning, middle, and end of each sample (except for stationary, boat-mounted plankton samples where a single depth was recorded). Mean depth was used for analysis when more than one depth was recorded. At the center of the sampling area, a near-bottom velocity measurement was recorded and a petite Ponar grab sampler (152 mm x 152 mm, Ponar hereafter) was used to collect benthic invertebrates after fish were collected and processed.

Upon capture, fork length was measured when a well-defined fork was present; otherwise, total length (excluding the caudal filament) was measured (Braaten *et al*., 2007). This study focused on small age-0 sturgeon (< 55 mm) because a potential food limitation would likely occur during early life history (e.g., the transition from endogenous to exogenous feeding). Food limitation during this transition negatively affects the digestive tract (Gisbert and Doroshov, 2003) and may reduce growth and survival of young sturgeon (Gisbert and Williot, 1997; Deng *et al.*, 2003; Gisbert and Doroshov, 2003). Braaten *et al*. (2007) suggested that age-0 sturgeon ≤ 60 mm may be more dependent on local food availability because of a limited swimming ability. Additionally, Sechler *et al*. (2012) found that age-0 sturgeon ≤ 50 mm had reduced energy densities relative to larger individuals. After length was measured, a portion of the tail fin was clipped, preserved in 95% ethanol, and used for genetic species identification. The rest of the body was preserved separately in 95% ethanol for diet analysis. The esophagus and gut were removed (Sechler *et al*., 2012) and placed in a dish where diet items were extracted, identified to the lowest practical taxon (usually family), and quantified by number. The percentage of empty stomachs (PES) was calculated and fish with empty stomachs were excluded from further diet analyses. Then frequency of occurrence and relative abundance was calculated for each major taxon found in stomachs. A contract laboratory processed the Ponar samples by extracting, identifying, and quantifying benthic invertebrates.

RESULTS

We examined gut contents from 30 age-0 shovelnose sturgeon (confirmed by genetic analysis) ranging in length from 15 to 53 mm with a mean length (SD) of 29.3 mm (12.0). Three of the individuals captured had empty guts and were excluded from further analysis. Chironomid larvae dominated the diets, occurring in all guts that contained prey (Table 1) and comprising over 98% of the prey items removed. Chironomid pupae occurred in 52% of the guts that contained prey but comprised less than 2% of the prey items removed. Other prey items were nearly non-existent as non-chironomid prey accounted for only four (three ephemeropterans and one trichopteran) of the more than 4300 prey items removed during this study. Additionally, chironomid larvae relative abundance was usually high regardless of fish size, whereas the opposite was true for chironomid pupae (Figure 1). Ponar sampling resulted in a total of 12 prey types at sturgeon capture sites but most had relatively low mean counts (i.e., < 1 individual per Ponar). Chironomid larvae and nemerteans were the most numerous and consistently sampled, whereas hydropsychids were numerous in one sample (Table 1).

DISCUSSION

Age-0 shovelnose sturgeon almost exclusively consumed chironomids during this study. Chironomid larvae were usually dominant (i.e., relative abundance > 0.8) but four individuals did consume a relatively high abundance of chironomid pupae (Figure 1). Chironomids were also important to age-0 sturgeon in other systems. In the upper Missouri River, age-0 shovelnose sturgeon exclusively consumed dipterans (including chironomids) and ephemeropterans, shifting primarily to dipterans after exceeding 85 mm total length (Braaten *et al*., 2007). In the same river reach, Braaten *et al.* (2012) found that stocked age-0 pallid sturgeon also exclusively consumed dipterans and ephemeropterans, although this was based on only six individuals. In the middle Mississippi River, diets were dominated by chironomids and ephemeropterans;

however, there was no dietary shift as age-0 sturgeon consistently preferred chironomids regardless of size (Sechler *et al*., 2012). Sechler *et al.* (2013) found that ephemeropterans, dipteran pupae, and chironomids were the most consistently consumed prey and that diet composition (dry mass) was not significantly different for year, season, or age-0 sturgeon size class in the middle Mississippi River. In the lower Mississippi River, age-0 sturgeon diets primarily consisted of chironomids (Harrison *et al*., 2014). Interestingly, the dominance of chironomids during this study was extreme compared to previous work.

Gape limitation is one possible explanation for this dominance given that the average fish examined was 29 mm long. Interestingly, only one individual consumed ephemeropterans and this fish was relatively large (50 mm); however, the only two larger individuals examined during this study (53 mm each) consumed chironomids exclusively (Table 1). Although gape limitation was not directly assessed, previous studies examining diet by age-0 sturgeon size have not supported this hypothesis. Sechler *et al*. (2012) found that ephemeropterans and chironomids dominated the diets of all size classes of age-0 sturgeon in the middle Mississippi River. In the same system, Sechler *et al*. (2013) concluded that small age-0 sturgeon (< 50 mm) ate more large-bodied prey (ephemeropterans and dipteran pupae) than larger age-0 sturgeon despite finding no significant differences in prey composition by fish size. Similarly, consumption of ephemeropteran larvae and dipteran pupae was usually greatest for age-0 shovelnose sturgeon < 85 mm in the upper Missouri River (Braaten *et al*., 2007). Another possible explanation regarding the dominance of chironomids during this diet study is prey availability at age-0 sturgeon capture sites (Braaten *et al*., 2007). Most of our fish were captured from areas with velocities > 0.40 m/s (Table 1) and perhaps chironomids were the most abundant prey in these areas. Obtaining reliable estimates of prey availability is challenging in aquatic ecosystems due to potential gear bias (Bowen, 1996), especially in large flowing rivers. Although the Ponar was likely inappropriate for assessing prey availability in this study, chironomids were one of the most numerous taxa found in these samples while other prey identified as potentially important to age-0 sturgeon (e.g., ephemeropterans; Sechler *et al*., 2012) were extremely rare. Future study on gape limitation and prey availability would improve understanding of the factors potentially affecting age-0 sturgeon diets. Additionally, only one of the aforementioned field studies (Sechler *et al*., 2012) examined prey preference for age-0 sturgeon, which highlights an important information gap for *Scaphirhynchus* spp. in large river systems.

Despite the inability to reliably quantify prey availability, finding food did not appear to be an issue for age-0 shovelnose sturgeon during this study as PES was low (10%). Further, the three empty individuals (length range 15-19 mm) were possibly still feeding endogenously (Sechler *et al*., 2013) given that the yolk sack is absorbed around 18-19 mm (Snyder, 2002). Regardless, a PES of 10% was comparable to other studies. In the upper Missouri River, age-0 shovelnose sturgeon PES was 1% (Braaten *et al*., 2007). In the middle Mississippi River, PES was 2% for age-0 sturgeon ≤ 50 mm and 1% for individuals > 50 mm (Sechler *et al*., 2012). Similarly, Sechler *et al.* (2013) found PES for age-0 sturgeon < 50 mm was 8% compared to 0% for larger fish (50-100 mm) in this system. In the lower Mississippi River, age-0 sturgeon PES was 4% (Harrison *et al*., 2014). Braaten *et al.* (2007) suggested that a low incidence of empty stomachs in the upper Missouri River may have indicated that their study areas had adequate food resources. Interestingly, our results found much greater numbers of consumed prey compared to Braaten *et al.* (2007). For example, the median number of dipteran and ephemeropteran larvae consumed by upper Missouri River fish up to 140 mm long was one and three per gut, respectively, whereas the median number of chironomid larvae during our study was 16 per gut for fish up to 53 mm long. Given that chironomids can be an “energetically efficient food source” for age-0 sturgeon (Sechler *et al*., 2012), it appears unlikely that a lack of food was a major factor affecting the individuals captured during this study.

These results provide important information to help guide ongoing adaptive management efforts in the LMOR; however, a potential limitation of this study was sample size. Using new information as it becomes available is important to the adaptive management process currently being implemented in the LMOR (Gemeinhardt *et al*., in press), and this study may reduce uncertainty by mitigating the need to completely rely on information from age-0 sturgeon diet studies conducted in other systems. Furthermore, our results largely agreed with those studies, providing confidence in this study despite a less-than-ideal sample size. It is also worth noting that some of the other studies had limited sample sizes (70 and 100 fish reported in Harrison *et al*. [2014] and Braaten *et al*. [2007], respectively).

The information presented here helps address an important information gap but more comprehensive field study is needed, especially regarding age-0 sturgeon condition. Although inferences regarding the potential lack of food can be made by examining the prevalence of empty stomachs and the amount of prey items consumed while relating these measures to feeding success (e.g., Braaten *et al*., 2007); ultimately, evaluating the condition of age-0 sturgeon will more directly determine if individuals are successfully feeding on nutritious prey. Further, this would provide more conclusive evidence in determining if lack of nutritious food is a limiting factor for age-0 sturgeon.

More conclusive study regarding the assumption that age-0 sturgeon field studies adequately represent pallid sturgeon prey consumption is also important but not currently feasible in the LMOR. Additionally, only limited information on age-0 pallid sturgeon diets outside the LMOR is currently available from field (see discussion above regarding Braaten *et al.* [2012]) or laboratory work (see Rapp, 2014). While these studies provide important information, clearly more research specific to age-0 pallid sturgeon prey consumption is needed. For the first time in the LMOR, three individuals (collected during 2014) were genetically confirmed as age-0 pallid sturgeon. These three fish, and hopefully others in the future, will allow us to begin testing the assumption that age-0 pallid and shovelnose sturgeon diets are similar. This information will help build upon past and present efforts to ultimately evaluate hypothesized factors that may be limiting age-0 sturgeon populations, which is critical to the successful implementation of management actions focused on benefitting the endangered pallid sturgeon in the LMOR. If diets are similar between these congeners and a lack of nutritious food is not limiting, then adaptive management efforts should focus on other factors (e.g., insufficient spawning habitat, lack of spawning adults, altered drift dynamics) that may limit pallid sturgeon population growth.

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REFERENCES

Bowen SH. 1996. Quantitative description of the diet. In *Fisheries techniques, 2nd edition*, Murphy BR, Willis DW (eds). American Fisheries Society: Bethesda; 513-529.

Braaten PJ, Fuller DB, McClenning ND. 2007. Diet composition of larval and young-of-year shovelnose sturgeon in the upper Missouri River. *Journal of Applied Ichthyology* **23**: 516-520. DOI: 10.1111/j.1439-0426.2006.00822.x.

Braaten PJ, Fuller DB, Lott RD, Haddix TM, Holte LD, Wilson RH, Bartron ML, Kalie JA, DeHaan PW, Ardren WR, Holm RJ, Jaeger ME. 2012. Natural growth and diet of known-age pallid sturgeon (*Scaphirhynchus albus*) early life stages in the upper Missouri River basin, Montana and North Dakota. *Journal of Applied Ichthyology* **28**: 496-504. DOI: 10.1111/j.1439-0426.2012.01964.x.

Deng DF, Koshio S, Yokoyama S, Bai SC, Shao Q, Cui Y, Hung SSO. 2003. Effects of feeding rate on growth performance of white sturgeon (*Acipenser transmontanus*) larvae. *Aquaculture* **217**: 589-598. DOI: 10.1016/S0044-8486(02)00461-1.

Gemeinhardt TR, Gosch NJC, Morris DM, Miller ML, Welker TL, Bonneau JL. In press. Is shallow water a suitable surrogate for assessing efforts to address pallid sturgeon population declines? *River Research and Applications*. DOI: 10.1002/rra.2889.

Gisbert E, Doroshov SI. 2003. Histology of the developing digestive system and the effect of food deprivation in larval green sturgeon (*Acipenser medirostris*). *Aquatic Living Resources* **16**: 77-89. DOI: 10.1016/S0990-7440(03)00029-9.

Gisbert E, Williot P. 1997. Larval behavior and effect of the timing on initial feeding on growth and survival of Siberian sturgeon (*Acipenser baeri*) larvae under small scale hatchery production. *Aquaculture* **156**: 63-76. DOI: 10.1016/S0044-8486(97)00086-0.

Gosch NJC, Miller ML, Gemeinhardt TR, Sampson SJ, Bonneau JL. 2015. Age-0 sturgeon accessibility to constructed and modified chutes in the lower Missouri River. *North American Journal of Fisheries Management* **35**: 75-85. DOI:10.1080/02755947.2014.975300.

Harrison AB, Slack WT, Killgore KJ. 2014. Feeding habits of young-of-year river sturgeon *Scaphirhynchus* spp. in the lower Mississippi River. *American Midland Naturalist* **171**:54-67. DOI: http://dx.doi.org/10.1674/0003-0031-171.1.54.

Murphy DD, Weiland PS, Cummins KW. 2011. A critical assessment of the use of surrogate species in conservation planning in the Sacramento-San Joaquin Delta, California (U.S.A.). *Conservation Biology* **25**: 873-878. DOI: 10.1007/s13412-014-0165-0.

Rapp T. 2014. Determinants of growth and survival of larval pallid sturgeon: a combined laboratory and field approach. PhD dissertation. South Dakota State University, Brookings.

Sechler DR, Phelps QE, Tripp SJ, Garvey JE, Herzog DP, Ostendorf DE, Ridings JW, Crites JW, Hrabik RA. 2012. Habitat for age-0 shovelnose sturgeon and pallid sturgeon in a large river: interactions among abiotic factors, food, and energy intake. *North American Journal of Fisheries Management* **32**: 24-31. DOI:10.1080/02755947.2012.655848.

Sechler DR, Phelps QE, Tripp SJ, Garvey JE, Herzog DP, Ostendorf DE, Ridings JW, Crites JW, Hrabik RA. 2013. Effects of river stage height and water temperature on diet composition of year-0 sturgeon (*Scaphirhynchus* spp.): a multi-year study. *Journal of Applied Ichthyology* **29**: 44-50. DOI: 10.1111/jai.12047.

Snyder DE. 2002. Pallid and shovelnose sturgeon larvae – morphological description and identification. *Journal of Applied Ichthyology* **18**: 240-265. DOI: 10.1046/j.1439-0426.2002.00429.x.

Table I. Age-0 shovelnose sturgeon length (mm) and number of prey consumed by taxon as well as the depth (m), velocity (m/s), and number of prey sampled in Ponar samples at fish capture sites. Prey data were restricted to chironomid larvae and pupae because other prey were almost non-existent. Ponar data were restricted to taxa with a mean count of at least 1 individual per sample. Individuals with length in bold had empty stomachs and those with the same depth, velocity, and Ponar data were sampled at the same site. CL = chironomid larvae, CP = chironomid pupae, HY = hydropsychids, NE = nemertean.

Site	Date	Length (mm)	CL prey	CP prey	Depth (m)	Velocity (m/s)	CL Ponar	HY Ponar	NE Ponar
Jameson	7 June	18	1	0	1.1	0.82	0	0	1
		19	0	0					
		20	4	0					
		20	6	0					
		20	12	1					
		20	4	1	1.2	0.25	0	0	0
		21	10	2					
		21	9	7					
		26	20	4					
		25	6	19	0.9	0.41	0	0	1
	20 June	25	9	16	1.0	0.52	1	0	0
		38	69	3					
	4 Sept	22	27	0	2.3	0.90	9	0	25
		31	47	0					
	10 Sept	43	374	0	1.5	0.80	1	0	2
Lisbon	23 May	**18**	0	0	1.3	0.71	2	0	100
	6 June	50	28	0	1.3	0.70	0	0	0
	5 Sept	28	27	3	2.2	0.65	3	0	0
	13 Sept	32	109	1	3.6	0.95	14	0	0
		46	405	0					
		53	668	0					
		53	764	1					
Overton	15 May	**15**	0	0	2.2	0.40	2	0	0
	13 June	17	2	3	1.4	0.73	3	0	25
	11 Sept	33	197	0	4.0	0.57	25	94	2
		37	435	0					
		44	311	0	2.4	0.80	1	0	0
	24 Sept	46	718	1	3.6	0.62	3	0	1
Pelican	16 May	18	6	0	1.0	0.24	1	0	6
		20	8	1					

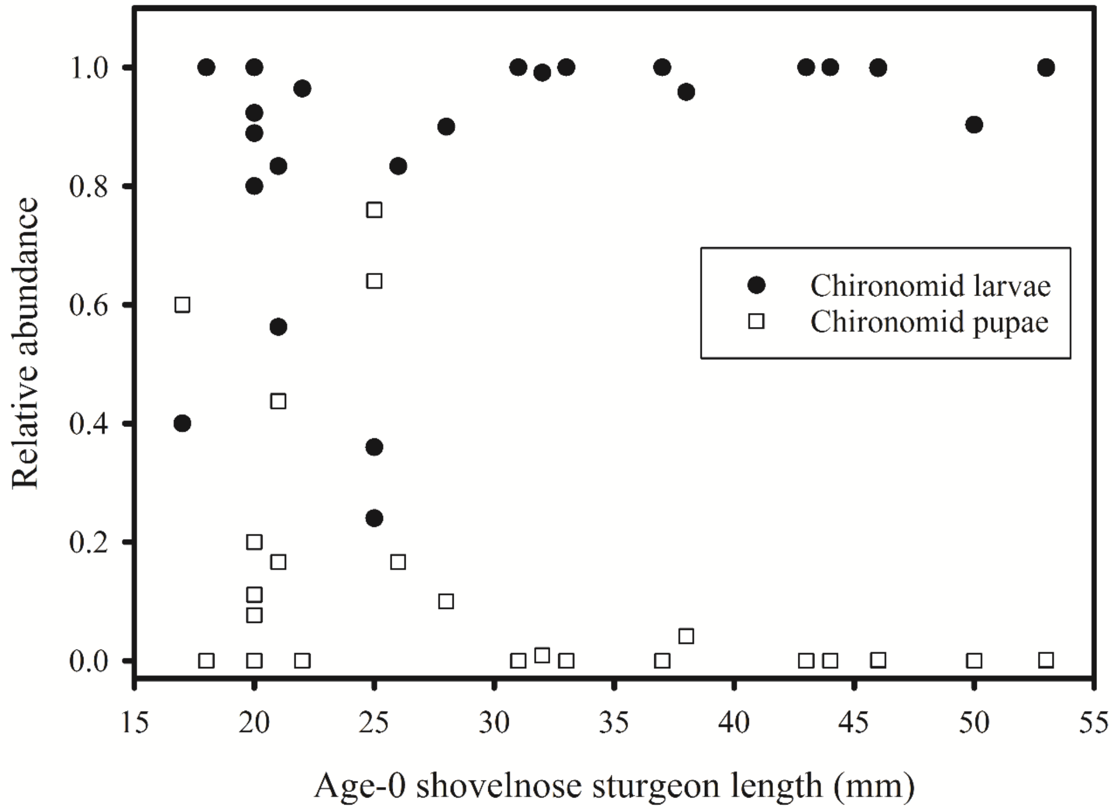


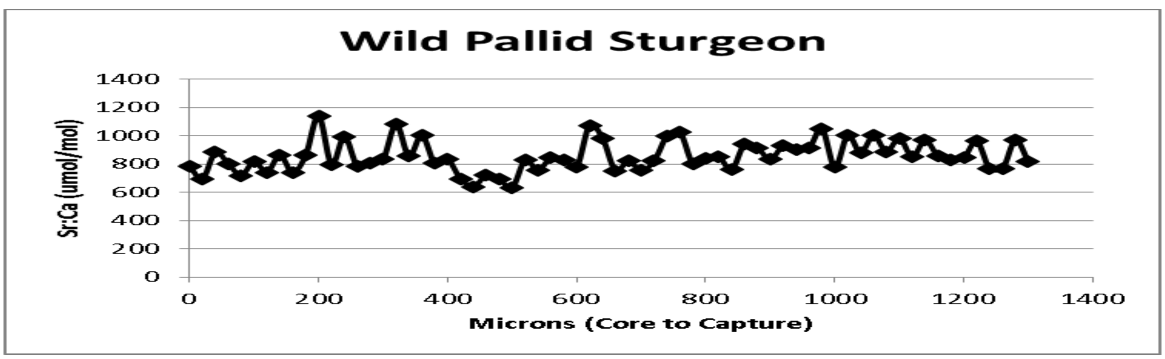
Figure 1. Scatterplot of relative abundance values by length (mm) for each age-0 shovelnose sturgeon containing prey in the stomach (n = 27). Data are restricted to chironomid larvae and pupae because other prey were almost non-existent.

Pallid Sturgeon Environmental Life History Draft Progress Report

Prepared by Seth Love, Quinton Phelps, and Dave Herzog

Understanding the environmental life history of highly migratory species is important for conservation and effective management. This knowledge is especially important in regards to federally endangered species which travel through and across state boundaries (such as the Pallid Sturgeon). Therefore, the objective of this project is to acquire information about the movement patterns of Pallid Sturgeon (from origin to collection) in order to bolster the sparse biological information available to managers and researchers assisting in species restoration.

To date, approximately 170 Pallid Sturgeon fin rays from wild, hatchery, and unknown origin individuals have been collected from various collaborators working on the Lower Missouri and Middle Mississippi Rivers. These rays have been sectioned and polished for laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS), and three trips to the University of Massachusetts at Boston were made this year to analyze samples. The most recent trip involved analyzing 40 rays collected around the Kansas City area, and three YOY individuals. Below is a graph depicting the environmental life history of a wild collected pallid sturgeon in the Lower Missouri River (e.g. Sample D1; Figure 1). Based on previous environmental history work (e.g. Phelps et al 2012), this individual was likely spawned in the Lower Missouri River and remained in that portion of the river up to capture. Tentatively, one of the YOY Pallid Sturgeon depicted similar environmental life history (Figure 2).



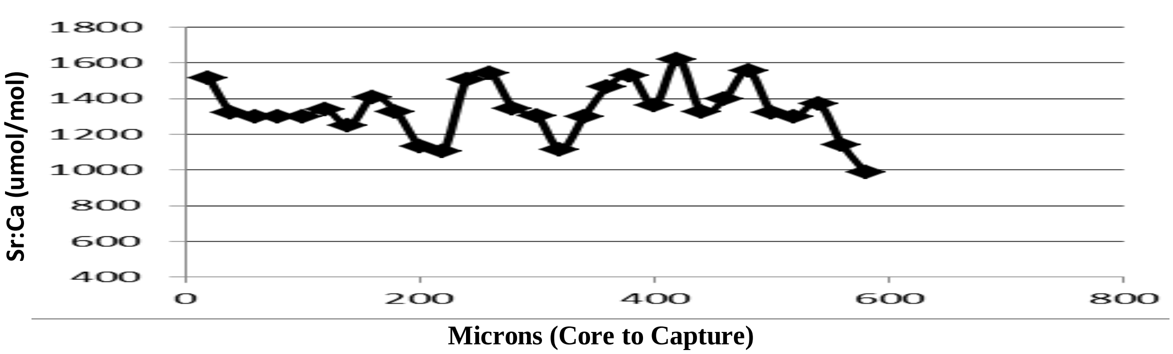


Figure 1 and 2. Ablation transect of a wild adult caught Pallid Sturgeon (top) and a larval pallid sturgeon (bottom). As can be seen, these individuals appear to have originated from the Lower Missouri River where they remained until capture.

Habitat Assessment and Monitoring Program

2014 Annual Report

Characterizing Best Achievable Habitat Conditions for Missouri River Side-Channels

Prepared for the U.S. Army Corps of Engineers – Missouri River Recovery Program
In partial fulfillment of Contract No. W9128F-10-D-0016 Task Order DH08
&
For the Nebraska Game and Parks Commission

By:

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May 26, 2015

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INTRODUCTION

Anthropogenic modifications of the Missouri River for navigation resulted in the river becoming shorter, narrower, deeper, faster, and clearer. These modifications resulted in the loss of over 40,000 hectares of aquatic habitat, with the majority of the habitat lost being shallow water habitat (SWH). Some of the most notable SWH that was eliminated consisted of side channels, islands and sand bars. The diversity of water depths and velocities associated with these side channels, islands, and sand bars provided valuable habitat diversity for fish and may have been critical habitat for larval and age-0 fishes.

The Pallid Sturgeon (*Scaphirhynchus albus*) was listed as federally endangered in 1990 (Dryer and Sandvol 1993) in part from loss of habitat and lack of reproductive success. The Pallid Sturgeon has not been the only species negatively impacted as result of these alterations to the historic river, there has been a decline in Blue Sucker, Shoal Chub, Sturgeon Chub, Sicklefin Chub, Flathead Chub, Plains Minnow, Western Silvery Minnow, Sauger, Shovelnose Sturgeon, and other native fishes (Galat et al. 2005, Steffensen et al. 2014a, Steffensen et al. 2014b, Steffensen et al. 2014c, Steffensen et al. 2015), and several avian species (Least Tern, Piping Plover, and Bald Eagle) have been federally listed.

The U.S. Fish and Wildlife Service (USFWS) issued a Biological Opinion (BiOP) (USFWS, 2000, amended 2003) for the Missouri River in response to the federal listing of Pallid Sturgeon. The BiOP recognized the loss of shallow water habitat as a critical factor affecting Pallid Sturgeon and called for the restoration of at least 8,000 hectares of SWH. Habitat restoration projects have focused on creating both off-channel (backwaters and side channels) and main channel (dike notches, chevrons and other rock structures with associated channel widening) habitats.

The first side channels constructed were monitored to document fish use and physical habitat conditions (Sterner et al. 2009). This study concluded that these side channels were providing different aquatic habitats than were available in the main channel, based on depth and velocity and that native fishes were using these newly created habitats. These large side channel restoration projects require ownership or control of large tracks of land to minimize impacts to private property; therefore the number of potential side channel projects available is limited by the ability to acquire suitable tracts of real estate adjacent to the main channel of the river. Since the completion of the Hamburg Bend side channel in 1996, a total of 17 side channels have been completed on the Missouri River along Nebraska's eastern border (Appendix A). Many of these sites were developed as pilot channels with the intention that riverine processes would widen them to design width over time. However due to floods and droughts, some side channels have developed rapidly while others hardly at all. Research has also shown it is possible for side channels to become too large and for the habitat within these chutes to become similar to habitats found in the main channel (Eder and Mestl 2012).

The 2011 flood event resulted in substantial change in in how many of the side channels along the Nebraska border were functioning: some side channels experienced extensive widening (Upper Hamburg, Lower Hamburg, Upper Kansas, and Deroin), sedimentation (Glovers Point, Middle Decatur, California (NE), California (IA), Boyer and Schilling), or minimal changes (Tobacco and Nishnabotna). Those sites that underwent extensive widening, now exhibit some of the most diverse habitats with wide ranges of depths and velocities. Extensive repair work was required to restrict flow into side channels that had widened in order to maintain the navigation channel and provide protection to vital infrastructure and property. This resulted in closure of the upstream entrances to Fawn Island, Upper Hamburg and Lower Hamburg side channels, and modification of the upstream entrance structure at Upper Kansas that severely restricted flow into side channel. The Deroin side channel entrance was also modified, but has still maintained relatively moderate inflow from the main channel. As constructed side channels continue to evolve and opportunities for new side channel construction projects decrease, efforts have begun to focus on more intense management of these sites.

In order to guide management of these sites our goal is to determine a range of best achievable conditions within side channels. Historic side channels which might be used to define best achievable conditions of abundance and diversity of native larval, young-of-year (age-0), and small-bodied fishes do not exist on the Nebraska reach of the Missouri River, although several side channels created more recently by high water on the lower river do. Therefore, best achievable conditions for side channels on the Missouri River will be determined by identifying that suite of physical conditions by reach that result in what biologists consider the optimal biological response for pallid sturgeon or other native fish species. An Adaptive Management Strategy for Creation of Shallow Water Habitat (SWHAMS) has been developed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service (2012) to guide this management.

The SWHAMS identified a list of best achievable side channels, based on professional input; Lisbon (upstream river mile (URM) 218), Cranberry Bend (URM 282), Little's Island (URM 11), and Pelican Island (URM 16), none of which occur in the Nebraska reach of the river. These are hypothesized to be the best achievable sites, but potentially do not fully consider possible longitudinal physical or biological limitations that may alter these definitions for sites in different reaches of the river. The Missouri Department of Conservation will evaluate these four hypothesized best achievable chutes in 2014 and 2015. The Nebraska Game and Parks Commission will evaluate four additional chutes encompassing a range of chute designs that were available in 2014 and 2015. By determining what is best achievable by river reach we can ultimately determine if an individual side channel is providing the best achievable habitat conditions, if its development is progressing in the desired direction or if side channel modifications are needed for further development.

Biologically, the abundance or presence of larval and age-0 Pallid Sturgeon, Shovelnose Sturgeon and native riverine small bodied fishes will be used to determine best achievable habitat diversity in constructed chutes. The SWHAMS recommends using depth and velocity distributions, wetted area/stage relationships, substrate diversity, and abundance of large woody debris to evaluate habitat conditions. The biological metrics and physical habitat conditions found in these side channels will be compared to those found in the hypothesized best achievable side channels being studied by the Missouri Department of Conservation. Ultimately the goal will be to develop a suite of habitat characteristics that define the best achievable conditions for side channels in each reach of the channelized Missouri River and utilize this information to guide future management of these sites.

METHODS

Study Sites

In 2014, we sampled four side channel sites at Deroin, Nishnabotna (Lower Kansas), Tobacco and Sandy Point Bends (Table 1). These sites were selected because they represent a range of side-channel habitat creation efforts within the Nebraska reach of the Missouri River.

The Sandy Point chute complex, located between river miles 657.8 and 654.8, was completed in 2012. This complex consists of two side channels connected with a tie channel. The inner, shorter chute also has three tie channels connecting it to the main channel. Both side channels have rock armored entrances, steep tree lined clay banks at the upstream end that have experienced limited movement, and lower downstream portions with sandy soil composition that have experienced extensive sloughing, widening, and natural large woody debris (LWD) input.

Tobacco chute, located between river miles 589.0 and 586.0, was completed in 2001. This side channel has experienced limited bank line movement since construction. Recent modifications to encourage the desired habitat development include a new entrance and new chute alignment away from sections constrained by rocky substrate. Active bank sloughing in the newly aligned portion was noted during 2014 and along with several LWD accumulations within the chute.

Nishnabotna (Lower Kansas) chute, located between river miles 543.3 and 542.0, was completed in 2004. The 2011 flood resulted in some habitat development in the upstream portion of this site where the top of the island was eroded away resulting in some sand bar habitat. The downstream portion of the chute has steep, clay banks and rock structures placed on the descending right bank that has allowed for minimal bank line movement as a result there has been limited LWD accumulation at this site.

Deroin chute, located between river miles 520.5 and 516.1, was completed in 2001. The 2011 flood altered this side channel by increasing channel width and subsequently flow through the chute. This increased flow into the side channel resulted in potential navigation issues in the main channel. In 2012, construction activities were implemented to reduce flow into the side channel, reduce velocity within the side channel, and provide protection to local levies. Habitat development in this chute as a result of the flood and subsequent construction activities has resulted in large sand bars, a large amount of LWD deposition, and diversity of water depths and velocities.

Physical Data Collection

Bathymetric surveys were conducted at all sites in 2014 using a 1200 kHz Rio Grande acoustic Doppler current profiler (ADCP Teledyne RDI, San Diego, California). WinRiver software (Teledyne RDI, San Diego, California) was used to log data and perform quality assurance verification. The ADCP internal compass was calibrated before the survey to within 0.3 degrees of error and surveys were conducted using Bottom Mode 7 and Water Mode 12. Boat speed was maintained at or below water velocity. Data were georeferenced using an Ashtech differential geographic positioning system (DGPS) or Trimble DGPS. Survey transects were conducted every 40 m. If obstructions (i.e. rock structures, LWD, sand bars, or hazards) were encountered, transects were terminated as close to the obstruction as was deemed safe or the boat was navigated immediately upstream or downstream of the obstruction to complete the transect. Depth-averaged velocity was used to present velocity data. Depth-averaged velocity is a column velocity that accounts for directional velocity (north, south, east and west) when calculating profiles. The USGS gage station (06610000) at Omaha, NE was used for discharge measurement for Sandy Point survey and measurements for all other surveys were taken from the USGS Nebraska City gage station (06807000).

Fish Sampling

Each side channel site was sampled using three gears intended to collect larval, age-0 and juvenile Pallid Sturgeon, Shovelnose Sturgeon and other native fish species. These gears included two small mesh benthic stern trawls (MOT02 and OT04) and a small mesh benthic push trawl (POT02). From May 13 through July 17, 2014 (larval fish season), a minimum of ten subsamples were collected every week with the MOT02 from each site. From July 18 through

October 9, 2014 (age-0 fish season) a minimum of ten subsamples were collected per month with each gear (MOT02, OT04 and POT02 benthic trawls) at each site.

The small mesh benthic push trawl (POT02) was a 2.4 m wide otter trawl with 4 mm mesh. The POT02 was lowered in front of the boat and pushed downstream slightly faster than the current. The design of the POT02 and its method of deployment allow it to sample shallower water, specifically water less than 2 m deep, more effectively than a towed net. The MOT02 benthic stern trawl consists of a 2.4 m wide otter trawl with 4 mm outer mesh with a 2 mm mesh cod end that retains more larval fish than the POT02 and OT04. It was deployed off the stern of the boat and towed downstream slightly faster than the current. It was used in a range of depths from <1 m to maximum available depths at each site. The small mesh benthic stern trawl (OT04) was 4.9 m wide otter trawl with 4 mm mesh. The OT04 was deployed off the stern of the boat and towed downstream slightly faster than the current. Because the OT04 and MOT02 are deployed off the stern they can be used to sample water deeper than 2 m, where the POT02 is limited to water less than 2m. Specifics about the deployment and design of these gears followed the standard Missouri River sampling methods described in Welker and Drobish (2012). Sampling areas were randomly selected at each study site for all gear types. Relative abundance was standardized across both gears similar to Ridenour et al. (2009, 2011) and was calculated as number of fish per $100m^2$.

All larval fish collected with these gears were preserved with 70% alcohol and identified in the laboratory to the lowest possible taxa. We used a maximum fork length of 109 mm for age-0 sturgeon because of previous age and growth studies (Pierce et al. 2003, Ridenour et al. 2011) and for consistency with other HAMP crews (USACE and MDC). A tissue sample was extracted from all age-0 sturgeon captured and sent to a third party lab (USFWS, Lamar, PA) for species confirmation.

RESULTS

All Sites

A total of 642 trawl samples were collected during 2014 (Table 2). These samples resulted in the collection of 18,930 fish (Table 3) with four species comprising majority of catch (54.2%); Freshwater Drum (N = 3,565), Shoal Chub (N = 2,378), River Shiner (N = 2,182), and Channel Catfish (N = 2,140) (Figure 1). We collected 43 age-0 *Scaphirhynchus* sp. less than 109 mm. Genetic results indicate that all age-0 *Scaphirhynchus* sp. were Shovelnose Sturgeon (N=41) or potential hybrids (N=2). The length of age-0 sturgeon collected ranged between 15mm and 103 mm (Figure 2). There was no discernable linear relationship between length and depth (r^2=0.16) or velocity (r^2=0.01) (Figure 3). These age-0 sturgeon were collected at depths ranging from 0.2 – 7.0 m and bottom velocities ranging between 0.08 – 0.69 m/s (Figure 4). The mean depth and bottom velocity at age-0 sturgeon collection locations was 1.98 m and 0.34 m/s (Figure 5) and where no age-0 sturgeon were collected the mean depth and bottom velocity were 1.62 m and 0.42 m/s. Other species of interest collected included: Pallid Sturgeon (N = 1), Shovelnose Sturgeon (N = 224 excluding age-0 sturgeon), Sturgeon Chub (N = 39), Sicklefin Chub (N = 3), age-0 *Macrhybopsis* spp. (N = 827), Sand Shiner (N = 1,404), Blue Sucker (N = 42), *Hybognathus* spp. (N = 130), Sauger (N = 17), and age-0 *Sander* spp. (N = 97).

Bathymetric surveys were conducted at each site in 2014. The Deroin side channel exhibited the greatest range (some scour holes exceeded 12m) and diversity of depths (with no single depth category exceeding more than 14% of the total diversity). Sandy Point had the smallest range of depths with no areas exceeding 7m. Tobacco, Nishnabotna, and Sandy Point had similar depth distributions, but differed by which depth categories were most prevalent. Percentage of each site with depths less than 1.5m was: Sandy Point (8.0%), Tobacco (22.0%), Nishnabotna (4.1%), and Deroin (13.5%). The depth and depth averaged velocity frequency distributions and cumulative frequency distributions for those surveys are located in appendix B.

Sandy Point

A total of 168 trawl samples were collected during 2014 at Sandy Point (Table 2). These samples resulted in the collection of 2,380 fish (Table 3) with four taxa comprising the majority of the catch (51.9%); Freshwater Drum (N = 542), age-0 Cyprinidae (N = 274), Channel Catfish (N = 221), and Red Shiner (N = 199) (Figure 1). No age-0 sturgeon were collected in 2014 from Sandy Point Chute. Other species of interest collected included: Shovelnose Sturgeon (N = 34), Sturgeon Chub (N = 1), age-0 *Macrhybopsis* spp. (N = 11), Sand Shiner (N = 167), Blue Sucker (N = 7), Sauger (N = 5), and age-0 *Sander* spp. (N = 15). Catch per unit effort calculations for species of interest collected with MOT02, POT02, and OT04 are located in appendix C.

A bathymetric survey of the site was conducted on October 28, 2014. Discharge from that day at the USGS Omaha gage ranged from 50,800 to 51,200 cfs. The depth and depth averaged velocity frequency distributions and cumulative frequency distributions for the survey are located in appendix B.

Tobacco

A total of 168 trawl samples were collected during 2014 at Tobacco (Table 2). These samples resulted in the collection of 6,744 fish (Table 3) with four species comprising the majority of the catch (57.6%); Channel Catfish (N = 1,187), Shoal Chub (N = 1,103), Sand Shiner (N = 956), and Freshwater Drum (N = 636). There were 2 age-0 sturgeon collected in 2014 from Tobacco Chute. These age-0 sturgeon were collected at mean depth of 1.4 m (range, 0.8 – 2.9 m) and mean bottom velocity of 0.63 m/s (range, 0.56 – 0.69 m/s)(Figure 4). The mean depth and bottom velocity were no age-0 sturgeon were captured was 1.63 m and 0.50 m/s. Other species of interest collected included: Pallid Sturgeon (N = 1), Shovelnose Sturgeon (N = 63 excluding age-0 sturgeon), Sturgeon Chub (N = 7), age-0 *Macrhybopsis* spp. (N = 56), Sand Shiner (N = 956), Blue Sucker (N = 23), *Hybognathus* spp. (N = 64), and age-0 *Sander* spp. (N = 5). Catch per unit effort calculations for species of interest collected with MOT02, POT02, and OT04 are located in appendix C.

A bathymetric survey of the site was conducted on August 20, 2014. Discharge from that day at the USGS Nebraska City gage ranged from 38,800 to 39,500 cfs. The depth and depth averaged velocity frequency distributions and cumulative frequency distributions for the survey are located in appendix B.

Nishnabotna

A total of 140 trawl samples were collected during 2014 at Nishnabotna (Table 2). These samples resulted in the collection of 3,271 fish (Table 3) with four species comprising the majority of the catch (54.7%); River Shiner (N = 556), Freshwater Drum (N = 448), Shoal Chub (N = 408), and Channel Catfish (N=377) (Figure 1). There were 2 age-0 sturgeon collected in 2014 from Nishnabotna Chute. These age-0 sturgeon were collected at mean depth of 2.6 m (range, 1.8 – 3.7 m) and mean bottom velocity of 0.41 m/s (range, 0.23 – 0.58 m/s)(Figure 3). The mean depth and bottom velocity were no age-0 sturgeon were captured was 1.85 m and 0.43 m/s. Other species of interest collected included: Shovelnose Sturgeon (N = 52 excluding age-0 sturgeon), Sturgeon Chub (N = 12), age-0 *Macrhybopsis* spp. (N = 70), Sand Shiner (N = 150), Blue Sucker (N = 8), *Hybognathus* spp. (N = 47), and age-0 *Sander* spp. (N = 9). Catch per unit effort calculations for species of interest collected with MOT02, POT02, and OT04 are located in appendix C.

A bathymetric survey of the site was conducted on September 25, 2014. Discharge from that day at the USGS Nebraska City gage ranged from 58,200 to 58,900 cfs. The depth and depth averaged velocity frequency distributions and cumulative frequency distributions for the survey are located in appendix B.

Deroin

A total of 166 trawl samples were collected during 2014 at Deroin (Table 2). These samples resulted in the collection of 6,535 fish (Table 3) with four taxa comprising the majority of the catch (66.5%); Freshwater Drum (N = 1,939), River Shiner (N = 883), Shoal Chub (N = 835), and age-0 *Macrhybopsis* spp. (N = 690) (Figure 1). There were 39 age-0 sturgeon collected in 2014 from Deroin Chute. These age-0 sturgeon were collected at mean depth of 2.0 m (range, 0.2 – 7.0 m) and mean bottom velocity of 0.33 m/s (range, 0.08 – 0.59 m/s)(Figure 3). The mean depth and bottom velocity were no age-0 sturgeon were captured was 1.63 m and 0.28 m/s. Other species of interest collected included: Shovelnose Sturgeon (N = 75 excluding age-0 sturgeon), Sturgeon Chub (N = 19), Sicklefin Chub (N = 3), age-0 *Macrhybopsis* spp. (N = 690), Sand Shiner (N = 131), Blue Sucker (N = 4), *Hybognathus* spp. (N = 19), Sauger (N = 12), and age-0 *Sander* spp. (N = 68). Catch per unit effort calculations for species of interest collected with MOT02, POT02, and OT04 are located in appendix C.

A bathymetric survey of the site was conducted on October 29th and 30th, 2014. Discharge over those two days at the USGS Nebraska City gage ranged from 55,400 to 56,500 cfs. The depth and depth averaged velocity frequency distributions and cumulative frequency distributions for the survey are located in appendix B.

DISCUSSION

We observed a range of physical conditions in the four side channels sampled in 2014 with certain sites standing out compared to other sites. In terms of velocity, Sandy Point and Nishnabotna had very high velocities compared to Deroin and Tobacco. Approximately 25% of the depth averaged velocities at Sandy Point and Nishnabotna exceeded 1 m/s when compared to 10.4% for Tobacco and less that 2% for Deroin. In addition to slower water, the Tobacco (22.0%) and Deroin (13.5%) sites had more shallow water under 1.5m available than Sandy Point (8.0%) and Nishnabotna (4.1%). The Sandy Point site is one of the newest side channels in the Nebraska stretch of the Missouri River(completed after the 2011 flood), but has experienced significant widening of the lower portion of the two side channels with natural LWD deposition starting to occur on site due to bank sloughing. This site has progressed rapidly compared to the much older sites Tobacco and Nishnabotna (both over 10 years old) which still have many areas with very steep bank lines (poor lateral connectivity) and minimal LWD input. Deroin has experienced the most change physically and exhibits key habitat features (large bars, good lateral connectivity in upper portion of site, LWD deposits, greatest range and diversity of depths, majority of velocities below 1m/s) critical to riverine fish that have limited or no access to these habitat features at the other sites.

Long term monitoring by Nebraska Game and Parks Commission has identified a disparity in the fish communities above and below the confluence of the Platte River with reduced fish catch per unit effort above the confluence. This may be an important factor in differences among fish communities at our sites because previous work indicates side channel fish communities may reflect the associated main channel fish community (Whiteman et al. 2011). Sandy Point yielded the lowest abundance of fish, which could be related to this site being the only site above the Platte confluence. However, this site did have the highest abundance of Centrarchids (Bluegill, Orange Spotted Sunfish, and Smallmouth Bass), Johnny Darters, and Redhorse. Tobacco and Deroin sites had the highest total abundance of fish and the highest total abundance for most individual species.

The Nishnabotna site was underwhelming in fish abundance for a site that is over a decade old. Coupled with the physical attributes of having relatively limited shallow water, high velocities, limited LWD deposits, and poor lateral connectivity, this site might be a potential candidate for modifications. The lower portion of this side channel has very stable steep clay banks with a deep, fast channel. The right descending bank cannot be modified due to concerns about the adjacent levy, but the left descending bank offers the opportunity to mechanically widen the side channel to improve lateral connectivity, the amount of available shallow water habitat, and to reduce overall water velocities. It would be beneficial if some type of structures (LWD or rock) could be added within the side channel away from the bank to provide velocity breaks/refuge areas for fish within the deep, fast portions and to allow for bar development downstream of the structures.

The Deroin site was not only the most physically diverse (large bars, LWD deposits, greatest range of depths, majority of velocities below 1m/s) of the four sites we studied this year, but was also one of the best biologically. It yielded the highest abundance of age-0 sturgeon, age-0 paddlefish, age-0 *Sander* spp., age-0 *Macrhybopsis* chubs, sturgeon chub, sicklefin chub, and sauger among all four sites. This site could potentially represent the best currently available site in the Nebraska reach of the Missouri River. It is also encouraging that similar physical attributes are available in other chutes that were extensively widened during the 2011 flood. Upper Hamburg, Lower Hamburg, and Upper Kansas may have the potential to provide similar benefits to native riverine species if they can be reopened and/or have entrances modified (Gosch et al. 2015).

There are several potential reasons for why Deroin had the highest numbers of age-0 sturgeon. The retention time within the chute due to large sand bar complexes and LWD accumulations which increased depth and velocity diversity, flows overtopped entrance structure during 2014 which may have enhanced age-0 sturgeon access to side channel, and the Deroin site is the most diverse site in terms of habitat and the furthest downstream sampling site for NGPC HAMP, which may increase the amount of drifting age-0 sturgeon available to enter this side channel. This is the first year of a two year study to determine biological and physical metrics in order to compare sites to determine best achievable site(s) and we will continue to evaluate these sites in 2015.

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REFERENCES

Eder, B. L. and G. E. Mestl. 2012. Documenting change at Upper Hamburg Bend: Nebraska's first side-channel restoration. Great Plains Research 22(2):147-161.

Dryer, M. P. and A. J. Sandvol. 1993. Pallid Sturgeon recovery plan. United States Fish and Wildlife Service, Bismarck, North Dakota.

Galat, D. L., C. R. Berry, W. M. Gardner, J. C. Hendrickson, G. E. Mestl, G. J. Power, C. Stone, and M. R. Winston. 2005. Spatiotemporal patterns and changes in Missouri River fishes. American Fisheries Society Symposium 45:249-291.

Gosch, N. J. C., M. L. Miller, T. R. Gemeinhardt, S. J. Sampson, and J. L. Bonneau. 2015. Age-0 sturgeon accessibility to constructed and modified chutes in the lower Missouri River. North American Journal of Fisheries Management 35:75-85.

Pierce, C. L., C.S. Guy, P. J. Braaten, and M. A. Pegg. 2003. Fish growth, mortality, recruitment, condition, and size structure: population structure and habitat use of benthic fishes along the Missouri and Yellowstone Rivers. Volume 4. U.S. Geological Survey, Cooperative Research Units, Iowa State University Press, Ames.

Ridenour, C. J., A. B. Starostka, W. J. Doyle, and T. D. Hill. 2009. Habitat used by *Macrhybopsis* chubs associated with channel modifying structures in a large regulated river: implications for river modification. River Research and Applications 25:472-485.

Ridenour, C. J., W. J. Doyle, and T. D. Hill. 2011. Habitats of age-0 sturgeon in the Lower Missouri River. Transactions of the American Fisheries Society 140:1351-1358.

Steffensen, K. D., S. Stukel, and D. A. Shuman. 2014a. The status of fishes in the Missouri River, Nebraska: Shovelnose Sturgeon (*Scaphirhynchus platorynchus*). Transactions of the Nebraska Academy of Sciences 34:16-26.

Steffensen, K. D., S. Stukel, and D. A. Shuman. 2014b. The status of fishes in the Missouri River, Nebraska: Sauger (*Sander canadensis*). Transactions of the Nebraska Academy of Sciences 34:68-79.

Steffensen, K. D., S. Stukel, and D. A. Shuman. 2014c. The status of fishes in the Missouri River, Nebraska: Shoal Chub (*Macrhybopsis hyostoma*), Sturgeon Chub (*M. gelida*), Sicklefin Chub (*M. meeki*), Silver Chub (*M. storeriana*), Flathead Chub (*Platygobio gracilis*), Plains Minnow (*Hybognathus placitus*), Western Silvery Minnow (*H. argyritis*), and Brassy Minnow (*H. hankinsoni*). Transactions of the Nebraska Academy of Sciences 34:49-67.

Steffensen, K. D., S. Stukel, and D. A. Shuman. 2015. The status of fishes in the Missouri River, Nebraska: Blue Sucker Cycleptus elongatus. Transactions of the Nebraska Academy of Sciences 35:1-11.

Sterner, V., R. Bowman, B. Eder, S. Negus, G. Mestl, K. Whiteman, D. Garner, V. Tranichek, J. Schloesser, J. McMullen, and T. Hill. 2009. Final Report, Missouri River Fish and Wildlife Mitigation Program, fish community monitoring and habitat assessment of off-channel mitigation sites. Nebraska Game and Parks Commission, Missouri Department of Conservation, Iowa Department of Natural Resources, and U.S. Fish and Wildlife Service. Final Report.

USACE and USFWS. 2012. Operational draft shallow water habitat adaptive management strategy.

USFWS. 2000. Biological Opinion on the operation of a Missouri River Main Stem Reservoir System, operation and maintenance of the Missouri River bank stabilization and navigation project, and operation of the Kansas River Reservoir System. Fort Snelling, MN.

USFWS. 2003. Amendment to the 2000 Biological Opinion on the operation of the Missouri River Main Stem Reservoir System, operation and maintenance of the Missouri River bank stabilization and navigation project, and operation of the Kansas River Reservoir System. Fort Snelling, MN.

Welker, T. L. and M. R. Drobish (editors). 2012. Missouri River Standard Operating Procedures for fish sampling and data collection. Volume 1.7. U.S. Army Corps of Engineers, Omaha District, Yankton, SD.

Whiteman, K. W., V. H. Travnichek, D. L. Garner, B. L. Eder, and K. D. Steffensen. 2011. Comparison of fish communities in recently constructed side-channel chutes with the main stem Missouri River. The Prairie Naturalist 43(3/4): 100-109.

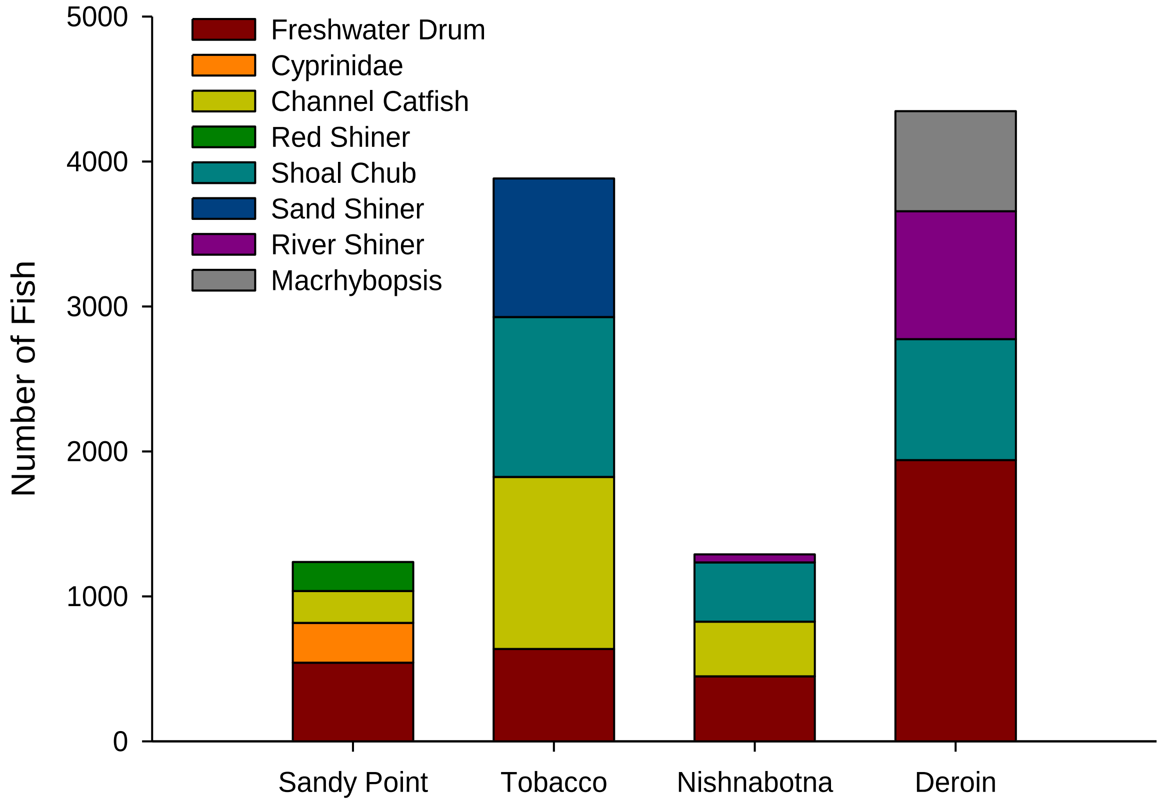

Figure 1. Four most abundant taxonomic groups by site in 2014.

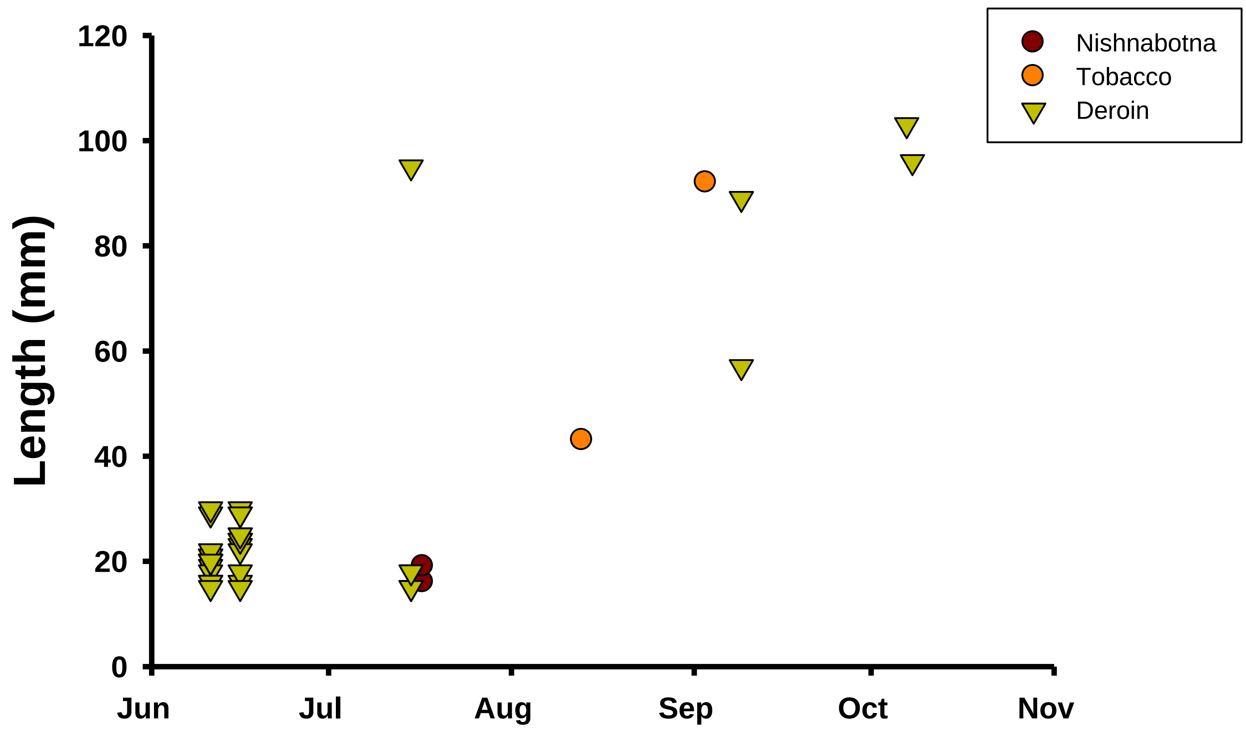

Figure 2**.** Length at capture of age-0 sturgeon <109mm by month from Nishnabotna, Tobacco and Deroin Chutes in 2014.

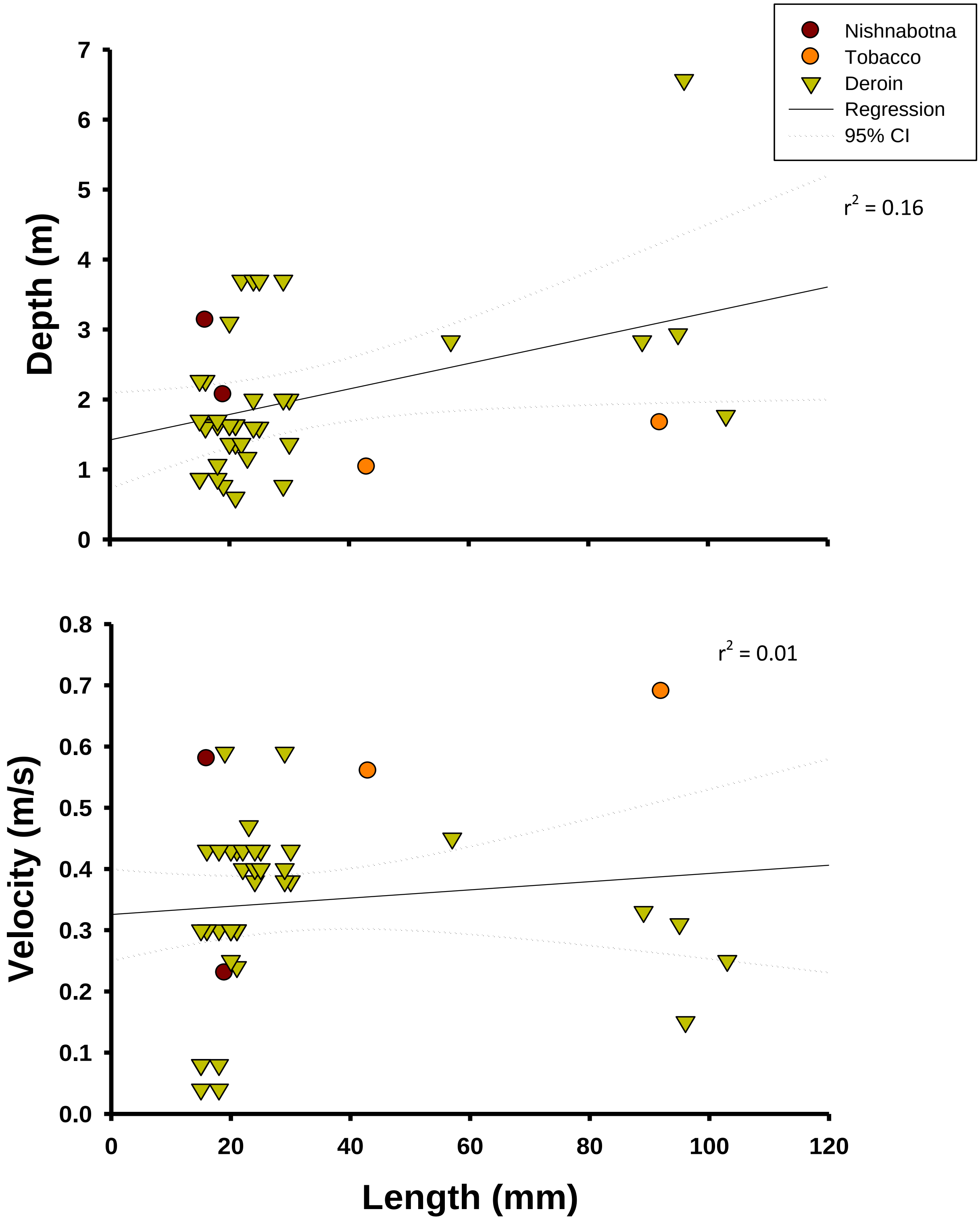

Figure 3. Depth (m; upper panel) and velocity (m/s; lower panel) by length of individual age-0 sturgeon <109mm captures from Nishnabotna, Tobacco and Deroin Chutes in 2014 with linear regression line and 95% confidence intervals.

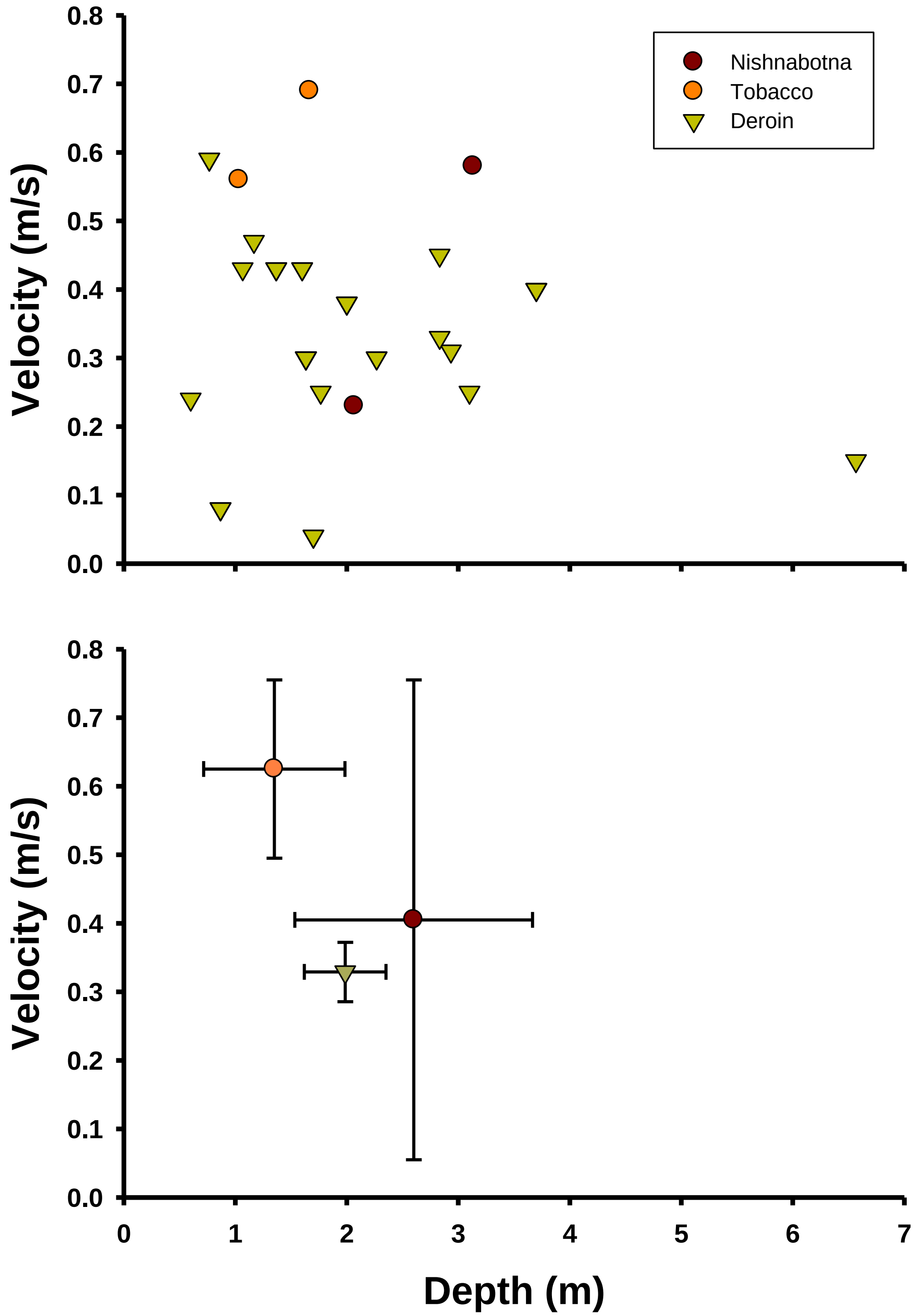

Figure 4. Depth (m) and bottom velocity (m/s) at capture locations of age-0 sturgeon <109mm from Nishnabotna, Tobacco and Deroin Chutes in 2014 (upper panel) and average depth and average bottom velocity for age-0 sturgeon <109mm from Nishnabotna, Tobacco and Deroin Chutes in 2014 (lower panel). Error bars represent +/- two standard errors.

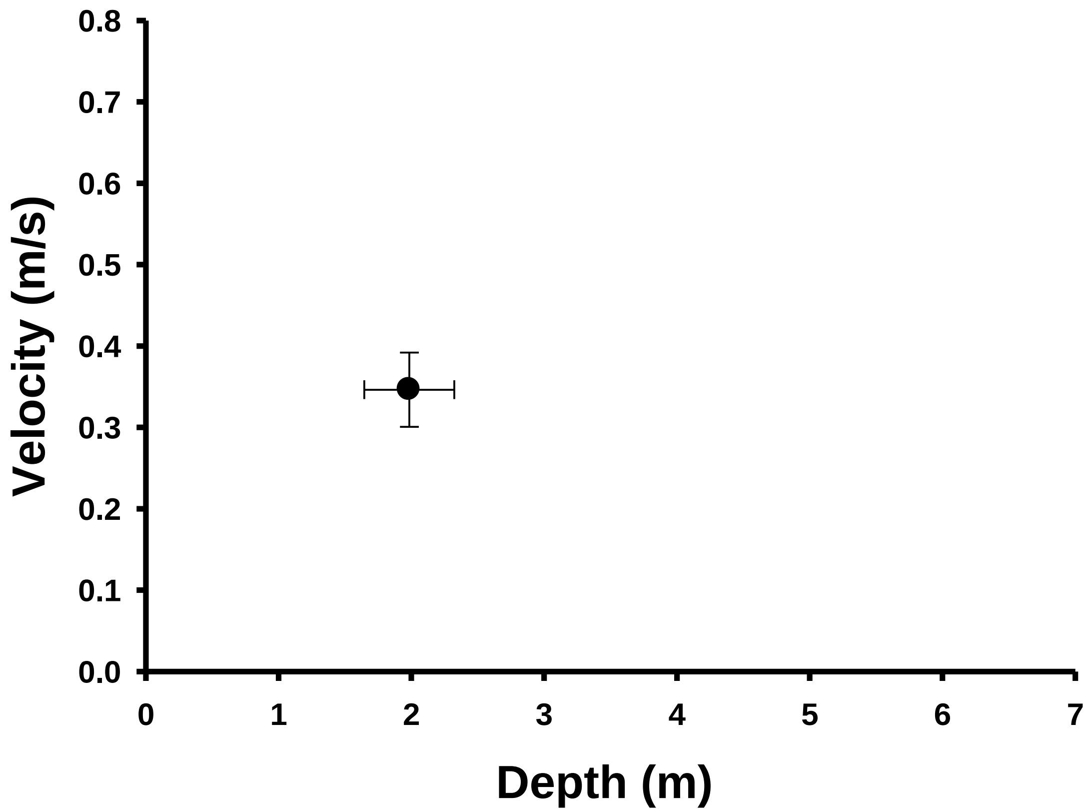

Figure 5. Average depth and average bottom velocity for age-0 sturgeon <109mm from all sites in 2014. Error bars represent +/- two standard errors.

Table 1. Side channel study site name, location (River Mile, RM), Length (miles), and age for Nebraska Game and Parks HAMP 2014 sampling season.

Site Name	Upstream RM	Downstream RM	Length	Age (years)
Sandy Point	657.8	654.8	1.6 mi	3
Tobacco	589.0	586.0	3.1 mi	13
Nishnabotna	543.3	542.0	1.0 mi	11
Deroin	520.5	516.1	3.0 mi	14

Table 2. The number of individual gear deployments by side channel site for Nebraska Game and Parks HAMP 2014 sampling season.

	Gear Code			
Site Name	MOT02 (n)	OT04 (n)	POT02 (n)	Total
Sandy Point	96	36	36	**168**
Tobacco	96	36	36	**168**
Nishnabotna	82	26	32	**140**
Deroin	94	36	36	**166**
Total	**368**	**134**	**140**	**642**

Table 3. Total catch for each species by site in 2014. Species captured are listed alphabetically and their codes are presented in Appendix A. Asterisks (*) with bold type indicate target species of the Pallid Sturgeon Population Assessment Program. Pound symbol (#) with bold type indicates age-0 sturgeon (USG) and age-0 *Sander* spp. (UST). No four letter code has been designated for Unidentified *Hiodon* spp.

Species	Nishnabotna	Sandy Point	Tobacco	Deroin	Total Catch
BHCP	0	0	1	0	**1**
BKCP	0	1	2	0	**3**
BLCF	153	0	171	122	**446**
BLGL	13	37	16	14	**80**
BMBF	8	4	2	1	**15**
BMSN	1	0	0	0	**1**
BUSK*	**8**	**7**	**23**	**4**	**42**
CARP	18	23	37	28	**106**
CNCF	377	221	1,187	355	**2,140**
ERSN	154	151	121	175	**601**
FHCF	3	1	43	2	**49**
FHMW	0	2	4	0	**6**
FWDM	448	542	636	1,939	**3,565**
GDEY	3	1	1	2	**7**
GNSF	1	19	4	7	**31**
GSCP	4	0	0	0	**4**
GZSD	7	38	7	14	**66**
HBNS*	**47**	**0**	**64**	**19**	**130**
HFCS	0	0	0	1	**1**
JYDR	0	13	1	0	**14**
LNGR	3	0	1	2	**6**
LVFS	5	9	14	27	**55**
Hiodon spp.	0	0	6	0	**6**
MQTF	0	0	0	1	**1**
OSSF	0	1	0	0	**1**
PDFH	0	0	0	12	**12**
PDSG*	**0**	**0**	**1**	**0**	**1**
RDSN	71	199	184	54	**508**
RVCS	7	14	21	24	**66**
RVSN	556	116	627	883	**2,182**
SFCB*	**0**	**0**	**0**	**3**	**3**
SFSN	41	128	74	9	**252**
SGCB*	**12**	**1**	**7**	**19**	**39**
SGER*	**0**	**5**	**0**	**12**	**17**

Species	Nishnabotna	Sandy Point	Tobacco	Deroin	Total Catch
SHRH	4	32	8	1	**45**
SJHR	0	0	0	1	**1**
SKCB*	**408**	**32**	**1,103**	**835**	**2,378**
SMBF	8	16	2	9	**35**
SMBS	2	15	0	1	**18**
SMMW	2	1	1	0	**4**
SNGR	2	0	6	19	**27**
SNSG*	**52**	**34**	**63**	**75**	**224**
SNSN*	**150**	**167**	**956**	**131**	**1,404**
STCT	33	19	53	4	**109**
SVCB	277	68	320	369	**1,034**
SVCP	46	50	176	14	**286**
UAC	36	5	81	5	**127**
UBC	1	1	17	1	**20**
UBF	0	1	0	3	**4**
UCA	0	1	0	0	**1**
UCF	17	1	19	0	**37**
UCN	0	2	1	1	**4**
UCT	6	11	30	6	**53**
UCY	174	274	288	327	**1,063**
UCYP	20	54	252	14	**340**
UHR	1	0	0	0	**1**
UHY	70	11	56	690	**827**
UIC	1	0	20	1	**22**
ULP	2	2	0	0	**4**
UMC	0	0	1	0	**1**
UNID	0	2	4	0	**6**
UNO	7	9	25	189	**230**
UPC	0	1	0	0	**1**
URH	1	20	0	0	**21**
USG#	**2**	**0**	**2**	**39**	**43**
UST#	**9**	**15**	**5**	**68**	**97**
UTB	0	0	0	1	**1**
WTBS	0	0	0	2	**2**
WTCP	0	1	0	0	**1**
YOYF	0	2	0	0	**2**
Total Catch	**3,271**	**2,380**	**6,744**	**6,535**	**18,930**

APPENDICES

Appendix A. List of Missouri River side channels located within the channelized river downstream of Ponca State Park located at river mile (RM) 750 to the Nebraska state border at RM 489.9 for 2014. The status designations are: (SD) refers to sites that have experienced issue with sediment deposition, (EC) upstream entrance closed with rock, (Open*) potential limited boat accessibility to all or portion of side channel due to shallow water or constructed rock structures, and (Open) no accessibility issues at this time.

Site Name	Above/Below Platte River	Upstream RM	Downstream RM	Length	Age (years)	Status
Glovers Point	Above	713.4	711.2	2.5	10	SD
Middle Decatur	Above	688.2	687.4	0.9	6	SD
Lower Decatur	Above	687.3	684.9	0.6	5	SD
Fawn Island	Above	674.1	673.3	0.6	5	EC
Sandy Point	Above	657.8	654.8	1.6	3	Open
California Iowa	Above	650.1	649.5	1.5	16	SD
California Nebraska	Above	650.1	648.5	2.0	12	SD
Boyer	Above	637.8	633.7	2.5	22	Open*
Council	Above	617.8	616.8	1.1	8	Open
Plattsmouth	Below	594.5	592.1	2.4	6	SD
Tobacco	Below	589.0	586.0	3.1	13	Open
Upper Hamburg	Below	555.9	552.2	3.2	19	EC
Lower Hamburg	Below	553.4	550.6	2.0	11	EC
Upper Kansas	Below	546.4	544.5	1.4	11	Open*
Nishnabotna	Below	543.3	542.0	1.0	11	Open
Deroin	Below	520.5	516.1	3.0	14	Open*
Rush Bottom	Below	502.0	499.0	1.4	8	Open

Appendix B. Figures of depth and velocity frequencies and cumulative frequency distributions from Sandy Point, Tobacco, Nishnabotna and Deroin Chutes from 2014 ADCP surveys.

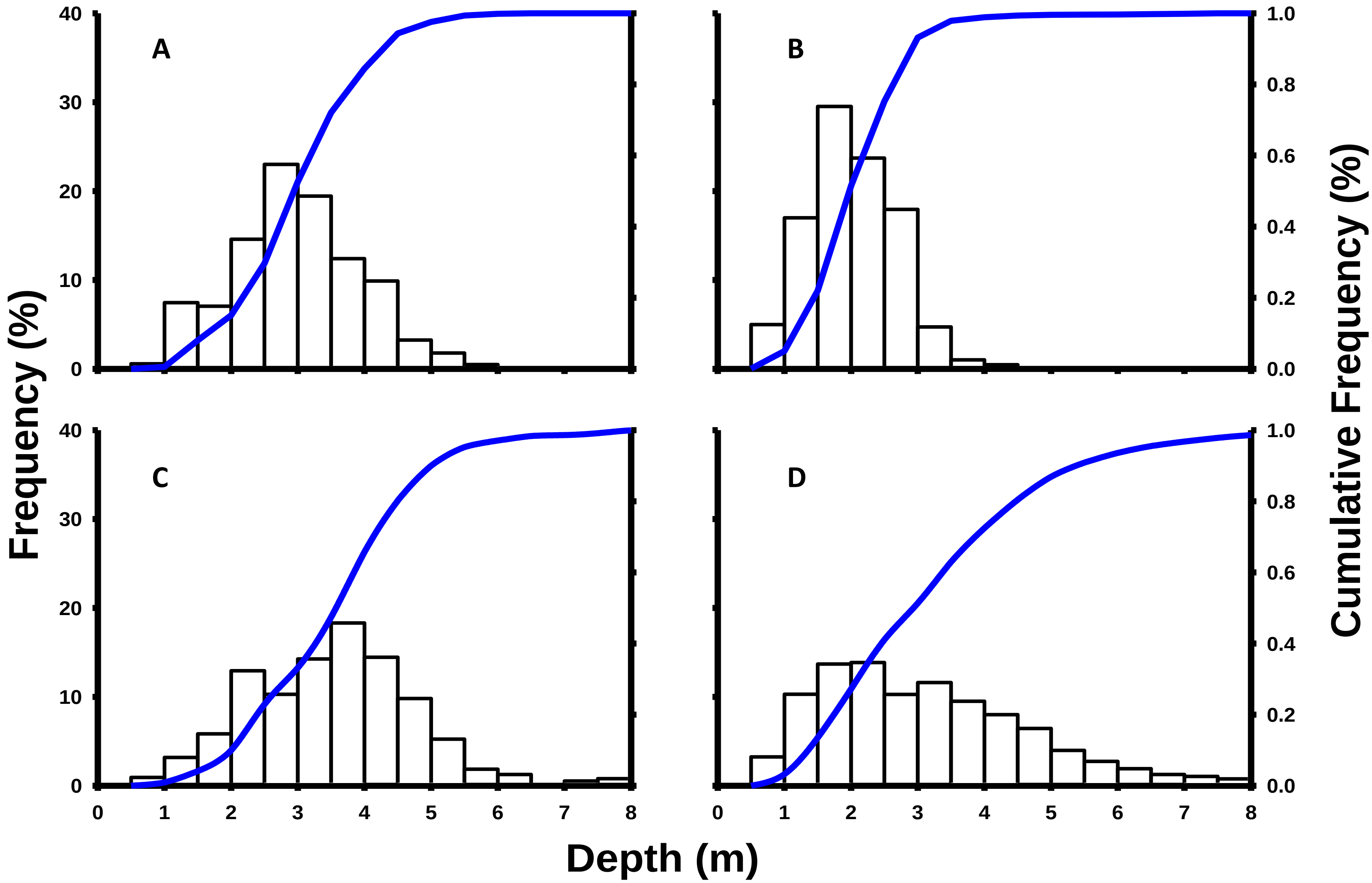

Figure B1. Depth frequency and cumulative frequency distributions from Sandy Point (A), Tobacco (B), Nishnabotna (C) and Deroin (D) Chutes from 2014 ADCP surveys.

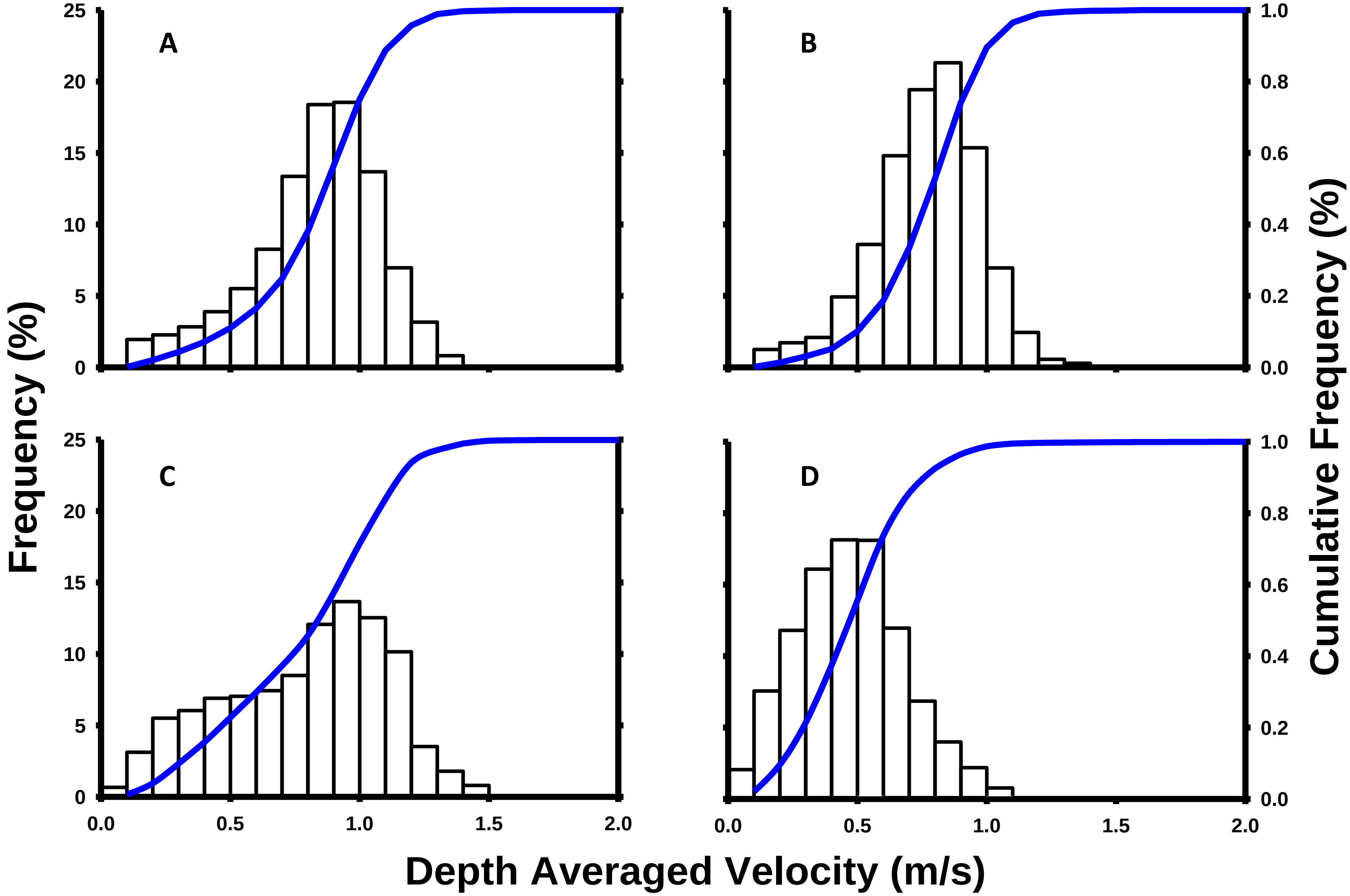

Figure B2. Depth averaged velocity frequency and cumulative frequency distributions from Sandy Point (A), Tobacco (B), Nishnabotna (C) and Deroin (D) Chutes from 2014 ADCP surveys

Appendix C. Figures of mean catch-per-unit-effort of age-0 sturgeon, Shoal Chub, Sturgeon Chub, *Macrhybopsis* spp., *Hybognathus* spp., and Shovelnose Sturgeon collected with small mesh Tri-Trawl (MOT02), small mesh push trawl (POT02), and small mesh stern trawl (OT04) at four side channels during 2014. Error bars represent +/- 2 standard errors.

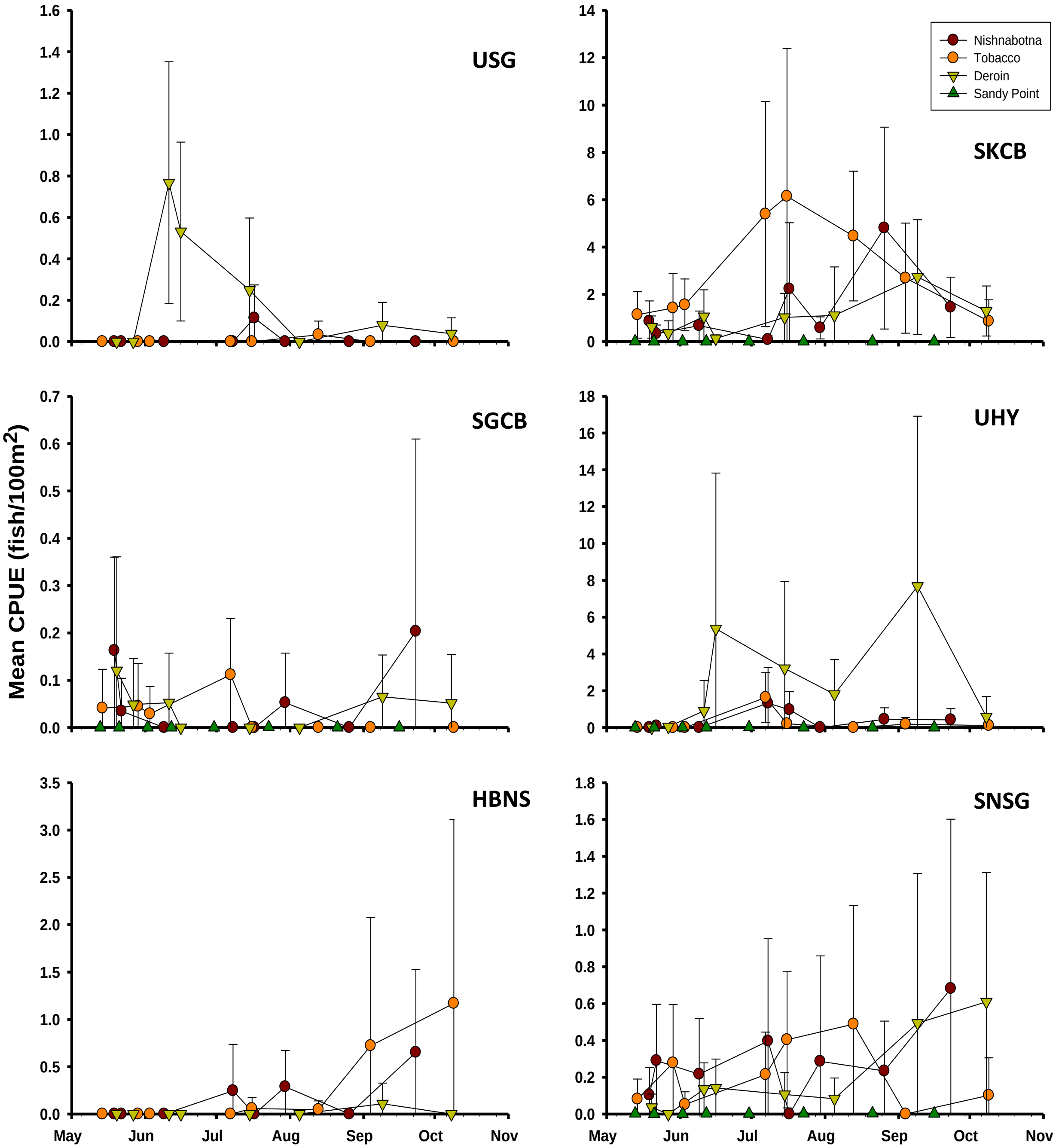

Figure C1. Mean Catch-Per-Unit-Effort of age-0 sturgeon (USG), Shoal Chub (SKCB), Sturgeon Chub (SGCB), *Macrhybopsis* spp. (UHY), *Hybognathus* spp. (HBNS), and Shovelnose Sturgeon (SNSG) collected with small mesh Tri-Trawl (MOT02) at four side channels during 2014. Error bars represent +/- 2 standard errors. Note that scale for mean CPUE differs for each graph.

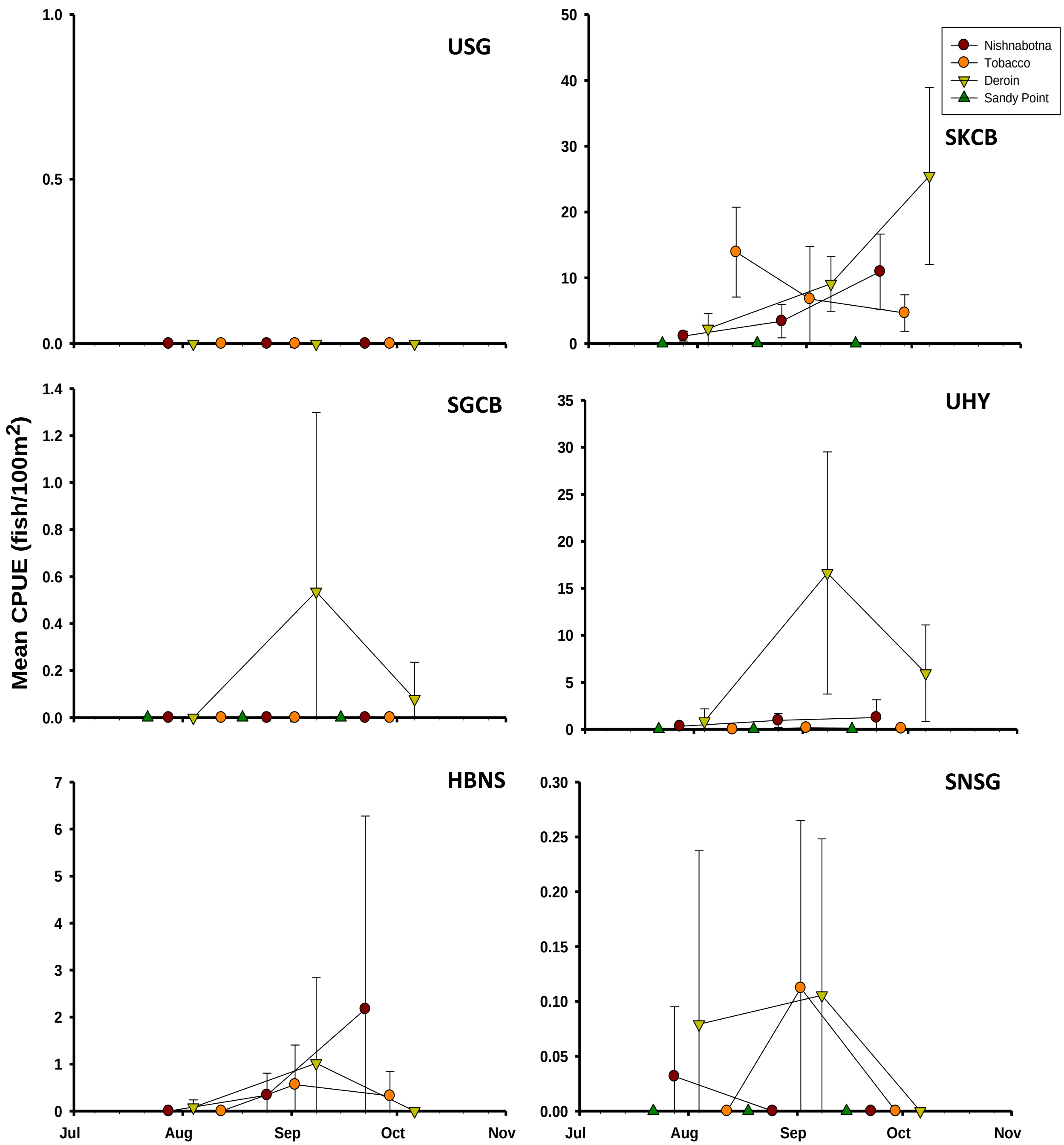

Figure C2. Mean Catch-Per-Unit-Effort of age-0 sturgeon (USG), Shoal Chub (SKCB), Sturgeon Chub (SGCB), Macrhybopsis spp. (UHY), Hybognathus spp. (HBNS), and Shovelnose Sturgeon (SNSG) collected with small mesh push trawl (POT02) at four side channels during 2014. Error bars represent +/- 2 standard errors. Note that scale for mean CPUE differs for each graph.

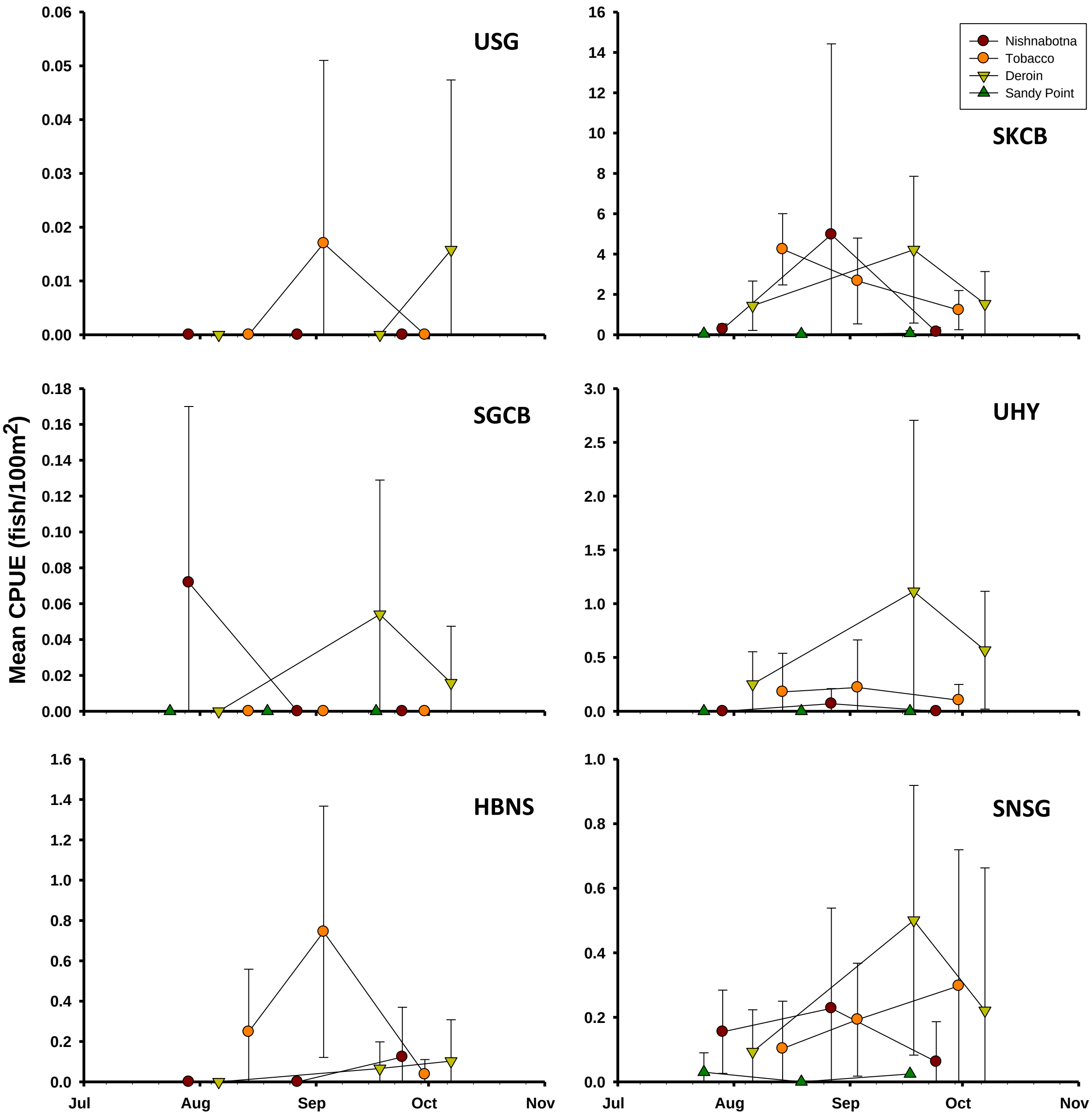

Figure C3. Mean Catch-Per-Unit-Effort of age-0 sturgeon (USG), Shoal Chub (SKCB), Sturgeon Chub (SGCB), *Macrhybopsis* spp. (UHY), *Hybognathus* spp. (HBNS), and Shovelnose Sturgeon (SNSG) collected with small mesh push trawl (OT04) at four side channels during 2014. Error bars represent +/- 2 standard errors. Note that scale for mean CPUE differs for each graph.

Appendix D. Missouri River fishes letter codes listed alphabetically along with associated common and scientific names. Asterisks (*) and bold type denote target species of the Pallid Sturgeon Population Assessment Program.

Letter Code	Common Name	Scientific Name
ALSD	Alabama shad	*Alosa alabamae*
ALWF	Alewife	*Alosa pseudoharengus*
AMEL	American eel	*Anguilla rostrata*
AMGL	American grayling	*Thymallus articus*
BCCC	Blue catfish x Channel catfish	*Ictalurus furcatus x punctatus*
BDDR	Banded darter	*Etheostoma zonale*
BDKF	Banded killifish	*Fundulus diaphanus*
BDSN	Bleeding shiner	*Luxilus zonatus*
BDSP	Banded sculpin	*Cottus carolinae*
BESN	Bigeye shiner	*Notropis boops*
BGRE	Bluegill x Redear Sunfish Hybrid	*L. macrochirus X L. macrolophus*
BHCP	Bighead carp	*Hypopthalmichthys nobilis*
BHMW	Bullhead Minnow	*Pimephales vigilax*
BKBF	Black Buffalo	*Ictiobus niger*
BKBH	Black bullhead	*Ameiurus melas*
BKCP	Black crappie	*Pomoxis nigromaculatus*
BKRH	Black redhorse	*Moxostoma duquesnei*
BKSB	Brook stickleback	*Culaea inconstans*
BKSS	Brook silverside	*Labidesthes sicculus*
BKTT	Brook trout	*Salvelinus fontinalis*
BLCF	Blue catfish	*Ictalurus furcatus*
BLCP	Black Carp	*Mylopharyngodon piceus*
BLGL	Bluegill	*Lepomis macrochirus*
BMBF	Bigmouth Buffalo	*Ictiobus cyprinellus*
BMSN	Bigmouth shiner	*Notropis dorsalis*
BNBH	Brown Bullhead	*Ameiurus nebulosus*
BNDC	Blacknose dace	*Rhinichthys atratulus*
BNMW	Bluntnose Minnow	*Pimelphales notatus*
BNSN	Blacknose shiner	*Notropis heterolepis*
BNTT	Brown trout	*Salmo trutta*
BPTM	Blackspotted topminnow	*Fundulus olivaceus*
BRBT	Burbot	*Lota lota*
BSDR	Blackside darter	*Percina maculata*
BSMW	Brassy Minnow	*Hybognathus hankinsoni*
BTDR	Bluestripe darter	*Percina cymatotaenia*
BTTM	Blackstripe topminnow	*Fundulus notatus*
BUSK *	**Blue sucker**	***Cycleptus elongatus***

Letter Code	Common Name	Scientific Name
BVSC	Bonneville ciscoe	*Prosopium cylindraceum*
BWFN	Bowfin	*Amia calva*
CARP	Common carp	*Cyprinus carpio*
CHSM	Coho salmon	*Oncorhynchus kisutch*
CKCB	Creek chub	*Semotilus atromaculatus*
CLDR	Crystal darter	*Ammocrypta asprella*
CLSR	Central stoneroller	*Campostoma anomalum*
CMSN	Common shiner	*Luxilus cornutus*
CNCF	Channel catfish	*Ictalurus punctatus*
CNLP	Chestnut lamprey	*Ichthyomyzon castaneus*
CNSM	Chinook salmon	*Oncorhynchus tshawytscha*
CNSN	Channel Shiner	*Notropis wickliffi*
CSCO	Ciscoe	*Coregonus artedi*
CTTT	Cutthroat trout	*Salmo clarki*
ERSN	Emerald shiner	*Notropis atherinoides*
FCSC	Flathead chub x sicklefin chub	*Platygobio gracilis x Macrhybopsis meeki*
FHCB	Flathead chub	*Platygobio gracilis*
FHCF	Flathead catfish	*Pylodictus olivaris*
FHMW	Fathead Minnow	*Pimephales promelas*
FKMT	Freckled madtom	*Noturus nocturnus*
FSDC	Finescale dace	*Phoxinus neogaeus*
FTDR	Fantail darter	*Etheostoma flabellare*
FWDM	Freshwater drum	*Aplodinotus grunniens*
FWEL	Freshwater Eel Family	Anguillidae
GDEY	Goldeye	*Hiodon alosoides*
GDFH	Goldfish	*Carassius auratus*
GDRH	Golden redhorse	*Moxostoma erythrurum*
GDSN	Golden shiner	*Notemigonus crysoleucas*
GDTT	Golden trout	*Salmo aguabonita*
GFCC	Goldfish x Common carp	*Carassius auratus x Cyprinus carpio*
GLDR	Gilt darter	*Percina evides*
GNSF	Green sunfish	*Lepomis cyanellus*
GSBG	Green sunfish x Bluegill	*Lepomis cyanellus x macrochirus*
GSCP	Grass carp	*Ctenopharyngodon idella*
GSDR	Greenside darter	*Etheostoma blennioides*
GSOS	Green sunfish x Orangespotted	*Lepomis cyanellus x L. humilis*
GSPK	Grass pickerel	*Esox americanus vermiculatus*
GSTS	Gizzard shad x Threadfin shad	*Dorosoma cepedianum x petenense*
GSUK	Green sunfish x unknown	*Lepomis cyanellus x sp.*
GTSN	Ghost shiner	*Notropis buchanani*
GVCB	Gravel chub	*Erimystax punctatus*

Letter Code	Common Name	Scientific Name
GZSD	Gizzard shad	*Dorosoma cepedianum*
HBNS *	**Hybognathus spp.**	***Hybognathus sp.***
HFCS	Highfin carpsucker	*Carpiodes velifer*
HHCB	Hornyhead chub	*Nocomis biguttatus*
IODR	Iowa darter	*Etheostoma exile*
JYDR	Johnny darter	*Etheostoma nigrum*
LESF	Longear sunfish	*Lepomis megalotis*
LGPH	Logperch	*Percina caprodes*
LKCB	Lake chub	*Couesius plumbeus*
LKSG	Lake sturgeon	*Acipenser fulvescens*
LKSK	Lake Chubsucker	*Erimyzon sucetta*
LKTT	Lake trout	*Salvelinus namaycush*
LKWF	Lake whitefish	*Coregonus clupeaformis*
LMBS	Largemouth bass	*Micropterus salmoides*
LNDC	Longnose dace	*Rhinichthys cataractae*
LNGR	Longnose gar	*Lepisosteus osseus*
LNSK	Longnose sucker	*Catostomus catostomus*
LSSR	Largescale stoneroller	*Campostoma oligolepis*
LTDR	Least darter	*Etheostoma microperca*
LVEG	Unknown larval fish egg	
LVFS	Unidentified Larval Fish	
LVLP	Unidentified Larval Lamprey	
MDMN	Central Mudminnow	*Umbra limi*
MDSP	Mottled sculpin	*Cottus bairdi*
MMSN	Mimic shiner	*Notropis volucellus*
MNEY	Mooneye	*Hiodon tergisus*
MQTF	Mosquitofish	*Gambusia affinis*
MSDR	Missouri saddled darter	*Etheostoma tetrazonum*
MSKG	Muskellunge	*Esox masquinongy*
MTSK	Mountain sucker	*Catostomus platyrhyncus*
MTWF	Mountain whitefish	*Prosopium williamsoni*
NBLP	Northern brook lamprey	*Ichthyomyzon fossor*
NDNF	Net Did Not Fish	
NFSH	No Fish Collected	
NHSK	Northern hog sucker	*Hypentelium nigricans*
NRBD	Northern redbelly dace	*Phoxinus eos*
NTPK	Northern pike	*Esox lucius*
NTSF	Northern studfish	*Fundulus catenatus*
OSBG	Orangespotted sunfish hybrid x Bluegill	
OSSF	Orangespotted sunfish	*Lepomis humilis*
OTDR	Orangethroat darter	*Etheostoma spectabile*

Letter Code	Common Name	Scientific Name
OZMW	Ozark minnow	*Notropis nubilus*
PDFH	Paddlefish	*Polyodon spathula*
PDSG *	**Pallid sturgeon**	***Scaphirhynchus albus***
PEMT	Peamouth	*Mylocheilus caurinus*
PGMW	Pugnose minnow	*Opsopoeodus emiliae*
PKLF	Plains killifish	*Fundulus zebrinus*
PLDC	Pearl dace	*Margariscus margarita*
PNFH	Sunfish/Crappie/Rock Bass	*Lepomis, Pomoxis, Ambloplites*
PNMW *	**Plains Minnow**	***Hybognathus placitus***
PNSD	Pumpkinseed	*Lepomis gibbosus*
POLY	Paddlefish Family	*Polyodontidae*
PTMW	Plains topminnow	*Fundulus sciadicus*
QLBK	Quillback	*Carpiodes cyprinus*
RBDR	Rainbow darter	*Etheostoma caeruleum*
RBST	Rainbow smelt	*Osmerus mordax*
RBTT	Rainbow trout	*Oncorhynchus mykiss*
RDSN	Red shiner	*Cyprinella lutrensis*
RDSS	Redside shiner	*Richardsonius balteatus*
RESF	Redear Sunfish	*Lepomis microlophus*
RFSN	Redfin Shiner	*Lythrurus umbratilus*
RKBS	Rock bass	*Ambloplites rupestris*
RRDR	River darter	*Percina shumardi*
RUDD	Rudd	*Scardinius erythrophthalmus*
RVCS	River carpsucker	*Carpiodes carpio*
RVRH	River redhorse	*Moxostoma carinatum*
RVSN	River shiner	*Notropis blennius*
RYSN	Rosyface shiner	*Notropis rubellus*
SBLR	Southern brook lamprey	*Ichthyomyzon gagei*
SBSN	Silverband shiner	*Notropis shumardi*
SBWB	Striped bass x White bass	*M. saxatilis X M. chrysops*
SCSC	Sturgeon chub x Sticklefin chub	*Macrhybopsis gelida x meeki*
SDBS	Striped bass	*Morone saxatilis*
SDMT	Slender madtom	*Noturus exilis*
SESM	Sockeye salmon	*Oncorhynchus nerka*
SFCB *	**Sicklefin chub**	***Macrhybopsis meeki***
SFSN	Spotfin shiner	*Cyprinella spiloptera*
SGCB *	**Sturgeon chub**	***Macrhybopsis gelida***
SGER *	**Sauger**	***Sander canadensis***
SGWE	Sauger x Walleye	*Sizostedion canadense x vitrieum*
SHDR	Slenderhead darter	*Percina phoxocephala*
SHRH	Shorthead redhorse	*Moxostoma macrolepidotum*

Letter Code	Common Name	Scientific Name
SJHR	Skipjack herring	*Alosa chrysochloris*
SKCB *	**Speckled chub**	***Macrhybopsis aestivalis***
SLDR	Slough darter	*Etheostoma gracile*
SMBF	Smallmouth Buffalo	*Ictiobus bubalus*
SMBS	Smallmouth bass	*Micropterus dolomieu*
SMMW	Suckermouth Minnow	*Phenacobius mirabilis*
SNGR	Shortnose gar	*Lepisosteus platostomus*
SNPD	Shovelnose x Pallid Hybrid	*Scaphirhynchus platorynchus x albus*
SNSG *	**Shovelnose sturgeon**	***Scaphirhynchus platorynchus***
SNSN *	**Sand shiner**	***Notropis stramineus***
SOPH	Sacromento Perch	*Archoplites interruptus*
SPSK	Spotted sucker	*Minytrema melanops*
SPSN	Striped shiner	*Luxilus chrysocephalus*
SPST	Speckled chub x Sturgeon chub	*Macrhybopsis aestivalis x gelida*
SRBD	Southern redbelly dace	*Phoxinus erythrogaster*
SSPS	Silverstripe shiner	*Notropis stilbius*
STBS	Spotted bass	*Micropterus punctulatus*
STCT	Stonecat	*Noturus flavus*
STGR	Spotted gar	*Lepisosteus oculatus*
STPD	Stippled darter	*Etheostoma punctulatum*
STSN	Spottail shiner	*Notropis hudsonius*
SVCB	Silver chub	*Macrhybopsis storeriana*
SVCP	Silver carp	*Hypopthalmichthys molitrix*
SVLP	Silver lamprey	*Ichthyomyzon unicuspis*
SVMW *	**Mississippi Silvery Minnow**	***Hybognathus nuchalis***
SVRH	Silver redhorse	*Moxostoma anisurum*
TFSD	Threadfin shad	*Dorosoma petenense*
TGMG	Tiger Muskellunge	*E. lucius X E. masquinongy*
TPMT	Tadpole madtom	*Noturus gyrinus*
TPSN	Topeka shiner	*Notropis topeka*
TTPH	Troutperch	*Percopsis omiscomaycus*
UAC	Unidentified Asian Carp	*Hypopthalmichthys spp.*
UBC	Unidentified Carpsucker or Buffalo	*Carpiodes or Ictiobus spp.*
UBF	Unidentified Buffalo	*Ictiobus sp.*
UBH	Unidentified Bullhead	*Ameiurus spp.*
UCA	Unidentified Catastomus	*Catastomus spp.*
UCF	Unidentified Catfish	*Other than Ictalurus*
UCN	Unidentified Sunfish	*Unidentified Centrarchidae*
UCS	Unidentified Carpsucker	*Carpiodes sp.*
UCT	Unidentified Sucker	*Catostomidae spp.*
UCY	Unidentified Minnow	*Cyprinidae spp.*

Letter Code	Common Name	Scientific Name
UDR	Unidentified Darter	*Percina or Etheostoma sp.*
UET	Unidentified Etheostoma	*Etheostoma sp.*
UHY	Unidentified Chub	*Macrhybopsis sp.*
UIC	Unidentified Ictalurus	*Ictalurus spp.*
ULP	Unidentified Lepomis	*Lepomis sp.*
ULY	Unidentified Lamprey	*Petromyzontidae*
UMC	Unidentified Micropterus	*Micropterus spp.*
UNID	Unidentified	*Unidentified*
UNO	Unidentified Shiner	*Notropis spp.*
UPC	Unidentified Percidae	*Unidentified Percidae*
UPM	Unidentified Crappie	*Pomoxis spp.*
UPN	Unidentified Percina	*Percina sp.*
UPP	Unidentified Pimephales	*Pimephales spp.*
URH	Unidentified Redhorse	*Moxostoma sp.*
USG	Unidentified Sturgeon	*Scaphirhynchus sp.*
UST	Unidentified Stizostedion	*Stizostedion spp.*
WCBC	White x black crappie hybrid	*P. annularis X P. nigromaculatus*
WLYE	Walleye	*Sander vitreum*
WRFS	Western redfin shiner	*Lythrurus umbratilis*
WRMH	Warmouth	*Lepomis gulosus*
WSMW *	**Western Silvery Minnow**	***Hybognathus argyritis***
WSSN	Wedgespot shiner	*Notropis greenei*
WTBS	White bass	*Morone chrysops*
WTCP	White crappie	*Pomoxis annularis*
WTPH	White perch	*Morone americana*
WTSK	White sucker	*Catostomus commersoni*
YLBH	Yellow bullhead	*Ameiurus natalis*
YOYF	Unidentified age0 fish	*YOY Unidentified*
YWBS	Yellow bass	*Morone mississippiensis*
YWPH	Yellow perch	*Perca flavescens*

2014 Annual Report

Habitat Assessment and Monitoring Project: Establishing chute reference conditions for Missouri River habitat restoration projects

Prepared for the U.S. Army Corps of Engineers – Missouri River Recovery Program

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EXECUTIVE SUMMARY

The pallid sturgeon *Scaphirhynchus albus* is a riverine species adapted to the historic large and free-flowing Missouri, Yellowstone, and Mississippi rivers. Anthropogenic changes to the Missouri River have greatly reduced or eliminated the original ecosystem composed of a main channel, backwaters, side channels, sandbars, sloughs, and the floodplain. These modifications to the river and lack of reproductive success of pallid sturgeon in the Missouri River warranted listing of the species as federally endangered in 1990 (Dryer and Sandvol, 1993). In response to habitat degradation as a major factor in the decline of the pallid sturgeon, the U.S. Army Corps of Engineers (USACE) formed the Habitat Assessment Monitoring Program (HAMP) to monitor biological responses of sturgeon and other fish species to habitat creation actions required in a U.S. Fish and Wildlife Service Biological Opinion. Evaluating habitat restoration projects, such as constructed chutes, requires an estimate of historic conditions of abundance and diversity of native age-0 and small-bodied fishes. Therefore, the scope of this HAMP project is to develop a set of reference conditions for comparison of created chute sites to best-achievable habitats in order to evaluate restoration objectives by focusing on relative abundance and species diversity of native age-0 and small-bodied fishes, including pallid sturgeon.

Sampling by the MDC during 2014 was focused on four best-achievable side channels and the respective main channel set in the lower 455 river kilometers of the Missouri River, between Waverly and Florissant, Missouri. A modified otter trawl was selected as the standard gear for small-bodied fish sampling for the project. Sampling was conducted at each bend at least 3 times a month from May – October, 2014. The 2014 effort produced 1,323 trawl deployments and 22,943 fish collected, with 49 fish species represented.

Two small age-0 pallid sturgeon (≤50 mm fork length [FL]), genetically verified as potentially wild, and two large age-0 (51-150 mm FL) hatchery-reared pallid sturgeon were collected. This was the first documented collection of small age-0 pallid sturgeon in the lower Missouri River in 15 years (Krentz 2000). Three of the age-0 pallid sturgeon captured were at Brickhouse bend, approximately 16 rkms from the confluence of the Mississippi River. A total of 767 shovelnose sturgeon were collected, of these, 542 were small (≤50 mm FL) and 104 were large age-0 (51-110 mm FL). Age-0 shovelnose sturgeon were found in highest relative abundance in the main channel, and at Salt Creek bend. Hatch dates were established for

shovelnose sturgeon based off of models developed by Snyder (2002). The largest cohort of hatching shovelnose sturgeon occurred in late May, though hatching continued through August.

In addition to sturgeon, seven native Missouri River species of interest were captured during 2014; sturgeon chub *Macrhybopsis gelida* (n=661), sicklefin chub *M. meeki* (n=1530), shoal chub *M. aestivalis* (n=5016), sand shiner *Notropis stramineus* (n=111), Mississippi silvery minnow *Hybognathus nuchalis* (n=1), blue sucker *Cycleptus elongates* (n=22), and sauger *Sander canadense* (n=24). Target chub species were captured at all bends and macrohabitats. Sturgeon chubs were captured at higher abundances at Salt Creek bend, whereas shoal and sicklefin chubs occurred at higher abundances at Brickhouse bend. Highest catch rates of sand shiners occurred in shallower waters (<0.9m) and warmer water temperatures, and were found in higher abundances in side channels and at Brickhouse bend. The majority of blue suckers captured were less than 700 mm TL and this suggests that recruitment is occurring in the lower Missouri River. Blue suckers were captured at all bends and macrohabitats. Few saugers were captured during the sampling season, but higher catch rates were observed at Brickhouse bend with no saugers captured at Pelican and Salt Creek bends.

Fish community structure was compared along bends and macrohabitats of the lower Missouri River. All sites and macrohabitats were dominated by members of the genus *Macrhybopsis* and *Ictalurus.* Species richness was significantly different between macrohabitats, with side channels having more species (n=28). The diversity of side channels was influenced by rare species, particularly members of the genus *Percina*. Species richness was also highest at Brickhouse bend (n=31).

The effort to establish reference conditions in 2014 not only produced valuable information on the relative abundance of native fish species, but also provided insight into the fish diversity and community structure of best-achievable habitats along the lower Missouri River. The data presented here will benefit from subsequent years of collection, as it is difficult to draw conclusions on a single year of biological data. Reference conditions for 2014 will be combined with subsequent sampling to provide reference data for the evaluation of future habitat modifications and development.

This document may be cited as:

Winders, K., C. Ames, and L. McGallagher. 2015. Pallid Sturgeon Habitat Assessment and Monitoring Program 2014 Annual Report. Missouri Department of Conservation. Chillicothe, MO.

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Introduction

Dramatic habitat alterations have occurred along most of the Missouri River (Funk and Robinson, 1974). The Missouri River Bank Stabilization and Navigation Project (BSNP) and Pick Sloan Project included seven different acts of legislation that has brought about the damming and channelization of the Missouri River since the early 1900s. These various acts have resulted in 67% of the river's length being impounded or channelized (Hesse, 1987) and have eliminated 98% of the islands from Rulo, NE to the mouth (Funk and Robinson, 1974). The chutes between the islands and shore, which were relatively shallow and had slower current velocities than the main channel, provided valuable diversity to the fish habitat, and likely served as nursery and feeding areas for many aquatic species (Funk and Robinson, 1974).

Following the habitat changes that have occurred over time along much of the Missouri River, there has been a concurrent temporal decline of the native fish community, including the pallid sturgeon (Galat et al., 2005). The pallid sturgeon *Scaphirhynchus albus* is a species that historically ranged throughout central North America from the entire Missouri River, the lower half of the Mississippi River, and the Yellowstone River. This species was listed as federally endangered throughout its range in 1990 (Dryer and Sandvol, 1993), largely because of the loss of habitat and lack of reproductive success within the Missouri and Yellowstone rivers. Due to habitat alterations along the Missouri River related to the BSNP and Pick Sloan projects and the listing of pallid sturgeon as endangered, the U.S. Fish and Wildlife Service (USFWS) completed a Biological Opinion related to the operation of the Missouri River in 2000 (USFWS, 2000) and amended it in 2003 (USFWS, 2003). In light of these documents, the U.S. Army Corps of Engineers (USACE) responded by funding multiple habitat restoration and monitoring programs throughout the main channel.

Evaluations of the development of these habitat restoration projects, such as constructed chutes, require an estimate of historic or best-achievable conditions. Historic conditions of abundance and diversity of native age-0 and small-bodied fishes are lacking. Therefore, biological assessments of reference sites in areas having the same land-surface form, soil, and potential fish community predominant in large, relatively homogeneous regions may provide a measure of best-achievable conditions. These best-achievable conditions are useful reference values for setting biological and environmental criteria in which to measure success and compare progress towards desired biological responses.

The objective of this work is to develop a set of reference conditions for comparison of created chute sites to best-achievable habitats in order to evaluate progress towards restoration objectives by focusing on relative abundance and species diversity of native age-0 and small-bodied fishes, including pallid sturgeon.

Methods

Data collected were entered in the field during independent surveys using a Xplore iX104 tablet computer using a Microsoft Access program created by the USACE. Data were then uploaded to a website managed by the USACE and the MDC. Data was checked and approved by the database manager, housed at MDC, before it was used for annual reporting purposes.

Sampling season during 2014 was during 22 May 2014 through 30 October 2014. Sampling gear during the 2014 season included small-mesh otter trawls (see Sampling Gear section for gear specifications). This gear was designed to capture small bodied fishes, particularly age-0 sturgeons.

In addition to pallid sturgeon, we identified eleven fishes from the associated fish community that were of particular interest due to their ecology (e.g., surrogate species to pallid sturgeon, obligate big river species, benthic species, potential prey of pallid sturgeon, etc.). These species were identified as “species of interest” and include: shovelnose sturgeon *Scaphirhynchus platorynchus*, blue sucker *Cycleptus elongatus*, sauger *Sander canadensis,* sturgeon chub *Macrhybopsis gelida*, sicklefin chub *M. meeki*, shoal chub *M. aestivalis*, *Hybognathus* spp. (including: western silvery minnow *Hybognathus argyritis*, plains minnow *H. placitus*, brassy minnow *H. hankinsoni*, and Mississippi silvery minnow, *H. nuchalis*), and sand shiner *Notropis stramineus*.

All captured fish were identified to species when feasible and measured (mm) to total length (TL), except sturgeon that were measured to fork length (FL) and paddlefish *Polyodon spathula* were measured eye-fork length. Small sturgeon and paddlefish which lacked a well-defined caudal fork (≤50 mm) were measured to total length, not including the caudal filament if present (Braaten et al. 2007). Sturgeon were classified as age-0 based on length or known-age in the case of hatchery-reared pallid sturgeon. Pallid sturgeon and shovelnose sturgeon ≤150 mm and ≤110 mm were considered age-0, respectively (Ridenour et al. 2011). Age-0 sturgeon were further classified as small (≤50 mm) or large (>50 mm) similar to Sechler et al. (2012). All fish >200 mm were weighed to the nearest gram (g).

Sturgeon less than 170 mm FL are difficult to differentiate morphometrically, therefore tissue samples were collected from unidentified sturgeon and sent to Dr. Edward Heist at Southern Illinois University for genetic analysis. All pallid sturgeon were examined for markings, indicating the origin of the fish (i.e. hatchery or wild), which included elastomer markings, coded wire tags (CWT), removed scutes, and passive integrated transponder (PIT) tags. Elastomer markings consist of a colored liquid plastic injected just under the skin of the fish. Year class (and stocking site in some cases) is indicated by the color and orientation of the tag. CWT are small (<10mm) tags implanted into the fish, which can be detected with a coded wire wand. Scute removal is also a method to indicate year class. The lateral scutes are numbered from the head in a posterior direction. The number and side of the scute removed designate the year class. PIT tags were specific to each individual fish, and many hatchery fish were marked with a PIT tag when they were stocked into the river. A tag number is retrieved with a BioMark® or Avid® pit tag reader. If no PIT tag was present, a PIT tag was implanted in the base of the dorsal fin and a 1 cm^2 piece of tissue was removed from the caudal fin for genetic analysis. Before each pallid sturgeon was released, voucher pictures were taken from a lateral, ventral, and whole body view of the fish with a datasheet listing capture information (e.g., PIT tag number, location, date, CI score, etc.).

Study Area

Site description

The study area consisted of four sites located within a 455 river kilometer (rkm) reach of the lower Missouri River (LMR) between Waverly, Missouri (rkm 472.2) and Florissant, Missouri (rkm 16.9). Study sites were chosen from the Adaptive Management Strategy for Creation of Shallow Water Habitat operational draft (SHWAM; USACE 2012), which identified four potential reference chutes between Sioux City and St. Louis. These four chutes (Lisbon, Cranberry Bend, Little's Island and Pelican Island) were identified based on habitat complexity metrics and fish use data. However, Jameson chute was selected as a better reference site than Lisbon chute because Lisbon had a highly restrictive control structure potentially reducing access of age-0 sturgeon relative to Jameson (Gosch et al. 2015). Therefore, we sampled Cranberry Bend, Jameson, Pelican Island and Little's Island chutes along with the Missouri River main stem directly adjacent of each chute.

Habitat description

Sampling sites (chute and main channel) were located at Brickhouse Bend (Little's Island), Pelican Bend (Pelican Island), Salt Creek Bend (Jameson), and Hill's Bend (Cranberry Bend), rkm 17.2, 27.0, 344.4, and 452.2, respectively. This stretch of the river has been highly altered by channelization for navigation, and is maintained by rock training structures (i.e. dikes, bank revetment). Each bend consisted of a main channel segment and a respective side channel chute, with each bend varying in composition of secondary habitat diversity (e.g. subterranean woody and herbaceous vegetation, sand bars, snags, and engineered modifications).

1. **Brickhouse Bend:** Little's chute is located on the left descending bank of Brickhouse Bend in St. Charles County, Missouri. The chute has a dike at the upstream entrance, the downstream exit, and one grade-control structure that bisects the chute 1/3 of its length downstream. Substrate is predominantly sand and silts, with several small isolated sand bars along the chute's length. Three wing dikes are located in the main channel, dividing it into four sampling areas, with two of these areas containing sand bars allowing bank side and channel side sampling.
2. **Pelican Bend:** Pelican chute is a long, sinuous side channel located on the right descending bank of Pelican Bend in St. Louis County, Missouri, a few kilometers upstream from Brickhouse Bend. The top entrance of the chute has a series of flow-control structures that completely block flow under low river conditions (gage height < 3.7 m approximately). Substrate is predominantly silt and sand, with braided sand bars distributed throughout the chute. A unique feature to this chute is an island complex situated about halfway down, and several collections of felled trees that contribute to habitat diversity. There are two large sand bars located in the main channel at the top of Pelican Bend (right descending bank), followed by 21 wing dikes along the inside bend and exit of the chute.
3. **Salt Creek Bend:** Jameson chute is located on the right descending bank of Salt Creek Bend in Saline County, Missouri. The chute is characterized by a high

collection of woody debris, with silt being the predominant substrate. The entrance to the side channel contains revetted bank on the left downstream side leading into a grade-control structure. The chute is very sinuous with several small stretches of sand bars along the bends of the side channel. The top of the main channel is composed of a complex system of dikes that contribute to a large sandbar formation. Both bank and channel sides can be sampled at all water levels. Downstream from the sandbar are five dikes on the inside bend and ten dikes on the outside bend. Sampling on the outside bend is restricted to the first 100m of submerged herbaceous vegetation, after this section the depth drops off and revetted embankment begins.

4. **Hill's Creek Bend:** Cranberry chute is located on the right descending bank of Hill's Bend in Saline County, Missouri. Cranberry is a short, non-sinuous chute containing a wing dike protruding diagonally in front of the entrance, and a short section of revetted bank halfway down on the right downstream side. Silt is the predominant substrate, followed by sand, which comprises a short bar at the end of the chute. The majority of sampling on the main channel occurs at a large sand bar composing the majority of the inside bend. No additional dikes are located in the sampling area.

Sampling Gear

Otter trawls

Otter trawls were a standard gear deployed throughout the sampling season. They were deployed from the bow of a custom-designed, jet boat while traveling in a downstream direction. Common sampling locations included open water areas below wing dikes and on channel sand bars. Towing ropes consisted of 13 mm low stretch nylon line attached to each otter door. Duration of sampling runs varied and was dependent on habitat, but ranged from 30 to 100 m. All otter trawls were a custom designed skate balloon with a 2.4 m headrope, 1.2 m mouth height, and overall length of 5.0 m. Paired wooden otter doors were 609 mm (24 in) x 305 mm (12 in).

Data Collection and Analysis

Associated Environmental Data

For every subsample, water depth (m) and temperature (ºC) were recorded. Additional habitat data (water velocity and turbidity measurements) were collected for a minimum of 25% of subsamples within each mesohabitat within each macrohabitat. For example, if two subsamples were conducted in the channel border of the side channel, habitat data were collected at one (i.e. 50%) of the subsamples. The subsamples for which habitat data were collected were randomly selected and determined *a priori*. Generally, habitat data were collected for three subsamples in the side channel and three subsamples for the inside bend, and occasionally one subsample in the outside bend. In addition to the collection of habitat data for randomly selected subsamples, these data were also collected for all subsamples that captured a field identified pallid sturgeon. These habitat data collections were recorded as non-random and were not included toward the 25% minimum of subsamples in that habitat.

Habitat parameters collected included turbidity and water velocity. Turbidity was determined using a Hach 2100 P Turbidimeter and reported as nephelometric turbidity units (NTUs). Water velocities (m/s) were measured at the bottom, 20%, and 80% of the water column depth using a Hach FH950.0 portable velocity meter.

All habitat parameters were collected at the midpoint of the sample, except depth which was collected at the start point, midpoint, and end point for otter trawls (depth averaged between three points). For example, if an otter trawl was hauled 100 m, habitat data were collected 50 m downstream from the starting point (the approximate midpoint of the tow).

Genetic Verification

All unidentified sturgeon and pallid sturgeon captured that did not appear to be previously marked were considered to be unknown fish pending genetic verification. Tissue samples collected at time of capture were subsequently sent to Dr. Edward Heist at Southern Illinois University to genetically determine the species and origin of the fish (i.e., hatchery-stocked or wild). Dr. Heist performed all genetic analysis including species determination and relatedness.

Analyses

All otter trawls were completed using a small-mesh trawl type similar to that described by Ridenour et al. (2011) except the body length of our trawl was 2.4 m compared to 1.8. Therefore, we assumed an effective net fishing width of our trawl to be similar to that reported by Ridenour et al. (2011). Catch for each species was standardized based on trawling effort where the unit of effort was square meters (m^2; product of duration and net fishing width [1.8]). Mean catch-per-unit-effort (CPUE) was calculated per individual species for each site sampled (sampling location) and for macrohabitat (chute and main channel separately). Then, a grand mean from all sites was derived to get an overall average CPUE for each fish species.

Univariate plots of CPUE for age-0 shovelnose sturgeon by water depth category (utilized all subsamples with collected depth data) and bottom velocity categories (subset of subsamples with measured water velocities) were constructed using SigmaPlot 12.0. Bivariate plots of CPUE for age-0 shovelnose sturgeon by average water depth and bottom velocity were constructed using Statistica 12.0 from a subset of subsamples because water velocities were not collected for every subsample, but only from a minimum of 25% of subsamples within each macro-mesohabitat combination.

Habitat use was analyzed using Friedman's chi-square (χ^2) goodness of fit test (Zar 1999). Chi-square statistics were calculated as:

$$\chi^2 = \sum (O - E^2 / E),$$

where *O* was the number of fish observed and *E* was the number of fish expected if the number of fish captured in each habitat was proportional to the amount of effort expended there. All tests were conducted at the 0.05 level of significance.

Species richness, Pielou's eveness index, and the effective number of species were analyzed for fish community comparisons between each sampling sites and for macrohabitat. Species richness was calculated as the total number of species present *S*; Pielou's evenness index:

$$J' = \frac{H'}{H'_{max}}$$

where H' is derived from Shannon's diversity index:

$$H' = -\sum_{i=1}^{S} P_i ln P_i$$

where p_i is the proportion of the total count arising from the *i*th species and H'_{max} is the maximum possible value of Shannon diversity if all species were equally abundant:

$$H'_{max} = -\sum_{i=1}^{S} \frac{1}{S} ln \frac{1}{S} = lnS$$

Effective number of species is derived by taking the exponential of *H'*. Comparisons of species richness, evenness, and effective number of species were compared using analysis of variance (ANOVA) across sampling sites and macrohabitat.

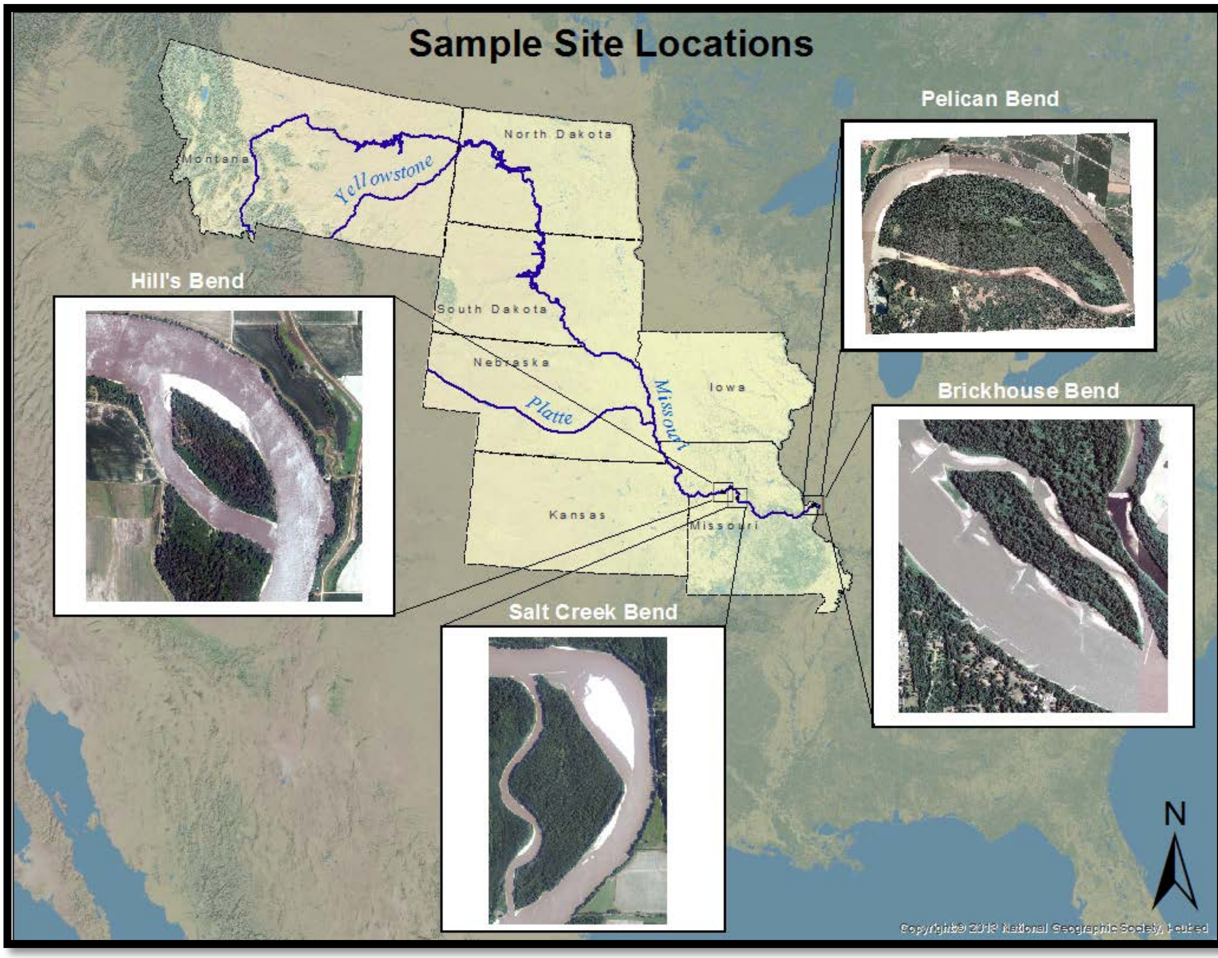

Figure 1. Map of the sample reaches located along the lower 430 rkms of the Missouri River.

Results

Effort

The 2014 sampling effort began on 22 May 2014 and continued through 30 October 2014. During the sampling period, 1,323 otter trawls were completed resulting in 121,719 m^2 of river sampled (Table 1). Depths and velocities ranged from 0.37-7.40 m and 0.22-0.72 m/s for main channels, and 0.30-5.93 m and 0.53-0.76 m/s for chutes, respectively. Of the sampled area, macrohabitats were equally sampled; 61769 m^2 of river were trawled in side channels and 59951 m^2 in the main channel (51% and 49% of total river covered, respectively). Targeted mesohabitats were sampled proportionally to habitat available, with 25,593 m^2 (21% of total) of sandbars and 96,126 m^2 (79% of total) of channel border covered. Bends were not sampled equally, as trawling was driven by the size, abundance of snags, presence of training structures, and the accessibility of the side channels. River area covered was highest in Hill's bend (39,501 m^2; 32% total), and decreased with Salt Creek bend (35,041 m^2; 29%), Brickhouse bend (28,782 m^2; 24%), and Pelican bend (18,395 m^2; 15%).

The total sampling effort resulted in the collection of 22,943 individuals representing 49 species and 13 unidentified families or genera (see Missouri Fish Community). The otter trawl generally recruited small-bodied fish that ranged in length from 1 – 1671 mm, but averaged at 46 mm.

Table 1. Total number of otter trawl deployments by month and by macrohabitat during the 2014 sampling season.

Site	Macrohabitat[a]	Month						Total
		MAY	JUN	JUL	AUG	SEP	OCT	
Brickhouse Bend	SCCL	10	40	20	30	30	42	172
	ISB	10	40	20	30	30	40	170
Pelican Bend	SCCL	0	20	30	10	10	20	90
	ISB	0	20	30	10	10	20	90
Salt Creek Bend	SCCL	10	40	40	40	20	40	190
	ISB	10	40	40	40	20	42	192
Hill's Bend	SCCL	19	40	40	40	30	42	211
	ISB	20	40	40	40	30	38	208
Total		79	280	260	240	180	284	**1323**

[a] Habitat abbreviations and definitions presented in Appendix B.

Pallid Sturgeon

Four pallid sturgeon were collected during the 2014 sampling period and ranged in size from 24 – 143 mm in fork length (Figure 2). Two individuals were hatchery-reared pallid sturgeon and identified in the field (Table 2). Stocking and recapture information is listed in Table 2. The other two were classified as small age-0 sturgeon and later identified as pallid sturgeon by Dr. Heist with New Hybrid scores of 0.997. The two small age-0 pallid sturgeon were highly related with a relatedness score of 0.64 indicating the two individuals were full siblings. The parents of the small age-0 pallid sturgeon assigned to the Central Lowlands or Interior Highlands Management Unit, therefore they were not offspring of any hatchery stocked fish from the Great Plains Management Unit. Therefore, the parents were likely wild pallid sturgeon or could have been from the 1992 or 1997 year classes. Ages of the two small age-0 sturgeon were estimated using growth models from Snyder (2002) (Table 3). CPUE for pallid sturgeon ranged from 0 – 0.007 fish/100m^2 (Figure 3).

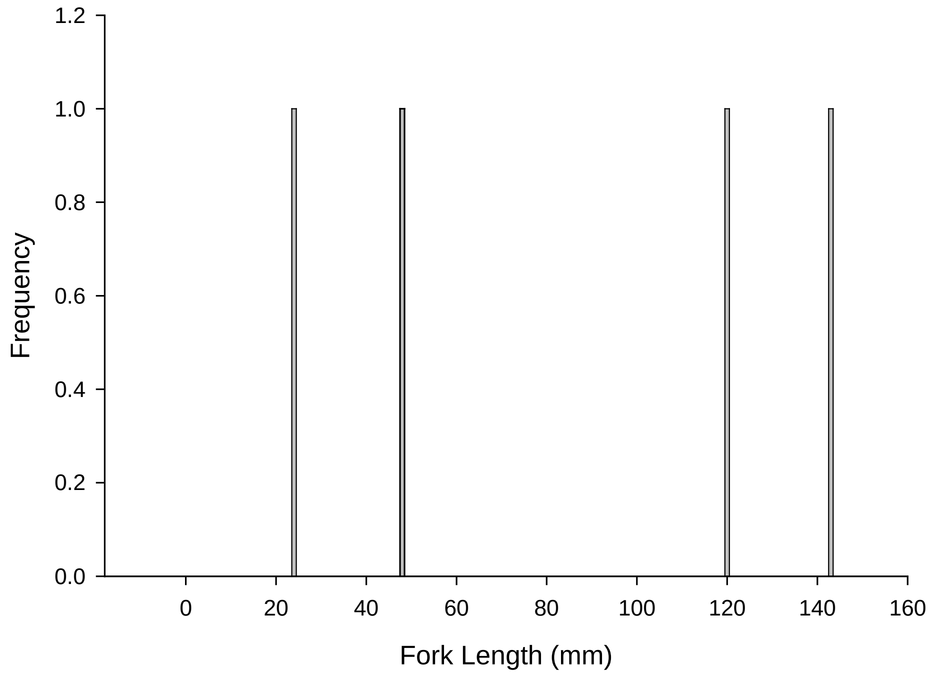

Figure 2. Length frequency distribution of pallid sturgeon captured during 2014.

Table 2. Stocking date and location, recapture date and location, and fork length of hatchery-reared pallid sturgeon captured during 2014.

Year Class	Stocking Data		Recapture Data		
	Date	Location (rkm)	Date	Location (rkm)	Length (mm)
2014	9/18/2014	90.6	10/7/2014	16.1	143
2014	9/18/2014	422.9	10/9/2014	344.4	120

Table 3. Capture date, location, fork length, and estimated hatch date, age, and growth of small age-0 pallid sturgeon (≤50 mm) captured during 2014. Ages were estimated by using growth models reported by Snyder (2002).

Capture Data			Estimated Age Data		
Date	Location (rm)	Length (mm)	Hatch Date	Age (d)	Growth (mm/d)
6/11/2014	15.4	24	5/30/2014	12	2
6/23/2014	15.4	48	5/19/2014	35	1.4

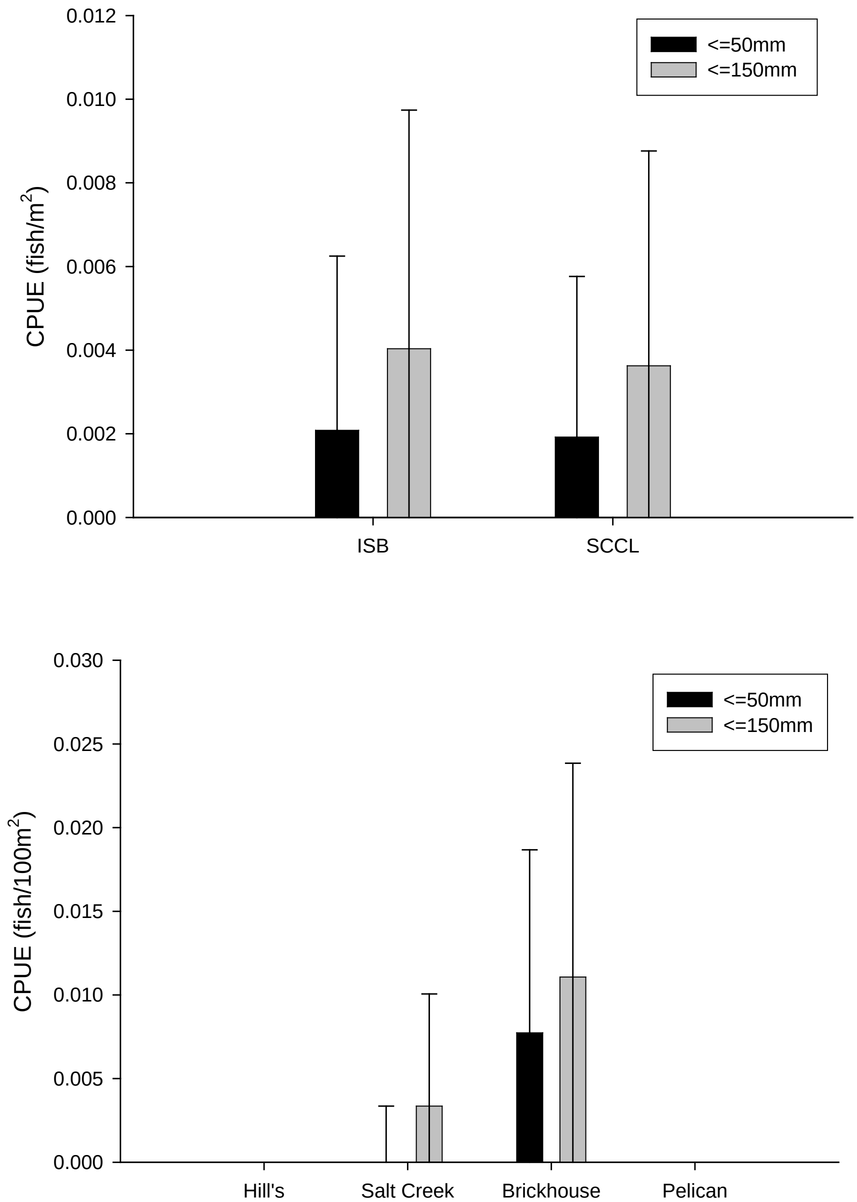

Figure 3. Mean otter trawl catch per unit effort (+/- 2 SE) of small (≤50 mm; black bars) and all (≤150 mm; gray bars) age-0 pallid sturgeon during 2014 by macrohabitat (top panel) and by site (bottom panel). Habitat abbreviations and definitions presented in Appendix B.

Habitat Associations

The two age-0 hatchery-reared pallid sturgeon were captured at average depths of 2.3 and 3.6 m, bottom velocity of 0.61 and 0.45 m/s, surface water temperature of 12.8 and 10.1 °C, and turbidity of 505 and 476 NTU. The two naturally produced, small age-0 pallid sturgeon were captured at average depths of 4.5 and 3.2 m and surface water temperature of 23.5 and 26.8 °C. No velocities or turbidities were recorded during the trawls that captured the two small age-0 pallid sturgeon because the subsamples were not selected randomly for taking habitat measurements and the age-0 sturgeon were not identifiable as pallid sturgeon in the field. Capture locations for small and large age-0 pallid sturgeon were equally distributed among macrohabitats, but more individuals were captured at Brickhouse bend (n = 3), including both age-0 pallid sturgeon (Figures 3, 4; Tables 4, 5). CPUE was highest in the mainstem channel border macro-mesohabitat (0.007 fish/m^2) (Figure 3).

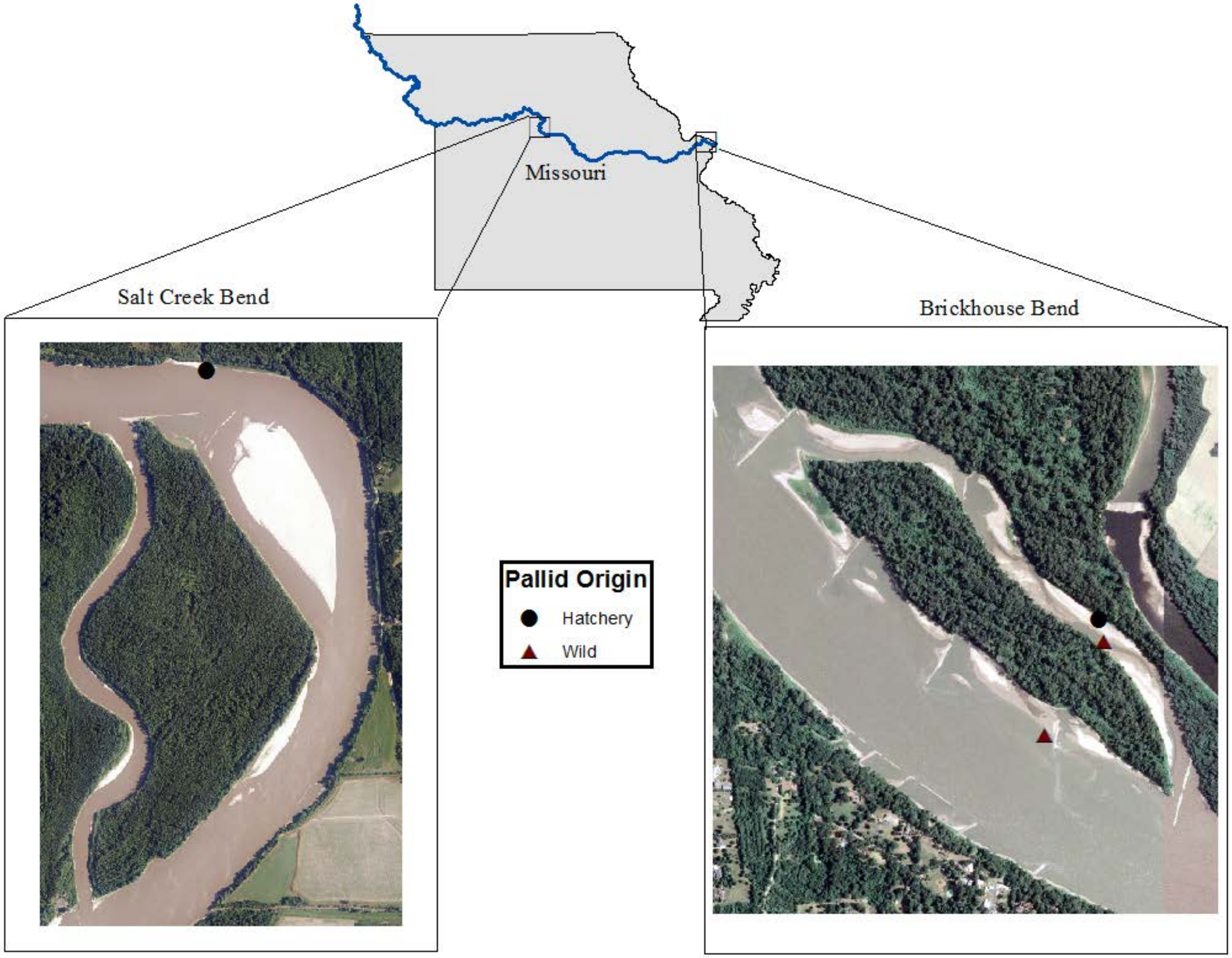

Figure 4. Map of captured pallid sturgeon locations.

Table 4. Total number of small age-0 pallid sturgeon (≤50 mm) captured by month and by macrohabitat during the 2014 sampling season. Habitat abbreviations and definitions presented in Appendix B.

Site	Macrohabitat[a]	Month					
		MAY	JUN	JUL	AUG	SEP	OCT
Brickhouse Bend	SCCL		1				
	ISB		1				
Pelican Bend	SCCL						
	ISB						
Salt Creek Bend	SCCL						
	ISB						
Hill's Bend	SCCL						
	ISB						

Table 5. Total number of large age-0 pallid sturgeon (51-150 mm) captured by month and by macrohabitat during the 2014 sampling season. Habitat abbreviations and definitions presented in Appendix B.

Site	Macrohabitat[a]	Month					
		MAY	JUN	JUL	AUG	SEP	OCT
Brickhouse Bend	SCCL						1
	ISB						
Pelican Bend	SCCL						
	ISB						
Salt Creek Bend	SCCL						
	ISB						1
Hill's Bend	SCCL						
	ISB						

Targeted Native River Species

Shovelnose Sturgeon

A total of 767 shovelnose sturgeon were collected during the 2014 sampling period and ranged in size from 10 – 1671 mm (average 91 mm) in fork length (Figure 5). The majority were small (N=542; ≤50 mm) and large age-0 sturgeon (N=104; 51-110 mm) (Table 6 and 7, respectively). Ages were estimated for all shovelnose sturgeon ≤ 110 mm using models from Snyder (2002). Age-0 sturgeon ages ranged from 1- 110 days post hatch (Figure 6). Estimated hatch dates for shovelnose sturgeon revealed four distinguishable cohorts hatching approximately late-May, mid-June, early July, and mid-August (Figure 6). Catch curve analysis of shovelnose sturgeon ages displayed that the trawl did not recruit individuals less than 7 days post hatch (Figure 7). Overall, mean otter trawl CPUE of age-0 shovelnose sturgeon was 0.75 fish/100m^2 (range of 0 – 55.5 fish/100m^2) and was highest overall in inside bend macrohabitat within Salt Creek Bend (Figure 8).

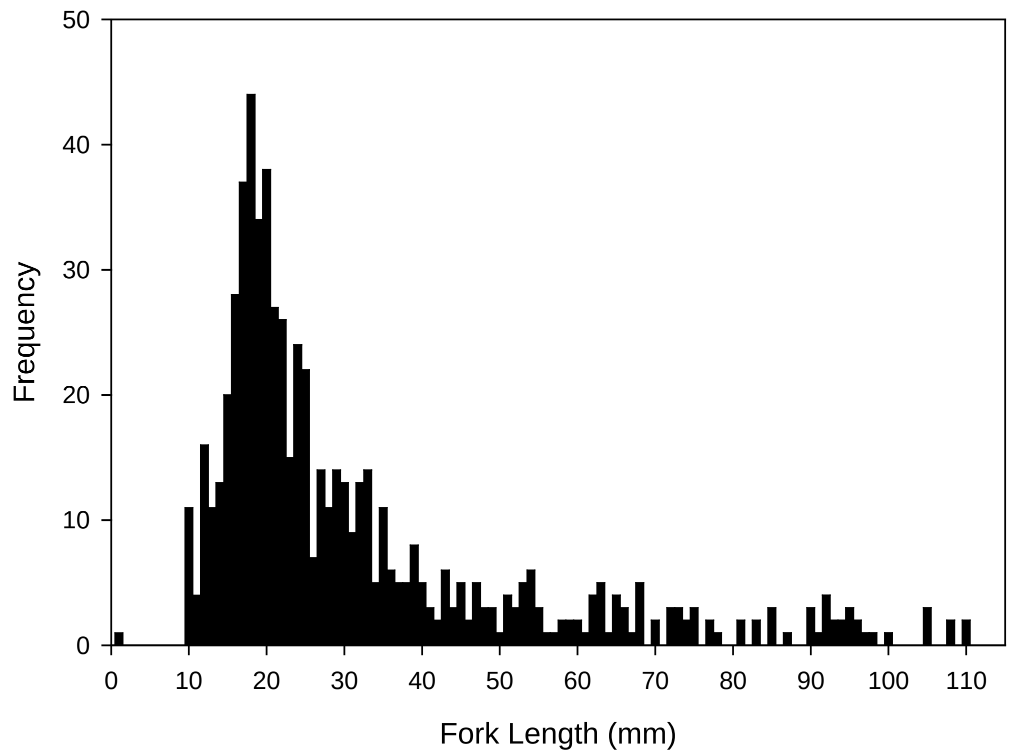

Figure 5. Length frequency distribution of age-0 shovelnose sturgeon ≤110 mm captured during 2014.

Table 6. Total number of small age-0 shovelnose sturgeon (≤50 mm) captured by month and by macrohabitat during the 2014 sampling season. Habitat abbreviations and definitions presented in Appendix B.

Site	Macrohabitat[a]	Month						Total
		MAY	JUN	JUL	AUG	SEP	OCT	
Brickhouse Bend	SCCL	4	8	18	4	21	0	55
	ISB	5	50	21	2	12	1	91
Pelican Bend	SCCL		5	2	0	2	0	9
	ISB		19	11	0	1	0	31
Salt Creek Bend	SCCL	1	11	27	68	4	3	114
	ISB	2	96	10	36	13	2	159
Hill's Bend	SCCL	0	5	3	17	4	0	29
	ISB	10	12	21	6	5	0	54
Total		22	206	113	133	62	6	**542**

Table 7. Total number of age-0 shovelnose sturgeon (≤110 mm) captured by month and by macrohabitat during the 2014 sampling season. Habitat abbreviations and definitions presented in Appendix B.

Site	Macrohabitat[a]	Month						Total
		MAY	JUN	JUL	AUG	SEP	OCT	
Brickhouse Bend	SCCL	4	9	23	5	26	3	70
	ISB	5	52	22	8	15	2	104
Pelican Bend	SCCL		5	4	0	2	0	11
	ISB		19	20	0	2	2	43
Salt Creek Bend	SCCL	1	11	27	70	7	5	121
	ISB	2	96	13	39	17	5	172
Hill's Bend	SCCL	0	5	6	23	10	3	47
	ISB	10	12	29	11	10	6	78
Total		22	209	144	156	89	26	**646**

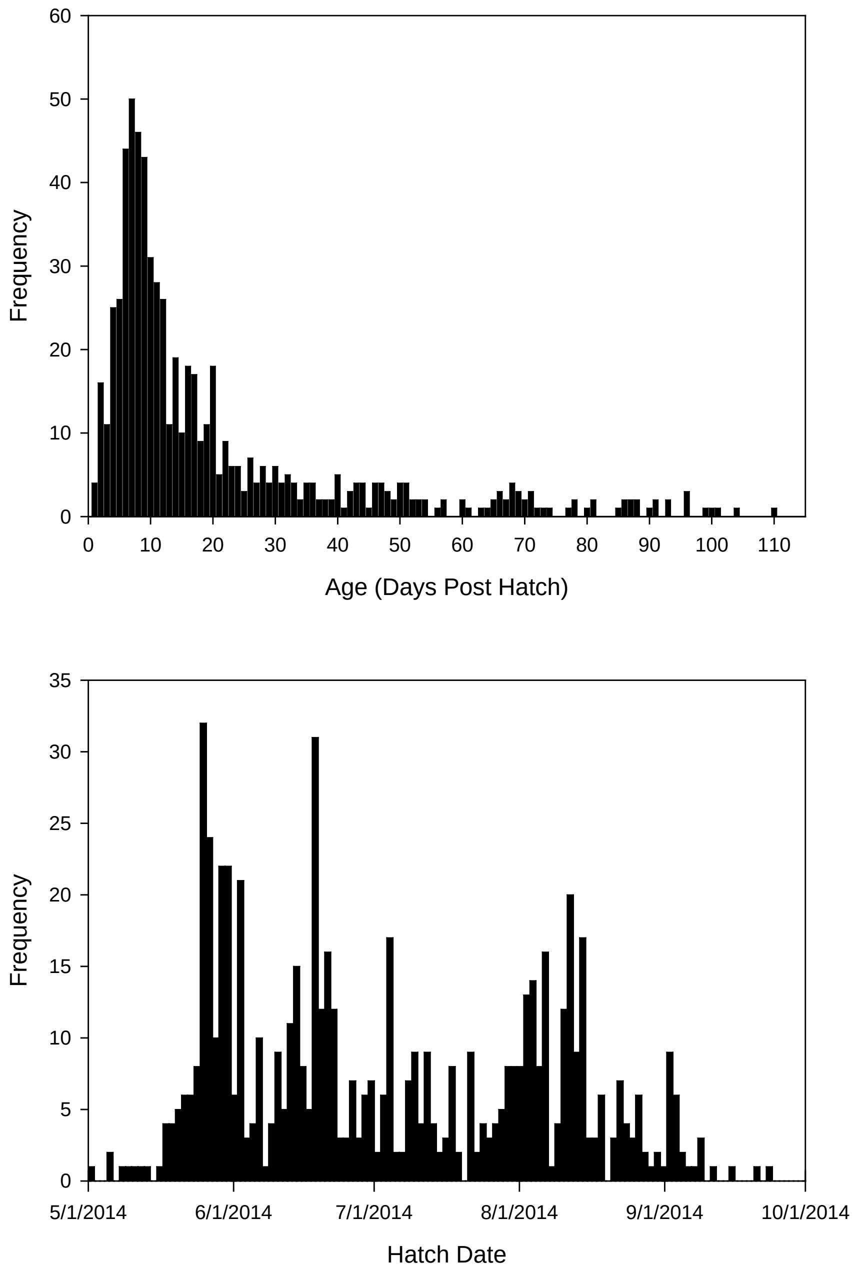

Figure 6. Age frequency distribution (top panel) and estimated hatch dates (bottom panel) of shovelnose sturgeon ≤110 mm captured during 2014. Ages were estimated by using growth models reported by Snyder (2002).

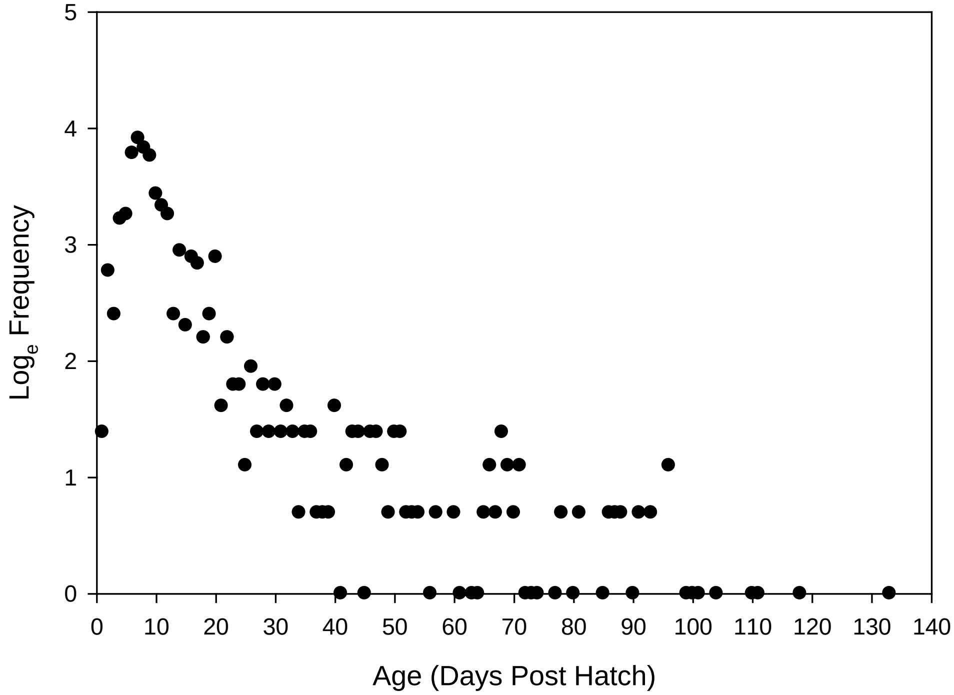

Figure 7. Catch curve of age-0 shovelnose sturgeon. Ages were estimated by using growth models reported by Snyder (2002).

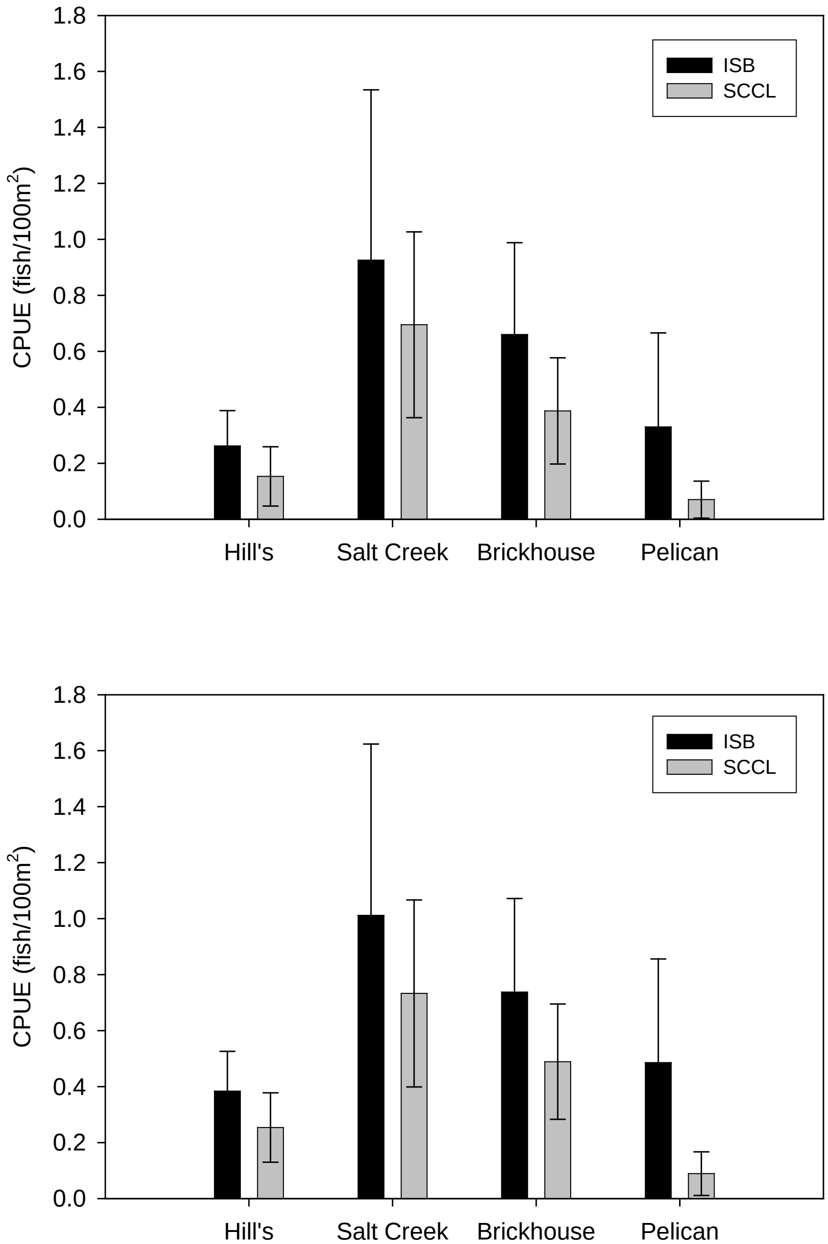

Figure 8. Mean otter trawl catch per unit effort (+/- 2 SE) of small (≤50 mm; top panel) and all age-0 (≤110 mm; bottom panel) shovelnose sturgeon during 2014 by macrohabitat and site. Habitat abbreviations and definitions presented in Appendix B.

Habitat Associations

Age-0 shovelnose sturgeon (N=646) were captured at an average depth of 2.3 m (0.56 – 5.6 m), an average bottom velocity of 0.49 m/s (0.01 – 1.8 m/s), an average temperature of 26.2 °C (9 – 30.8 °C), and an average turbidity of 478 NTU (34 – 2460 NTU). Bottom velocity and turbidity was not measured during all otter trawl deployments, but only for a subset (see Data Collection and Analysis section). The trawl with the highest CPUE of age-0 shovelnose sturgeon (55.5 fish/100m^2) had an average depth of 3.2 m and a bottom velocity of 0.58 m/s. Overall, age-0 sturgeon were captured in higher densities (e.g. CPUE) in depths near 2 or 3 m and bottom velocities near 0.25-0.5 m/s (Figures 9 and 10). CPUE was also high in the bottom velocity category of 1.75+ m/s; however, there was only one otter trawl deployment in this category (Figure 10). Catch rates of small age-0 shovelnose sturgeon were significantly different between macrohabitat and sample sites ($X^2(3, N = 1323) = 26.22$, $p = 0.0001$). Similarly, catch rates of large age-0 shovelnose sturgeon were significantly different between macrohabitats and sample sites ($X^2(3, N = 1323) = 17.75$, $p = 0.0005$). The main channel had significantly higher CPUE of small and large age-0 shovelnose sturgeon (0.57 fish/100m^2 and 0.67 fish/100m^2, respectively) than the adjacent side channels (0.36 fish/100m^2 and 0.43 fish/100m^2, respectively) (Figure 8). Salt Creek bend had significantly higher catch rates of small (0.81 fish/100m^2) and large age-0 shovelnose sturgeon (0.87 fish/100m^2) than all other sites except Brickhouse bend (Figure 8). Observationally, the main channel-inside bend of Salt Creek bend (small: 0.92 fish/100m; large: 1.01 fish/100m^2) had higher catch rates than all other sites and macrohabitats for age-0 shovelnose sturgeon (Figure 8).

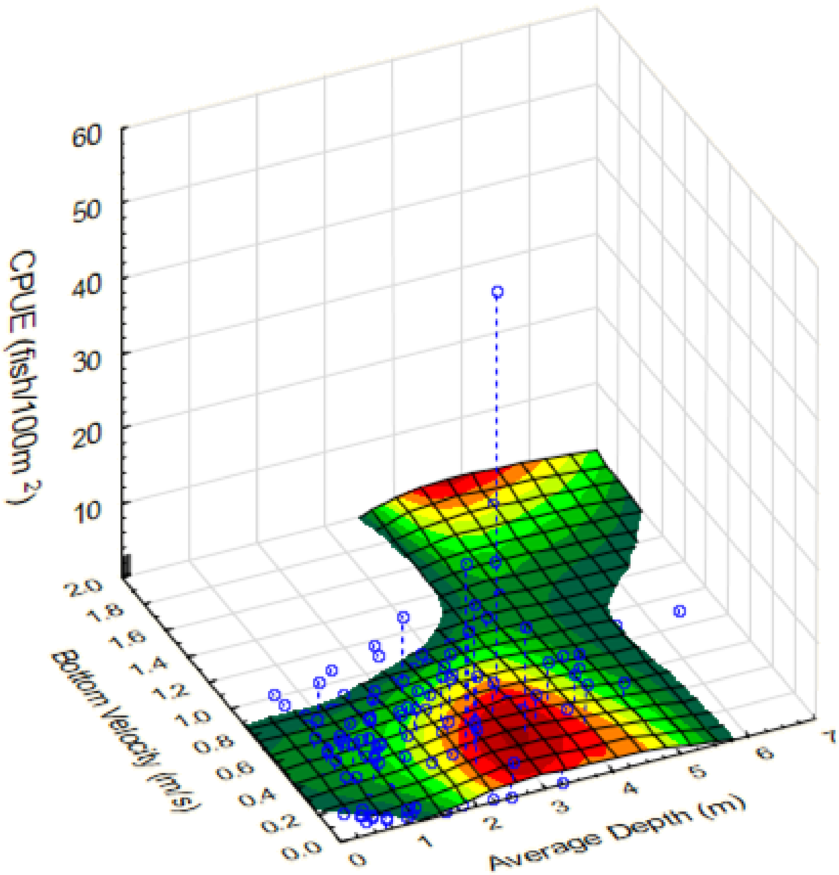

Figure 9. Catch per unit effort (CPUE) of age-0 shovelnose sturgeon (blue circles) by average water depth and bottom water velocity (data from subsamples with both depth and velocities measured). Contours represent distance weighted least squares.

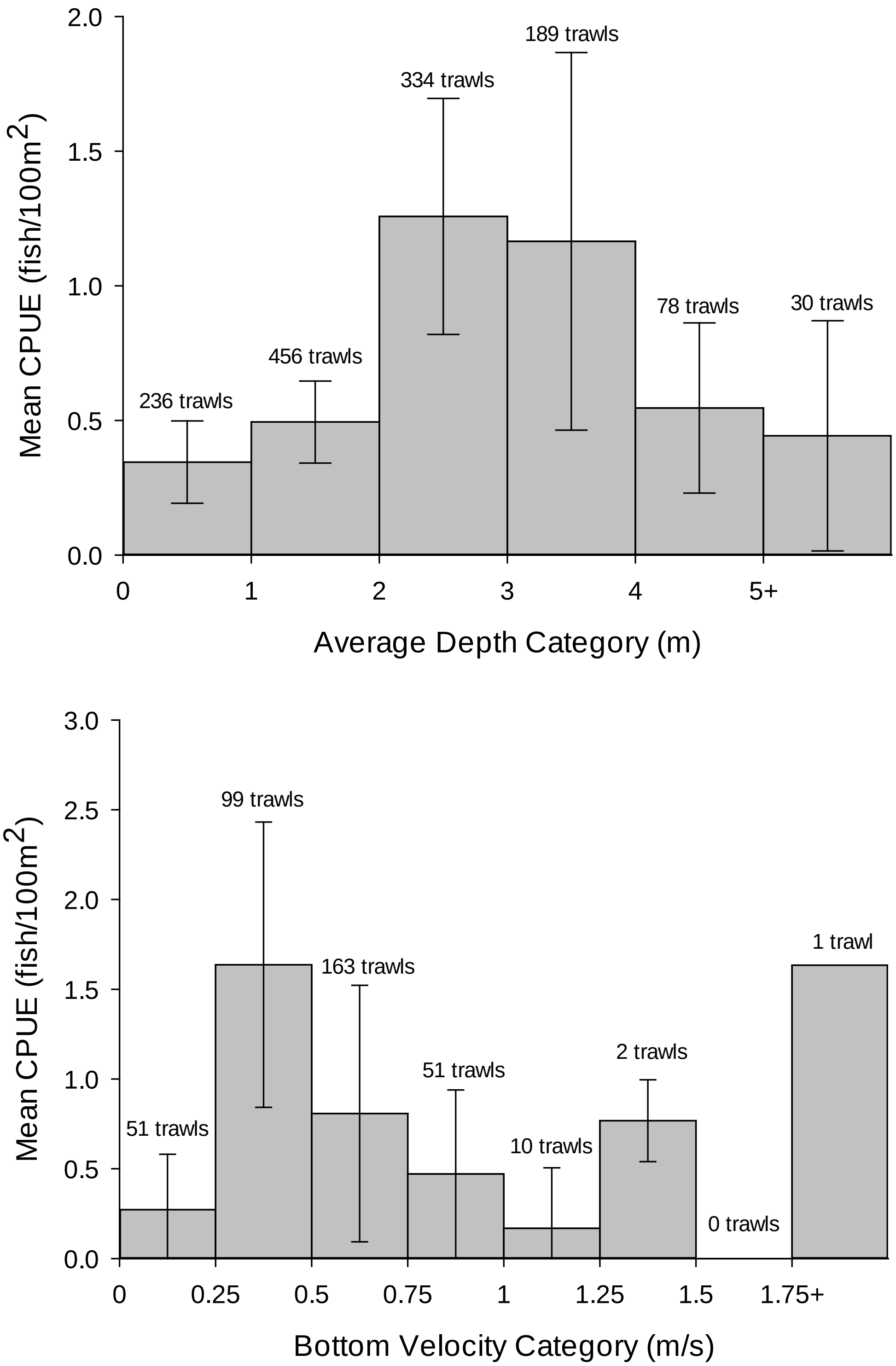

Figure 10. Mean catch per unit effort (+/- 2 SE) of age-0 shovelnose sturgeon by average water depth category (top panel; all trawl samples used N=1323) and by bottom water velocity category (bottom panel; velocity only measured on subset of trawls N=377).

Sturgeon Chub

A total of 661 sturgeon chub were collected during the 2014 sampling period and ranged in size from 11 – 87 mm (average 39 mm) in total length (Figure 11). CPUE for sturgeon chub ranged from 0 – 68.3 fish/100m^2 (Figure 12).

Sturgeon chub were captured at an average depth of 1.4 m (0.3 – 6.5 m), an average bottom velocity of 0.49 m/s (0.01 – 1.15 m/s), an average temperature of 25.5 °C (8 – 30.7 °C), and an average turbidity of 230 NTU (44 – 2044 NTU). Catch rates of sturgeon chub were not significantly different between macrohabitats (Figure 12). There was a significant difference in CPUE between sample sites ($X^2(3, N = 1323) = 26.38$, $p < 0.0001$) as Salt Creek bend (1.13 fish/100m^2) had the highest catch rates compared to all other sites (Figure 12).

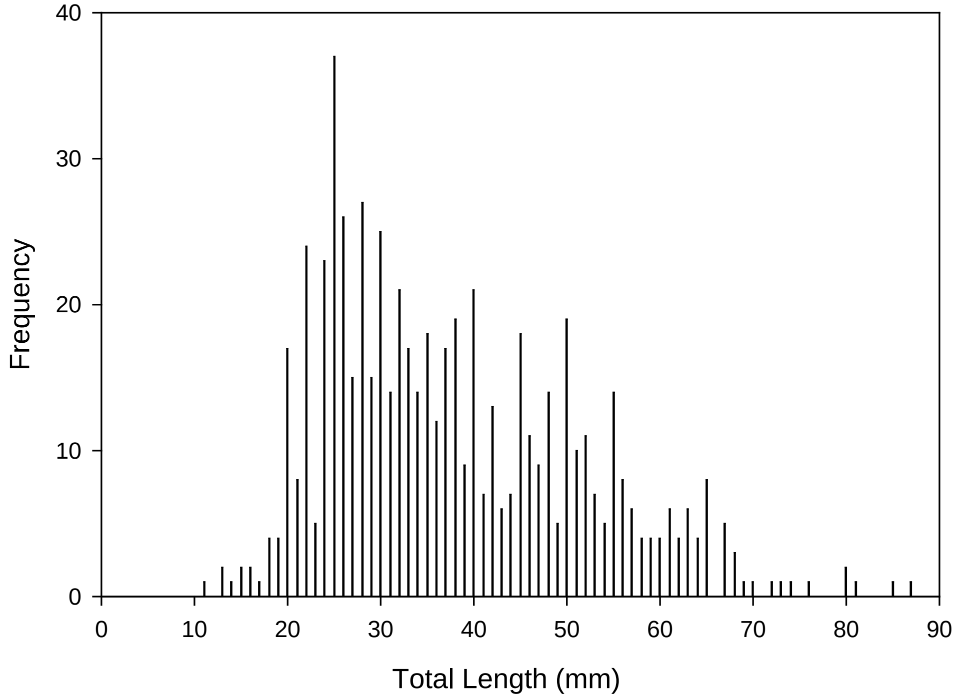

Figure 11. Length frequency of sturgeon chub during 2014.

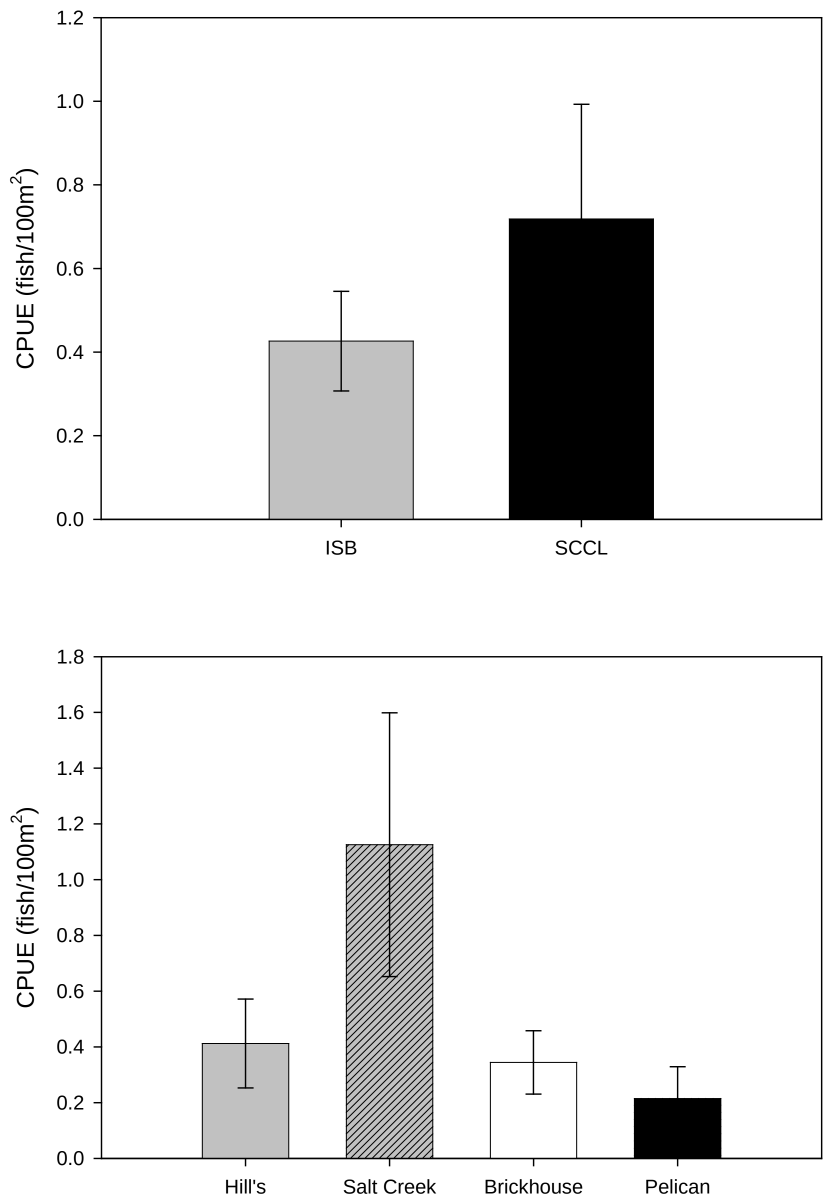

Figure 12. Mean otter trawl catch per unit effort (+/- 2 SE) of sturgeon chub during 2014 by macrohabitat (top panel) and by site (bottom panel).

Sicklefin Chub

A total of 1,530 sicklefin chub were collected during the 2014 sampling period and ranged in size from 3 – 107 mm (average 41 mm) in total length (Figure 13). CPUE for sicklefin chub ranged from 0 – 72 fish/100m^2 (Figure 14).

Sicklefin chub were captured at an average depth of 1.7 m (0.3 – 9.2 m), an average bottom velocity of 0.38 m/s (0.01 – 1.8 m/s), an average temperature of 24.7 °C (8 – 30.8 °C), and an average turbidity of 263 NTU (35 – 2070 NTU). Catch rates of sicklefin chub were significantly different between macrohabitats and sample sites ($X^2(3, N = 1323) = 5.77$, $p = 0.0163$) (Figure 14). Side channels (1.62 fish/100m^2) had significantly higher CPUE of sicklefin chub than the adjacent main channel (1.05 fish/100m^2) (Figure 14). Brickhouse bend (2.17 fish/100m^2) had significantly higher catch rates compared to Hill's and Pelican bend but not Salt Creek bend (Figure 14).

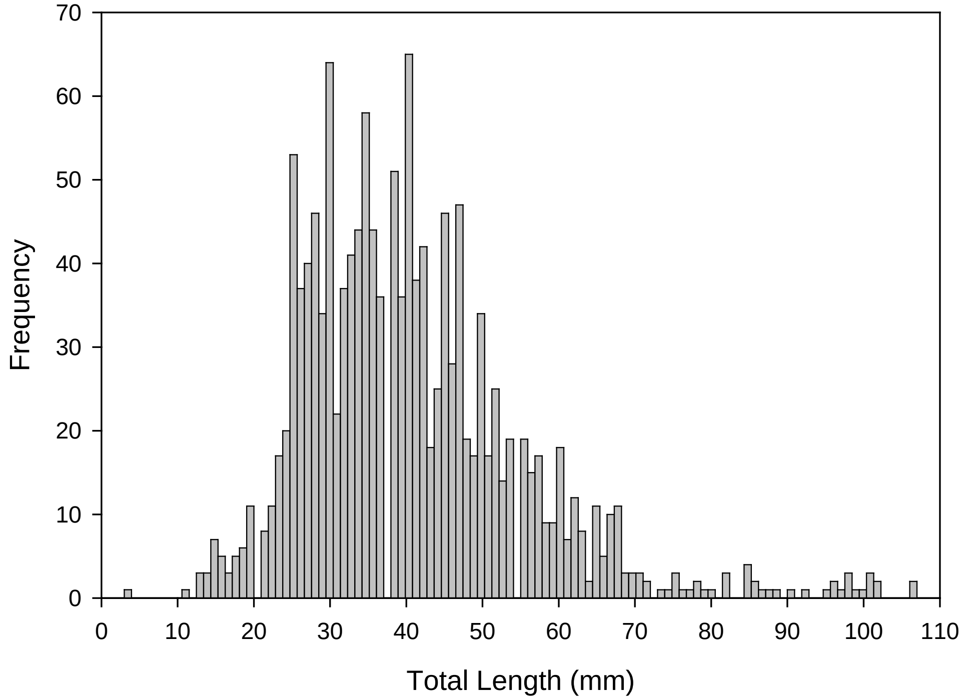

Figure 13. Length frequency of sicklefin chub during 2014.

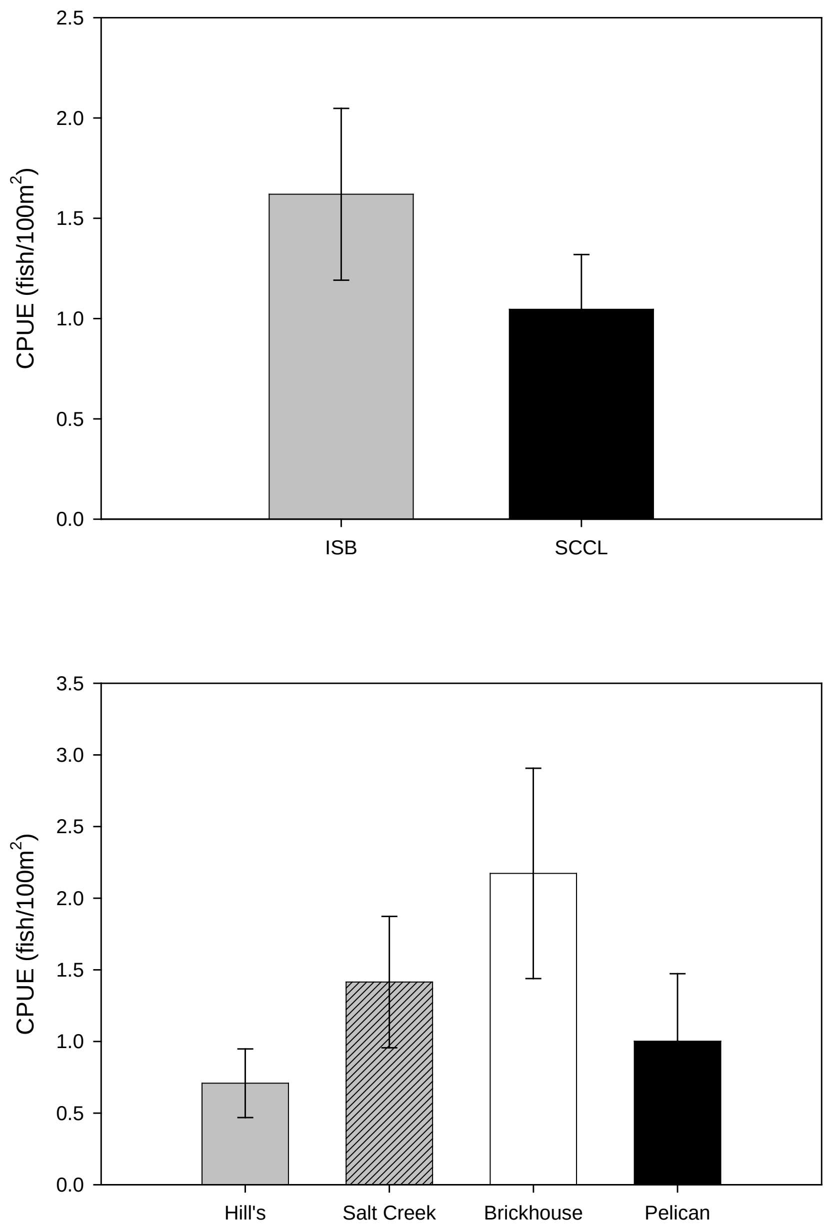

Figure 14. Mean otter trawl catch per unit effort (+/- 2 SE) of sicklefin during 2014 by macrohabitat (top panel) and by site (bottom panel).

Shoal Chub

A total of 5,016 shoal chub were collected during the 2014 sampling period and ranged in size from 14 – 93 mm (average 38 mm) in total length (Figure 15). CPUE for shoal chub ranged from 0 – 181 fish/100m^2 (Figure 16).

Shoal chub were captured at an average depth of 1.7 m (0.2 – 6.7 m), an average bottom velocity of 0.43 m/s (0.01 – 1.27 m/s), an average temperature of 24.3 °C (8 – 30.7 °C), and an average turbidity of 389 NTU (34 – 2460 NTU). Catch rates of shoal chub were not significantly different between macrohabitats (Figure 16). There was a significant difference in CPUE between sample sites ($X^2(3, N = 1323) = 76.65$, $p < 0.0001$) as Little's bend (6.35 fish/100m^2) had the highest catch rates compared to Cranberry and Pelican bends but not Salt Creek bend (Figure 16).

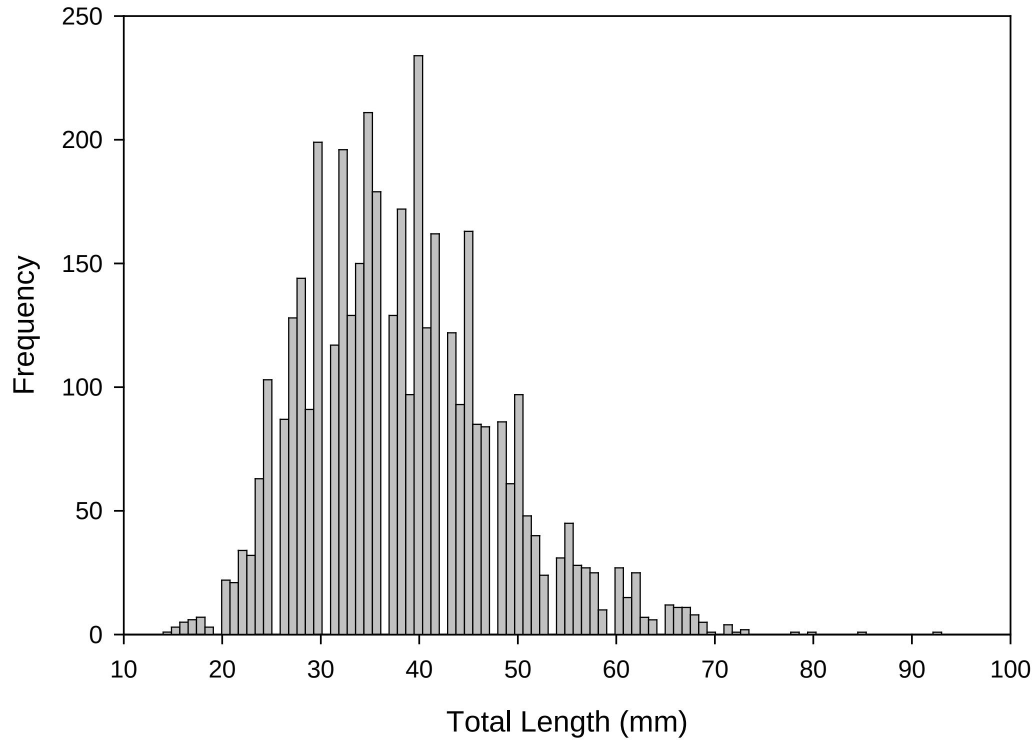

Figure 15. Length frequency of shoal chub during 2014.

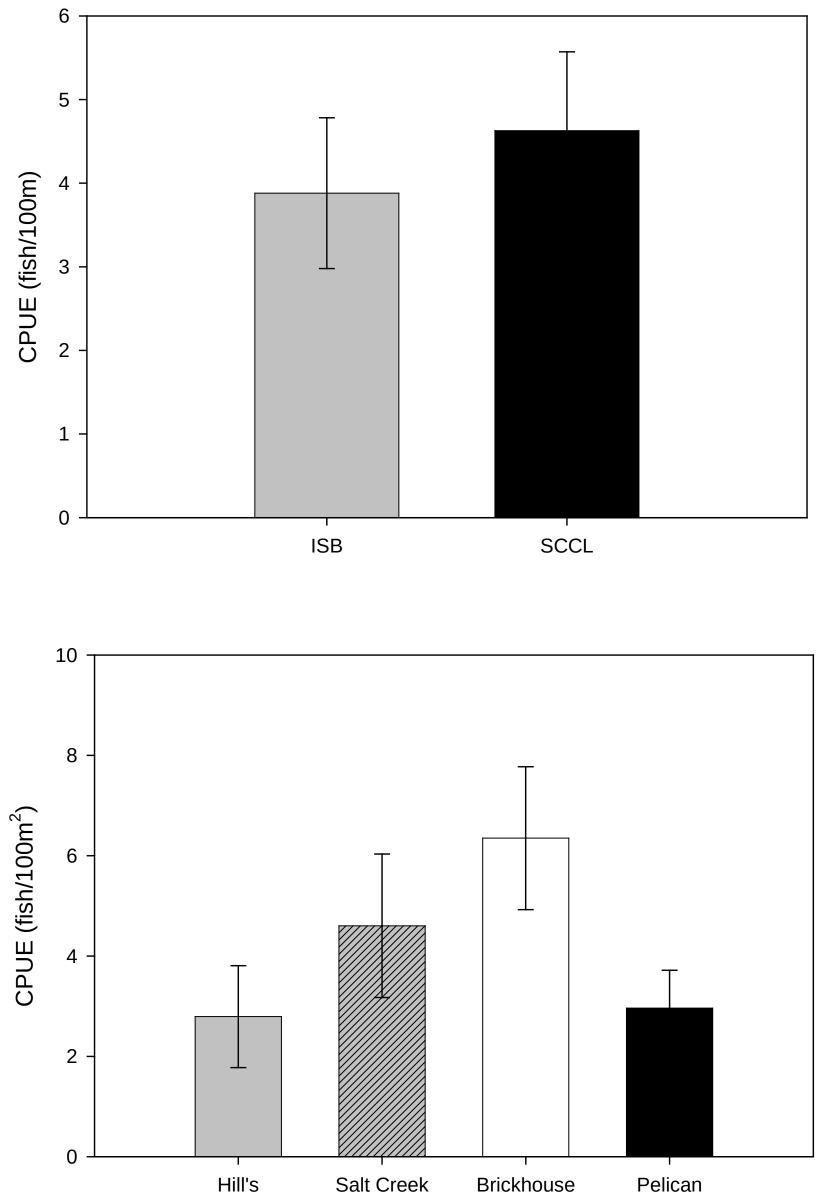

Figure 16. Mean otter trawl catch per unit effort (+/- 2 SE) of shoal chub during 2014 by macrohabitat (top panel) and by site (bottom panel).

Sand Shiner

A total of 111 sand shiners were collected during the 2014 sampling period and ranged in size from 20 – 70 mm (average 42 mm) in total length (Figure 17). CPUE for sand shiner ranged from 0 – 27.3 fish/100m^2 (Figure 18).

Sand shiners were captured at an average depth of 0.9 m (0.4 – 2.6 m), an average bottom velocity of 0.42 m/s (0.09 – 0.7 m/s), an average temperature of 27 °C (15.8 – 30.3 °C), and an average turbidity of 156 NTU (52 – 2000 NTU). Catch rates of sand shiners were significantly different between macrohabitats and sample sites ($X^2(3, N = 1323) = 4.5, p < 0.03$) (Figure 18). Side channels (0.16 fish/100m^2) had higher catch rates compared to the main channel (Figure 18). Brickhouse bend (0.22 fish/100m^2) had higher catch rates than all other sample sites (Figure 18).

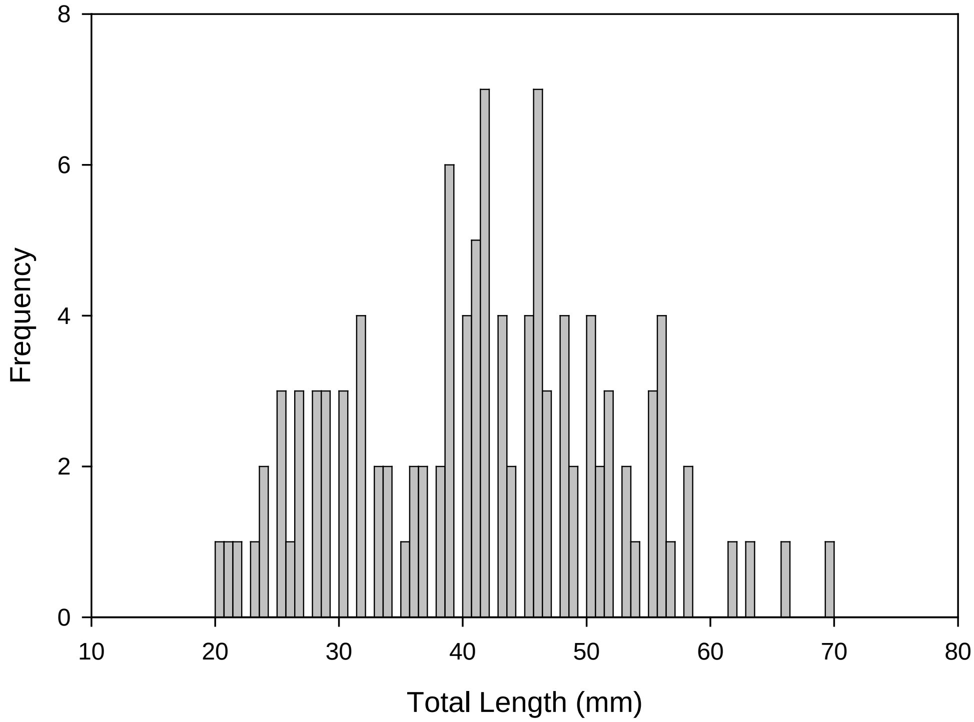

Figure 17. Length frequency of sand shiner during 2014.

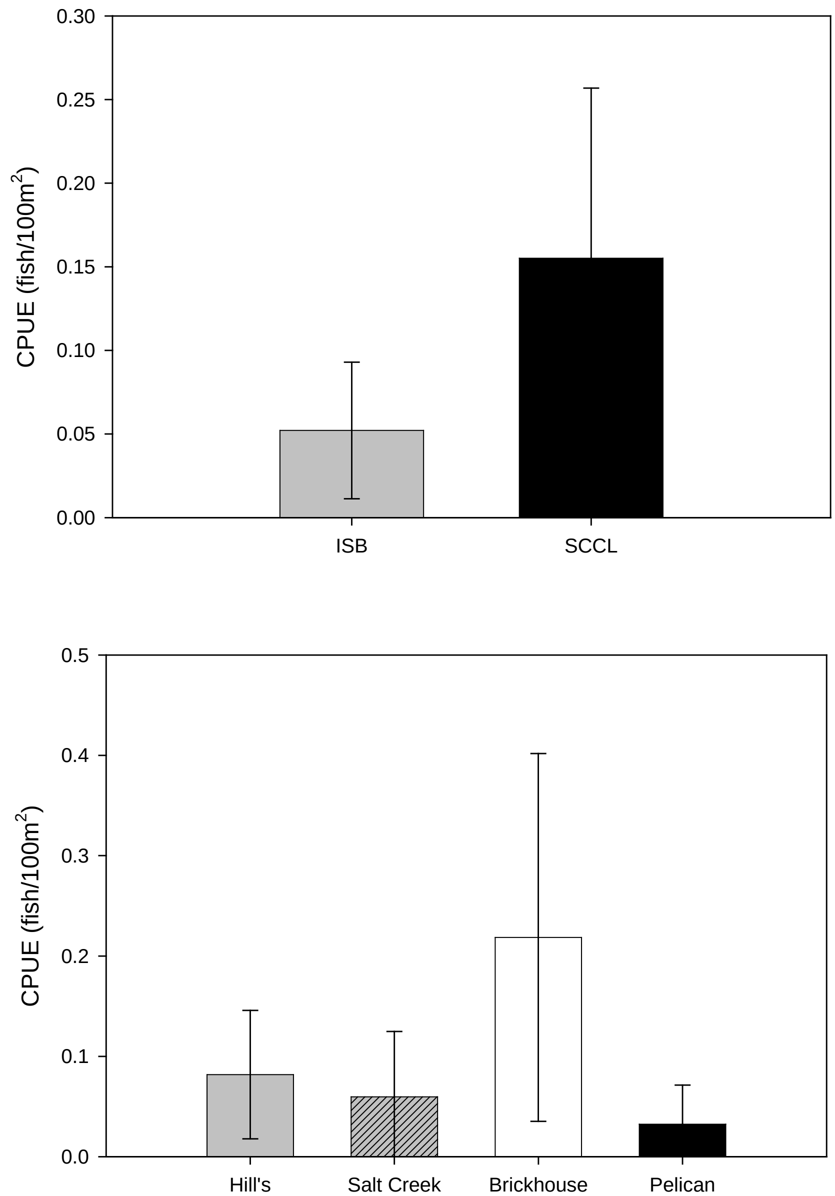

Figure 18. Mean otter trawl catch per unit effort (+/- 2 SE) of sand shiner during 2014 by macrohabitat (top panel) and by site (bottom panel).

***Hybognathus* spp.**

Only one Mississippi silvery minnow (*Hybognathus nuchalis*) was collected during the 2014 sampling period and was 49 mm in total length. CPUE for Mississippi silvery minnow ranged from 0 – 0.98 fish/100m^2.

There were no random habitat parameter samples taken at the time of capture of the Mississippi silvery minnow, so turbidity and velocity measurements were not recorded. The Mississippi silvery minnow was captured in a channel border of a side channel at Brickhouse Bend where the water depth was 1.3 m and the temperature was 24 °C.

Blue Sucker

A total of 22 blue suckers were collected during the 2014 sampling period and ranged in size from 156 – 734 mm (average 497 mm) in total length (Figure 19). CPUE for blue suckers ranged from 0 – 2.6 fish/100m^2 (Figure 20).

Blue suckers were captured at an average depth of 2.2 m (0.5 – 5 m), an average bottom velocity of 0.53 m/s (0.24 – 0.82 m/s), an average temperature of 25.1 °C (11 – 29.8 °C), and an average turbidity of 242 NTU (44 – 864 NTU). Catch rates of blue suckers were not significantly different between macrohabitats or sample sites (Figure 20).

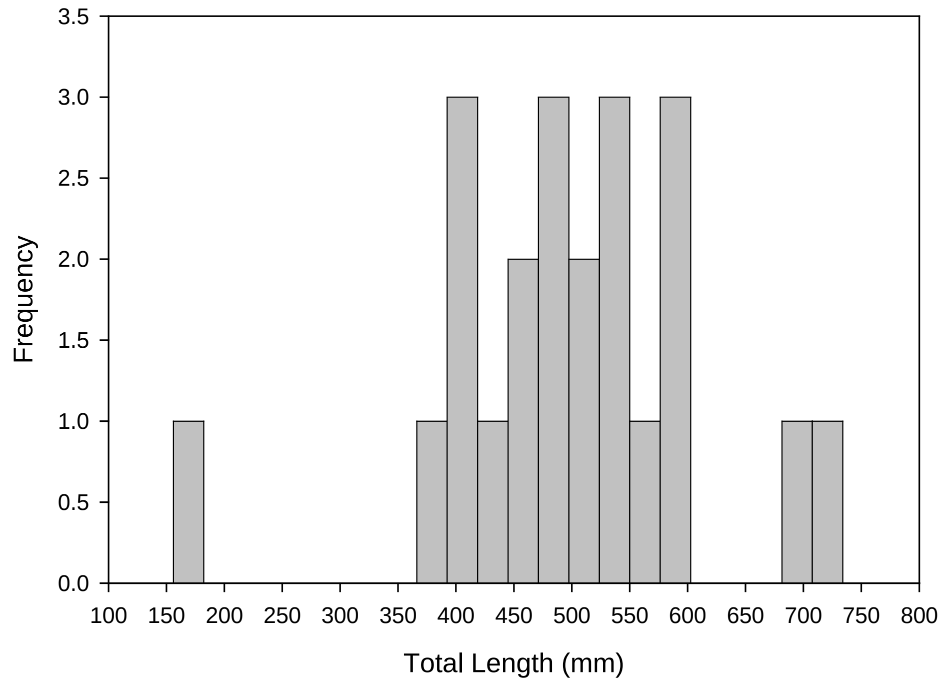

Figure 19. Length frequency of blue sucker during 2014.

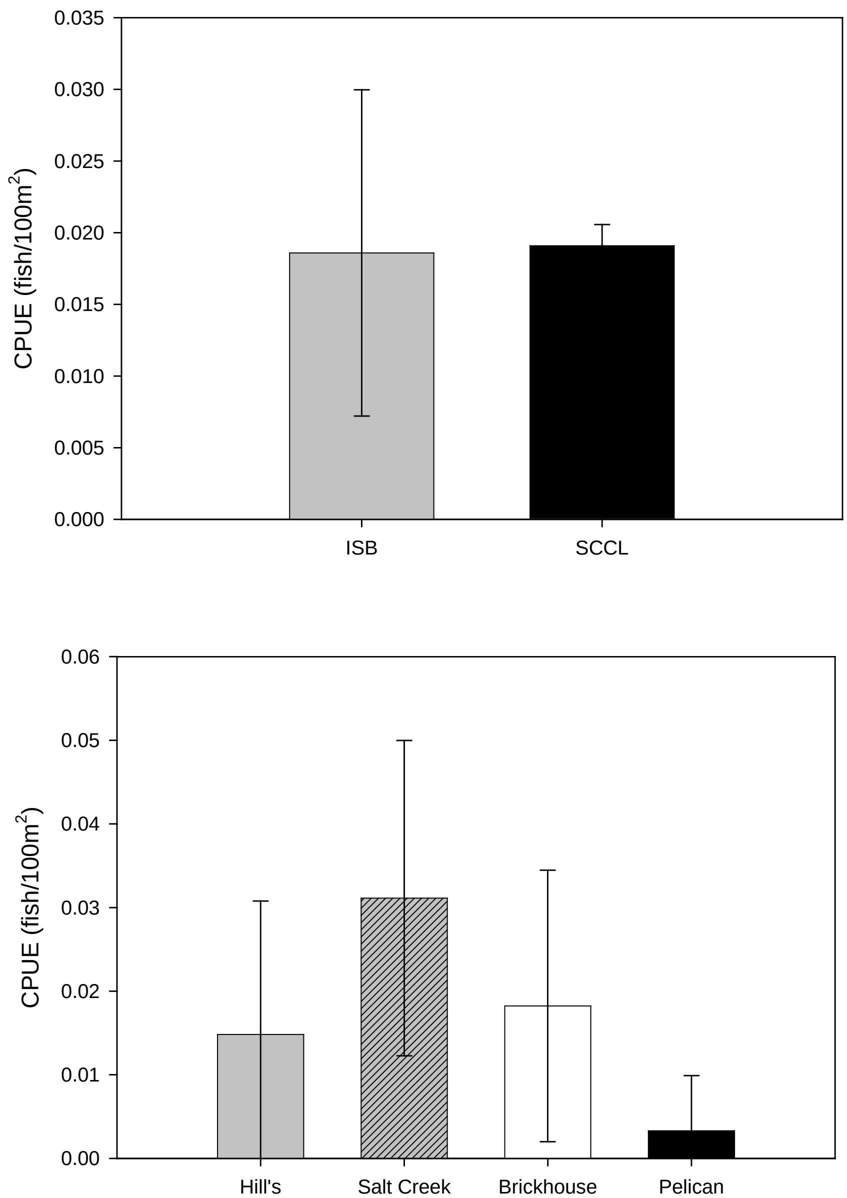

Figure 20. Mean otter trawl catch per unit effort (+/- 2 SE) of blue suckers during 2014 by macrohabitat (top panel) and by site (bottom panel).

Sauger

A total of 24 saugers were collected during the 2014 sampling period and ranged in size from 30 – 258 mm (average 50 mm) in total length (Figure 21). CPUE for saugers ranged from 0 – 14.9 fish/100m^2 (Figure 22).

Random habitat sampling occurred only once while capturing saugers. They were captured at an average depth of 1.1 m (0.5 – 1.4 m), a bottom velocity of 0.21 m/s, an average temperature of 27.3 °C (24.5 – 28 °C), and a turbidity of 90 NTU. Catch rates of saugers were not significantly different between macrohabitats (Figure 22). Catch rates of sauger were significantly higher at Brickhouse bend ($X^2(3, N = 1323) = 8.68$, $p < 0.0338$; 0.08 fish/100 m^2) when compared to all other sites (Figure 22).

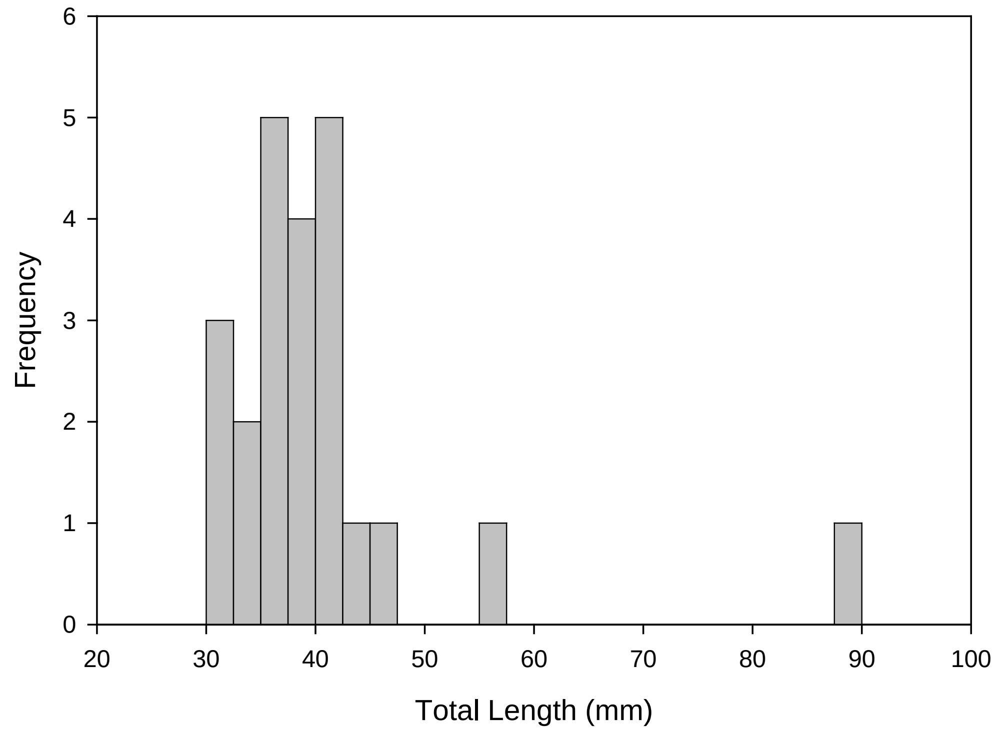

Figure 21. Length frequency of sauger during 2014.

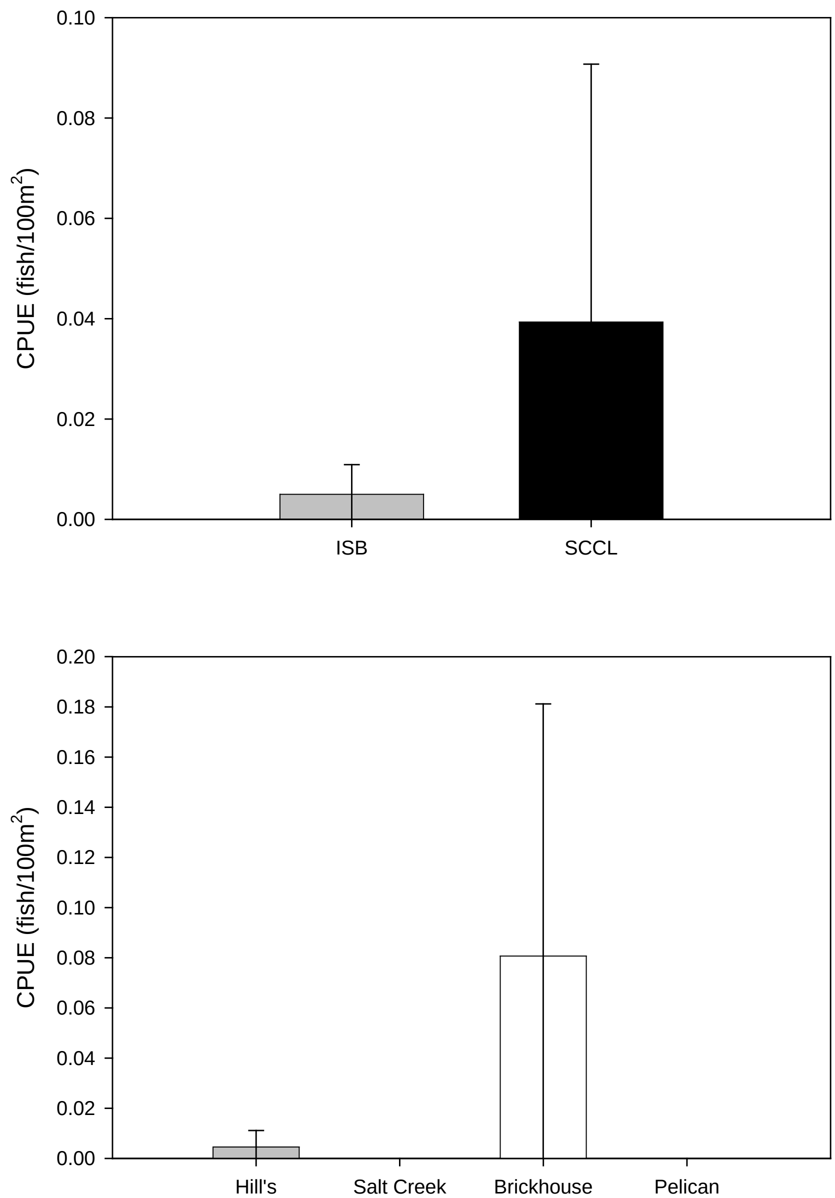

Figure 22. Mean otter trawl catch per unit effort (+/- 2 SE) of sauger during 2014 by macrohabitat (top panel) and by site (bottom panel).

Missouri River Fish Community

The fish community for our sampling sites was comprised of 22,943 individuals captured representing 49 species, excluding 13 unidentified families or genera that were removed from community indices analysis (Table 8). There were significant differences in the fish community structure between macrohabitats and sites. Species richness was significantly higher ($F (1, 7) = 21.17$, $p = 0.016$) in side channels ($M = 27.8$, $SD = 3.59$) compared to the mainstem Missouri River ($M = 23.5$, $SD = 4.20$) (Figure 23). Species richness was higher at Brickhouse bend ($M=31$, $SD = 3.54$) when compared to Hills bend ($M = 25.0$, $SD = 1.41$), Salt Creek bend ($M = 24.5$, $SD = 3.54$), and Pelican bend ($M = 22.0$, $SD = 4.24$) (Figure 23).

Of the identified species, four genera of fishes composed 94.3% of the total catch; *Macrhybopsis*, (49.4%), *Ictalurus*, (30.3%), *Notropis*, (11.0%) and *Scaphirhynchus* (3.6%) (Table 10). Shoal chubs were the most abundant species sampled, and composed 21.9% of all fish captured (Table 9). The next most populous species was channel catfish (*Ictalurus punctatus*) with 19.7% of captured fish. Channel shiners (*Notropis wickliffi*), sicklefin chubs, and blue catfish (*I. furcatus*), 7.6%, 6.7%, and 5.3% respectively, round out the top 5 most abundant species (Table 10).

Species unique to side channels were: bighead carp (*Hypophthalmichthys nobilis; n* = 2), blackside darter (*Percina maculata; n* = 2), golden redhorse (*Moxostoma erythrurm; n* = 1), gilt darter (*P. evides; n* = 1), johnny darter (*Etheostoma nigrum; n* = 1), logperch (*P. caprodes; n* = 3), orangespotted sunfish (*Lepomis humilis; n* = 1), mimic shiner (*N. volucellus; n* = 9), slenderhead darter (*P. phoxocephala; n* = 1), smallmouth buffalo (*Ictiobus bubalus; n* = 2), spottail shiner (*N. hudsonius; n* = 1), and Mississippi silvery minnow (*Hybognathus nuchalis; n* = 1).

Species only found in the main channel included: bluegill (*L. macrochrius; n* = 3), ghost shiner (*N. buchanani; n* = 1), and white sucker (*Catostomus commersonii; n* = 1).

Table 8. Species richness, species evenness, and effective number of species by sample site and macrohabitat. Habitat definitions and codes presented in Appendix B.

Sample Site	Macrohabitat	Richness	Evenness	Effective
Hill’s	SCCL	26	0.5705	6.4158
	ISB	24	0.5632	5.9884
Salt Creek	SCCL	27	0.4708	4.7193
	ISB	22	0.5981	6.3523
Brickhouse	SCCL	33	0.5288	6.3524
	ISB	29	0.5601	6.5934
Pelican	SCCL	25	0.4737	4.5939
	ISB	19	0.3246	2.6006

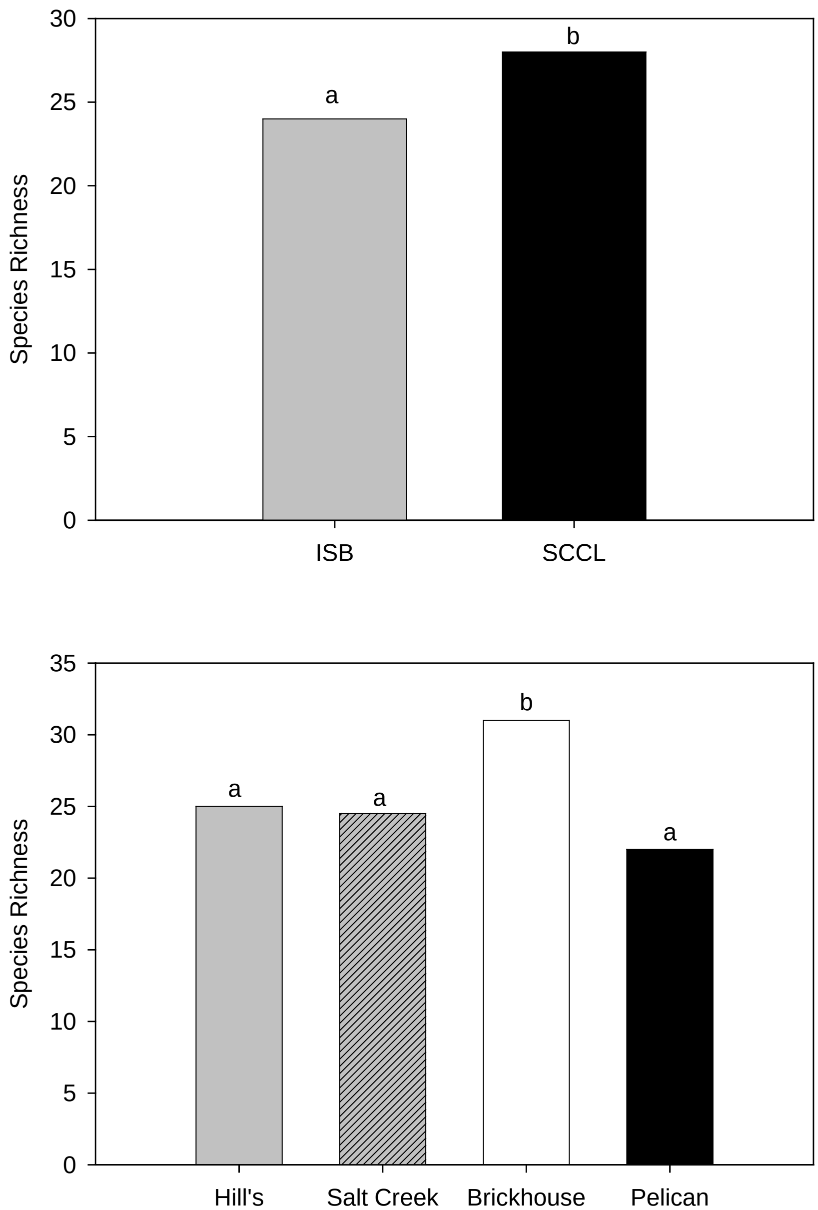

Figure 23. Species richness by macrohabitat and sampling site. Letters denote significant differences (p = 0.016). Habitat definitions and codes presented in Appendix B.

Table 9. Top genera captured with percentage of the total captured individuals for 2014.

Genera	Individuals	Percentage
Macrhybopsis	11331	49.39%
Ictalurus	6941	30.25%
Notropis	2529	11.02%
Scaphirhynchus	822	3.58%
Grand Total	21623	94.25%

Table 10. Top ten species captured with respective abundance and percentage of the total captured individuals for 2014. Species abbreviations are listed in Appendix A.

Species	Individuals	Percentage
SKCB	5016	21.86%
CNCF	4518	19.69%
CNSN	1737	7.57%
SFCB	1530	6.67%
BLCF	1218	5.31%
SNSG	818	3.57%
SGCB	661	2.88%
FWDM	418	1.82%
RDSN	292	1.27%
SVCB	260	1.13%
Grand Total	16468	71.78%

Discussion

The Missouri Department of Conservation HAMP crew sampled 4 bends and their respective side channels during the 2014 sampling season. The otter trawl was deployed at all bends, though Pelican bend was not sampled as extensively due to low water access issues. A total of 1,323 trawl deployments were completed resulting in the collection of 22,943 fish.

Data collected from this project contributes to the objective of establishing reference conditions of best achievable side channels. Reference data of native larval, YOY, and small bodied fishes including pallid sturgeon will facilitate future restoration efforts in the lower Missouri River. As data collection continues, temporal differences will be documented and biological responses to side channel modifications can be inferred.

The modified otter trawl selected for the HAMP project was specifically designed for the capture of small bodied fishes. Fish length histograms and catch curves show that the net is capable of capturing fish of a wide size range, but full recruitment is limited to individuals above 20 mm in total length. Recruitment limitation is likely a response of trawl mesh size, or fish life history. For example, catch curves of shovelnose sturgeon show that individuals less than 7 days post hatch were not fully recruited (Figure 7). This is likely due to the inability of a benthic trawl to capture shovelnose sturgeon in the drift stage of their life cycle, and lack of sampling of the thalweg (Braaten et al. 2008). Study of larval fishes will benefit from the supplement of plankton nets and other collection methods.

Few pallid sturgeon were captured during the sampling period, and limits observational information. Two genetically verified wild, age-0 pallid sturgeon were captured during sampling. This is the first genetically verified account of age-0 pallid sturgeon captured in the lower Missouri River and the first year documented since 1999 (Krentz 2000, Boley and Heist 2011). Both age-0 pallid sturgeon were captured in June at Brickhouse bend approximately 16 rkms from the confluence of the Mississippi River (Figure 3, Table 3). The individuals were categorized by length to be in the exogenous stage of their life history, exiting the endogenous drift stage with the ability for retention in suitable habitat (Braaten et al. 2008). Two hatchery reared YOY pallid sturgeon were also collected, with one individual also being collected at Brickhouse bend. Both hatchery reared sturgeon were collected approximately 120 rkms downstream, three weeks from the stocking date (Figure 3, Table 2).

Age-0 shovelnose sturgeon were captured throughout the sampling period, but 78% were captured June through August. Age histograms of age-0 shovelnose sturgeon display that the largest cohort hatched in late May, when water temperatures ranged from 17-25 °C (Figure 6). These water temperatures are consistent with optimum spawning temperatures found for shovelnose sturgeon in the Mississippi River (Phelps et al. 2010). In contrast to the optimum spawning temperatures observed in the Mississippi River, three distinguishable hatching cohorts of shovelnose sturgeon were observed at temperatures exceeding 20 °C following June (Figure 6). Hatch rates were lower on those dates and could be linked to mortality at warmer temperatures (Phelps et al. 2010). Fall spawning may be common for shovelnose sturgeon, however, has never been documented for pallid sturgeon.

Higher densities of age-0 shovelnose sturgeon were observed in depths near 2 or 3 m and bottom velocities 0.25-0.5 m/s (Figures 9 and 10). This is similar to the range of velocities and depths that have been recently reported for age-0 sturgeon in the lower Missouri River by Ridenour et al. (2011) and Gosch et al. (2015). Higher catch rates of age-0 shovelnose sturgeon in the main channel and at Salt Creek bend were driven by high relative abundances found associated with the tip of a large sandbar structure in the inside bend. The complex of wing dikes and sand bar at Salt Creek bend may act as a nursery or refuge for young shovelnose sturgeon. Gosch et al. (2015) also state that Salt Creek bend had high catch rates for age-0 sturgeon. Contrasting to this report, they observed more age-0 sturgeon in the chute when compared to the mainstem (Gosch et al. 2015). Discontinuity between catch rates could be explained by the variability in water levels between sampling periods of each study. Lower catch rates of age-0 sturgeon in chutes may not be a preference in the species, but an effect of the inaccessibility of drifting sturgeon to enter chutes. Recent papers suggest that the type of chute inlet structure may limit the accessibility of sturgeon (especially those in the drift stage) to enter chutes, and that modifications to existing inlets would increase access (Ridenour et al. 2011, Gosch et al. 2015). Special consideration should be made to evaluate not only the inlet structure itself, but also the effect of water level on the inlet during the drift stage of age-0 sturgeon (ex. May-June).

Catch rates of other target species varied by bend, macrohabitat, and habitat parameters. Target chub species (sturgeon chub, sicklefin chub, and shoal chub) were captured at all bends and macrohabitats. Sturgeon chubs were captured at lower depths and higher temperatures than shoal and sicklefin chubs, as well as having higher abundances at Salt Creek bend. Shoal and sicklefin chubs were found in deeper water, and both occurred at higher abundances at Brickhouse bend. Sand shiners were captured in shallower waters (<0.9m) and warmer water temperatures. Highest catch rates of sand shiners were found in side channels and at Brickhouse bend. *Hybognathus spp.* individuals were only represented by one collected specimen of the Mississippi silvery minnow. The ability of the modified trawl to capture similar species suggests that these individuals are extirpated, occur at very low densities, or are specific to habitats that are difficult to trawl (snags, woody debris). A total of twenty small blue suckers (< 700 mm TL) were captured during sampling suggesting that recruitment is occurring in the lower Missouri River. Blue suckers were typically captured at deeper depths (> 1.2 m) and were captured at all bends and macrohabitats. Few saugers were captured during the sampling season, but higher catch rates were observed at Brickhouse bend with no saugers captured at Pelican and Salt Creek bends. The low catch rates of sauger are likely due to low abundances of the species in the lower Missouri River or low recruitment to trawling.

The fish community of the lower Missouri River was diverse, with 49 species being captured in 2014. All sites and macrohabitats were dominated by members of the genus *Macrhybopsis* (particularly shoal chubs [21.9% total catch]) and *Ictalurus* (particularly channel catfish [19.7% total catch]), although there were significant differences between macrohabitats, with side channels having more species (n=28). Side channel diversity was driven by the low occurrence of rare species, particularly members of the genus *Percina*. A study by Whiteman et al. (2011) suggested that side channels provide additional habitat for rare species, with only a few unique to the main river. Species richness was also highest at Brickhouse bend (n=31).

The HAMP side channel reference project has provided baseline data of small bodied fish abundances and community structure, though the current design evaluating four bends with “best achievable” chutes may not represent the lower Missouri River as a whole. From this report, it is discernable that main channels and side channels contain different relative abundances of fish species, and the community structure is different. It should also be noted that not all side channels are similar and their respective fish abundances and composition are driven by multiple factors. For example, the close proximity of Brickhouse bend to the Mississippi River, high species richness, and high abundances of several species of interests may be a function of the river continuum concept or the matrix of control structures (Vannote et al. 1980). Another example observed are the high abundances of shovelnose sturgeon at Salt Creek bend, and the lack of knowledge as to why they congregate there. The next approach to be taken is to couple the biological data presented here with habitat modeling and imaging to present a dynamic picture of the lower Missouri River for future restorative actions.

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References

Boley, R. M. and E. J. Heist. 2011. Larval surveys indicate low levels of endangered pallid sturgeon reproduction in the middle Mississippi River. Transactions of the American Fisheries Society. 140(6) 1604-1612.

Braaten, P. J., D. B. Fuller, L. D. Holte, R. D. Lott, W. Viste, T. F. Brandt, and R. G. Legare. 2008. Drift dynamics of larval pallid sturgeon and shovelnose sturgeon in a natural side channel of the upper Missouri River, Montana. North American Journal of Fisheries Management. 28(3) 808-826.

Dryer, M. P., and A. J. Sandvol. 1993. Pallid sturgeon recovery plan. U. S. Fish and Wildlife Service, Bismarck, North Dakota.

Funk, J. L. and J. W. Robinson. 1974. Changes in the channel of the lower Missouri River and effects on fish and wildlife. Missouri Department of Conservation Aquatic Series No. 11. Jefferson City.

Galat, D. L., C. R. Berry Jr., E. J. Peters, and R. G. White. 2005. Missouri River. Pages 427-480 *in* A. C. Benke and C. E. Cushing (editors). Rivers of North America. Elsevier, Oxford.

Gemeinhardt, T. R., N. J. C. Gosch, D. M. Morris, M. L. Miller, T. L. Welker and J. L. Bonneau. 2015. Is shallow water a suitable surrogate for assessing effort to address pallid sturgeon decline? River Research and Application. Published Online.

Gosch, Nathan J. C., M. L. Miller, T. R. Gemeinhardt, S. J. Sampson, and J. L. Bonneau. 2015. Age-0 sturgeon accessibility to constructed and modified chutes in the lower Missouri River. North American Journal of Fisheries Management 35(1) 75-85.

Hesse, L. W. 1987. Taming the wild Missouri River: what has it cost? Fisheries 12:2–9.

Krentz, S. 2000. Pallid sturgeon recovery update. U. S. Fish and Wildlife Service. Columbia, Missouri.

Phelps, Q. E., S. J. Tripp, W. D. Hintz, J. E. Garvey, D. P. Herzog, D. E. Ostendorf, J. W. Ridings, J. W. Crites, and R. A. Hrabik. 2010. Water temperature and river stage influence mortality and abundance of naturally occurring Mississippi River Scaphirhynchus sturgeon. North American Journal of Fisheries Management. 30(3) 767-775.

Ridenour, C. J., W. J. Wyatt, and T. D. Hill. 2011. Habitats of age-0 sturgeon in the lower Missouri River. Transactions of the American Fisheries Society. 140(5) 1351-1358.

Sechler, D. R., Q. E. Phelps, S. J. Tripp, J. E. Garvey, D. P. Herzog, D. E. Ostendorf, J. W. Ridings, J. W. Crites and R. A. Hrabik. 2012. Habitat for age-0 shovelnose sturgeon and pallid sturgeon in a large river: interactions among abiotic factors, food, and energy intake. North American Journal of Fisheries Management. 32:24-31.

Sheehan, R. J., R. C. Heidinger, P. S. Wills, M A. Schmidt, G. A. Connover, and K. L. Hurley. 1999. Guide to the pallid sturgeon shovelnose sturgeon character index (CI) and morphometric character index (mCI). SIUC Fisheries Bulletin No. 14, Southern Illinois University, Carbondale, Illinois.

Snyder, D. E., 2002: Pallid and shovelnose sturgeon larvae –morphological description and identification. Journal of Applied Ichthyology. 18:240–265.

U. S. Army Corps of Engineers (USACE). 2012. Operational draft shallow water habitat adaptive management strategy.

U. S. Fish and Wildlife Service (USFWS). 2000. Biological opinion on the operation of the Missouri River Main Stem Reservoir System, operation and maintenance of the Missouri River Bank Stabilization and Navigation Project, and operation of the Kansas River Reservoir System. U.S. Fish and Wildlife Service. Fort Snelling, Minnesota.

U. S. Fish and Wildlife Service. 2003. Amendment to the 2000 Biological Opinion on the operation of the Missouri River Main Stem Reservoir System, operation and maintenance of the Missouri River bank stabilization and navigation project, and operation of the Kansas River Reservoir System. Fort Snelling, Minnesota.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences. 37(1) 130-137.

Whiteman, K. W., V. H. Travnichek, D. L. Garner, B. Eder, and K. Steffensen. 2011. Comparison of fish communities in recently constructed side-channel chutes with the main stem Missouri River. The Prairie Naturalist. 43(3/4) 100-109.

Zarr, J. H. 1999. Biostatiscal analysis, 4th ed. Prentic Hall, Upper Saddle River, New Jersey.

Appendices

Appendix A. Phylogenetic list of Missouri River fishes with corresponding letter codes used in the long-term pallid sturgeon and associated fish community sampling program. The phylogeny follows that used by the American Fisheries Society, Common and Scientific Names of Fishes from the United States and Canada, 5th edition. Asterisks and bold type denote targeted native Missouri River species.

Scientific name	Common name	Letter Code
	CLASS CEPHALASPIDOMORPHI-LAMPREYS	
	ORDER PETROMYZONTIFORMES	
	Petromyzontidae – lampreys	
Ichthyomyzon castaneus	Chestnut lamprey	CNLP
Ichthyomyzon fossor	Northern brook lamprey	NBLP
Ichthyomyzon unicuspis	Silver lamprey	SVLP
Ichthyomyzon gagei	Southern brook lamprey	SBLR
Petromyzontidae	Unidentified lamprey	ULY
Petromyzontidae larvae	Unidentified larval lamprey	LVLP
	CLASS OSTEICHTHYES – BONY FISHES	
	ORDER ACIPENSERIFORMES	
	Acipenseridae – sturgeons	
Acipenser fulvescens	Lake sturgeon	LKSG
Scaphirhynchus spp.	Unidentified Scaphirhynchus	USG
Scaphirhynchus albus	**Pallid sturgeon**	**PDSG***
Scaphirhynchus platorynchus	**Shovelnose sturgeon**	**SNSG***
S. albus X S. platorynchus	Pallid-shovelnose hybrid	SNPD
	Polyodontidae – paddlefishes	
Polyodon spathula	Paddlefish	PDFH
	ORDER LEPISOSTEIFORMES	
	Lepisosteidae – gars	
Lepisosteus oculatus	Spotted gar	STGR
Lepisosteus osseus	Longnose gar	LNGR
Lepisosteus platostomus	Shortnose gar	SNGR
	ORDER AMMIFORMES	
	Amiidae – bowfins	
Amia calva	Bowfin	BWFN
	ORDER OSTEOGLOSSIFORMES	
	Hiodontidae – mooneyes	
Hiodon alosoides	Goldeye	GDEY
Hiodon tergisus	Mooneye	MNEY
	ORDER ANGUILLIFORMES	
	Anguillidae – freshwater eels	
Anguilla rostrata	American eel	AMEL
	ORDER CLUPEIFORMES	
	Clupeidae – herrings	
Alosa alabame	Alabama shad	ALSD
Alosa chrysochloris	Skipjack herring	SJHR
Alosa pseudoharengus	Alewife	ALWF
Dorosoma cepedianum	Gizzard shad	GZSD
Dorosoma petenense	Threadfin shad	TFSD

Appendix A. (continued).

Scientific name	Common name	Lettter Code
D. cepedianum X D. petenense	Gizzard-threadfin shad hybrid	GSTS
	ORDER CYPRINIFORMES	
	Cyprinidae – carps and minnows	
Campostoma anomalum	Central stoneroller	CLSR
Campostoma oligolepis	Largescale stoneroller	LSSR
Carassius auratus	Goldfish	GDFH
Carassus auratus X Cyprinius carpio	Goldfish-Common carp hybrid	GFCC
Couesius plumbens	Lake chub	LKCB
Ctenopharyngodon idella	Grass carp	GSCP
Cyprinella lutrensis	Red shiner	RDSN
Cyprinella spiloptera	Spotfin shiner	SFSN
Cyprinus carpio	Common carp	CARP
Erimystax x-punctatus	Gravel chub	GVCB
Hybognathus argyritis	**Western slivery minnow**	**WSMN***
Hybognathus hankinsoni	Brassy minnow	BSMN
Hybognathus nuchalis	Mississippi silvery minnow	SVMW
Hybognathus placitus	**Plains minnow**	**PNMW***
Hybognathus spp.	Unidentified Hybognathus	HBNS
Hypophthalmichthys molitrix	Silver carp	SVCP
Hypophthalmichthys nobilis	Bighead carp	BHCP
Luxilus chrysocephalus	Striped shiner	SPSN
Luxilus cornutus	Common shiner	CMSN
Luxilus zonatus	Bleeding shiner	BDSN
Lythrurus unbratilis	Western redfin shiner	WRFS
Macrhybopsis aestivalis	**Shoal chub**	**SKCB***
Macrhybopsis gelida	**Sturgeon chub**	**SGCB***
Macrhybopsis meeki	**Sicklefin chub**	**SFCB***
Macrhybopsis storeriana	Silver chub	SVCB
M. aestivalis X M. gelida	Shoal-Sturgeon chub hybrid	SPST
M. gelida X M. meeki	Sturgeon-Sicklefin chub hybrid	SCSC
Macrhybopsis spp.	Unidentified chub	UHY
Margariscus margarita	Pearl dace	PLDC
Mylocheilus caurinus	Peamouth	PEMT
Nocomis biguttatus	Hornyhead chub	HHCB
Notemigonus crysoleucas	Golden shiner	GDSN
Notropis atherinoides	Emerald shiner	ERSN
Notropis blennius	River shiner	RVSN
Notropis boops	Bigeye shiner	BESN
Notropis buchanani	Ghost shiner	GTSN
Notropis dorsalis	Bigmouth shiner	BMSN
Notropis greenei	Wedgespot shiner	WSSN
	Cyprinidae – carps and minnows	
Notropis heterolepsis	Blacknose shiner	BNSN
Notropis hudsonius	Spottail shiner	STSN
Notropis nubilus	Ozark minnow	OZMW
Notropis rubellus	Rosyface shiner	RYSN
Notropis shumardi	Silverband shiner	SBSN
Notropis stilbius	Silverstripe shiner	SSPS
Notropis stramineus	**Sand shiner**	**SNSN***
Notropis topeka	Topeka shiner	TPSN
Notropis volucellus	Mimic shiner	MMSN

Appendix A. (continued).

Scientific name	Common name	Letter Code
Notropis wickliffi	Channel shiner	CNSN
Notropis spp.	Unidentified shiner	UNO
Opsopoeodus emiliae	Pugnose minnow	PNMW
Phenacobius mirabilis	Suckermouth minnow	SMMW
Phoxinus eos	Northern redbelly dace	NRBD
Phoxinus erythrogaster	Southern redbelly dace	SRBD
Phoxinus neogaeus	Finescale dace	FSDC
Pimephales notatus	Bluntnose minnow	BNMW
Pimephales promelas	Fathead minnow	FHMW
Pimephales vigilax	Bullhead minnow	BHMW
Platygobio gracilis	Flathead chub	FHCB
P. gracilis X M. meeki	Flathead-sicklefin chub hybrid	FCSC
Rhinichthys atratulus	Blacknose dace	BNDC
Rhinichthys cataractae	Longnose dace	LNDC
Richardsonius balteatus	Redside shiner	RDSS
Scardinius erythrophthalmus	Rudd	RUDD
Semotilus atromaculatus	Creek chub	CKCB
	Unidentified Cyprinidae	UCY
	Unidentified Asian Carp	UAC
	Catostomidae - suckers	
Carpiodes carpio	River carpsucker	RVCS
Carpiodes cyprinus	Quillback	QLBK
Carpiodes velifer	Highfin carpsucker	HFCS
Carpiodes spp.	Unidentified Carpiodes	UCS
Catostomus catostomus	Longnose sucker	LNSK
Catostomus commersonii	White sucker	WTSK
Catostomus platyrhynchus	Mountain sucker	MTSK
Catostomus spp.	Unidentified *Catostomus* spp.	UCA
Cycleptus elongatus	**Blue sucker**	**BUSK***
Hypentelium nigricans	Northern hog sucker	NHSK
Ictiobus bubalus	Smallmouth buffalo	SMBF
Ictiobus cyprinellus	Bigmouth buffalo	BMBF
Ictiobus niger	Black buffalo	BKBF
Ictiobus spp.	Unidentified buffalo	UBF
Minytrema melanops	Spotted sucker	SPSK
Moxostoma anisurum	Silver redhorse	SVRH
Moxostoma carinatum	River redhorse	RVRH
Moxostoma duquesnei	Black redhorse	BKRH
Moxostoma erythrurum	Golden redhorse	GDRH
Moxostoma macrolepidotum	Shorthead redhorse	SHRH
Moxostoma spp.	Unidentified redhorse	URH
Catostomidae - suckers	Unidentified Catostomidae	UCT
	ORDER SILURIFORMES	
	Ictaluridae – bullhead catfishes	
Ameiurus melas	Black bullhead	BKBH
Ameiurus natalis	Yellow bullhead	YLBH
Ameiurus nebulosus	Brown bullhead	BRBH
Ameiurus spp.	Unidentified bullhead	UBH
Ictalurus furcatus	Blue catfish	BLCF

Appendix A. (continued).

Scientific name	Common name	Letter Code
Ictalurus punctatus	Channel catfish	CNCF
I. furcatus X I. punctatus	Blue-channel catfish hybrid	BCCC
Ictalurus spp.	Unidentified *Ictalurus* spp.	UCF
Noturus exilis	Slender madtom	SDMT
Noturus flavus	Stonecat	STCT
Noturus gyrinus	Tadpole madtom	TPMT
Noturus nocturnus	Freckled madtom	FKMT
Pylodictis olivaris	Flathead catfish	FHCF
	ORDER SALMONIFORMES	
	Esocidae - pikes	
Esox americanus vermiculatus	Grass pickerel	GSPK
Esox lucius	Northern pike	NTPK
Esox masquinongy	Muskellunge	MSKG
E. lucius X E. masquinongy	Tiger Muskellunge	TGMG
	Umbridae - mudminnows	
Umbra limi	Central mudminnow	MDMN
	Osmeridae - smelts	
Osmerus mordax	Rainbow smelt	RBST
	Salmonidae - trouts	
Coregonus artedi	Lake herring or cisco	CSCO
Coregonus clupeaformis	Lake whitefish	LKWF
Oncorhynchus aguabonita	Golden trout	GDTT
Oncorhynchus clarkii	Cutthroat trout	CTTT
Oncorhynchus kisutch	Coho salmon	CHSM
Oncorhynchus mykiss	Rainbow trout	RBTT
Oncorhynchus nerka	Sockeye salmon	SESM
Oncorhynchus tshawytscha	Chinook salmon	CNSM
Prosopium cylindraceum	Bonneville cisco	BVSC
Prosopium williamsoni	Mountain whitefish	MTWF
Salmo trutta	Brown trout	BNTT
Salvelinus fontinalis	Brook trout	BKTT
Salvelinus namaycush	Lake trout	LKTT
Thymallus arcticus	Arctic grayling	AMGL
	ORDER PERCOPSIFORMES	
	Percopsidae – trout-perches	
Percopsis omiscomaycus	Trout-perch	TTPH
	ORDER GADIFORMES	
	Gadidae - cods	
Lota lota	Burbot	BRBT
	ORDER ATHERINIFORMES	
	Cyprinodontidae - killifishes	
Fundulus catenatus	Northern studfish	NTSF
Fundulus diaphanus	Banded killifish	BDKF
Fundulus notatus	Blackstripe topminnow	BSTM
Fundulus olivaceus	Blackspotted topminnow	BPTM
Fundulus sciadicus	Plains topminnow	PTMW

Appendix A. (continued).

Scientific name	Common name	Letter Code
Fundulus zebrinus	Plains killifish	PKLF
	Poeciliidae - livebearers	
Gambusia affinis	Western mosquitofish	MQTF
	Atherinidae - silversides	
Labidesthes sicculus	Brook silverside	BKSS
	ORDER GASTEROSTEIFORMES	
	Gasterosteidae - sticklebacks	
Culaea inconstans	Brook stickleback	BKSB
	ORDER SCORPAENIFORMES	
	Cottidae - sculpins	
Cottus bairdi	Mottled sculpin	MDSP
Cottus carolinae	Banded sculpin	BDSP
	ORDER PERCIFORMES	
	Percichthyidae – temperate basses	
Morone Americana	White perch	WTPH
Morone chrysops	White bass	WTBS
Morone mississippiensis	Yellow bass	YWBS
Morone saxatilis	Striped bass	SDBS
M. saxatilis X M. chrysops	Striped-white bass hybrid	SBWB
	Centrarchidae - sunfishes	
Ambloplites rupestris	Rock bass	RKBS
Archoplites interruptus	Sacramento perch	SOPH
Lepomis cyanellus	Green sunfish	GNSF
Lepomis gibbosus	Pumpkinseed	PNSD
Lepomis gulosus	Warmouth	WRMH
Lepomis humilis	Orangespotted sunfish	OSSF
Lepomis macrochirus	Bluegill	BLGL
Lepomis megalotis	Longear sunfish	LESF
Lepomis microlophus	Redear sunfish	RESF
L. cyanellus X L. macrochirus	Green sunfish-bluegill hybrid	GSBG
	Centrarchidae - sunfishes	
L. cyanellus X L. humilis	Green-orangespotted sunfish hybrid	GSOS
L. macrochirus X L. microlophus	Bluegill-redear sunfish hybrid	BGRE
Lepomis spp.	Unidentified *Lepomis*	ULP
Micropterus dolomieu	Smallmouth bass	SMBS
Micropterus punctulatus	Spotted sunfish	STBS
Micropterus salmoides	Largemouth bass	LMBS
Micropterus spp.	Unidentified *Micropterus* spp.	UMC
Pomoxis annularis	White crappie	WTCP
Pomoxis nigromaculatus	Black crappie	BKCP
Pomoxis spp.	Unidentified crappie	UCP
P. annularis X P. nigromaculatus	White-black crappie hybrid	WCBC
Centrarchidae	Unidentified Centrarchidae	UCN
	Percidae - perches	
Ammocrypta asprella	Crystal darter	CLDR

Appendix A. (continued).

Scientific name	Common name	Letter Code
Etheostoma blennioides	Greenside darter	GSDR
Etheostoma caeruleum	Rainbow darter	RBDR
Etheostoma exile	Iowa darter	IODR
Etheostoma flabellare	Fantail darter	FTDR
Etheostoma gracile	Slough darter	SLDR
Etheostoma microperca	Least darter	LTDR
Etheostoma nigrum	Johnny darter	JYDR
Etheostoma punctulatum	Stippled darter	STPD
Etheostoma spectabile	Orange throated darter	OTDR
Etheostoma tetrazonum	Missouri saddled darter	MSDR
Etheostoma zonale	Banded darter	BDDR
Etheostoma spp.	Unidentified Etheostoma spp.	UET
Perca flavescens	Yellow perch	YWPH
Percina caprodes	Logperch	LGPH
Percina cymatotaenia	Bluestripe darter	BTDR
Percina evides	Gilt darter	GLDR
Percina maculata	Blackside darter	BSDR
Percina phoxocephala	Slenderhead darter	SHDR
Percina shumardi	River darter	RRDR
Percina spp.	Unidentified Percina spp.	UPN
	Unidentified darter	UDR
Sander canadense	**Sauger**	**SGER***
Sander vitreus	Walleye	WLEY
S. canadense X S. vitreus	Sauger-walleye hybrid/Saugeye	SGWE
Sander spp.	Unidentified *Sander* (formerly *Stizostedion*) spp.	UST
	Unidentified Percidae	UPC
	Sciaenidae - drums	
Aplodinotus grunniens	Freshwater drum	FWDM
	NON-TAXONOMIC CATEGORIES	
	Age-0/Young-of-year fish	YOYF
	No fish caught	NFSH
	Unidentified larval fish	LVFS
	Unidentified	UNID
	Net Malfunction (Did Not Fish)	NDNF
	Turtles	
Chelydra serpentine	Common Snapping Turtle	SNPT
Chrysemys picta bellii	Western Painted Turtle	PATT
Emydoidea blandingii	Blanding's Turtle	BLDT
Graptemys pseudogeographica	False Map Turtle	FSMT
Trachemys scripta	Red-Eared Slider Turtle	REST
Apalone mutica	Smooth Softshell Turtle	SMST
Apalone spinifera	Spiny Softshell Turtle	SYST
Terrapene ornata ornata	Ornate Box Turtle	ORBT
Sternotherus odoratus	Stinkpot Turtle	SPOT
Graptemys geographica	Map Turtle	MAPT
Graptemys kohnii	Mississippi Map Turtle	MRMT
Graptemys ouachitensis	Ouachita Map Turtle	OUMT
Pseudemys concinna metteri	Missouri River Cooter Turtle	MRCT
Terrapene carolina triunguis	Three-toed Box Turtle	TTBT

Appendix B. Definitions and codes used to classify standard Missouri River habitats in the long-term pallid sturgeon and associated fish community sampling program.

Habitat	Scale	Definition	Code
Braided channel	Macro	An area of the river that contains multiple smaller channels and is lacking a readily identifiable main channel (typically associated with unchannelized sections)	BRAD
Main channel cross over	Macro	The inflection point of the thalweg where the thalweg crosses from one concave side of the river to the other concave side of the river, (i.e., transition zone from one-bend to the next bend). The upstream CHXO for a respective bend is the one sampled.	CHXO
Tributary confluence	Macro	Area immediately downstream, extending up to one bend in length, from a junction of a large tributary and the main river where this tributary has influence on the physical features of the main river	CONF
Dendritic	Macro	An area of the river where the river transitions from meandering or braided channel to more of a treelike pattern with multiple channels (typically associated with unchannelized sections)	DEND
Deranged	Macro	An area of the river where the river transitions from a series of multiple channels into a meandering or braided channel (typically associated with unchannelized sections)	DRNG
Dam Tailwaters	Macro	An area of the river downstream and near mainstem dams that characterized by altered flow and temperature regimes, reduced turbidities, bank armoring, and/or channel bed degradation (incision).	DTWT
Main channel inside bend	Macro	The convex side of a river bend	ISB
Main channel outside bend	Macro	The concave side of a river bend	OSB
Secondary channel-connected large	Macro	A side channel, open on upstream and downstream ends, with less flow than the main channel, large indicates this habitat can be sampled with trammel nets and trawls based on width and/or depths > 1.2 m	SCCL
Secondary channel-connected small	Macro	A side channel, open on upstream and downstream ends, with less flow than the main channel, small indicates this habitat cannot be sampled with trammel nets and trawls based on width and/or on depths < 1.2 m	SCCS
Secondary channel-non-connected	Macro	A side channel that is blocked at one end	SCCN
Tributary	Macro	Any river or stream flowing in the Missouri River	TRIB
Tributary large mouth	Macro	Mouth of entering tributary whose mean annual discharge is > 20 m^3/s, and the sample area extends 300 m into the tributary	TRML
Tributary small mouth	Macro	Mouth of entering tributary whose mean annual discharge is < 20 m^3/s, mouth width is > 6 m wide and the sample area extends 300 m into the tributary	TRMS
Wild	Macro	All habitats not covered in the previous habitat descriptions	WILD
Bars	Meso	Sandbar or shallow bank-line areas with depth < 1.2 m	BARS
Pools	Meso	Areas immediately downstream from sandbars, dikes, snags, or other obstructions with a formed scour hole > 1.2 m	POOL
Channel border	Meso	Area in the channelized river between the toe and the thalweg, area in the unchannelized river between the toe and the maximum depth	CHNB
Thalweg	Meso	Main channel between the channel borders conveying the majority of the flow	TLWG
Island tip	Meso	Area immediately downstream of a bar or island where two channels converge with water depths > 1.2 m	ITIP

Appendix C. Total otter trawl catch, overall mean catch per unit effort [CPUE (fish / 100 m^2)], and mean CPUE by mesohabitat within a macrohabitat for all species caught during 2014. Species captured are listed alphabetically and their codes are presented in Appendix A. Asterisks with bold type indicate targeted native Missouri River species and habitat abbreviations are presented in Appendix B. First line represents CPUE and 2 standard errors on second line.

Species	Total Catch	Overall CPUE	ISB		SCCL	
			CHNB	BARS	CHNB	BARS
BHCP	2	0.002	0	0	0.005	0
		0.003	0	0	0.004	0
BHMW	86	0.072	0.045	0.079	0.056	0.228
		0.032	0.018	0.054	0.022	0.063
BLCF	1218	1.092	0.98	1.068	1.01	1.86
		0.198	0.18	0.163	0.204	0.261
BLGL	3	0.003	0.007	0	0	0
		0.003	0.005	0	0	0
BMSN	10	0.009	0	0.072	0.002	0
		0.017	0	0.049	0.003	0
BSDR	2	0.002	0	0	0.004	0
		0.003	0	0	0.005	0
BUSK	**22**	**0.012**	**0.024**	**0**	**0.017**	**0.026**
		0.009	**0.009**	**0**	**0.009**	**0.009**
CARP	4	0.004	0.003	0	0.007	0
		0.004	0.003	0	0.005	0
CNCF	4518	4.04	2.94	3.854	3.297	11.24
		0.944	0.623	0.508	0.954	1.803
CNSN	1737	1.496	0.662	0.622	0.798	8.297
		0.697	0.372	0.132	0.374	1.878
ERSN	39	0.035	0.053	0.023	0.016	0.06
		0.03	0.048	0.009	0.009	0.014
FHCF	14	0.012	0.005	0	0.019	0.027
		0.008	0.004	0	0.009	0.013
FWDM	418	0.379	0.282	1.054	0.243	0.499
		0.219	0.195	0.498	0.093	0.094
GDEY	22	0.02	0.197	0.235	0.013	0.047

Species	Total Catch	Overall CPUE	ISB		SCCL	
			CHNB	BARS	CHNB	BARS
		0.012	0.014	0.012	0.01	0.013
GDRH	1	0.001	0	0	0.007	0
		0.001	0	0	0.004	0
GLDR	1	0.001	0	0	0.009	0
		0.002	0	0	0.006	0
GTSN	1	0.001	0.002	0	0	0
		0.002	0.003	0	0	0
GZSD	11	0.01	0.002	0.017	0.008	0.035
		0.008	0.003	0.011	0.005	0.017
JYDR	1	0.001	0	0	0	0.009
		0.002	0	0	0	0.006
LGPH	3	0.003	0	0	0.004	0.008
		0.003	0	0	0.004	0.005
LMBS	5	0.005	0	0	0.009	0.009
		0.004	0	0	0.006	0.006
LNGR	3	0.003	0.003	0	0.005	0
		0.003	0.003	0	0.004	0
MMSN	9	0.008	0	0	0	0.079
		0.013	0	0	0	0.04
MNEY	4	0.004	0.005	0.007	0	0.009
		0.005	0.006	0.005	0	0.006
NFSH	223					
OSSF	1	0.001	0	0	0.002	0
		0.002	0	0	0.003	0
PDFH	18	0.013	0.018	0.006	0.015	0
		0.008	0.009	0.004	0.009	0
PDSG	**4**	**0.004**	**0.005**	**0**	**0.005**	**0**
		0.004	**0.007**	**0**	**0.006**	**0**
RDSN	292	0.243	0.224	0.329	0.108	0.739
		0.138	0.179	0.13	0.076	0.154

Species	Total Catch	Overall CPUE	ISB		SCCL	
			CHNB	BARS	CHNB	BARS
RFSN	2	0.001	0	0.004	0	0.097
		0.002	0	0.002	0	0.006
RVCS	8	0.007	0.006	0.008	0.007	0.01
		0.006	0.004	0.006	0.007	0.006
RVSN	190	0.178	0.091	0.604	0.043	0.537
		0.118	0.059	0.29	0.03	0.156
SBSN	23	0.013	0.022	0.002	0.002	0.01
		0.011	0.015	0.003	0.003	0.006
SDMT	11	0.01	0.003	0	0.018	0.018
		0.01	0.003	0	0.015	0.017
SFCB	**1530**	**1.33**	**1.527**	**1.919**	**0.863**	**1.769**
		0.253	**0.27**	**0.388**	**0.177**	**0.244**
SGCB	**661**	**0.574**	**0.327**	**0.747**	**0.518**	**1.495**
		0.151	**0.067**	**0.122**	**0.107**	**0.372**
SGER	**24**	**0.022**	**0.002**	**0.016**	**0.03**	**0.075**
		0.026	**0.002**	**0.008**	**0.037**	**0.04**
SHDR	1	0.001	0	0	0.002	0
		0.002	0	0	0.003	0
SKCB	**5016**	**4.257**	**3.379**	**5.501**	**3.918**	**7.421**
		0.653	**0.544**	**0.863**	**0.666**	**0.664**
SMBF	2	0.002	0	0	0.005	0
		0.003	0	0	0.004	0
SNGR	6	0.006	0.005	0.008	0	0.027
		0.005	0.004	0.005	0	0.01
SNSG	**767**	**0.653**	**0.875**	**0.389**	**0.641**	**0.181**
		0.12	**0.162**	**0.069**	**0.095**	**0.025**
SNSN	**111**	**0.104**	**0.019**	**0.161**	**0.051**	**0.562**
		0.056	**0.009**	**0.057**	**0.025**	**0.15**
STCT	47	0.043	0.05	0.008	0.046	0.045
		0.021	0.026	0.005	0.019	0.015
STSN	1	1.033	0	0	0	0.01

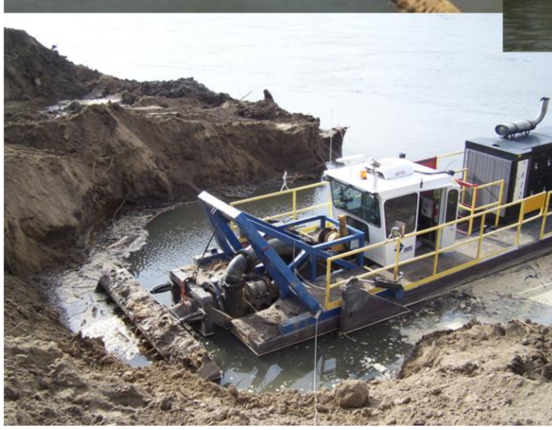
Species	Total Catch	Overall CPUE	ISB		SCCL	
			CHNB	BARS	CHNB	BARS
		0.002	0	0	0	0.006
SVCB	260	0.221	0.132	0.436	0.174	0.486
		0.067	0.044	0.079	0.073	0.073
SVCP	19	0.017	0.021	0.016	0.016	0.008
		0.009	0.011	0.008	0.008	0.005
SVMW	**1**	**0.001**	**0**	**0**	**0.002**	**0**
		0.001	**0**	**0**	**0.002**	**0**
UAC	12	0.011	0.007	0	0.021	0
		0.014	0.005	0	0.021	0
UBC	1	0.001	0	0	0.002	0
		0.001	0	0	0.002	0
UCA	194	0.17	0.055	1.234	0.01	0.008
		0.29	0.056	0.845	0.01	0.005
UCF	252	0.233	0.298	0.168	0.258	0.149
		0.082	0.074	0.008	0.105	0.049
UCS	15	0.012	0	0.102	0	0
		0.024	0	0.07	0	0
UCT	37	0.037	0.095	0	0	0.009
		0.07	0.114	0	0	0.006
UCY	3	0.002	0.002	0.006	0.002	0
		0.003	0.002	0.004	0.002	0
UDR	1	0.001	0	0	0.002	0
		0.002	0	0	0.003	0
UGR	1	0.001	0.001	0	0	0
		0.001	0.002	0	0	0
UHY	3864	3.626	5.02	5.253	1.956	3.168
		3.427	5.274	2.637	0.975	0.508
UIC	1205	1.047	0.784	0.251	1.496	1.182
		0.34	0.173	0.051	0.483	0.312
UMC	3	0.003	0	0	0.007	0
		0.006	0	0	0.009	0

Species	Total Catch	Overall CPUE	ISB		SCCL	
			CHNB	BARS	CHNB	BARS
UNID	19	0.017	0.008	0.008	0.024	0.029
		0.012	0.005	0.006	0.017	0.014
UNO	26	0.024	0.003	0	0.054	0.019
		0.043	0.003	0	0.068	0.009
UTB	2	0.001	0.003	0	0	0
		0.002	0.003	0	0	0
WSSN	88	0.072	0	0	0.082	0.382
		0.091	0	0	0.074	0.245
WTSK	1	0.001	0	0.009	0	0
		0.002	0	0.006	0	0
YOYF	58	0.052	0.094	0.127	0.004	0
		0.059	0.086	0.053	0.004	0

Habitat Assessment and Monitoring Program

Biological Assessment for Deer Island and Lower Decatur Bend



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Executive Summary

The Iowa Department of Natural Resources was contracted by the U.S. Army Corps of Engineers under the Habitat Assessment and Monitoring Program to evaluate the biological response to shallow water habitat construction at Deer Island and Lower Decatur Bend. The objective was to compare catch of larval, young of the year and small bodied fishes, including pallid sturgeon *Scaphirhynchus albus*, at constructed habitats with those already available in river. A sixteen foot, small mesh otter trawl, push trawl and mini fyke nets were selected as sampling gears. Four hundred and fifty gear deployments were conducted between May 19th and October 1st. A total of 5,419 fish were collected representing 39 species. Catch was dominated by cyprinids, freshwater drum *Aplodinotus grunniens* and gizzard shad *Dorosoma cepedianum*. No pallid sturgeon were collected. Thirteen of the fifteen total shovelnose sturgeon collected were sampled at Deer Island including one young of the year. This is the 2nd consecutive year that young of the year shovelnose sturgeon were collected at Deer Island. Mini fyke net catch per unit effort at the two shallow water habitat sites exceeded the control for 14 species but only one species each for otter trawl and push trawl. The only significant difference detected (P=0.02) was for silver chubs *Macrhybopsis storeriana* collected with the otter trawl where catch at the control site, Middle Little Sioux Bend, was higher than Decatur Bend.

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Introduction

Construction and operation of the Bank Stabilization and Navigation Project resulted in the elimination of over 100,000 acres of aquatic habitat from the Missouri River. The once wide, shallow sinuous and braided channel was transformed to a single swift deep channel. The islands, secondary channels, backwaters and shallow bar habitats necessary to the life history of many fish and wildlife species were eliminated. The U.S. Army Corps of Engineers (2003) reports a 15 million pound reduction in the standing stock of fish in the channelized segment of the Missouri River. The National Research Council (2002) reported that 51 of 67 native main-stem fish species are rare, uncommon or decreasing in all or part of their range.

Pallid sturgeon were listed as endangered under the Endangered Species Act in 1990. The U.S. Fish and Wildlife Service issued the "*Biological Opinion on the Operation of the Missouri River Main System Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project and Operation of the Kansas River Reservoir System"* in 2000 (USACE 2000). The document proposed numerous "reasonable and prudent alternatives" to remove pallid sturgeon from jeopardy. One of the proposed actions of the BIOP is the creation of 20 to 30 acres of shallow water habitat (SWH) per river mile by 2020. Shallow water habitat is intended to benefit early life stages of pallid sturgeon and was defined as less than 5 feet deep with a current velocity of less than 2.5 feet/second (USACE 2000). In 2009, the service further clarified the definition of SWH as "*side channels, backwaters and depositional sandbars detached from the bank….dynamic nature with depositional and erosive areas, predominance of shallow depths intermixed with deeper holes and secondary side channels, lower velocities, and higher water temperatures than main channel habitats"* (USACE 2012). The creation of SWH could be accomplished through flow management, widening the river channel top width or creation/restoration of secondary channels and backwaters or a combination thereof (USACE 2003). Historically, the 140 mile segment between the Big Sioux River confluence and the Platte River confluence contained approximately 107 acres of SWH per river mile (USACE 2000). In 2000, the BIOP estimated the current area of SWH as 1.8 acres per river mile for this segment and 4.6 acres per river mile for the Platte River to Kansas River segment.

The U. S. Army Corps of Engineers (USACE) has actively pursued habitat restoration. The USACE reported 3443 total acres of SWH created through 2010 (Jahili and Pridal 2010). Numerous project types and design strategies have been utilized in the SWH program. The Habitat Assessment and Monitoring Program (HAMP) was established in 2006 to determine if SWH projects are providing areas that recruit and rear larval and young of the year pallid sturgeon and other native Missouri River fish. To date, HAMP monitoring projects have been unable to detect any difference in fish catches between project bends and control bends using a before-after/control-impact design. A recently developed SWH Adaptive Management Strategy (USACE 2012) reported it is necessary to determine if biological responses are occurring at the project scale. The Iowa Department of Natural Resources was contracted by the USACE under HAMP to perform biological monitoring at Deer Island, Lower Decatur Bend and the Middle Little Sioux Reach. The objective is to assess the biological response of created habitats by comparing catch rates of larval and young of the year pallid sturgeon and other native fishes between created SWH and habitats already available in adjacent bends. Hypotheses developed for the study are;

1. Drifting larval pallid sturgeon and other larval fishes drift into created habitats from the main channel.
2. Young of the year pallid sturgeon and other fishes are retained to a higher degree in created SWH than habitats already available.
3. Small bodied and young of the year fishes are present in higher numbers in created SWH than habitats already available.

Study Areas

The Deer Island site is a river top-widening project is located in Harrison County, Iowa at river miles 670.7 to 672.8. Construction began in 2012 and was completed in 2014. At approximately 135 acres, it is the largest channel widening project ever completed under the SWH Program. Project design included hydraulic dredging of over 2 million cubic yards of material and the placement of 60 rock and large woody debris (LWD) structures. Previously constructed river top-width widening projects were designed to utilize natural river processes of erosion and deposition to create the desired habitat. Deer Island was constructed to the desired end state.

The Decatur Bend Project was revetment set back constructed in 2008. It is located at river miles 685.7 to 687.2. Armoring was removed to a depth of 5 feet below construction reference plane along a 1.5 mile segment of the revetment. The objective was to allow the river to erode a shallow shelf on the outside bend of the river. Hard points were installed 175 feet from the bank to stabilize the project boundary. Initial construction was 3.3 acres of SWH. Thirty three acres were expected when the project reached the desired state. The flood of 2011 left the site much wider and deeper than intended. Widths of over 400 feet were measured in some locations. Very little area met the 5 foot depth requirement. Dikes and closing structures were constructed and SWH is developing. Project area is currently 51 acres.

The Middle Little Sioux Reach is the adjacent river bend upstream of Deer Island at river miles 673 to 675. It was selected as a control site. Minor dike notching was conducted at the bend over the previous decade but it remains a typical stable inside bend dike field.

Figure 2. Location of Middle Little Sioux Bend and Lower Decatur Bend, Deer Island SWH project sites.

Methods

Fish sampling was conducted from May 19, 2014 through October 1, 2014. The sampling period was divided into two week intervals resulting in ten individual sampling periods. Initial gears used in the study were mini fyke net and push trawl. A small mesh 16 foot otter trawl was added in August and used for the remainder of the study. A description of these gears and protocols for deployment are detailed in the Missouri River Standard Operating Procedures for Fish Sampling and Data Collection (Welker and Drobish 2011). Individual gear deployment locations were based on available habitat and gear requirements with a general intention of equidistant spacing. A minimum of eight samples were collected with each gear at each site during each sampling cycle with several exceptions. A high water event peaked at 80,600 ft^3/sec on June 20th. Due to safety concerns and a lack of SWH at these discharges no sampling occurred during the June 16th to June 29th sampling period. River discharges were well above normal again in September eliminating all SWH at Decatur Bend and appropriate mini fyke locations at Middle Little Sioux Bend (Figure 2). All adult fish and some juveniles were measured and released in the field. The remaining fish were bagged and preserved with 95% ethanol. Fish were identified and enumerated in the lab with lengths collected on select species. Depth and longitude/latitude coordinates were collected at the beginning, middle and end of trawl deployments and at the frame of mini fyke nets. Water velocity measurements were collected near the bottom with a Marsh-McBirney flowmeter at the middle of at least 25% of trawls and when sturgeon species were collected.

Catch per unit effort (CPUE) was calculated as fish per 100 meters for push trawl and otter trawl samples. Mini fyke net CPUE was expressed as fish per net night. CPUE and standard error were calculated for all species collected. CPUE data were transformed [$log_{10}(C/f +1)$] to meet the assumption of normality. One way analysis of variance (ANOVA) was used to detect differences in catch rates between sample sites (Zar 1999). Statistical significance was determined at $\alpha = 0.05$ for all analyses. When differences among catch rates were detected, the Tukey's honest significance test was used to determine where differences occurred.

Results

A total of 450 samples were collected. Mean depth of gear deployments were similar between sites (Table 1). A total of 5,419 fish were sampled representing 39 species (Table 2). River shiner *Notropis blennius* dominated the catch followed by unidentified larval fish and freshwater drum. Five hundred and eighty two fish were identified only to family or genus. Table 3 displays the number of species collected by site and gear. Eighty four percent of the catch was collected with mini fyke nets (Table 4). CPUE and standard error for mini fyke, otter trawl and push trawl respectively are reported in Tables 5, 6 and 7.

No pallid sturgeon were collected. One YOY shovelnose sturgeon was collected on September 25, 2015with the push trawl at Deer Island. It measured 166 millimeters. Fish less than 191 mm are assumed YOY (Hamel 2013 cited by Hall et al). Figure 3 displays bottom contour and depth at the beginning, middle and end of the trawl. Depth of the sample that collected the YOY sturgeon mirrors the mean depth of all push trawl samples collected. Current velocity measured near the bottom at the mid-point of the trawl was measured at 0.26 meters/second. Substrate composition was 100% sand. Thirteen of the fifteen total adult shovelnose sturgeon *Scaphirhynchus platorynchus* collected came from Deer Island. Fourteen of the fifteen total shovelnose captured were collected with the OT04 otter trawl.

Mini fyke net catch rates were higher in the two SWH sites than the control site for 14 taxa (Table 4). Conversely, mini fyke catch rates were higher in the control sites for seven taxa. However, there were no significant differences in mini fyke catch rates. The only significant difference detected was otter trawl CPUE for silver chubs *Macrhybopsis storeriana* (F=4.00, df=121, P=.021). Tukey's honest significance test determined that silver chub CPUE was higher at Middle Little Sioux Bend than at Decatur Bend (q=3.357). Several species were approaching significance ($0.05<P<0.10$). They include; freshwater drum collected with mini fyke nets and otter trawl and shovelnose sturgeon collected with otter trawl (Table 8).

Unidentified larval fish accounted for 13% of the total catch. Although unidentified, these fish were examined and determined to be other than sturgeon. Catch of unidentified larval fish was higher at Deer Island than the other 2 sites.

Catch of larval Catostomidae spp. and Cyprinidae spp. were also highest at Deer Island. Catch of channel catfish *Ictalurus punctatus* was higher at Deer Island. Larval Sander spp. was more common in the 2 SWH sites than the control.

Discussion

1. Drifting larval pallid sturgeon and other larval fishes drift into created habitats from the main channel.

No larval sturgeon were collected at any site. Absence of larval pallid sturgeon does not support the hypothesis. Unidentified larval fish and fish identified to genus or family were collected at all sites. Presence of larval fish at created SWH sites support the hypothesis of recruitment of "other larval fish" from the main channel drift. Larval fish were entrained into the control site as well. Hall et al (2014) documented larval shovelnose sturgeon in 2013 and suggested that the unique design, scale and proximity to the main channel of the Deer Island site would allow for increased recruitment of larval sturgeon drift. We found no evidence of this.

2. Young of the year pallid sturgeon and other fishes are retained to a higher degree in created SWH than habitats already available.

No young of the year pallid sturgeon were collected at any site, as such, no pallid sturgeon were retained. Retention infers that once present at a location a species would persist through time. Hall (2014) sampled YOY shovelnose on three different dates ranging from July 3 to October 7, 2014. Our specimen was sampled September 25. Four of the five specimens were large enough (>68 mm) to be mobile and likely selected for this habitat. Collectively these samples point to a persistence or retention of YOY shovelnose sturgeon at Deer Island but this observation does not confirm the hypothesis.

3. Small bodied and young of the year fishes are present in higher numbers in created SWH than habitats already available.

CPUE was not significantly higher at created SWH than the control site for any taxa. Otter Trawl CPUE for silver chub was significantly higher at the control site, Middle Little Sioux Bend, than created habitat at Lower Decatur Bend. Silver chubs are common in off-channel habitats in this river segment (Sterner et al 2010). Pflieger (1997) described silver chubs as an inhabitant of quiet pools and backwaters so it is not surprising that they were less abundant in main channel bar habitat.

The USACE has completed dozens of shallow water habitat projects in the upper channelized river. The unique element of the Deer Island Project is that is built to the desired end state rather than allowing natural river processes to achieve the desired end state. The project was also much larger in scale than any previous project. There was no bathymetry data collected in this study but visual observations suggest the project conforms well to the criteria for shallow water habitat described in the BIOP. Our results do not support any of the hypotheses for this study. However, for a second consecutive year YOY shovelnose sturgeon were collected at the recently constructed SWH site at Deer Island. No YOY sturgeon were collected at this location previous to construction by either HAMP or Pallid Sturgeon Population Assessment Program crews (Hall et al 2014). Individual collections of YOY shovelnose sturgeon are rare in the upper channelized river. Multiple collections over 2 years at a single project site suggest a positive biological response.

Recommendations

Our investigation used multiple gears spread over multiple study sites which are typical of monitoring programs in the Missouri River Recovery Program (MRRP). Multiple gears are often used in broad fish community assessment programs because of the inherent bias of certain gears towards species or habitats (Guy 2009). However, dividing effort among multiple sites and gears reduces the power of statistical analysis (Schloesser et al 2012). Future investigations should consider focusing effort to the Deer Island SWH site (and a control bend) utilizing gears most efficient in collecting the species in question. Small mesh otter trawl (OT04) was our most effective gear for sampling all sizes of shovelnose sturgeon and has been effective in sampling shovelnose in other programs (Schloesser et al 2015). Recent collections of YOY shovelnose sturgeon at Deer Island with the push trawl (POT02) warrant the continued use of this gear. Mini fyke nets did not capture any sturgeon species in this study and have been ineffective in collecting sturgeon species in other MRRP monitoring programs. Use of mini fyke nets could be discontinued. Reallocating effort expended at Decatur Bend to Deer Island utilizing two efficient gears could increase the number of samples by 50% or more thereby increasing power for statistical analysis. Use of the otter trawl and push trawl also provide the best potential for detecting YOY pallid sturgeon if present.

Literature cited

Gemeinhardt, T. R., N. J. C. Gosch, D. M. Morris, M.L. Miller, T.L. Welker and J.L. Bonneau. 2015. Is Shallow Water a Suitable Surrogate For Assessing Efforts to Address Pallid Sturgeon Population Declines. River Research Applications. Published online in Wiley Online Library. (wileyonlinelibrary.com) DOI: 10.1002/rra.2889.

Guy C.S., Braaten P.J., Herzog D.P., Pitlo J., Rogers R.S. 2009. Warmwater fish in rivers. In: Bonar S, Willis DW, Hubert WA (eds) Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, MD

Hall J. R., S.J. Sampson, K. J. Hatten, and G. Mestl. 2014. Habitat Assessment and Monitoring Program, 2013 Annual Report, Nebraska Game and Parks Commission, Lincoln, Nebraska.

Hamel, M. J. 2013. Determining Scaphirhynchus Sturgeon Population Demographics and Dynamics: Implications for Rang-Wide Management, Recovery, and Conservation. Dissertations and Theses in Natural Resources. Paper 78. University of Nebraska, Lincoln, NE

Jahili, S. and D. Pridal. 2010. Missouri River Shallow Water Habitat Accounting Report. U.S. Army Corps of Engineers, Kansas City and Omaha Districts.

National Research Council. 2002. The Missouri River ecosystem-exploring the prospects of recovery. National Academy Press, Washington, DC.

Pflieger, W. L. 1997. The fishes of Missouri, 2nd edition. Missouri Department of Conservation, Jefferson City, Missouri.

Schloesser J.T., Paukert C.P., Doyle W.J., Hill T.D., Steffensen K.D., Travnichek V.H. (2012) Heterogeneous detection probabilities for imperiled Missouri River fishes: implications for large-river monitoring programs. Endang Species Res 16: 211−224

Sterner V, Bowman R, Eder B, Negus S, Mestl G, Whiteman K, Garner D, Travnichek V, Schloesser J, McMullen J, Hill T. 2009. Final Report, Missouri River Fish and Wildlife Mitigation Program, Fish Community Monitoring and Habitat Assessment of Off-channel Mitigation Sites. Nebraska Game and Parks

Commission, Missouri Conservation Department, Iowa Department of Natural Resources and U.S. Fish and Wildlife Service.

USFWS. 2000. Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. Fort Snelling, MN.

USFWS. 2003. Amendment to the 2000 Biological Opinion on the operation of the Missouri River Main Stem Reservoir System, operation and maintenance of the Missouri River bank 18 stabilization and navigation project, and operation of the Kansas River Reservoir System. Fort Snelling, MN

USACE (U.S. Army Corps of Engineers). 2003. Final supplemental environmental impact statement for the Missouri River fish and wildlife mitigation project. U.S. Army Corps of Engineers, Kansas City and Omaha Districts.

USACE (U.S. Army Corps of Engineers). 2012. Operational Draft Shallow Water Habitat Adaptive Management Strategy. U.S. Army Corps of Engineers, Kansas City and Omaha Districts.

Welker, T.L., and M.R. Drobish (editors). 2011. Missouri River Standard Operating Procedures for Sampling and Data Collection, Volume 1.6. U.S. Army Corps of Engineers, Omaha Districts, Yankton, SD.

Zar, J. H. 1999. Biostatistical Analysis, Fourth Edition. Prentice-Hall, Upper Saddle River, N.J.

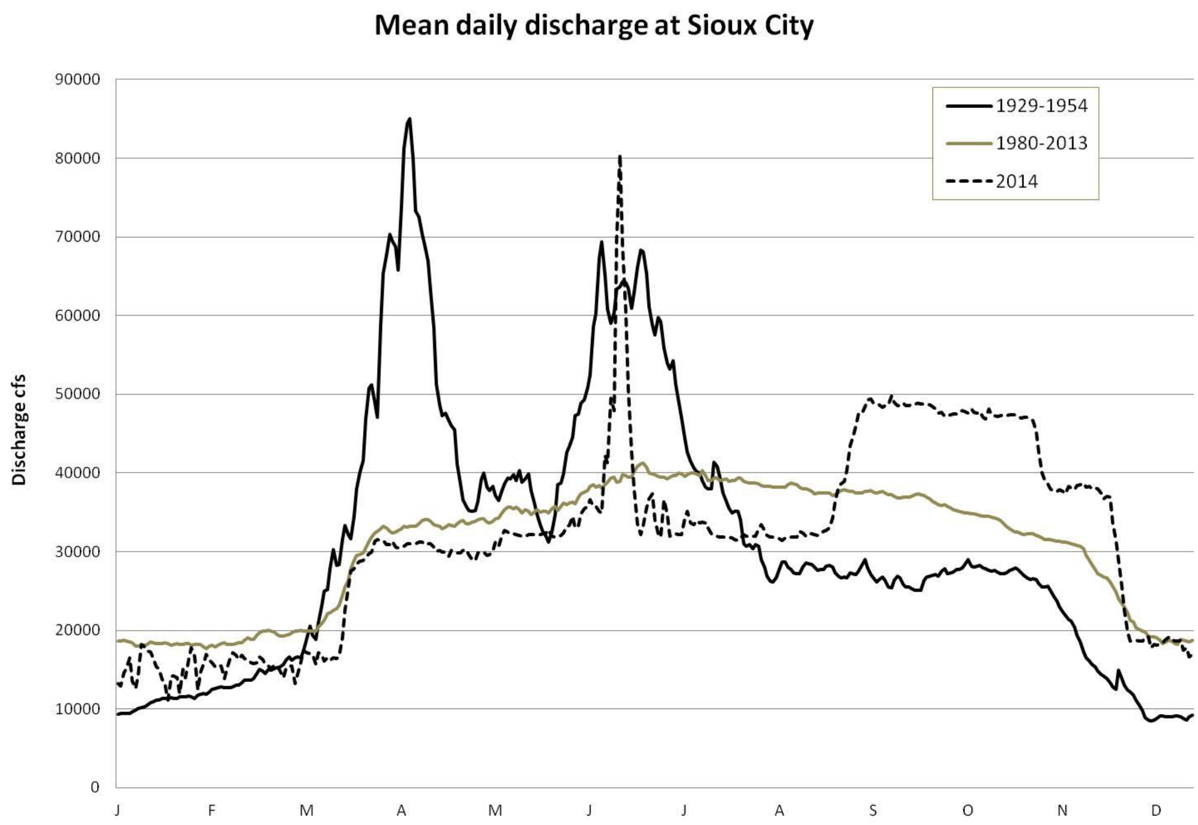

Figure 2. Missouri River discharge at Sioux City, Iowa. Source: http://waterdata.usgs.gov/ne/nwis/uv?site_no=06486000.

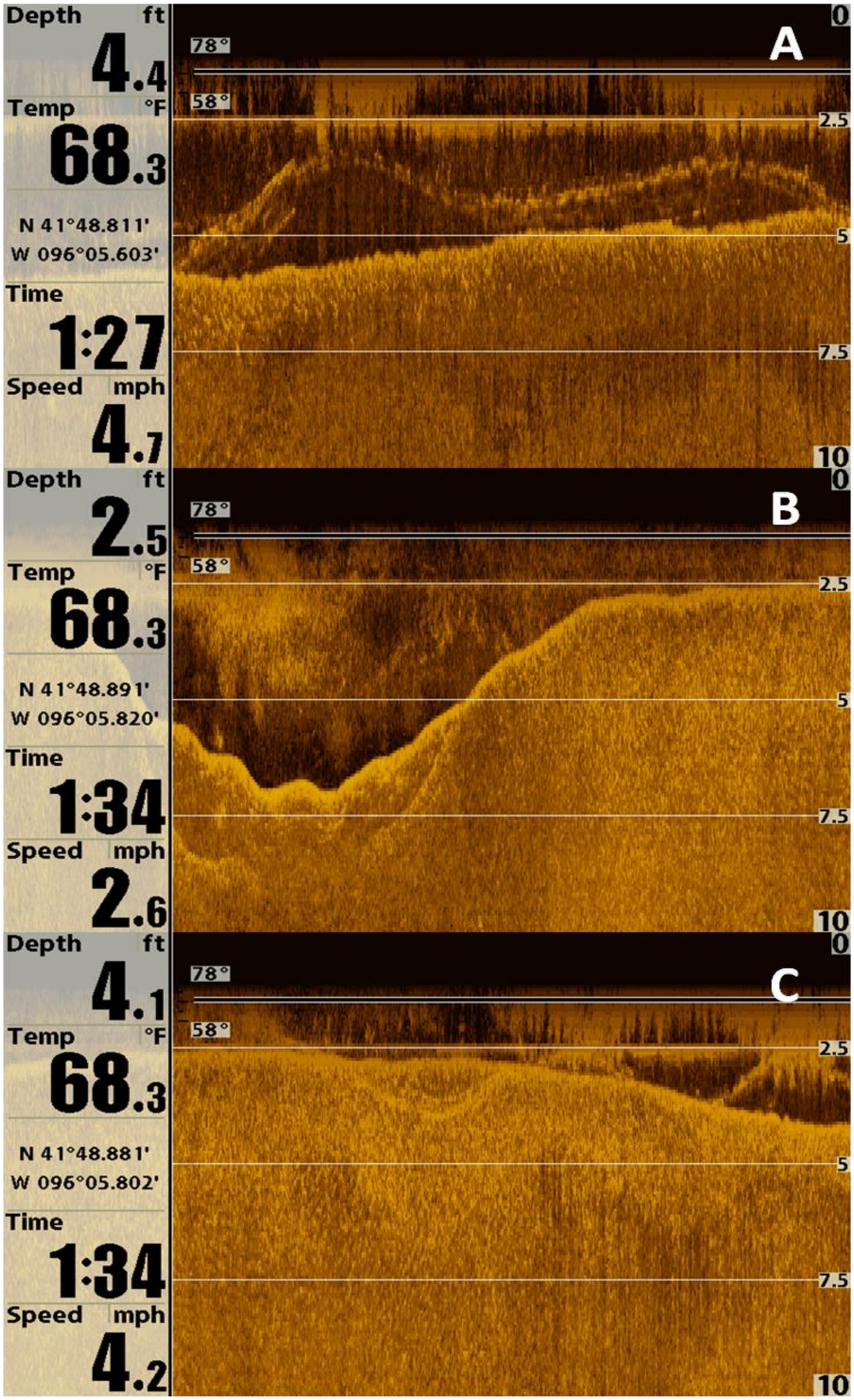

Figure 3. Hummingbird side-scan screen shots displaying depth and bottom contours at the beginning (A), midpoint (B) and end (C) of a push trawl deployment that captured a young of the year shovelnose sturgeon at Deer Island Shallow Water Habitat Project on September 25th, 2014.

Depth	Mini Fyke	Otter Trawl	Push Trawl
Deer Island	0.75	2.69	1.11
Decatur Bend	0.83	2.74	1.11
Middle Little Sioux Bend	0.87	2.56	1.10
Bottom velocity			
Deer Island	NA	0.49	0.45
Decatur Bend	NA	0.33	0.31
Middle Little Sioux Bend	NA	0.54	0.27
Trawl distance			
Deer Island	NA	97.8	77.8
Decatur Bend	NA	90.7	70.1
Middle Little Sioux Bend	NA	81.6	49.3

Table 1. Mean depth, current velocity measured near the bottom and trawl distance of gear deployments at Deer Island, Decatur Bend and Middle Little Sioux Bend.

Common name	Deer Island	Decatur Bend	Middle Little Sioux Bend	Total
Bigmouth buffalo	17	40	9	66
Black crappie	0	0	1	1
Blue sucker	0	0	2	2
Bluegill	6	11	7	24
Channel catfish	84	29	28	141
Common carp	1	11	1	13
Emerald shiner	68	113	70	251
Fathead minnow	5	2	0	7
Flathead catfish	0	1	0	1
Freshwater drum	108	170	170	448
Gizzard shad	352	6	6	364
Green sunfish	17	25	47	89
Green sunfish x Bluegill	1	0	0	1
Largemouth bass	6	6	7	19
Larval fish Unidentified	313	153	237	703
Longnose gar	1	3	2	6
Northern pike	1	0	0	1
Orangespotted sunfish	0	5	6	11
Plains topminnow	0	1	0	1
Red shiner	82	101	54	237
River carpsucker	53	8	7	68
River redhorse	1	0	0	1
River shiner	458	818	259	1535
Sand shiner	56	13	15	84
Sauger	6	4	1	11
Shorthead redhorse	1	1	0	2
Shortnose gar	5	23	21	49
Shovelnose sturgeon	13	1	1	15
Silver carp	16	67	50	133
Silver chub	23	3	34	60
Smallmouth buffalo	27	101	15	143
Speckled chub	10	2	2	14
Spotfin shiner	159	64	94	317
Stonecat	2	0	0	2
Tadpole madtom	1	0	0	1
Unidentified asian carp	2	3	9	14
Unidentified buffalo	2	23	10	35
Unidentified carpsucker	1	0	0	1
Unidentified crappie	12	1	0	13

Unidentified chub	0	0	1	1
Unidentified micropterus	0	0	1	1
Unidentified minnow	68	0	24	92
Unidentified stizostedion	27	86	1	114
Unidentified sucker	270	9	9	288
Unidentified sunfish	6	1	16	23
Walleye	1	0	0	1
White bass	1	2	2	5
White crappie	3	3	3	9
White sucker	0	0	1	1
	2286	1910	1223	5419

Table 9. Total catch from mini fyke net, small mesh otter trawl and push trawl deployments at Deer Island, Decatur Bend and Middle Little Sioux Bend from May19 to October 1, 2014.

	Mini Fyke	Otter Trawl	Push Trawl
Deer Island	32	8	26
Decatur Bend	33	6	8
Middle Little Sioux Bend	32	11	8

Table 3. Number of species collected with mini fyke net, small mesh otter trawl and push trawl deployments at Deer Island, Decatur Bend and Middle Little Sioux Bend from May19 to October 1, 2014.

	Mini Fyke	Otter Trawl	Push Trawl
Deer Island	1790	87	409
Decatur Bend	1772	57	81
Middle Little Sioux Bend	955	91	177
	4517	235	667

Table 4. Total catch collected with mini fyke net, small mesh otter trawl and push trawl deployments at Deer Island, Decatur Bend and Middle Little Sioux Bend from May19 to October 1, 2014.

Mini Fyke Net

Common name	Deer Island		Decatur Bend		Middle Little Sioux Bend	
	CPUE	SE	CPUE	SE	CPUE	SE
Black crappie	0.00	--	0.00	--	0.02	0.02
Bluegill	0.07	0.04	0.28	0.09	0.13	0.07
Bigmouth buffalo	0.29	0.15	1.00	0.65	0.16	0.13
Blue sucker	0.00	--	0.00	--	0.00	--
Common carp	0.02	0.02	0.28	0.16	0.00	--
Channel catfish	0.25	0.16	0.18	0.13	0.14	0.07
Emerald shiner	0.96	0.30	2.38	1.01	1.09	0.39
Flathead catfish	0.00	--	0.03	0.03	0.00	--
Fathead minnow	0.09	0.06	0.05	0.05	0.00	--
Freshwater drum	1.23	0.27	0.20	0.99	2.43	0.45
Green sunfish	0.23	0.15	3.63	0.39	0.84	0.32
Gizzard shad	6.27	4.61	0.63	0.10	0.05	0.03
Largemouth bass	0.07	0.04	0.00	0.09	0.13	0.06
Longnose gar	0.00	--	0.13	0.04	0.04	0.03
Larval fish Unidentified	2.11	1.38	0.15	2.51	2.57	1.44
Northern pike	0.00	--	0.08	--	0.00	--
Orange spotted sunfish	0.00	--	0.13	0.09	0.11	0.06
Plains top minnow	0.00	--	0.03	0.03	0.00	--
Red shiner	1.34	0.56	2.52	0.85	0.88	0.31
River carpsucker	0.88	0.84	0.20	0.09	0.04	0.04
River redhorse	0.02	0.02	0.00	--	0.00	--
River shiner	7.71	2.70	19.30	7.52	3.66	1.19
Spotfin shiner	2.63	0.70	1.60	0.99	1.63	0.53
Sauger	0.07	0.04	0.08	0.08	0.02	0.02
Shorthead redhorse	0.00	--	0.03	0.03	0.00	--
Speckled chub	0.00	--	0.00	--	0.00	--
Smallmouth buffalo	0.48	0.27	2.53	2.13	0.21	0.20
Shortnose gar	0.02	0.02	0.58	0.23	0.38	0.29
Shovelnose sturgeon	0.00	--	0.00	--	0.00	--
Sand shiner	0.43	0.17	0.23	0.14	0.27	0.14
Stone cat	0.04	0.03	0.00	--	0.00	--
Silver chub	0.02	0.02	0.00	--	0.02	0.02
Silver carp	0.29	0.15	1.68	1.38	0.89	0.46
Tadpole madtom	0.00	--	0.00	--	0.00	--
Unidentified asian carp	0.04	0.04	0.08	0.08	0.16	0.10
Unidentified buffalo	0.04	0.04	0.58	0.58	0.18	0.10
Unidentified centrachid	0.04	0.04	0.03	0.03	0.29	0.16

Unidentified carpsucker	0.02	0.02	0.00	--	0.00	--
Unidentified sucker	4.48	3.07	0.23	0.11	0.16	0.12
Unidentified minnow	1.21	0.72	0.00	--	0.43	0.20
Unidentified chub	0.00	--	0.00	--	0.02	0.02
Unidentified micropterus	0.00	--	0.00	--	0.02	0.02
Unidentified pomoxis	0.13	0.08	0.03	0.03	0.00	--
Unidentified stizostedion	0.48	0.45	2.15	1.97	0.02	0.02
Walleye	0.00	--	0.00	--	0.00	--
White bass	0.00	--	0.05	0.05	0.04	0.03
White crappie	0.04	0.04	0.08	0.08	0.05	0.03
White sucker	0.00	--	0.00	--	0.02	0.02

Table 5. CPUE (fish per net night) of fish collected with mini fyke nets at Deer Island, Decatur Bend and Middle Little Sioux Bend from May19 to October 1, 2014.

Small Mesh Otter Trawl

	Deer Island		Decatur Bend		Middle Little Sioux Bend	
Common name	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**
Blue sucker	0.00	--	0.00	--	0.06	0.04
Common carp	0.00	--	0.00	--	0.04	0.04
Channel catfish	1.05	0.33	0.87	0.35	0.84	0.33
Emerald shiner	0.12	0.07	1.33	1.03	0.15	0.09
Freshwater drum	0.10	0.06	0.57	0.23	0.78	0.32
Gizzard shad	0.00	--	0.00	--	0.02	0.02
River carpsucker	0.00	--	0.00	--	0.19	0.19
River shiner	0.00	--	0.00	--	0.04	0.04
Shorthead redhorse	0.02	0.02	0.00	--	0.00	--
Speckled chub	0.23	0.21	0.03	0.03	0.08	0.06
Shovelnose sturgeon	0.30	0.14	0.03	0.03	0.06	0.06
Silver chub	0.38	0.20	0.11	0.09	1.06	0.42

Table 10. CPUE (fish per 100 meters) of fish collected with small mesh otter trawl at Deer Island, Decatur Bend and Middle Little Sioux Bend from May19 to October 1, 2014.

	Push Trawl					
	Deer Island		Decatur Bend		Middle Little Sioux Bend	
Common name	**CPUE**	**SE**	**CPUE**	**SE**	**CPUE**	**SE**
Bluegill	0.036	0.025	0.000	--	0.000	--
Bigmouth buffalo	0.019	0.019	0.000	--	0.000	--
Channel catfish	0.489	0.458	0.000	--	0.000	--
Emerald shiner	0.237	0.118	0.000	--	0.168	0.085
Freshwater drum	0.698	0.424	0.601	0.405	0.372	0.294
Green sunfish	0.065	0.046	0.000	--	0.000	--
Gizzard shad	0.019	0.018	0.040	0.040	0.069	0.048
Largemouth bass	0.037	0.026	0.000	--	0.000	--
Longnose gar	0.017	0.017	0.000	--	0.000	--
Larval fish Unidentified	4.007	2.309	0.666	0.355	3.220	2.954
Northern pike	0.017	0.017	0.000	--	0.000	--
Red shiner	0.133	0.133	0.000	--	0.182	0.182
River carpsucker	0.093	0.048	0.000	--	0.000	--
River shiner	0.515	0.238	2.318	1.909	2.177	1.650
Spotfin shiner	0.245	0.145	0.000	--	0.151	0.151
Sauger	0.036	0.025	0.000	--	0.000	--
Speckled chub	0.000	--	0.022	0.020	0.000	--
Smallmouth buffalo	0.000	--	0.000	--	0.109	0.109
Shortnose gar	0.081	0.041	0.000	--	0.000	--
Shovelnose sturgeon	0.026	0.026	0.000	--	0.000	--
Sand shiner	0.547	0.510	0.269	0.269	0.000	--
Silver chub	0.195	0.113	0.040	0.040	0.030	0.030
Unidentified centrachid	0.114	0.114	0.000	--	0.000	--
Unidentified sucker	0.332	0.274	0.000	--	0.000	--
Unidentified pomoxis	0.092	0.055	0.000	--	0.000	--
Walleye	0.028	0.028	0.000	--	0.000	--
White bass	0.014	0.014	0.000	--	0.000	--
White crappie	0.019	0.019	0.000	--	0.000	--

Table 7. CPUE (fish per 100 meters) of fish collected with push trawl at Deer Island, Decatur Bend and Middle Little Sioux Bend from May19 to October 1, 2014.

		Deer Island	Decatur Bend	Middle Little Sioux Bend			
Gear	**Common name**	**CPUE**	**CPUE**	**CPUE**	***df***	***F***	***P***
MF	Bigmouth buffalo	0.29	1.00	0.16	151	1.01	0.37
MF	Emerald shiner	0.96	2.38	1.09	151	0.53	0.59
MF	Freshwater drum	1.23	0.20	2.43	151	2.84	0.06
MF	Gizzard shad	6.27	0.63	0.05	151	2.12	0.12
MF	Larval fish Unidentified	2.11	0.15	2.57	151	0.16	0.86
MF	Red shiner	1.34	2.52	0.88	151	1.73	0.18
MF	River shiner	7.71	19.30	3.66	151	1.92	0.15
MF	Spotfin shiner	2.63	1.60	1.63	151	1.54	0.22
MF	Smallmouth buffalo	0.48	2.53	0.21	151	0.96	0.39
MF	Sand shiner	0.43	0.23	0.27	151	0.62	0.54
MF	Silver carp	0.29	1.68	0.89	151	0.32	0.72
OT04	Channel catfish	0.25	0.18	0.14	121	0.24	0.79
OT04	Emerald shiner	0.96	2.38	1.09	121	0.70	0.50
OT04	Freshwater drum	1.23	0.20	2.43	121	3.02	0.05
OT04	Speckled chub	0.00	0.00	0.00	121	0.28	0.76
OT04	Shovelnose sturgeon	0.00	0.00	0.00	121	2.84	0.06
OT04	Silver chub	0.02	0.00	0.02	121	4.00	0.02
POT02	Channel catfish	0.25	0.18	0.14	175	1.40	0.25
POT02	Freshwater drum	1.23	0.20	2.43	175	0.60	0.55
POT02	Larval fish Unidentified	2.11	0.15	2.57	175	0.42	0.66
POT02	River shiner	7.71	19.30	3.66	175	0.03	0.97
POT02	Sand shiner	0.43	0.23	0.27	175	0.79	0.45

Table 8. CPUE and one way ANOVA results for fish collected with push trawl at Deer Island, Decatur Bend and Middle Little Sioux Bend from May19 to October 1, 2014.

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Title: Influence of habitat on young-of-year Shovelnose Sturgeon prey use

The lower Missouri River has been highly modified and it is hypothesized that loss of shallow-water habitat (SWH) has decreased prey items and survivability for young-of-year (YOY) Sturgeon. Early life stages of Sturgeon depend on these habitats for recruitment. In this study, we sought to quantify diets of Shovelnose Sturgeon (*Scaphirhynchus platorynchus*) and how they vary by the amount of SWH. Five reaches (from 24 to 41 km in length) between Kansas City, MO and Saint Louis, MO that varied in amount of SWH were sampled bi-monthly from May through October 2014. We captured 506 YOY Sturgeon ranging from 15 to 120 mm FL. We found that diet items were restricted to mainly three macroinvertebrate orders: Diptera, Ephemeroptera, and Trichoptera. Less than 5% of YOY Sturgeon had empty guts. Of the remaining fish, we identified 80,909 diet items, of which 93.55% were Diptera larvae, 5.95% Diptera pupae, 0.45% Ephemeroptera, and 0.05% Trichoptera. Prey-specific abundance varied according to length category and reach location for Diptera larvae and Ephemeroptera but no interaction was present for Diptera pupae. These results will help identify restoration goals to improve conditions suitable for YOY Shovelnose Sturgeon.

Table 1

Metrics for Diptera larvae, Diptera pupae, and Ephemeroptera in the gut of 506 young-of-year shovelnose sturgeon sampled in the lower Missouri River during 2014.

Metric	Diptera larvae	Diptera pupae	Ephemeroptera
Frequency of occurrence (%)	88	46	29
Median number per gut	37	0	0
25% quartile number per gut	3	0	0
75% quartile number per gut	174	3.75	1
Minimum number per gut	0	0	0
Maximum number per gut	1345	475	16

Table 2

Number of empty guts of 506 young-of-year shovelnose sturgeon by length category and reach.

Length Category	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Totals
0-20 mm	3	4	7	0	6	20
21-40 mm	0	1	0	0	0	1
41-60 mm	0	0	0	0	0	0
61-80 mm	0	0	0	0	0	0
81-100 mm	0	0	0	0	0	0
101-120 mm	0	0	0	0	0	0

Table 3

Number of certain prey type by reach and the percent of the total diet.

Prey Type	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Totals	Percent of Diet
Ephemeroptera	154	42	31	53	81	361	0.45%
Diptera larvae	9765	11114	23534	19667	11614	75694	93.55%
Diptera pupae	215	1167	1313	1868	253	4816	5.95%
Trichoptera	16	0	1	3	18	38	0.05%
Totals	10150	12323	24879	21591	11966	80909	

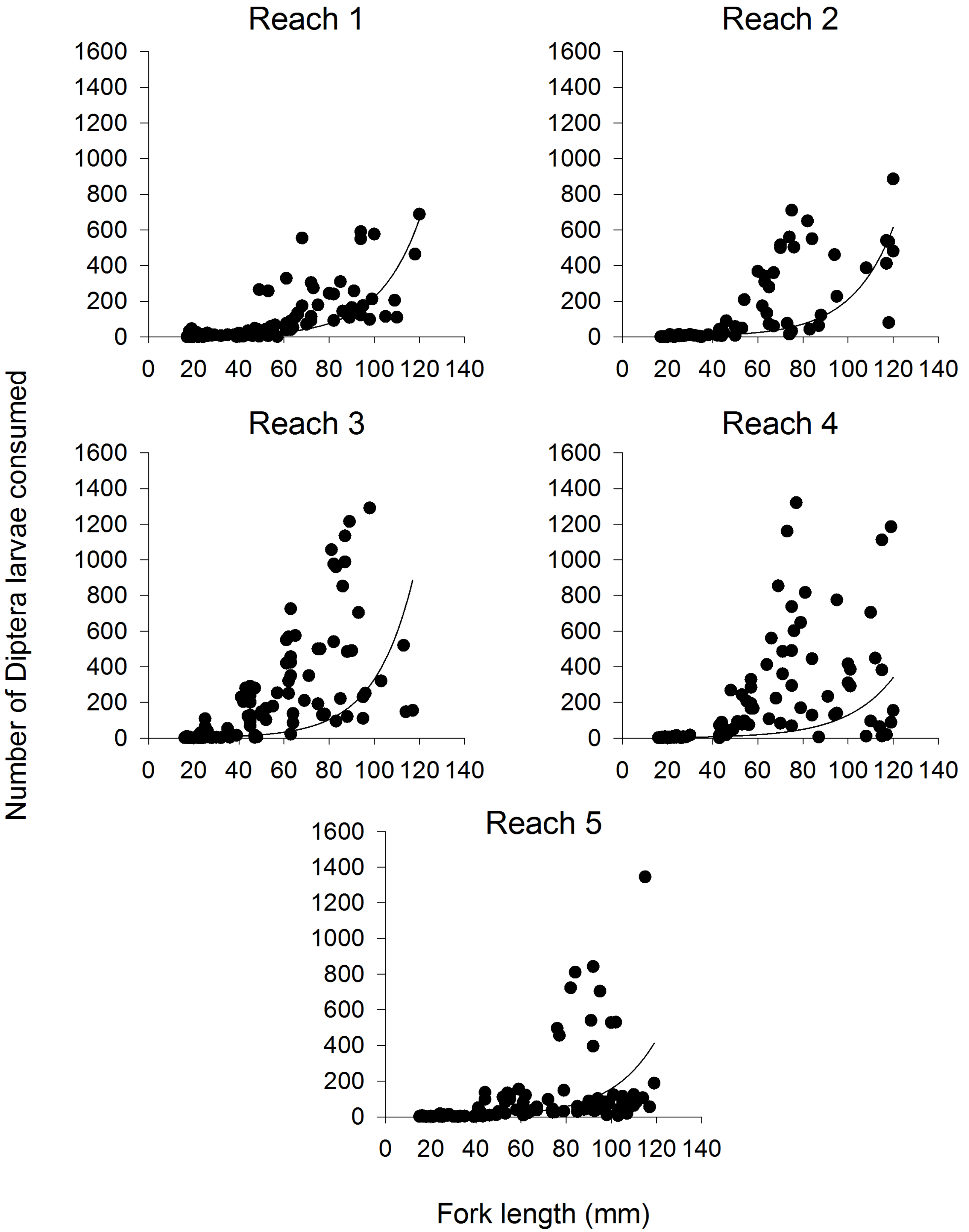

Figure 1. Relationships between number of Diptera larvae consumed by Shovelnose Sturgeon in the lower Missouri River in 2014 according to five reaches sampled.

2015 NEBRASKA GAME AND PARKS COMMISSION BROODSTOCK COLLECTION

Kirk Steffensen

Pallid Sturgeon Recovery Efforts

The Nebraska Game and Parks Commission - Fisheries Division organized the eighth annual intensive effort targeted towards sampling pallid sturgeon in reproductive condition in the upper channelized Missouri River. Volunteers were solicited from area universities, colleges, state and federal agencies, and the general public to assist NGPC Missouri River Program personnel from Monday, April 6 through Friday, April 17.

Five sampling crews targeted the area from the confluence of the Platte and Missouri Rivers (River Mile [RM] 595.0) downstream to Lower Barney Bend south of Hamburg, IA (RM 546.2). With the additional help from volunteers, crews sampled approximately 50 river miles which included 18 different river bends.

Sampling was conducted using 200-foot trotlines with 40 hooks per line baited with nightcrawlers. Throughout the eleven day sampling effort, 22,000 hooks were deployed with 4,896 total fish and 212 pallid sturgeon collected, which included 43 pallid sturgeon transferred to hatchery facilities for reproductive assessment.

Left to right Bob Harms (USFWS), Tony Korth (NGPC), Matt Rabbe (USFWS), and Jeff Runge (USFWS) pose with 4 pallid sturgeon near Plattsmouth, NE.

Background

Pallid sturgeon are native to the Missouri and Mississippi River systems, and due to population declines, the species was listed as federally endangered in 1990. The construction of the mainstem dams and channelization drastically modified the river from its natural state by changing the temperature, turbidity, and natural flow regime of the river. Additionally, river modifications caused widespread alteration and destruction of spawning areas, blocked fish migrations and reduced food availability as populations of many native fish species have shapely declined throughout the Missouri River. Several recovery projects have been initiated to monitor the current population status of pallid sturgeon and other native river species, to evaluate changes in habitat alterations/improvements, and to identify and understand various life history characteristics of pallid sturgeon, particularly reproductive behaviors. In addition to these recovery projects, an artificial propagation and stocking program was developed to ensure the persistence of the species until pallid sturgeon are able to reproduce naturally and become self-sustaining. Early stockings into this reach of the Missouri River relied on the availability of surplus fish from Upper Basin progeny. However in the spring 2007, NGPC initiated a small scale effort and attempted to collect adult broodstock from the Middle Basin for the stocking program. This effort was greatly expanded in 2008 when NGPC organized and conducted the first large scale effort targeted at collecting locally reproductively ready pallid sturgeon from the Propagation Program. Since then, staff from the Missouri Department of Conservation have conducted similar collection efforts. These local broodstock sampling efforts along with standardized efforts have resulted in the capture of 31 adult male and 19 female pallid sturgeon that were successfully spawned in hatchery facilities producing 75,538 progeny.

Rebecca Bozarth (USACE) showing off a pallid sturgeon captured during the coldest day of the 2015 broodstock effort.

2014 NEBRASKA GAME AND PARKS COMMISSION BROODSTOCK COLLECTION

Pallid Sturgeon Captures

A total of 212 pallid sturgeon were collected during the 2015 intensive broodstock collection effort, 43 of which were potential broodfish and were transported to Gavins Point National Fish Hatchery (N = 18) and Blind Pony State Fish Hatchery in Sweet Springs, MO (N = 25). Pallid sturgeon lengths ranged from 341 mm (13.4") to 1,180 mm (46.5"; Figure 1) with weights ranging from 130 g (0.3 lbs) to 5,186 g (11.4 lbs.). An additional 15 pallid sturgeon were collected during NGPC's Population Assessment's standardized sampling and were transported to Gavins Point NFH. Overall, during the intensive broodstock effort, 150 known hatchery-reared pallid sturgeon and 62 of unknown origin (potentially "wild" with genetic results pending) were collected. Only suspected "wild" pallid sturgeon (e.g. no marks or tags) are transferred to the hatchery; therefore, 19 unmarked, sub-adult pallid sturgeon were collected.

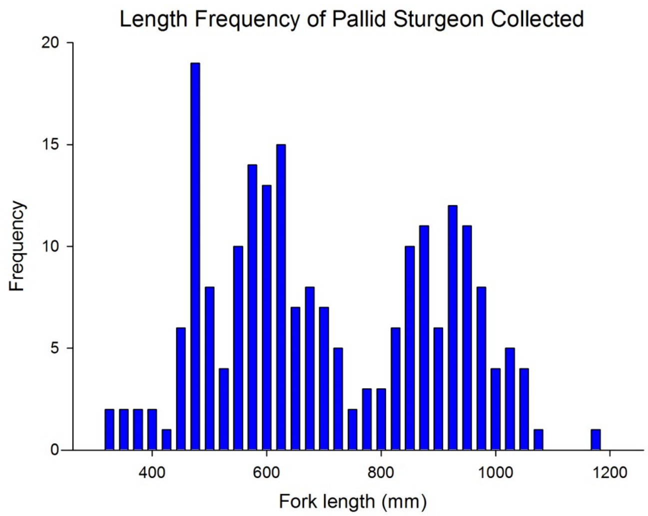

Figure 1. Length frequency of pallid sturgeon caught during the 2015 broodstock collection effort.

Upon arrival at the hatchery, broodstock fish were placed in raceways until a reproductive diagnosis could be conducted. Currently, Gavins Point is holding 2 reproductive females and 9 reproductive males and Blind Pony is also holding 2 reproductive females and 9 reproductive males. Spawning efforts will occur in late-April to early-May and their progeny will be stocked early fall or next spring. All fish will be released back into the river near their capture sites.

Above: Marc Miller (USACE) displays a big hatchery-reared pallid sturgeon.

Below: Amanda Kelly and Kai Kelly show off a pallid sturgeon with

Hatchery Recapture Data

With information gathered from PIT tags in recaptured pallid sturgeon, 61 of the 150 known hatchery-reared pallid sturgeon could be traced back to their hatchery, stocking site, and the year they were produced (i.e. year class). Fish reared at Neosho National Fish Hatchery (N=23) represented 38% of the total known hatchery catch followed by Gavins Point National Fish Hatchery (N=22) and Garrison National Fish Hatchery (N=16). The most common stocking locations of recaptured hatchery-raised fish were Booneville, MO (RM 195.0; N=9), Bellevue, NE (RM 601.0; N=7) and Mulberry, NE (RM 775.0; N=6). The largest downstream movement of a stocked pallid sturgeon was from Sunshine Bottoms, NE (RM 866.2) through the Gavins Point Dam to Otoe Bend (RM 557.0) traveling 309.2 miles. There were 12 fish stocked above Gavins Point Dam (RPMA #3) that passed through the dam and were caught. The largest movement was by a fish that traveled upstream 400 miles from Boonville, MO (RM 195.0) to Upper Plattsmouth Bend (RM 595.0). Age of recaptured hatchery reared pallid sturgeon ranged from 4 to 23 years. The 2002 year class (N=18) was most represented followed by the 2009 YC (N=17) and the 2001, 2007 and 2008 YC's (N=4). Hatchery-reared pallid sturgeon were sampled from 11 of the 17 years classes stocked in the lower Missouri River.

2014 NEBRASKA GAME AND PARKS COMMISSION BROODSTOCK COLLECTION

Sampling Effort

Five crews fished daily from Monday, April 6 through Friday, April 17. A total of 175 volunteers, representing universities, colleges, government agencies, and the public worked a total of 210 days. There were 20 NGPC Missouri River Program employees that led this effort and worked a total of 146 days. All combined, 356 days of effort were expended during the 12-day effort. A total of 550 trotlines were deployed resulting in 22,000 hook nights. The majority, 4,410 of 4,896 or 90% of fish collected were either pallid or shovelnose sturgeon. Additionally, channel catfish (N = 207) were the most frequently captured non-sturgeon species followed by freshwater drum (N = 66) and blue catfish (N = 65). Overall, 14 different fish species were captured.

During the intensive broodstock effort, the number of pallid sturgeon captured ranged from 9 to 27 per day with at least one pallid sturgeon shipped each day the crews were fishing (shipped daily; min = 1 - max = 9). During this effort, there were 15 pallid sturgeon caught twice. Catch rates of pallid sturgeon were similar to the past couple year's, but the total number of fish caught was substantially higher (Table 1). Historic catch rates over the past eight year's broodstock collection efforts are presented below.

Historic Catch Numbers

Year	2008	2009	2010	2011	2012	2013	2014	2015	Overall
Total Fish	4,254	3,982	4,774	4,957	2,811	2,598	3,095	4,869	31,367
CPUE (fish / line)	14.0	9.4	13.8	10.9	5.8	5.9	5.7	8.8	9.3
Total PDSG	168	160	167	212	84	194	221	212	1,418
PDSG Shipped	31	45	37	45	7	33	36	43	277
Progeny Produced	6,663	14,593	6,812	21,736	99	6,053	19,582*		75,538

Table 1. Total number of fish and pallid sturgeon (PDSG) captured then the subsequent number transferred to a hatchery for reproductive assessment during the intensive broodstock effort from the upper channelized Missouri River from 2008-2015. *Additional fish being reared at Neosho National Fish Hatchery.

Sampling gears were deployed in a variety of habitat types and catch rates were highly variable between crews (Table 2). Overall, there was a tie between the Plattsmouth South and Nebraska City North crew for the number of pallid sturgeon shipped to the hatcheries. While the Plattsmouth North crew edged the Hamburg crew for the total number of fish collected, the Hamburg crew captured the only lake sturgeon and first since our 2012 effort.

Capture Rates by Crew

	Plattsmouth North	Plattsmouth South	NE City North	NE City South	Hamburg
Total Fish	1.189	620	838	1,066	1,116
Total PDSG	53	42	45	43	29
PDSG Shipped	9	10	10	5	9

Table 2. Total number of fish, pallid sturgeon (PDSG) captured and shipped by crew during the intensive broodstock effort from the upper channelized Missouri River from 2008-2015.

During this effort, water temperatures ranged from 9.7 to 17.2°C, which were warmer than 2014 (4.6 to 12.4°C).

Average daily discharge during this two week period at Nebraska City was 39,100 cubic-feet per second (cfs) and only varied 2,700 cfs, which was similar to the past three years, but approximately half of the 75,500 cfs seen during our 2011 efforts.

Links

NGPC Pallid Sturgeon Broodstock Facebook page: http://www.facebook.com/NGPCpallid.

NGPC Missouri River Program Flickr page: http://www.flickr.com/photos/ngpc/sets/72157630760869282/

2014 NEBRASKA GAME AND PARKS COMMISSION BROODSTOCK COLLECTION

Sampling Facts

- **4,896 - Total number of fish collected**
    - **212 - Pallid sturgeon**
    - **4,198 - Shovelnose sturgeon**
    - **1 - Lake sturgeon**
    - **11 - Hybrid sturgeon**
- **43 - Number of pallid sturgeon sent to the hatchery for evaluation**
    - **15 - Pallid sturgeon shipped to the hatchery prior to our broodstock effort**
- **22 - Number of pallid sturgeon subsequently determined to be in reproductive condition**
    - **4 females and 18 males**
- **11.4 Pounds - Heaviest pallid sturgeon collected**
- **46.5 inches - Longest pallid sturgeon collected**
- **20.8 - Miles of trot lines deployed**
- **22,000 - Approximate number of night crawlers used**
- **1.829- Miles of night crawlers used if laid end to end**
- **36°F - Coldest sampling day**
- **75°F - Warmest sampling day**
- **175 - Total number of volunteers**
- **3,560 - Estimated number of hours worked by NGPC personnel and volunteers**
- **4 - Most days worked by a volunteer (Randy Stutheit)**
- **1,418 - Total number of pallid sturgeon sampled during the eight years of broodstock efforts**
- **149- Number of reproductive pallid sturgeon collected in the last eight years**
- **31,367 - Total number of fish sampled during the seven years of broodstock efforts.**

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Amanda Kelly
Andrea Ciurej
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Brett Miller
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Nathan Michl
Neil Bass
Nicholas Gollin
Noah Luedtke
Rachel Neisius
Randy Stutheit
Rebecca Bozarth
Rick Lafler
Rick Stasiak
Rob Korgie
Robert Harms
Ross Lawrence
Russ Wilhelm
Ryan Vencil
Sam Cowan
Sam Thompson
Sarah Nodskov
Sarah Purcell
Sarah Zink
Scott Luedtke
Sean Loken
Seth Barnes
Susie Bliss
Terry Lundgren
Tim Lawry
Tim Shew
TJ Fontaine
Tony Barada
Tony Korth
Travis Hazard
Travis Shepler
Trent Lundgren
Zach Utemark
Zachary Kuhr
Brandon Eder
Brian Hammond
Dane Pauley
Dave Adams
Derek Tomes
Gerald Mestl
Holly Evans
Jamie Kindschuh
Jerrod Hall
Joe Spooner
Josh Wilhelm
Justin Haas
Kirk Steffensen
Nate Klar
Riley Schubert
Ryan Ruskamp
Seth Lundgren
Thad Huenemann