2010 Annual Report

Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River: Segments 5 &6

Prepared for the U.S. Army Corps of Engineers – Missouri River Recovery Program

By:

Dane A. Shuman, Robert A. Klumb, Greg A. Wanner, and Kristen L. Grohs

United States Fish and Wildlife Service
Great Plains Fish and Wildlife Conservation Office
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EXECUTIVE SUMMARY

Pallid sturgeon *Scaphirhynchus albus* and the Missouri River fish community were sampled in the unchannelized Missouri River downstream of Fort Randall Dam to the headwaters of Lewis and Clark Lake (Recovery Priority Management Area 3; [RPMA 3]) with standardized gears and protocols from fall of 2009 to fall of 2010 (i.e., 2010 season). Ten randomly selected bends were sampled with a minimum of 8 deployments for each standard gear expended in each bend. The confluence of a major tributary, the Niobrara River, delineates Segment 5 (upstream of the confluence) from Segment 6 (the confluence to the headwaters of Lewis and Clark Lake); however, both segments were pooled for this report. Water conditions within Segments 5 and 6 were dramatically different than previous years, but similar to 2009 with high water levels observed throughout the summer and fall. These elevated water levels increased the wetted width and depth of the river, which increased the area of depths >1.2 m where gears could sample. High water also made deployment of mini-fyke nets difficult due to decreased areas of exposed bars and presence of flooded emergent vegetation along shorelines, especially in the Niobrara River Delta of Segment 6.

A total of 150 pallid sturgeon were captured in 2010; 95% were of known hatchery origin, with passive integrated transponder (PIT) tags detected in 78% of captured fish. Genetic analysis of 26 unmarked fish identified five hatchery fish from the 2001 year class, two fish from the 2002 year class, three fish from the 2004 year class, two fish from the 2005 year class, five fish from the 2006 year class, 1 fish from the 2007 year class, four fish from the 2008 year class, and four fish of unknown origin. Of these four unknown origin fish two possessed dangler tags which were present on the 1997 and 1998 year classes only, while two pallid sturgeon (525 and 544 mm fork length [FL]), with unique genetic markers when compared to known hatchery broodstock, were of similar size to other hatchery propagated fish. Due to the lack of complete parental genetic history from the hatchery broodstock, we cannot definitively determine if fish were hatchery propagated or of wild origin. Twenty-three percent of our unmarked genetically confirmed hatchery propagated fish were from a single stocking of the 2001 year class, demonstrating elevated PIT tag loss within this year class for the third consecutive year. Additionally, nine fish from the 2006 year class had no PIT tag implanted at stocking but were identified by a removed scute or genetics.

Recaptured pallid sturgeon in 2010 represented all years classes stocked (1997 - 1999 and 2001 – 2009) as part of population supplementation efforts. For standardized gears, 14 pallid sturgeon were captured with gill nets, 33 with trammel nets, and 22 with otter trawls. In 2010, the relative abundance of hatchery-reared pallid sturgeon captured in gill nets was 3.5 times lower than 2009 and 1.3 times lower compared to the overall running average (2003 – 2009). Hatchery-reared pallid sturgeon relative abundance in 2010 indexed by drifted trammel nets increased 72% during the fall through spring (i.e. the sturgeon season) and decreased 3% during the summer (i.e. fish community season), when compared to the overall running average (2003-2009). Additionally, hatchery-reared pallid sturgeon relative abundance in the otter trawl slightly increased, 5% and 1% during the sturgeon and fish community seasons, respectively when compared to the overall mean (2005 – 2009). An increase in yearly CPUE for all pallid sturgeon (i.e., fish of known hatchery origin and unknown origin combined) in trammel nets (28%) and a decrease in otter trawls (4%) were also observed when compared to the long-term average.

Spatially, pallid sturgeon were captured throughout most of the length of Segments 5 and 6 (river mile 870 to 829) but 59% of recaptures were in the delta formed downstream of the confluence of the Niobrara and Missouri rivers in Segment 6. Forty-two percent of pallid sturgeon were caught in the same location where an active gear initially captured a pallid sturgeon (i.e., duplicate samples). A total of 64 pallid sturgeon were captured with all gears (trammel nets, gill nets, otter trawl, and trot lines), at two bends within Segment 6: bend 8 (n = 32) and bend 9 (n = 32). These observed aggregations were comprised of multiple year classes based on indentifying tags or marks as well as a wide range of fork lengths (378 – 958 mm) and weights (155 – 3,175 g). Mean relative condition (K_n) of recaptured pallid sturgeon by year class ranged from 0.75 to 1.51, which was similar to previous years. The mean absolute growth rates of fish aged 11 – 13 years was < 0.066 mm/d, while growth rates for fish aged 2- 9 years ranged from 0.102 – 0.286 mm/d. Pallid sturgeon were recaptured in the channel border mesohabitat of braided channels (59%), outside bends (20%), channel crossovers (17%), inside bends (3%), and large secondary connected channels (1%). A total of 150 shovelnose sturgeon *S. platorynchus* were captured in standard gears during 2010: 95 with gill nets, 45 with trammel nets, and 10 with otter trawls. All shovelnose sturgeon have been floy-tagged as part of a U.S. Geological Survey study of population size and survival. No young-of-year *Scaphirhynchus* spp. were captured and the ratio of pallid sturgeon to shovelnose sturgeon in random deployments of standard gears was 1:3.0 in 2010 which was similar to previous two years.

In addition to sturgeon, eight native Missouri River species were targeted for assessment: shoal chub *Macrhybopsis aestivalis*, sturgeon chub *M. gelida*, sicklefin chub *M. meeki*, western silvery minnow *Hybognathus argyritis*, plains minnow *H. placitus*, sand shiner *Notropis stramineus*, blue sucker *Cycleptus elongatus*, and sauger *Sander canadense*. No sturgeon chubs, sicklefin chubs, or shoal chubs were captured in 2010, similar to the previous seven years. A total of 125 *Hybognathus spp*. were captured in mini-fyke nets during the fish community season. All *Hybognathus spp*. were brassy minnows, *H. hankinsoni*. Sand shiners were captured with mini-fyke nets (n = 5) during summer and otter trawls (n = 1) during spring. A total of four blue suckers were captured with standard gears: three in gill nets and one in a trammel net. During 2010, a total of 89 saugers were caught randomly with standard gears: 14 in trammel nets, 13 in otter trawls, 52 in gill nets, and 10 in mini-fyke nets. Saugers were captured (n = 76) primarily during the sturgeon season. A total of 48 fish species and one hybrid were caught in Segments 5 and 6 of the Missouri River during 2010. None of the four exotic Asian carps, bighead carp *Hypophthalmichthys noblis*, silver carp *H. molitrix*, grass carp *Ctenopharyngodon idella*, and black carp *Mylopharyngodon piceus*, were captured or observed.

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Introduction

A team of biologists representing State and Federal resource management agencies was assembled in 2002 to develop and implement a standardized long-term resource monitoring program for the Missouri River. This team is now known as the "Pallid Sturgeon Population Assessment Team" (Welker and Drobish 2010). The primary goal of this monitoring program is to assess the status and recovery of endangered pallid sturgeon *Scaphirhynchus albus* (Dryer and Sandoval 1993). However, the monitoring program is also directed towards the native riverine fish community (Appendix A). This team developed standardized protocols for habitat classification (Appendix B), gear types and deployment methods (Appendix C), as well as data reporting (Welker and Drobish 2010). Four pallid sturgeon Recovery Priority Management Areas (RPMAs), were identified in the recovery plan (Dryer and Sandoval 1993), which encompass nearly 1,775 km (1,100 miles) of the Missouri River system. The Pallid Sturgeon Population Assessment Team delineated 14 sampling segments within these RPMAs to implement the monitoring program. Each sampling segment was selected based on a variety of characteristics such as water temperature, turbidity, tributary influence, presence of degrading or aggrading stream beds, stream gradient, natural hydrograph, spillway releases, and flow fluctuations (Berry and Young 2001; Welker and Drobish 2010). Sampling within these segments allows biologists to monitor trends in pallid sturgeon and native Missouri River fish abundance in relation to flow modification, mitigation efforts, and shallow water habitat restoration projects. Standardized monitoring throughout the Missouri River Basin facilitates comparison of fish relative abundance and size structure in disparate habitats (e.g. Upper vs. Middle basins or unchannelized vs. channelized river banks).

Pallid sturgeon downstream of Fort Randall Dam (also known as RPMA 3) in South Dakota and Nebraska (Figure 1), have been supplemented through stocking since 2000 (Appendices D and E). From June of 2000 through October of 2010, a total of 10,928 juvenile pallid sturgeon were released consisting of 12 year classes: 1997 - 1999 and 2001 - 2009. Additionally, 12 adult fish which were former broodstock or rehabilitated fish were translocated to RPMA 3 from Lake Sharpe, South Dakota (Appendix E). Most hatchery-reared fish were stocked at age-1; however during September of 2008 the first stocking of age-0 fingerlings occurred. There are four stocking locations downstream of Fort Randall Dam: the most upstream site was Sunshine Bottoms at the Boyd County, Nebraska boat ramp, the middle site was at the Verdel, Nebraska boat ramp, and the two downstream sites are at the Running Water boat ramp on the South Dakota side and Chief Standing Bear Bridge on the Nebraska side (Figure 1). This long-term monitoring program serves to assess the success of hatchery propagated fish and guide future stocking efforts. On October 29, 2010, 12 age-6 pallid sturgeon, outfitted with internal sonic telemetry tags with a battery life of 3 years, were stocked at Verdel for a new study of detection probability and catchability for standard fishing gear used in this long-term monitoring program. These age-6 pallid sturgeon were surplus captive broodstock from the U.S. Fish and Wildlife Service Gavins Point National Fish Hatchery in Yankton, South Dakota.

Because current pallid sturgeon abundance is extremely low, data collection that solely targets pallid sturgeon likely would not provide adequate information to evaluate restoration projects and flow modifications to the Missouri River. An ecologically based long-term population assessment approach was adopted to address this concern and evaluate the entire warm water benthic fish community in the Missouri River as required by the U. S. Fish and

Wildlife Service's (USFWS) 2000 Biological Opinion on operations of the main-stem Missouri River dams (USFWS 2000). Additionally, evaluating responses of other native, short-lived Missouri River fishes to changes in habitat or flow modifications may be a more sensitive indicator of habitat change in the near term compared with the rare, long-lived pallid sturgeon. Information derived from this project will be vital for developing sound management recommendations for recovering the native Missouri River fish fauna. Because the pallid sturgeon is a known piscivore (Carlson et al. 1985; Gerrity et al. 2006; Wanner et al. 2007a; Grohs et al. 2009), assessment of the native benthic Missouri River fish assemblage, which likely serves as pallid sturgeon prey, is also a critical component of the monitoring program. A representative group of nine native Missouri River fishes was selected as indicator species for detecting improvement in the warm water benthic fish community. The species selected were: shovelnose sturgeon *S. platorynchus*, western silvery minnow *Hybognathus argyritis*, plains minnow *H. placitus*, shoal chub *Macrhybopsis aestivalis*, sturgeon chub *M. gelida*, sicklefin chub *M. meeki*, sand shiner *Notropis stramineus*, blue sucker *Cycleptus elongatus*, and sauger *Sander canadense.* Counts and lengths of all fish collected during population assessment activities are recorded; however, weight data are only collected from pallid sturgeon and the representative group of nine native Missouri River species.

Goals

Although the Pallid Sturgeon Population Assessment Program itself will not aid in the direct recovery of pallid sturgeon, information derived from this program will be used to evaluate the progress of current and proposed management actions, a key component of implementing an adaptive management approach (Walters and Holling 1990). Restoration of pallid sturgeon in the Missouri River can be divided into three broad categories: population supplementation with hatchery-reared pallid sturgeon, habitat restoration, and changes in current operations of the main-stem dams (i.e., natural hydrograph or “spring rise”). These three actions are all directed towards the ultimate goal of recovery of pallid sturgeon and require monitoring to ascertain success within an adaptive management framework. Therefore, the specific overall goals of this population assessment program for the Missouri River are:

1. Provide needed information to detect change in pallid sturgeon and nine native targeted species populations and
2. Determine habitat preferences over time for pallid sturgeon and nine selected native species.

Objectives

Six objectives have been identified for the monitoring program. Detailed hypotheses for each objective can be found in Welker and Drobish (2010).

1. Document annual results and long-term trends in pallid sturgeon population abundance and geographic distribution throughout the Missouri River system.
2. Document annual results and long-term trends of habitat use of wild pallid sturgeon and hatchery-stocked pallid sturgeon by season and life stage.
3. Document population structure and dynamics of pallid sturgeon in the Missouri River system (i.e., size structure, condition, growth, and survival).
4. Evaluate annual results and long-term trends in population abundance and geographic distribution throughout the Missouri River system of nine targeted native species.
5. Document annual results and long-term trends of habitat usage of nine targeted native

species by season and life stage.

6. Document annual results and long-term trends population abundance and geographic distribution throughout the Missouri River system of all other non-target species where sample size is greater than fifty individuals.

Success Criteria

Evaluation of success will be tied directly to the results of the Pallid Sturgeon Population Assessment Program and the resulting information that these assessments provide. The following four statements may be used to determine program success:

1. The program has the ability to detect population changes.
2. The program has the ability to measure survival of hatchery-reared and stocked pallid sturgeon in the river.
3. The program has the ability to detect reproduction of pallid sturgeon in the Missouri River.
4. The program has the ability to detect recruitment of wild pallid sturgeon in the Missouri River.

Study Area

Lewis and Clark Lake, the most downstream reservoir of the Missouri River, was formed by the closure of Gavins Point Dam in 1955 and is bounded upstream by Fort Randall Dam (Figure 1). Both dams are operated by the U. S. Army Corps of Engineers (USACE). The primary function of Gavins Point Dam is to level out release fluctuations from upstream dams to serve downstream purposes such as navigation, flood control, and municipal water supply. The riverine section of Lewis and Clark Lake extends approximately 89 river kilometers (rkm) from Fort Randall Dam to Springfield, South Dakota (Figure 1). Maximum depth of the riverine section of Lewis and Clark Lake is about 12 m and channel width ranges from 45 - 90 m. Downstream of Springfield, South Dakota, Lewis and Clark Lake becomes more like a reservoir. However, sediment from the Niobrara River has formed a large braided delta, which starts near rkm 1,358 and ends near rkm 1331. This delta has progressively expanded downriver into the reservoir. The riverine section of Lewis and Clark Lake was selected in the Pallid Sturgeon Recovery Plan (Dryer and Sandoval 1993) as 1 of 4 RPMAs in the Missouri River for potential recovery of the species and was designated as RPMA 3.

The riverine section of Lewis and Clark Lake retains many natural characteristics such as sandbars, sandbar pools, side channels, backwater areas, islands, old growth riparian forest, and year round flows. However the historical temperature and flow (i.e., the hydrograph) in the riverine section has been altered due to operation of Fort Randall Dam (Pegg et al. 2003). Water levels substantially fluctuate daily and seasonally (Troelstrup and Hergenrader 1990). Diel water levels are subjected to changes of almost 1 m. Lowest daily flows generally occur at 0600 hours with peak flows occurring between 1200 to 1900 hours in support of power generation demands (USACE 1994). The USACE Missouri River Main Stem Reservoirs 2000 - 2001 Annual Operating Plan (http://www.nwd-mr.usace.army.mil/rcc/reports/aop.html) reported highest seasonal releases from Fort Randall Dam during August through November to support navigation on the Missouri River downstream of Sioux City, Iowa. Lowest releases were during December through April to prevent flooding due to ice jams.

Based on the presence of a major tributary, the Niobrara River in Nebraska, the riverine section of Lewis and Clark Lake (RPMA 3) was divided into two sampling segments by the

Population Assessment Team. Segment 5 (rkm 1416 - 1358, river mile [rm] 880 – 844) encompassed the riverine section downstream of Fort Randall Dam to the Niobrara River confluence. In this segment, water temperatures are depressed by hypolimnetic discharges from Fort Randall Dam and turbidity is low. Segment 6 (rkm 1358 - 1331, rm 844 – 827) encompassed the riverine section downstream of the confluence of the Missouri and Niobrara rivers to the headwaters of Lewis and Clark Lake (Figure 1). This segment has increased water temperatures and turbidity due to inflows from the Niobrara River and includes the large braided delta formed in the headwaters of Lewis and Clark Lake.

Methods

Our sampling protocol followed the detailed guidelines identified in the "Pallid Sturgeon Population Assessment Project and the Missouri River Standard Operating Procedures for Fish Sampling and Data Collection" developed by the Pallid Sturgeon Population Assessment Team (Welker and Drobish 2010). A general summary of those guidelines follows.

Habitat Classification

The basic habitat classification system used in the Benthic Fishes Study (Berry and Young 2001) was adopted by this program (Appendix B). The Benthic Fishes Study was conducted in the late 1990's by the U. S. Geological Survey Cooperative Fish and Wildlife Research Units located at universities throughout the Missouri River Basin. This basic habitat classification system was further modified to address both broad and specific habitats using a hierarchical classification system (e.g., macrohabitat, mesohabitat, and microhabitat) to aid in consistent and comparable data collection across all segments of the Missouri River. Three continuous macrohabitats are present in every bend: outside bends, inside bends, and channel crossovers. An additional 10 discrete macrohabitats have been identified that may not be present in each bend: large tributary mouths, small tributary mouths, confluence areas, large and small secondary connected channels, secondary non-connected channels, deranged channels, braided channels, dendritic channels, and dam tailwaters. Mesohabitats and microhabitats have been defined to further describe fish habitat use. This hierarchal approach provides continuity with previous studies (e.g., Benthic Fish Study) while providing a more detailed and flexible habitat classification system for future work. All habitats were classified based on the conditions at the time of sampling.

The bend served as the basic hydrologic unit sampled within each river segment. A bend was comprised of three continuous macrohabitats: an outside bend (main channel), an inside bend (main channel) and a channel crossover (main channel). Bends were determined by the hydrologic nature of the river and extended from the upstream crossover to just upstream of the next downstream crossover and also encompassed any islands and secondary channels (i.e., discrete habitats) between these two crossovers. Typically, the river channel parallels the adjacent geographic landforms in the channelized river. However, in the unchannelized portions of the Missouri River, bends do not necessarily follow the general form of the landscape; multiple meanders occur within what appears as one large bend based on the shape of the entire river channel. Also, in unchannelized sections, the location of bends and the number of bends within a segment may change over time. The habitat classification scheme allows for bend comparisons between the channelized and unchannelized river despite changes in scale.

Sampling effort

All bends within each segment were sequentially numbered, from upstream to downstream, and then 10 bends (five per segment) were randomly selected for sampling (Appendix I). In past years (2003 and 2004) eight bends were randomly selected and two bends, one upstream and one downstream of the confluence of the Niobrara and Missouri rivers, were non-randomly selected. Following the 2004 sample season, no non-random bends were sampled (i.e., all five bends in each segment were randomly selected). Additional randomly selected bends were sampled to increase sample size as time allowed. Each mesohabitat within a macrohabitat was sampled using standard gears (Appendices B and C). A minimum of two subsamples were required for each standard gear type for each macrohabitat within that bend where a particular gear can effectively be deployed. Habitat data (velocity and turbidity) were collected at each pallid sturgeon capture site and in each bend for one of the two sub-samples from each mesohabitat sampled. Sample location (degrees latitude and longitude), time of day, depth (m) and temperature (°C) were recorded for all subsamples. Detailed habitat data collection methods are found in Welker and Drobish (2010).

A minimum number of gear deployments for each standard gear was used, 10 for gill nets and eight for all other gears in each bend, to ensure sufficient sample size for comparisons between segments (Table 1). The standard gears were selected to sample specific habitats, fish species, and seasons. Some gears were selected to maximize capture of pallid sturgeon, while others targeted the fish community. However, all gears sampled multiple species despite targeting pallid sturgeon. All species captured were enumerated and measured to the nearest mm as total length (TL) except sturgeons were measured to fork length (FL) while paddlefish

Polyodon spathula were measured eye to FL. Wet weight (0.1 g) was only measured for pallid sturgeon and the nine targeted native Missouri River fishes.

The sampling year was divided into two seasons: sturgeon season and fish community season. The sturgeon season encompassed the fall through spring while the fish community season occurred during summer. The sturgeon season focused on the assessment of sturgeon species while collections in the fish community season continued to assess sturgeon but placed additional emphasis and effort towards description of the native fish community. Sampling during the fish community season targeted young-of-the-year (YOY) fishes to provide evidence of recruitment. Delineation between the sturgeon and fish community seasons is primarily based on water temperature. Based on the pallid sturgeon collection and handling protocols (USFWS 2005) pallid sturgeon can only be collected with gill nets at water temperatures < 12.5 °C (< 55 °F). Due to the diversity of habitats and longitudinal changes in climate along the Missouri River, a wide time frame was necessary to facilitate comparable sampling effort among the 14 segments. For example, gill netting downstream of Fork Randall and Gavins Point dam in Nebraska and South Dakota (Segments 5 – 9) is typically not feasible throughout winter because of ice. However, lack of ice in the lower reaches of the Missouri River permit gill netting during most of the winter. Additional gears were deployed during the fish community season to assess the main channel and shallow water habitats (< 1.2 m) and their associated fish communities. The fish community season ran between July 1 and October 30 and the intensive sturgeon sampling occurred when possible for the remainder of the year. Data in this report covers the time period from November 1, 2009 through October 30, 2010 and herein is referred to as the 2010 sampling season. Focused studies have been previously initiated in conjunction with the population assessments program to fulfill unique biological information gaps (e.g., food habits, sturgeon hormone and disease studies, shovelnose sturgeon population estimates, gear evaluations, telemetry, and geographic information system (GIS) projects).

Sampling Gear

Multiple standard gears were deployed to sample deep and shallow water habitats of the Missouri River (Appendix C). Gill nets, trammel nets, and otter trawls were fished in deep waters (≥ 1.2 m) of the main channel, large secondary connected channels, and large tributaries during the sturgeon season. In the fish community season, trammel nets and otter trawls were again used with the addition of mini-fyke nets to sample shallow water (< 1.2 m) habitats (i.e. bars). Multi-filament gill nets (1.8 m deep x 38 m length) consisted of five 8-m long panels with bar mesh sizes of 2.5, 3.8, 5.1, 7.6, and 10.2 cm. A standard gill net consisted of four panels (3.8 – 10.2 cm); the smallest mesh (1 inch: 2.5 cm) was coded wild and not included in abundance calculations in this report. Trammel nets were 1.8 m deep x 38 m length with outside wall panels of 15.2 cm bar mesh and an inside wall panel of 2.5 cm (1 inch) bar mesh and herein is referred to as the "1-inch trammel net". All gill and trammel nets were dyed green during 2003 - 2006 to reduce net avoidance in Segments 5 and 6 due to low turbidity levels (< 10 nephelometric turbidity units [ntu]). However, a comparison study with white mesh nets found little difference in catch rates of sauger and shovelnose sturgeon (Wanner et al. 2010a) and now only white nets are used. The otter trawl (0.5 m deep x 9.1 m wide) had an outer chafing mesh of 64 mm bar mesh, inner bar mesh of 32 mm constructed of Sapphire®, and a 2-m long cod end. Mini-fyke nets consisted of a lead set at the bankline (4.5 m long x 0.6 m high) with two 1.2 m wide x 0.6 m high rectangular steel frames (cab) and two 0.6 m diameter circular hoops with 3 mm "ACE" type nylon mesh. Mini-fyke nets were set with part of the cab above the waterline to prevent drowning turtles. All captured turtles were enumerated (Appendix A). Gill nets and mini-fyke nets were set overnight for a maximum of 18 h and catch per unit effort (CPUE) was calculated as the number of fish per net night. Trammel nets were drifted and otter trawls were pulled downstream on the river bottom for a minimum distance of 75 m and a maximum distance of 300 m. A global positioning system (GPS) was used to quantify distance sampled for trammel nets and otter trawls with CPUE measured as numbers of fish per 100 m of distance deployed. All gear deployments followed the detailed standard operating procedures (SOP) outlined in Welker and Drobish (2010).

The stratified-random study design of the population assessment program shifts to targeted sampling whenever a pallid sturgeon is captured in the initial deployment of an active gear (i.e., otter trawls and drifted trammel nets). Successive passes (i.e., duplicate passes) over the same location are done until two deployments fail to collect additional pallid sturgeon up to a maximum of nine deployments. These non-random deployments are excluded from CPUE calculations for annual relative abundance assessments but provide additional recaptures for determination of survival, growth, condition, and size structure.

Analysis

The fundamental sampling unit (i.e., replicate) for the population assessment program was the bend. Therefore, our effective sample size was the number of bends sampled with each gear deployed in each season collectively for Segments 5 and 6 (Table 1). Data were pooled for Segments 5 and 6 because of the short length (in river miles) and low number of bends sampled in each segment (n = 5). Annual CPUE was calculated for each species captured in each gear for the entire year. Mean CPUE was also separately calculated for each species caught in each gear during each sampling season. First, the average CPUE for all sub-samples within a bend was calculated by year and season and then these "bend means" were averaged to calculate the overall mean CPUE for year and season, respectively. The overall CPUE was also calculated for each habitat effectively sampled by a particular gear in each season (Appendix F). Variability of mean CPUE was presented as two standard errors (2 SE) which approximates a 95% confidence interval.

Indices of fish condition (health) were calculated for pallid sturgeon and two native Missouri River species: shovelnose sturgeon (Quist et al. 1998) and sauger (Guy et al. 1990). Relative condition factor (K_n) was calculated to assess the condition of pallid sturgeon and used the weight-length relation for the Missouri River presented in Shuman et al. (2011). Relative weight (W_r) calculations require a length-specific standard weight derived from an overall standard weight-length relation encompassing multiple populations across a species' range. Standard weight relations have been derived for shovelnose sturgeon (Quist et al. 1998) and sauger (Guy et al. 1990). Detailed equations for calculating K_n, and W_r are found in (Anderson and Newman 1996).

Incremental proportional size distribution (PSD) was calculated to describe the population size-structure of pallid sturgeon and shovelnose sturgeon using methods proposed by Gabelhouse (1984). Length categories proposed by Shuman et al. (2006a) for pallid sturgeon, Quist et al. (1998) for shovelnose sturgeon, and Anderson and Newman (1996) for sauger were used to determine relative stock densities (PSD). For pallid sturgeon these fork length categories are stock –quality (330 – 629 mm), quality –preferred (630 – 839 mm), preferred –memorable (840 – 1,039 mm), memorable –trophy (1,040 – 1,269 mm), and trophy (≥ 1,270 mm). Sturgeon were calculated as percents of < stock, stock, and > stock sized fish captured in each macrohabitat and mesohabitat type. The sub-stock size category was further divided into fish < 250 mm FL for pallid sturgeon and into fish < 150 mm FL for shovelnose sturgeon, to provide greater resolution of recruitment by YOY sturgeon.

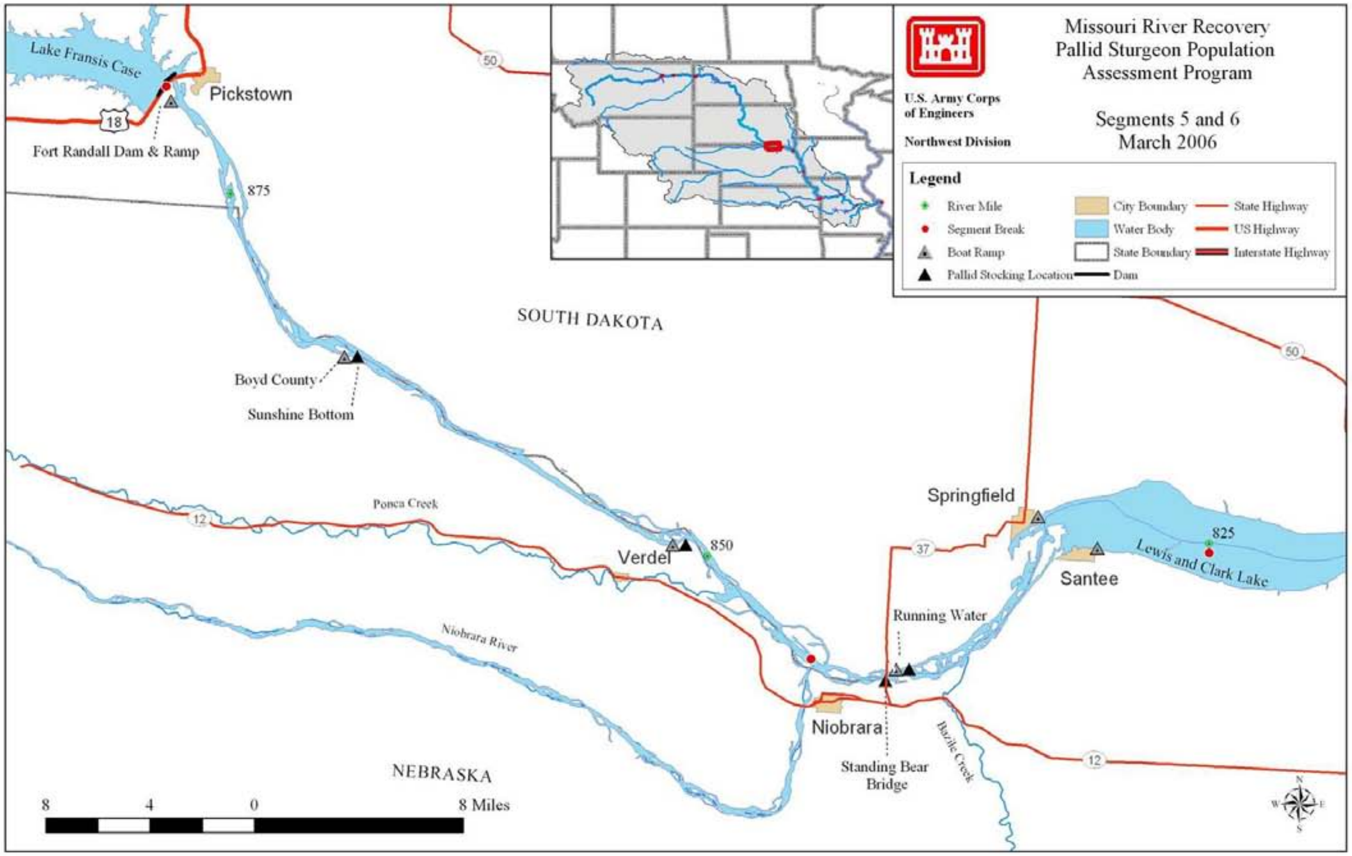

Figure 1. Map of Segments 5 & 6 of the Missouri River with major tributaries, common landmarks, and historic stocking locations for pallid sturgeon. Segments 5 & 6 encompass the Missouri River downstream from Fort Randall Dam (river mile 802) to the headwaters of Lewis and Clark Lake (river mile 827.5).

Results

Pallid sturgeon and the Missouri River fish community were sampled in randomly selected bends in Segments 5 and 6 of the unchannelized Missouri River downstream of Fort Randall Dam to the headwaters of Lewis and Clark Lake. Standardized gears and protocols established by Welker and Drobish (2010) were employed from fall of 2009 to fall of 2010. In 2010, ten randomly selected bends (Appendix I) were sampled with generally a minimum of 10 gill net deployments in spring and fall (i.e., 20 sets/bend/year) with eight deployments for trammel nets and otter trawls expended in each bend in each season (Table 1). Water conditions within Segments 5 and 6 were high throughout the summer and fall due to increased discharge from Fort Randall Dam, which was similar to the 2009 sampling year. High discharge typically increased current velocities, elevated water levels, and increased the area of depths >1.2 m where gears could sample. With the increase in depth, wetted width also increased making the deployment of mini-fyke nets difficult due to the decrease in exposed bars and increased influence of emergent vegetation along shorelines.

Table 1. Number of bends sampled, mean number of deployments, and total number of deployments (i.e., subsamples) by macrohabitat for Segments 5 & 6 on the Missouri River during the sturgeon season and fish community season in 2010.

Gear	Number of bends	Mean deployments	Macrohabitat[a]				
			BRAD	CHXO	ISB	OSB	SCCL
			Sturgeon season (fall through spring)				
1.0-inch trammel net	10	8.30	40	12	14	14	3
Gill net	12	16.67	100	33	30	31	6
Otter trawl	10	8.00	40	13	13	12	2
			Fish community season (summer)				
1.0-inch trammel net	10	8.1	40	13	11	15	2
Mini-fyke net	10	8.0	40	12	13	13	2
Otter trawl	10	8.0	40	13	12	13	2

[a]Habitat abbreviations and definitions presented in Appendix B.

Pallid Sturgeon

Objective 1. Document annual results and long-term trends in pallid sturgeon population abundance and geographic distribution throughout the Missouri River System.

Objective 2. Document annual results and long-term trends of habitat usage of wild pallid sturgeon and hatchery stocked pallid sturgeon by season and life stage.

Objective 3. Document population structure and dynamics of pallid sturgeon in the Missouri River system.

A total of 150 pallid sturgeon were captured during the 2010 season with 46 fish caught in standard random deployments: 16-ft otter trawl (n = 11), gill nets (n = 14), and drifted trammel nets (n = 21). A total of 75 duplicate passes were conducted for active gears. Duplicate passes with active gears caught 23 additional pallid sturgeon: 12 fish in the trammel nets and 11 fish with the 16-ft otter trawls. Additionally, 81 pallid sturgeon were collected in the spring with trotlines; a potentially new standard gear that was under its second year of evaluation in 2010 (Appendix J).

Overall, macrohabitats where pallid sturgeon were captured included outside bends, inside bends, channel crossovers, confluence areas, large secondary connected channels, and braided channels. All fish were captured in the channel border mesohabitat (Table 2). Pallid sturgeon were primarily captured in the braided channel border habitat (n = 89) at depths ranging from 1.4 – 6.1 m, bottom velocities ranging from 0.05 – 0.91 m/s, and turbidity ranging from 11 – 896 nephelometric turbidity units (NTU). Nearly 60% of the pallid sturgeon were captured in the braided, channel border habitat of Segment 6 at a mean depth of 3.8 m, mean bottom velocity of 0.38 m/s, and mean turbidity of 72 NTU. The two macrohabitats where pallid sturgeon were second most commonly collected were in outside bends (n = 30) and channel crossovers (n = 25). In outside bends, pallid sturgeon were captured at a mean depth of 4.1 m, mean bottom velocity of 0.37 m/s, and mean turbidity of 6 NTU. In channel crossovers, fish were captured at a mean depth of 2.3 m, mean bottom velocity of 0.42 m/s, and mean turbidity of 17 NTU.

Pallid sturgeon were captured throughout Segments 5 and 6 with > 32 fish captured at two locations, both within the Niobrara River Delta located in Segment 6 (Figure 2). On seven separate sampling occasions with active gears, four or more duplicate samples were deployed and, on a single occasion, the maximum deployment passes (n = 9) was achieved providing strong evidence that pallid sturgeon clustered in certain habitats. Forty-one duplicate passes in Segment 5 occurred in outside bend (n = 23), channel crossover (n = 15), and inside bend (n = 3) macrohabitats. The 34 duplicates in Segment 6 were all within the braided channel macrohabitat. Eight pallid sturgeon were captured with the otter trawl from one location on June 9, 2010 in bend 8 of Segment 6. Sizes of these eight fish were variable and ranged from 530 – 743 mm FL and 480 – 1,375 g with a total biomass of 6,300 g from this single location. In bend 15 of Segment 5, six pallid sturgeon were captured on June 9, 2010 with trammel nets; lengths ranged from 303 – 580 mm FL, weight ranged from 100 – 600 g, and total biomass was 2,245 g.

Pallid sturgeon from all 12 year classes stocked in RPMA 3 (Appendix E) were recaptured in Segments 5 and 6 during 2010 (Table 3). Passive integrated transponder (PIT) tag detection was 79%. Genetic analysis, based on available archived tissues from parental crosses, could not verify the origin of two pallid sturgeon (FL = 525 and 544 mm) without detectable tags, thus they were considered “unknown”. In 2010, the 2009 year class was the smallest size class present in RPMA 3 (minimum FL = 258 mm) and only three fish were recaptured. The three largest fish captured (FL = 903, 904, and 958 mm, weight = 2,500, 2,500, and 3,175 g, respectively) were from the 1997 year class and were collected in the two most downstream bends sampled in the delta during 2010.

Nearly all pallid sturgeon captured in 2010 were stock–quality length with only 17 quality–preferred length, four preferred–memorable length, and six sub-stock length fish (Tables 4 – 7; Figure 3). During 2010, most pallid sturgeon were of stock length (n = 122) with only six fish < stock size and 21 fish > quality size (Figure 3). During the sturgeon season the proportion of fish within the quality–preferred length category or larger was 2.5 times greater than that of the fish community season (Figure 3). Since 2004, the majority of pallid sturgeon caught in both seasons were of stock size but generally 15% of recaptures in the fall – spring and 6% of fish caught in summer were of quality size or greater (Figure 3).

All pallid sturgeon year classes continued to increase in length and weight since stocking in RPMA 3 (Table 3). Growth rates in terms of length (> 0.25 mm/d) were fastest for the youngest year classes. Pallid sturgeon ages 2 and 3 grew > 0.27 mm/d while ages 5 - 8 grew > 0.10 mm/d. After age-12, increases in FL declined to < 0.07 mm/d. Mean weight gain was > 0.19 g/d for all year classes and was highest for the 1997 year class (0.48 g/d).

Relative condition of all pallid sturgeon year classes declined since stocking with the exception of the 1998 year class (Table 3). Since 2007, mean relative condition of recaptured sub-stock fish increased from 0.92 to 1.2 (Figure 4). Condition of sub-stock sized pallid sturgeon in 2010 was 14.7% higher than the long-term average (2004 – 2010). In contrast, relative condition of stock-sized pallid sturgeon declined from 0.94 to 0.85 during 2007 – 2010 and condition in 2010 was 6.3% below the long-term average. Compared to the long-term average, relative condition of quality-sized pallid sturgeon was also lower in 2010 (7.5%). Preferred-sized pallid sturgeon relative condition in 2010 was 12% below the long-term average; however, numbers of recaptures in 2010 was limited (n = 4).

Despite stocking 3,410 age-0 juvenile pallid sturgeon in September of 2008 and 1,485 age-1 fish in the springs of 2008 and 2009, CPUE in Segments 5 and 6 in 2010 for all gears declined or remained similar to 2009. Overall, annual mean CPUE of hatchery-reared pallid sturgeon recaptured in 2010 decreased 72% for gill nets, 21% for trammel nets, and 34% for otter trawls when compared to 2009. Mean CPUE of hatchery-reared juvenile pallid sturgeon captured with gill nets was nearly 1.3 times lower in 2010 than the long-term average from 2003 to 2009 (Figure 5). However, when 2010 CPUE of hatchery-reared pallid sturgeon is compared to the long-term (i.e., 2003 – 2009) running average, CPUE increased 36% for trammel nets and was similar for otter trawls. Similarly, mean annual relative abundance of all pallid sturgeon (i.e., hatchery, wild, and unknown origin) decreased 68% for gill nets, 33% for otter trawls, and 21% for trammel nets in 2010 compared to 2009. Compared to the seven year average, CPUE of all pallid sturgeon increased 28% for trammel nets but decreased 26% for gill nets and 4% for otter trawls.

Mean CPUE for hatchery-reared pallid sturgeon varied by season within gears. Seasonally, pallid sturgeon CPUE in 2010 for trammel nets was 42% lower during summer compared to spring while otter trawl CPUE was 12% higher in summer. During the sturgeon season in 2010, mean CPUE for hatchery-reared pallid sturgeon decreased 23% for the otter trawl (Figures 6 and 7) when compared to 2009, while trammel net CPUE was similar (+2%). Compared to 2009, trammel net and otter trawl CPUE for hatchery-reared pallid sturgeon during the fish community season decreased 44% and 41%, respectively in 2010. Mean CPUE for hatchery-reared pallid sturgeon in drifted trammel nets in 2010 increased during the sturgeon season (72%) but slightly decreased during fish community seasons (3%) compared to the 2003 to 2009 seasonal running average (Figure 6). Relative abundance in the otter trawl also slightly increased during the sturgeon season (5%) and fish community season (<1%) when compared to the seven year average (Figure 7). Due to capture of few wild pallid sturgeon and few fish of unknown origin in 2010, seasonal changes for each gear for all categories of pallid sturgeon were generally similar to that for hatchery-reared fish (Figures 5 – 7). Nearly 89% of all pallid sturgeon were captured during the sturgeon (n = 134) compared to the fish community seasons (n = 16) in 2010. Mean catch per unit effort of all pallid sturgeon was 0.07 fish/net night in gill nets (Figure 5) with eight fish caught in the fall and six fish caught in the spring. No pallid sturgeons were captured in 2010 with mini-fyke nets set in summer (Tables 5 – 8) and none have been captured in this gear since monitoring began in 2003.

The primary mode in the size distribution of pallid sturgeon during 2010 was from 400 – 600 mm FL, with smaller modes representing recently stocked fish and the oldest year classes stocked (Figure 8). Fork lengths of pallid sturgeon ranged from 179 – 958 mm in Segments 5 and 6 during 2010 (Figure 8). Mean length of pallid sturgeon captured in 2010 varied by gear: trammel net (mean = 503 mm; range = 213 - 958 mm), gill net (mean = 535 mm; range = 400 - 696 mm), otter trawl (mean = 506 mm; range = 179 - 743 mm), and trot lines (mean = 542 mm; range = 378 - 904 mm).

Pallid sturgeon are continuing to grow and are progressively recruiting to larger length categories from previous years (Figure 3). Total catch of pallid sturgeon in 2010 was the second highest (n = 150) since monitoring began in 2003 (Figure 9). Before 2004, only 1,854 stocked juvenile pallid sturgeon were at large in Segments 5 and 6. After 2003, 5,642 yearlings and 3,410 age-0 fingerlings have been stocked into RPMA 3 (Appendix E). Annual captures of pallid sturgeon increased during 2004 – 2009, but is biased due to variable effort among years and implementation of new gears such as the otter trawl in 2005 and the trotline in 2009 and

2010 (Figure 9). A total of 81 pallid sturgeon were captured on trotlines during April 19-20, 2010. Trotlines, under evaluation in 2009 and 2010, will be deployed again in 2011 as a standard gear (Appendix J). The ratio of pallid sturgeon to shovelnose sturgeon captured in standard random deployments in 2010 (1 pallid sturgeon:3 shovelnose sturgeon) was similar to 2008 and 2009.

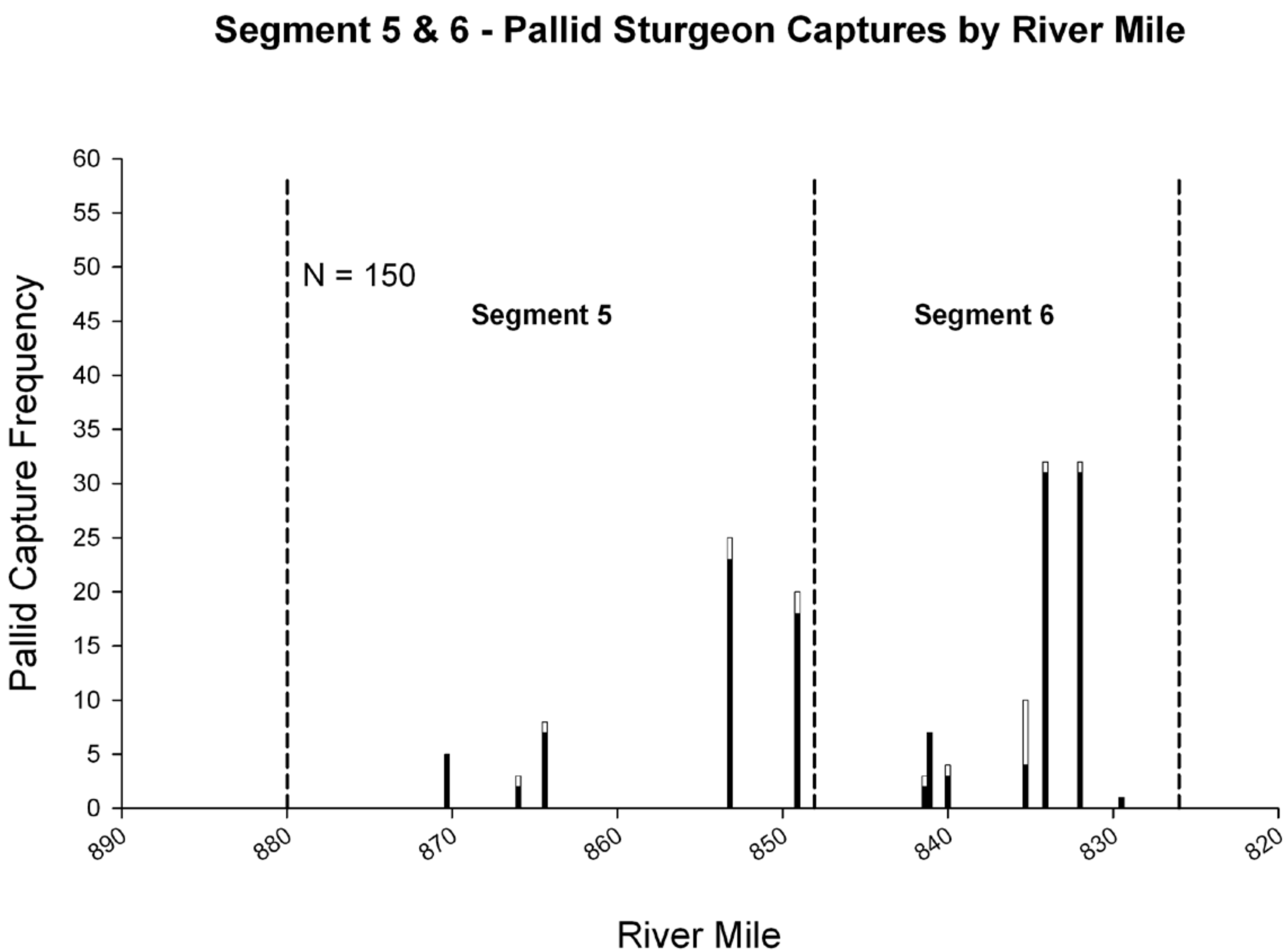

Figure 2. Distribution of pallid sturgeon captures by river mile for Segments 5 & 6 of the Missouri River during 2010. Black bars represent pallid captures during the sturgeon season and white bars during the fish community season. Figure includes all pallid captures including non-random and wild samples. Dash line identifies upstream and downstream boundaries for Segments 5 & 6.

Table 2. Pallid sturgeon capture summaries for all gears relative to habitat type and environmental variables on the Missouri River during 2010. Means (minimum and maximum) are presented. Habitat definitions and codes presented in Appendix B.

Habitat		Depth (m)		Bottom velocity (m/s)		Temperature (°C)		Turbidity (ntu)		Total catch
Macro-	Meso-	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	
BRAD	BARS	0.4 (0.3-0.7)		0.05 (0.00-0.11)		22.1 (19.0-24.4)		25 (15-39)		
	CHNB	3.2 (1.2-8.1)	3.6 (1.4-6.1)	0.51 (0.05-0.95)	0.45 (0.05-0.91)	15.6 (5.2-27.0)	13.5 (5.2-25.4)	79 (9-896)	93 (11-896)	89
CHXO	BARS	0.4 (0.3-0.5)		0.11 (0.06-0.17)		20.8 (18.7-23.6)		13 (11-15)		
	CHNB	2.4 (1.2-4.9)	2.3 (1.6-3.1)	0.44 (0.06-0.83)	0.42 (0.06-0.83)	13.1 (5.3-24.6)	11.0 (5.3-19.1)	11 (3-196)	17 (3-196)	25
ISB	BARS	0.4 (0.3-0.5)		0.08 (0.05-0.10)		20.6 (18.6-23.6)		8 (5-10)		
	CHNB	2.5 (1.3-6.0)	2.2 (1.8-2.6)	0.40 (0.08-0.80)	0.22 (0.08-0.37)	13.1 (5.4-24.6)	10.9 (6.7-18.1)	11 (2-160)	5 (2-11)	4
OSB	BARS	0.4 (0.3-0.5)		0.01 (0.00-0.02)		20.9 (17.9-23.8)		12 (3-28)		
	CHNB	3.9 (1.4-6.3)	4.1 (2.0-5.8)	0.44 (0.17-0.80)	0.37 (0.17-0.74)	13.7 (5.2-25.0)	12.3 (5.7-21.7)	12 (2-117)	6 (2-14)	30
SCCL	BARS	0.5 (0.5-0.5)		0.04 (0.04-0.04)		19.4 (19.3-19.5)		9 (9-9)		.
	CHNB	3.4 (2.5-4.3)	3.1 (2.9-3.2)	0.32 (0.10-0.64)	0.19 (0.10-0.27)	12.4 (6.4-21.7)	8.6 (8.6-8.6)	9 (3-27)	4 (3-5)	2

Table 3. Mean (± 2 SE) fork length, weight, relative condition factor (K_n) and absolute growth rates for hatchery-reared pallid sturgeon year classes at the time of stocking and recapture during 2010 from Segments 5 & 6 of the Missouri River. Relative condition factor was calculated using the equation in Shuman et al. (2011).

Year class	N	Stocking data			Recapture data			Growth rate	
		Length (mm)	Weight (g)	K_n	Length (mm)	Weight (g)	K_n	Length (mm/d)	Weight (g/d)
1997	5	560	720.6	1.022	884	2475.0	0.753	0.089	0.481
		(5)	(34.3)	(0.044)	(55)	(448.0)	(0.040)	(0.015)	(0.120)
1998	2	425	204.5	0.733	654	1020.0	0.839	0.066	0.234
		(4)	(15.0)	(0.031)	(179)	(710.0)	(0.166)	(0.047)	(0.188)
1999	2	388			595	665.0	0.770	0.070	
		(0)			(0)	(30.0)	(0.035)	(0.001)	
2001	15	206			596	745.3	0.838	0.132	
		(19)			(40)	(143.3)	(0.074)	(0.017)	
2002	17	247	62.7	1.347	566	621.5	0.836	0.125	0.211
		(13)	(9.3)	(0.049)	(22)	(81.1)	(0.022)	(0.008)	(0.027)
2003	10	337	133.3	1.004	544	532.7	0.821	0.102	0.196
		(27)	(29.3)	(0.048)	(28)	(86.6)	(0.028)	(0.012)	(0.036)
2004	24	298	110.6	1.278	505	431.5	0.862	0.120	0.185
		(9)	(12.2)	(0.033)	(9)	(26.1)	(0.028)	(0.006)	(0.016)
2005	28	312	130.5	1.280	496	401.6	0.847	0.135	0.201
		(14)	(19.1)	(0.062)	(14)	(32.8)	(0.028)	(0.014)	(0.027)
2006*	5	189	26.7	1.54	503	434.0	0.883	0.236	0.305
		(5)	(2.7)	(0.29)	(7)	(35.1)	(0.091)	(0.005)	(0.026)
2007	8	245	55.6	1.215	461	328.1	0.854	0.274	0.339
		(34)	(18.5)	(0.193)	(49)	(89.5)	(0.058)	(0.032)	(0.104)
2008*	5	330	112.0	0.939	422	233.0	0.837	0.286	0.393
					(34)	(59.2)	(0.034)		
2009	7	294	96.8	1.283	273	84.0	1.30	0.448	0.348
		(13)	(21.5)	(0.120)	(53)	(39.3)	(0.175)	(0.142)	(0.122)

*Mean length and weight at stocking derived from subsample of fish measured at tagging. All other year classes had passive integrated transponder (PIT) tags enabling growth rate calculations for individual fish. The 2006, 2008, and 2009 year classes had 0%, 8%, and 75% of the fish inserted with PIT tags respectively when stocked (Appendix E).

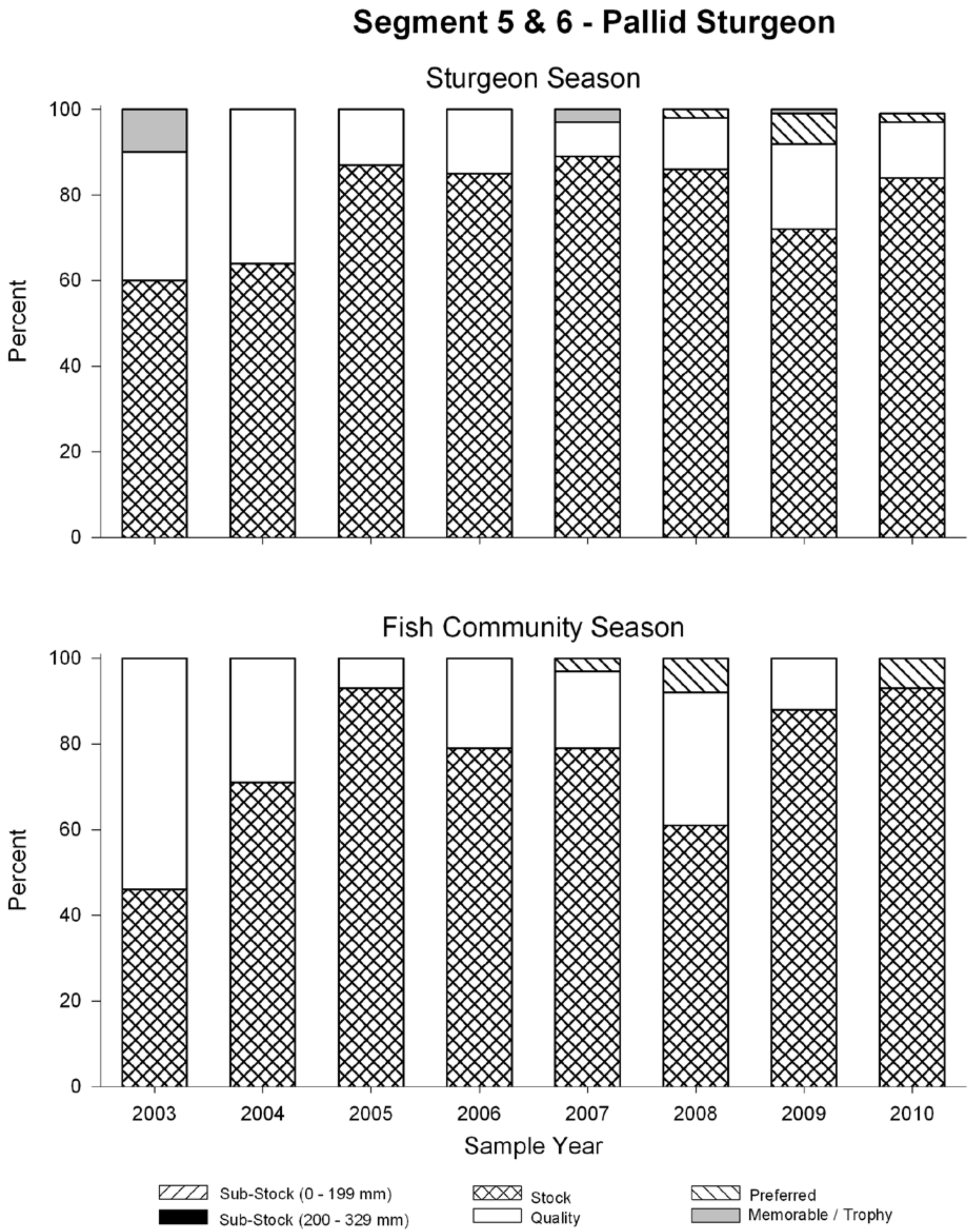

Figure 3. Proportion by length group for all pallid sturgeon captured with all gears by incremental proportional size distribution length category from 2003-2010 in Segments 5 & 6 in the Missouri River. Length categories determined using the methods proposed by Shuman et al. (2006a) with the exception of sub-stock categories.

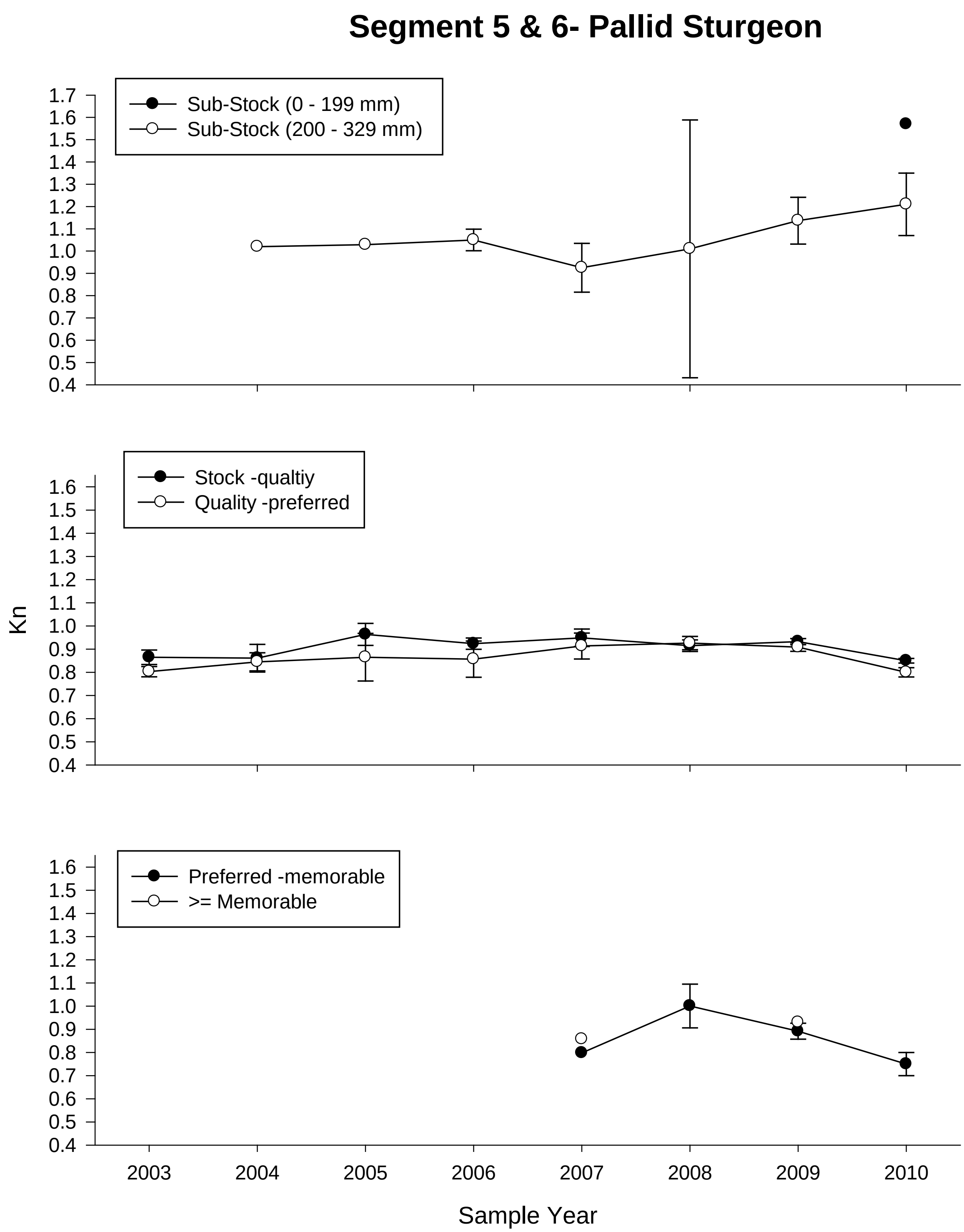

Figure 4. Relative condition factor (K_n) for all pallid sturgeon captured with all gear by incremental proportional size distribution (PSD) length category from 2003-2010 in Segments 5 & 6 in the Missouri River. Length categories determined using the methods proposed by Shuman et al. (2006a) with the exception of sub-stock categories. Relative condition factor was calculated using the equation in Shuman et al. (2011).

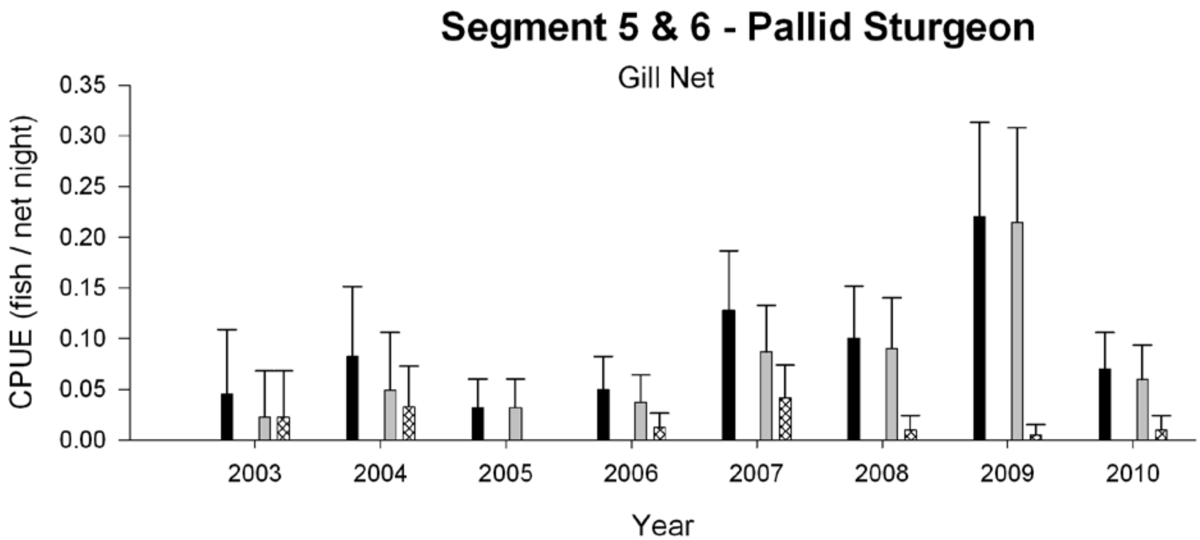

Figure 5. Mean annual catch per unit effort (± 2 SE) of all (black bars), wild (white bars), hatchery-reared (gray bars), and unknown origin (cross-hatched bars) pallid sturgeon using gill nets in Segments 5 & 6 of the Missouri River from 2003-2010.

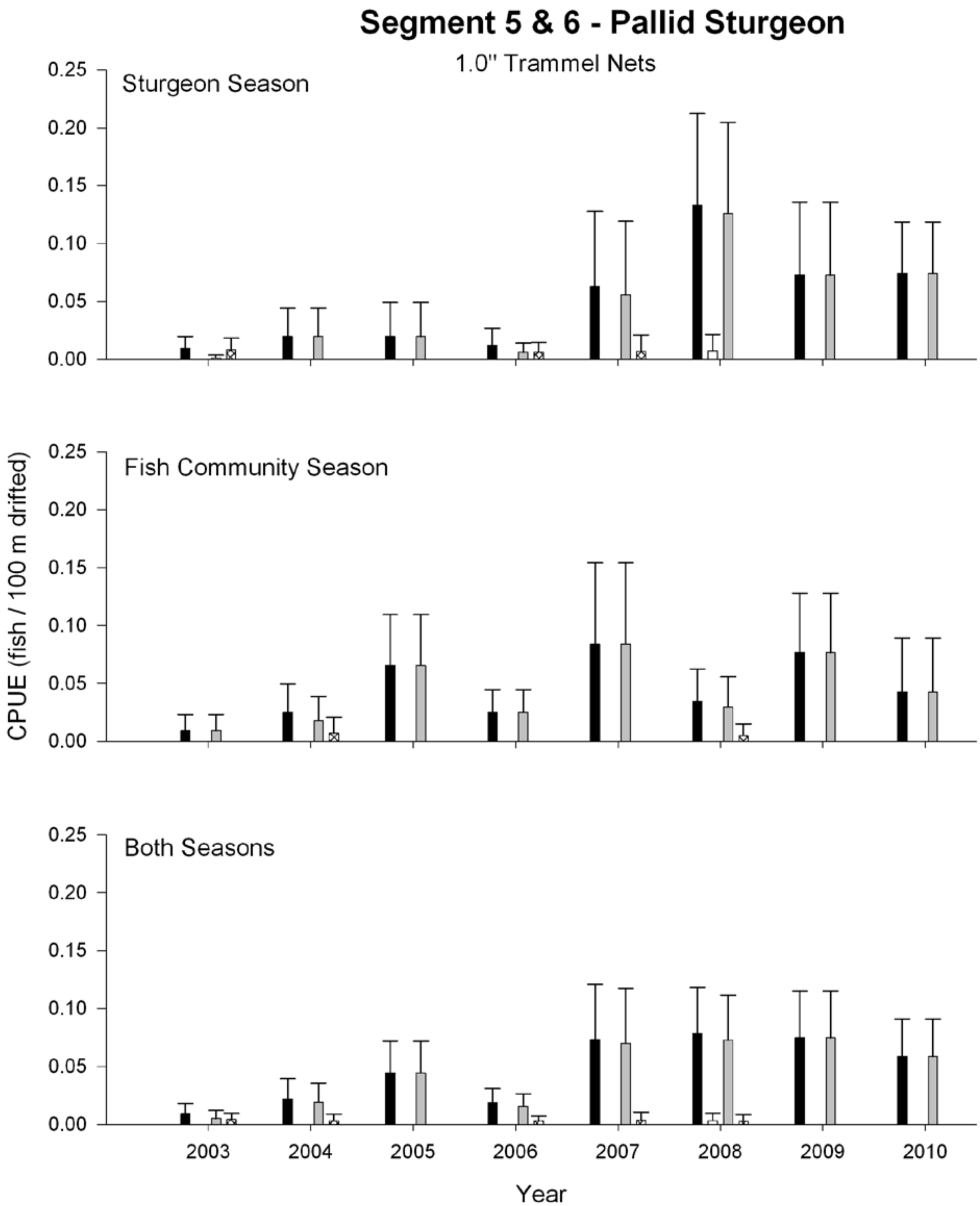

Figure 6. Mean annual catch per unit effort (± 2 SE) of all (black bars), wild (white bars), hatchery-reared (gray bars), and unknown origin (cross-hatched bars) pallid sturgeon using 1.0-inch trammel nets in Segments 5 & 6 of the Missouri River from 2003-2010.

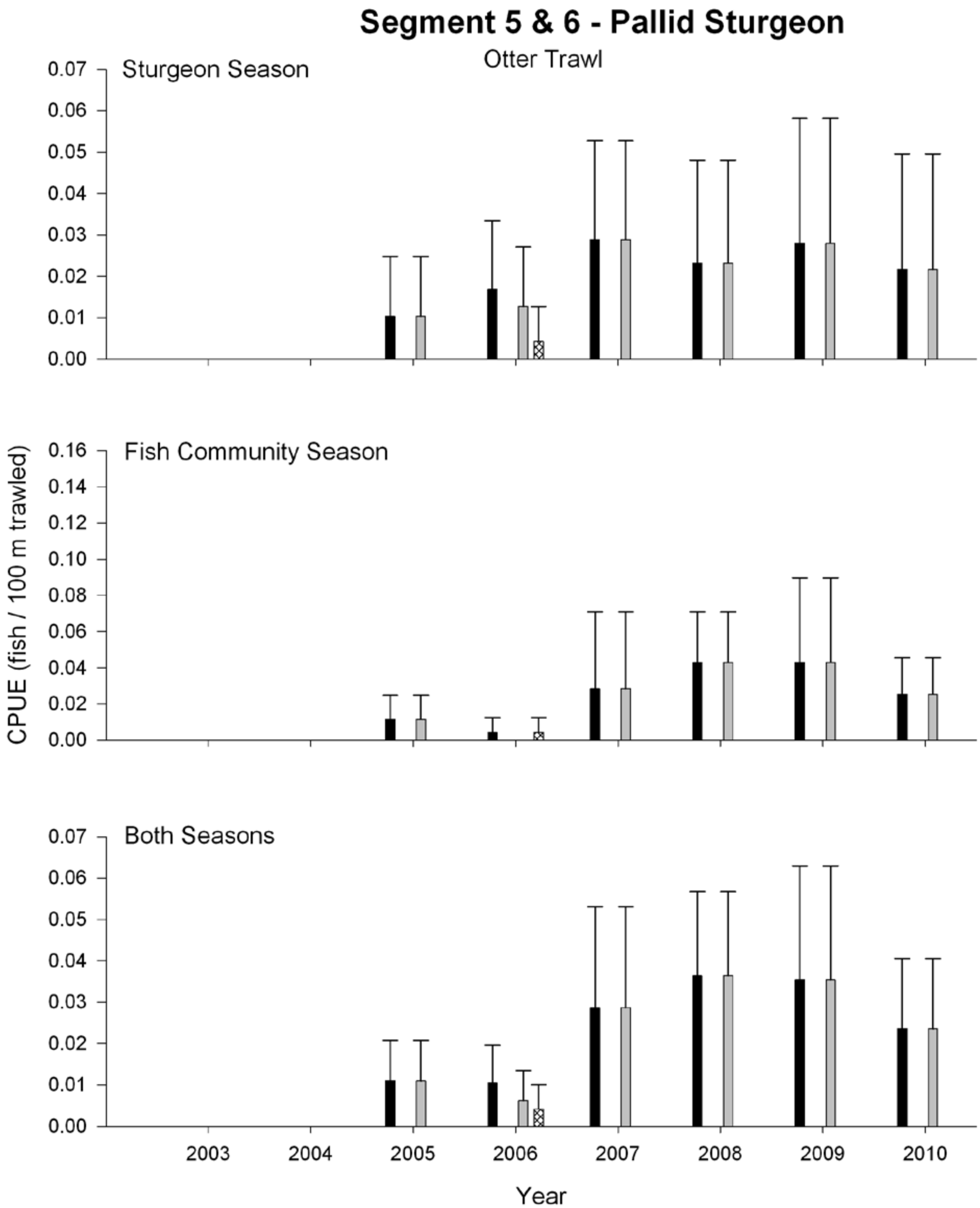

Figure 7. Mean annual catch per unit effort (± 2 SE) of all (black bars), wild (white bars), hatchery-reared (gray bars), and unknown origin (cross-hatched bars) pallid sturgeon using otter trawls in Segments 5 & 6 of the Missouri River from 2003-2010.

Table 5. Total number of sub-stock size (200-329 mm) pallid sturgeon captured for each gear during each season and the proportion caught within each macrohabitat type in Segments 5 & 6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
		Sturgeon season (fall through spring)				
1.0-inch trammel net	2	0	50	0	50	0
		53	14	15	16	2
Gill net	0	0	0	0	0	0
		50	17	15	16	3
Otter trawl	1	0	0	0	100	0
		51	17	16	14	2
		Fish community season (summer)				
1.0-inch trammel net	1	0	0	0	100	0
		53	17	12	16	2
Mini-fyke net	0	0	0	0	0	0
		50	15	16	16	3
Otter trawl	0	0	0	0	0	0
		50	17	15	15	2

Table 6. Total number of stock size (330-629 mm) pallid sturgeon captured for each gear during each season and the proportion caught within each macrohabitat type in Segments 5 & 6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
		Sturgeon season (fall through spring)				
1.0-inch trammel net	11	27	45	9	18	0
		53	14	15	16	2
Gill net	11	55	9	0	36	0
		50	17	15	16	3
Otter trawl	4	75	25	0	0	0
		51	17	16	14	2
		Fish community season (summer)				
1.0-inch trammel net	5	80	0	0	20	0
		53	17	12	16	2
Mini-fyke net	0	0	0	0	0	0
		50	15	16	16	3
Otter trawl	6	50	17	0	33	0
		50	17	15	15	2

Table 7. Total number of quality size and greater (≥ 630 mm) pallid sturgeon captured for each gear during each season and the proportion caught within each macrohabitat type in Segment 5 &6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
Sturgeon season (fall through spring)						
1.0-inch trammel net	1	100	0	0	0	0
		53	14	15	16	2
Gill net	3	100	0	0	0	0
		50	17	15	16	3
Otter trawl	0	0	0	0	0	0
		51	17	16	14	2
Fish community season (summer)						
1.0-inch trammel net	1	100	0	0	0	0
		53	17	12	16	2
Mini-fyke net	0	0	0	0	0	0
		50	15	16	16	3
Otter trawl	0	0	0	0	0	0
		50	17	15	15	2

Table 8. Total number of pallid sturgeon captured for each gear during each season and the proportion caught within each macrohabitat type in Segments 5 & 6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
		Sturgeon season (fall through spring)				
1.0-inch trammel net	14	29	43	7	21	0
		53	14	15	16	2
Gill net	14	64	7	0	29	0
		50	17	15	16	3
Otter trawl	5	60	20	0	20	0
		51	17	16	14	2
		Fish community season (summer)				
1.0-inch trammel net	7	71	0	0	29	0
		53	17	12	16	2
Mini-fyke net	0	0	0	0	0	0
		50	15	16	16	3
Otter trawl	6	50	17	0	33	0
		50	17	15	15	2

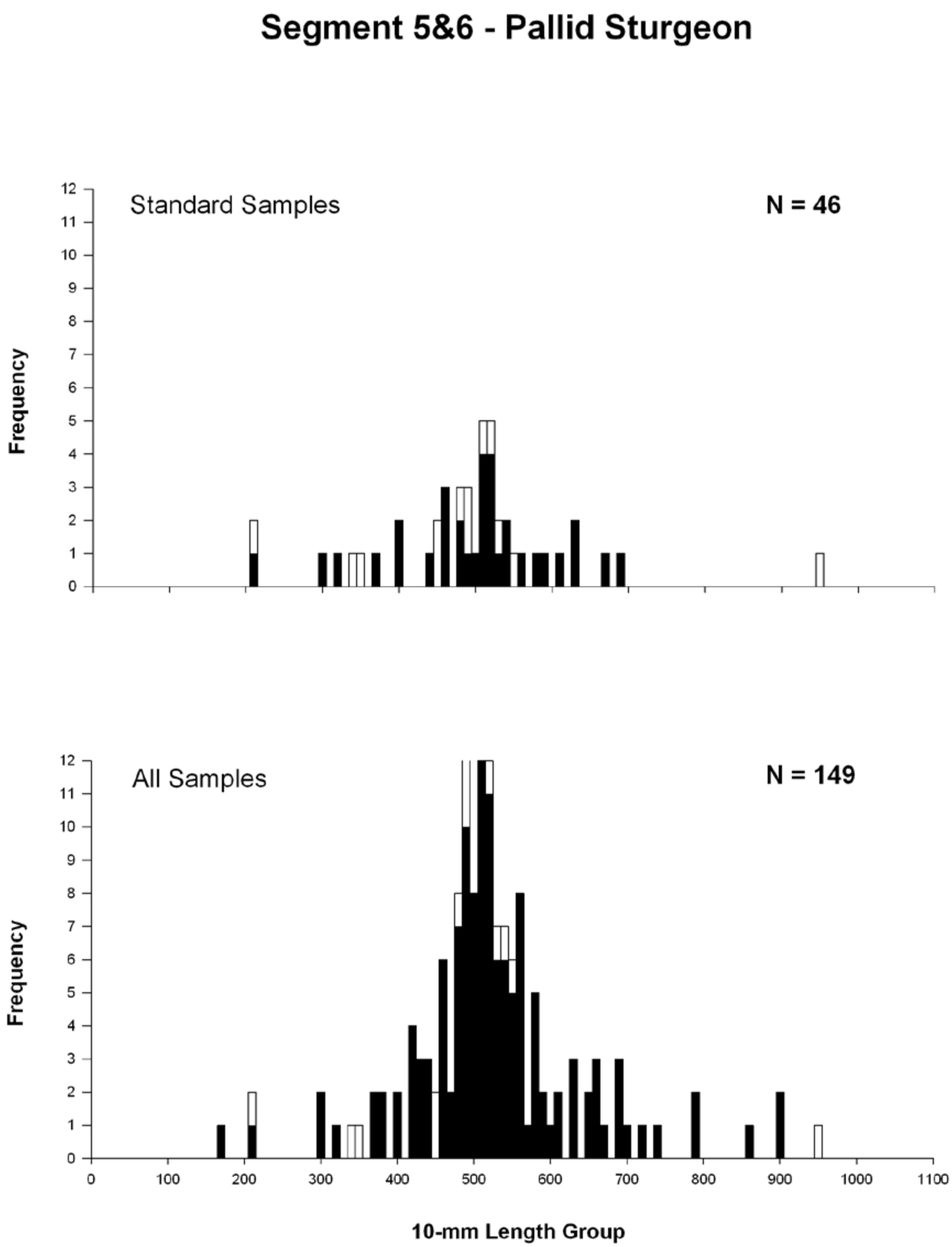

Figure 8. Length frequency of pallid sturgeon captured during the sturgeon season (black bars) and fish community season (white bars) in Segments 5 & 6 of the Missouri River during 2010. Standard samples include standard gears, random bends, and random subsamples. All samples include all sampling conducted during 2010.

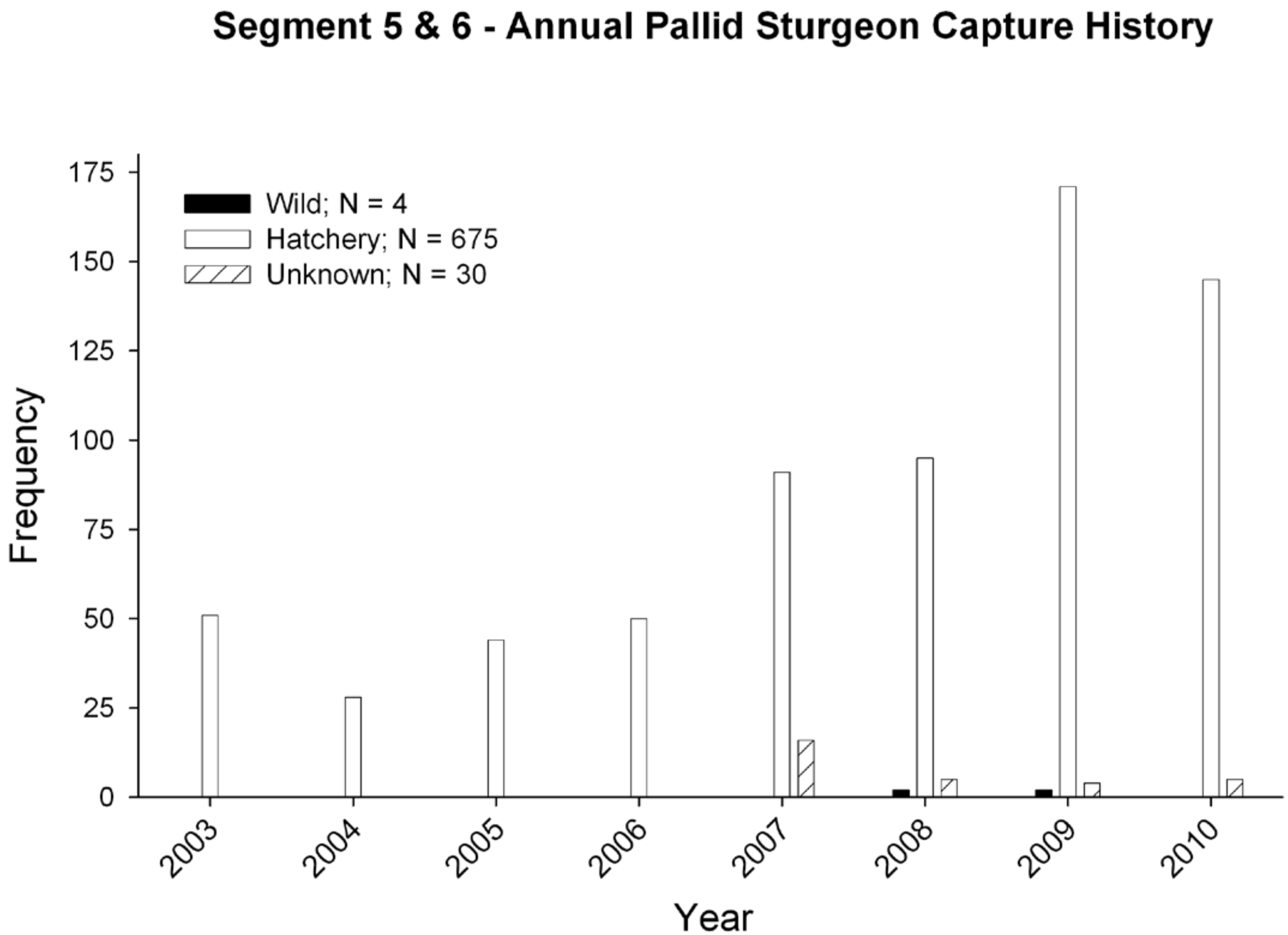

Figure 9. Annual capture history of wild (black bars), hatchery reared (white bars), and unknown origin (cross-hatched bars) pallid sturgeon collected in Segments 5 & 6 of the Missouri River from 2003-2010. Figure is designed to compare overall pallid sturgeon captures from year to year and is biased by variable effort among years. Figure includes all pallid captures including non-random and wild samples.

Shovelnose X Pallid Sturgeon Hybrids

No shovelnose X pallid sturgeon hybrids were captured in Segments 5 and 6 during 2010. Furthermore, no hybrid sturgeon have been captured in Segments 5 and 6 since monitoring began in 2003.

Targeted Native River Species

Objective 4. Document annual results and long-term trends in native target species population abundance and geographic distribution throughout the Missouri River system.

Objective 5. Document annual results and long-term trends of habitat usage of the target native species by season.

Shovelnose Sturgeon

A total of 137 shovelnose sturgeon were sampled with standard effort and an additional 13 fish were captured in duplicate passes for active gears. Trotlines caught an additional 48 shovelnose sturgeon (Appendix J). Standard gears that collected shovelnose sturgeon included gill nets (n = 95), trammel nets (n = 45), and otter trawls (n = 10).

During 2010, mean annual relative abundance of shovelnose sturgeon (sturgeon and fish community season pooled) > stock length decreased 45% in trammel nets and 55% in otter trawls compared to the seven year average. Annual CPUE of shovelnose sturgeon also declined 37% for trammel nets and 32% for otter trawls when compared to 2009. No shovelnose sturgeon were captured in the mini-fyke nets in 2010 or in any previous sampling year.

A total of 121 shovelnose sturgeon were captured in standard random samples during the sturgeon season while 16 fish were captured during the fish community season. Mean catch per unit effort of shovelnose sturgeon greater than stock length was 0.47 fish/net night in gill nets (Figures 10) with 37 fish caught in the fall and 58 fish caught in the spring. Mean annual CPUE in gill nets during 2010 decreased 31% from the running average for 2003 – 2009, and decreased

52% from the previous year (Figure 10). Compared to 2008, trammel net mean CPUE during both seasons decreased (77%) during 2010; however, 2010 relative abundance was similar to that from 2003 – 2007 and 2009 (Figure 11). The mean CPUE of shovelnose sturgeon in trammel nets in the sturgeon season (0.11 fish/100 m) was nearly twice that of the fish community season (0.06 fish/100 m). Mean CPUE of shovelnose sturgeon for the otter trawl in the spring (sturgeon seaon) and summer (fish community season) was the same (0.02 fish/100 m; Figure 12). In 2010, shovelnose sturgeon mean CPUE in otter trawls decreased 57% during the sturgeon season and 52% during the fish community season compared to the 2005 - 2009 running average: sturgeon season = 0.04 fish/100 m; fish community season = 0.05 fish/100 m.

Shovelnose sturgeon were found in all macrohabitats sampled in 2010 (Table 13). For all gears pooled, macrohabitats where shovelnose sturgeon were captured include braided channels (52%), channel crossovers (21%), outside bends (19%), inside bends (6%), and large secondary connected channels (2%) during the sturgeon season. During the fish community season, 48% of shovelnose sturgeon were captured in braided channels, 35% in outside bends, 9% in inside bends, 4% in large secondary connected channels, and 4% in channel crossovers. For the otter trawl and trammel net, the proportion of total shovelnose sturgeon captured greater than stock size was greater than the proportion of effort expended in the braided macrohabitat during both seasons. A greater proportion of shovelnose sturgeon were caught compared to effort expended with trammel nets in the channel crossover macrohabitat during the sturgeon season and the outside bend and large secondary connected channel macrohabitats during the fish community season. During the sturgeon season with gill nets the proportion of the total shovelnose sturgeon caught was greater than the proportion of effort expended in the braided and channel crossover macrohabitat. Additionally, during the fish community season the otter trawl captured a greater proportion of shovelnose sturgeon compared to the effort expended in inside bend macrohabitats. All shovelnose sturgeon were caught in the channel border mesohabitat and 52% of fish were captured in the Niobrara River delta of the Missouri River in Segment 6.

Two shovelnose sturgeon (FL = 315 and 357 mm) smaller than the quality–preferred size category (FL ≤ 510 mm) were captured downstream of Fort Randall Dam during 2010 (Figures 13 and 14). These two fish are the smallest shovelnose sturgeon captured since monitoring began in 2003. Fork lengths of shovelnose sturgeon ranged from 315 - 835 mm, with 73% of the fish between 600 – 700 mm (Figure 13). Incremental PSD for shovelnose sturgeon during the sturgeon season demonstrates the first potential recruitment observed in Segments 5 and 6 since 2003 with presence of stock sized fish (Figure 14). However, memorable sized shovelnose sturgeon have comprised 40 – 60% of the size distribution since 2003.

Shovelnose sturgeon captured during the sturgeon (n = 175) and fish community seasons (n = 23) exhibited a similar mean W_r of 97 and 93, respectively, when excluding the two smallest fish captured during the sturgeon season. The two smallest shovelnose sturgeon (FL = 315 and 357 mm) possessed relative weights (W_r = 208 and 501) that were outside three standard deviations of the mean (mean = 99.6, SD = 32.4) suggesting a transcription error in length or weight. Relative weight of shovelnose sturgeon quality–preferred and ≥ memorable–trophy length have remained stable since 2003 at 100 and 90, respectively (Figure 15).

Figure 10. Mean annual catch per unit effort (+/- 2 SE) of sub-stock size (0-149 mm; cross-hatched bars), sub-stock size (150-249 mm; black bars), stock size (250-379 mm; white bars), and quality and above size (> 380 mm; gray bars) shovelnose sturgeon using gill nets in Segments 5 & 6 of the Missouri River from 2003-2010.

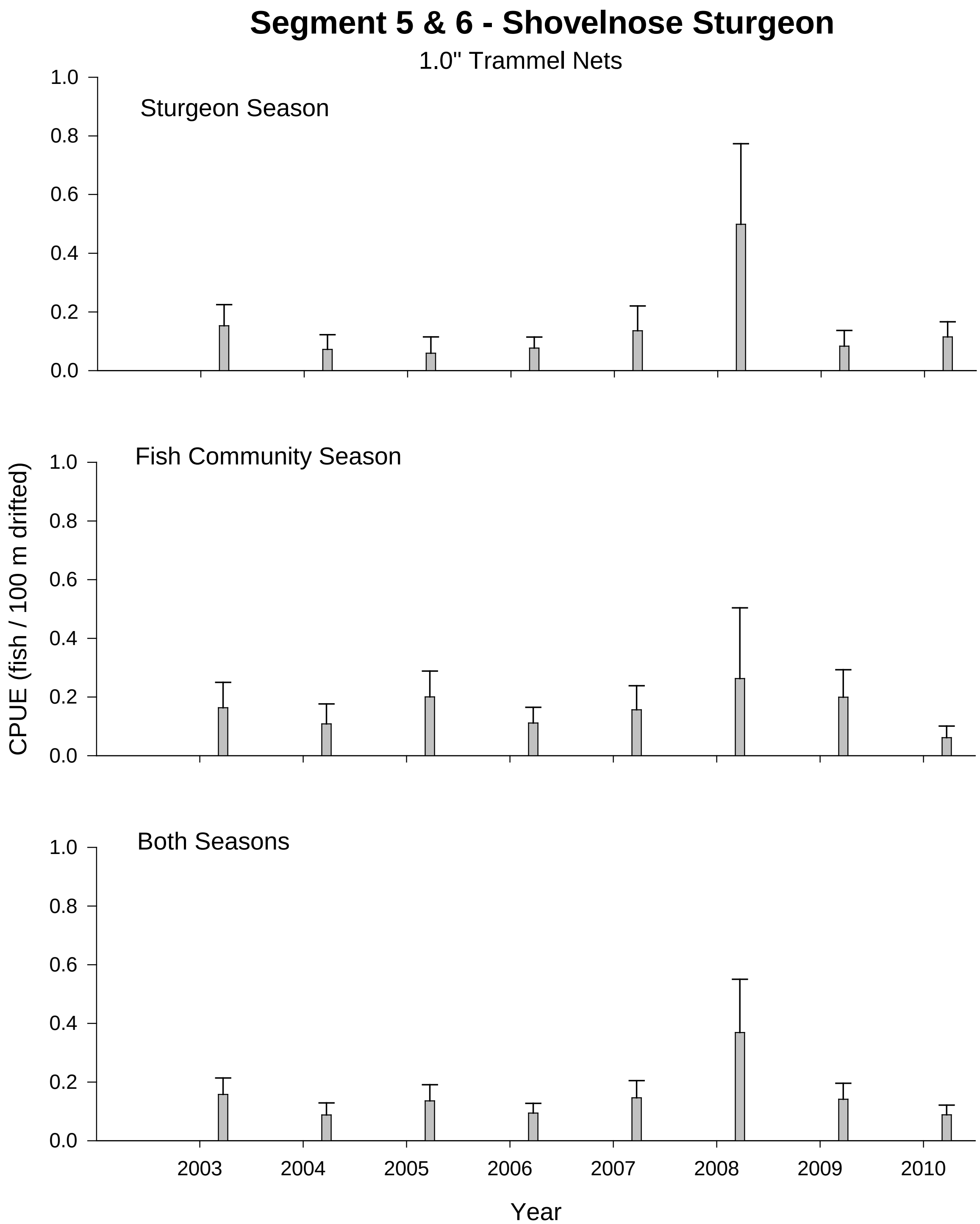

Figure 11. Mean annual catch per unit effort (+/- 2 SE) of sub-stock size (0-149 mm; cross-hatched bars), sub-stock size (150-249 mm; black bars), stock size (250-379 mm; white bars), and quality and above size (> 380 mm; gray bars) shovelnose sturgeon using 1-inch trammel nets in Segments 5 & 6 of the Missouri River from 2003-2010.

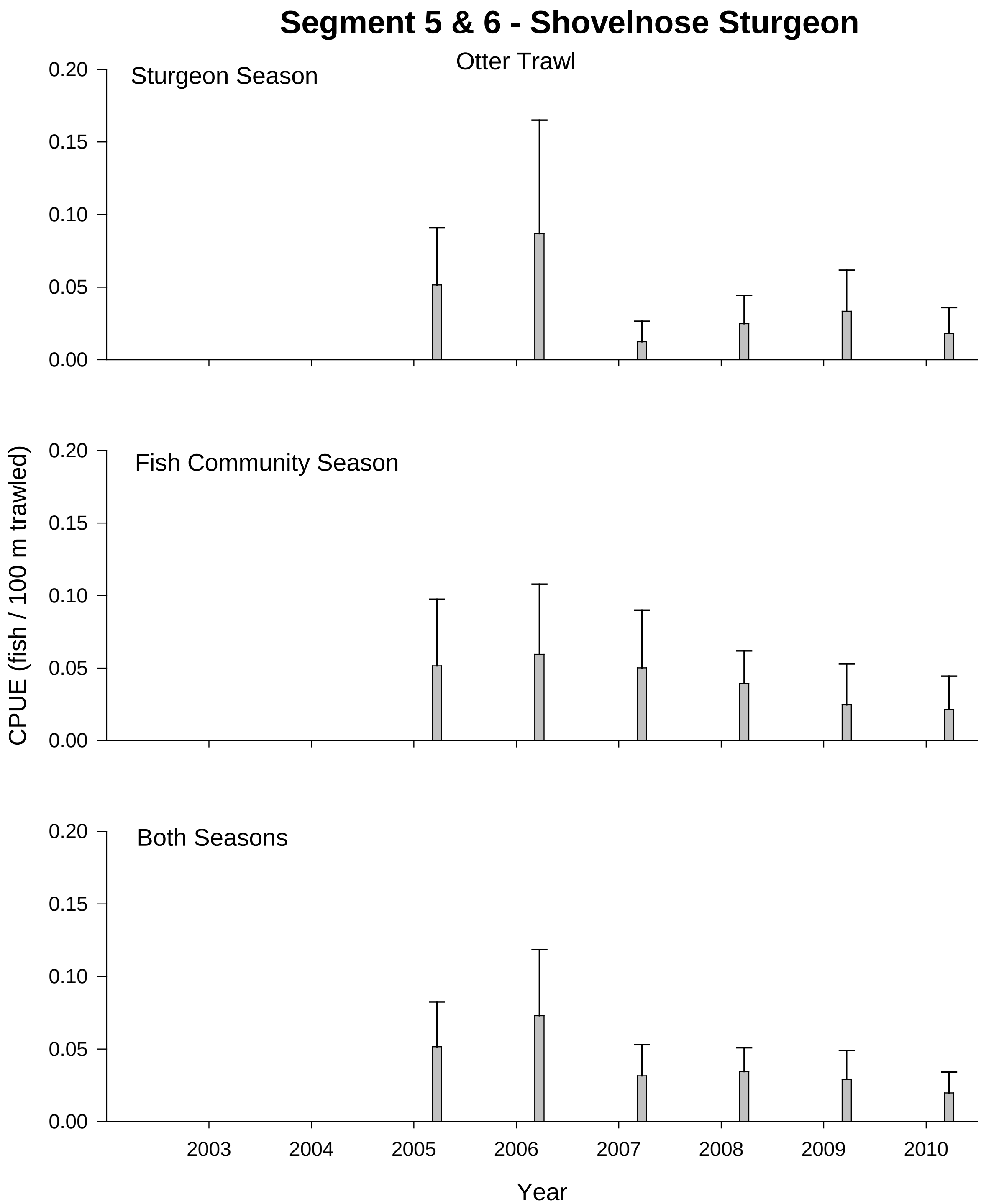

Figure 12. Mean annual catch per unit effort (+/- 2 SE) of sub-stock size (0-149 mm; cross-hatched bars), sub-stock size (150-249 mm; black bars), stock size (250-379 mm; white bars), and quality and above size (> 380 mm; gray bars) shovelnose sturgeon using otter trawls in Segments 5 & 6 of the Missouri River from 2003-2010.

Table 11. Total number of stock size (250-379 mm) shovelnose sturgeon captured for each gear during each season and the proportion caught within each macrohabitat type in Segments 5 & 6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
Sturgeon season (fall though spring)						
1-inch trammel net	0	0	0	0	0	0
		53	14	15	16	2
Gill net	1	0	100	0	0	0
		50	17	15	16	3
Otter trawl	0	0	0	0	0	0
		51	17	16	14	2
Fish community season (summer)						
1-inch trammel net	0	0	0	0	0	0
		53	17	12	16	2
Mini-fyke net	0	0	0	0	0	0
		50	15	16	16	3
Otter trawl	0	0	0	0	0	0
		50	17	15	15	2

Table 12. Total number of quality size and greater (≥380 mm) shovelnose sturgeon captured for each gear during each season and the proportion caught within each macrohabitat type in Segments 5 & 6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
Sturgeon season (fall through spring)						
1-inch trammel net	22	59	18	5	14	5
		53	14	15	16	2
Gill net	94	57	21	7	11	3
		50	17	15	16	3
Otter trawl	4	100	0	0	0	0
		51	17	16	14	2
Fish community season (summer)						
1-inch trammel net	11	55	9	0	27	9
		53	17	12	16	2
Mini-fyke net	0	0	0	0	0	0
		50	15	16	16	3
Otter trawl	5	60	0	40	0	0
		50	17	15	15	2

Table 13. Total number of shovelnose sturgeon captured for each gear during each season and the proportion caught within each macrohabitat type in Segments 5 & 6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
Sturgeon season (fall through spring)						
1-inch trammel net	22	59	18	5	14	5
		53	14	15	16	2
Gill net	95	57	22	7	11	3
		50	17	15	16	3
Otter trawl	4	100	0	0	0	0
		51	17	16	14	2
Fish community season (summer)						
1-inch trammel net	11	55	9	0	27	9
		53	17	12	16	2
Mini-fyke net	0	0	0	0	0	0
		50	15	16	16	3
Otter trawl	5	60	0	40	0	0
		50	17	15	15	2

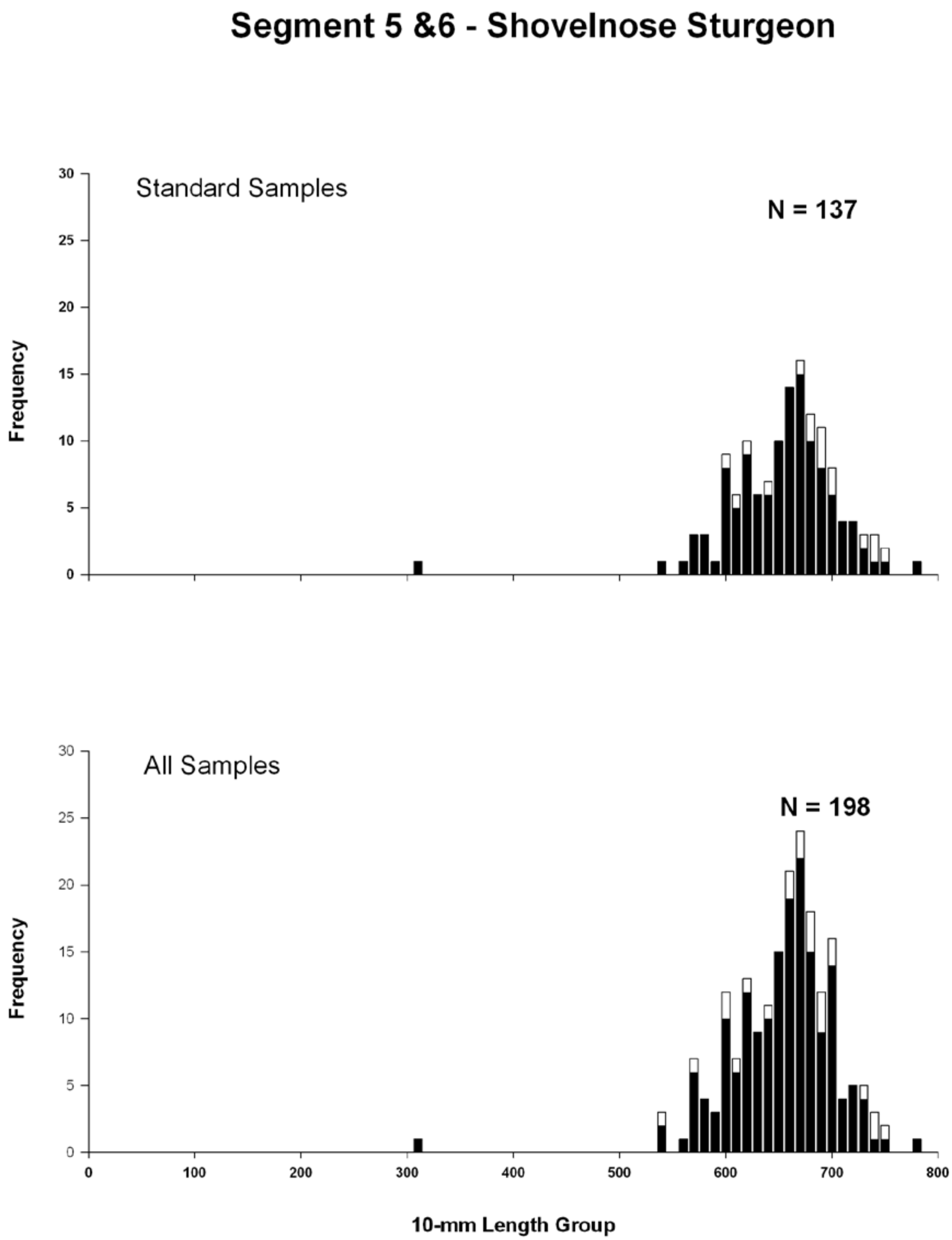

Figure 13. Length frequency of shovelnose sturgeon during the sturgeon season (black bars) and fish community season (white bars) in Segments 5 & 6 of the Missouri River during 2010. Standard samples include standard gears, random bends, and random subsamples. All samples include all sampling conducted during 2010.

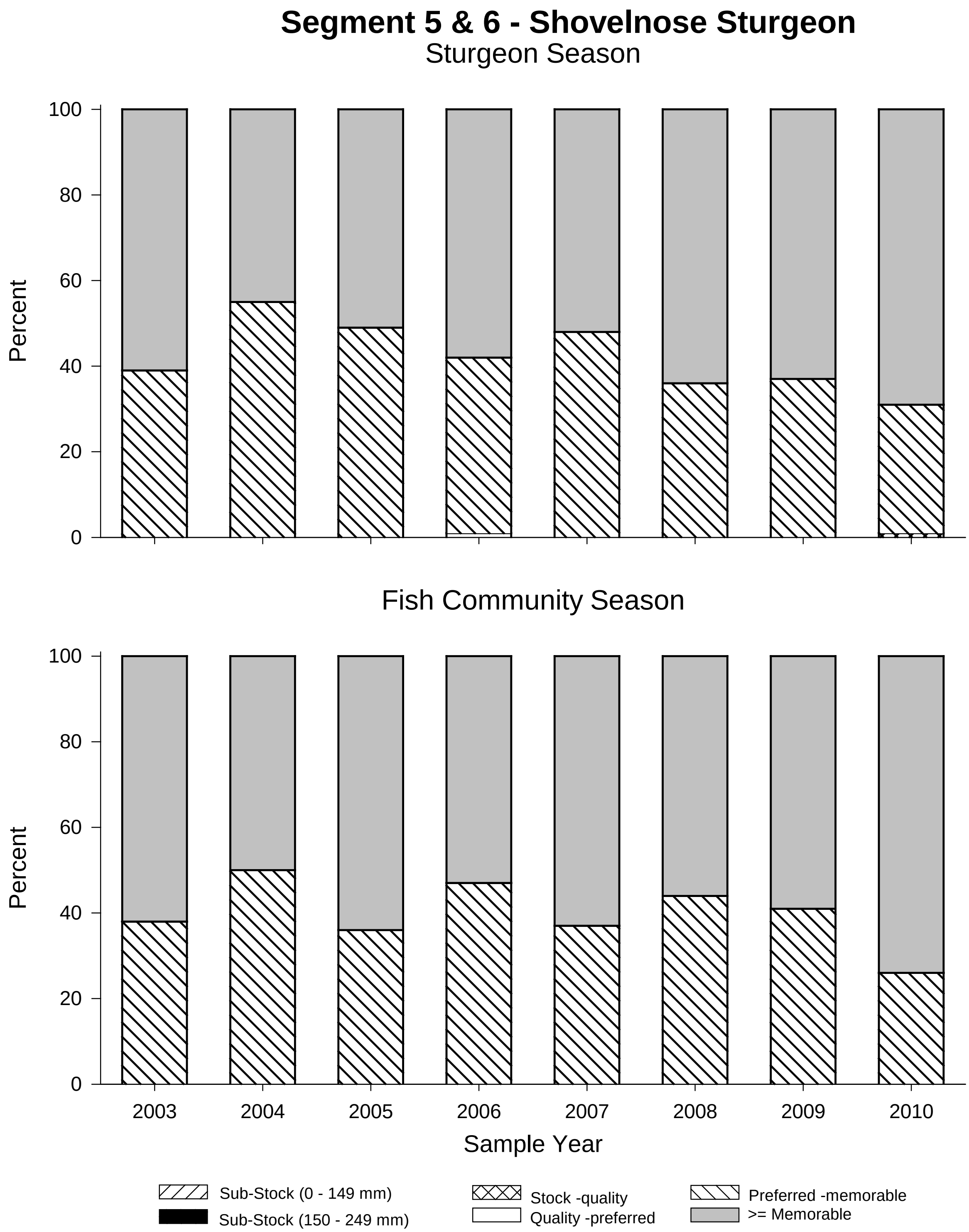

Figure 14. Proportion by length group for all shovelnose sturgeon captured with all gears by incremental proportional size distribution (PSD) length category from 2003 to 2010 in Segments 5 & 6 in the Missouri River. Length categories determined using the methods proposed by Quist et al. (1998) with the exception of sub-stock categories.

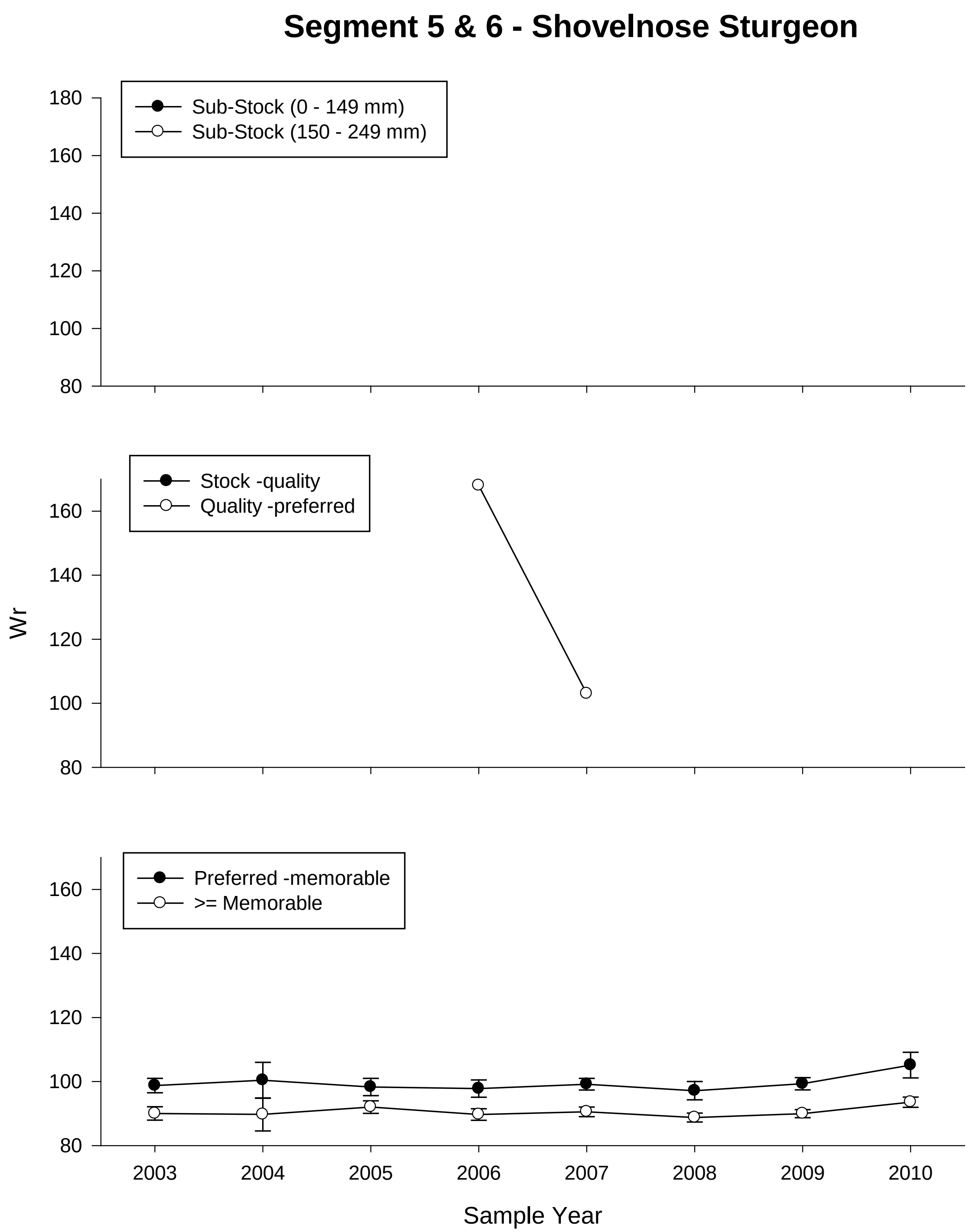

Figure 15. Relative weight (W_r) for all shovelnose sturgeon captured with all gears by incremental proportional size distribution (PSD) length categories from 2003-2010 in Segments 5 & 6 in the Missouri River. Length categories determined using the methods proposed by Quist et al. (1998) with the exception of sub-stock categories.

Sturgeon Chub

No sturgeon chubs were captured during the 2010 sampling season. This is the eighth consecutive year (2003 – 2010) with no sturgeon chubs captured in Segments 5 and 6.

Sicklefin Chub

No sicklefin chubs were captured during the 2010 sampling season. This is the eighth consecutive year (2003 – 2010) with no sicklefin chubs captured in Segments 5 and 6.

Shoal Chub

No shoal chubs were captured during the 2010 sampling season. This is the eighth consecutive year (2003 – 2010) with no shoal chubs captured in Segments 5 and 6.

Sand Shiner

The relative abundance of sand shiners dramatically declined (98%) in 2010 compared to 2008 and was the lowest observed since 2003, when no sand shiners were captured in mini-fyke nets. A total of five sand shiners were captured in mini-fyke nets during the fish community season (Figures 22 and 23) and one additional fish was captured in the otter trawl during the sturgeon season in 2010. Annual catch per unit effort during 2010 for mini-fyke nets decreased 28% compared to 2009 and 93% compared to the seven year mean (2003 – 2009). Sand shiners captured were collected from inside bend (n = 2), outside bend (n = 1), braided channel (n = 1), channel cross over (n = 1), and large secondary connected channel (n = 1) macrohabitats. Mini-fyke nets were only set in the bar mesohabitat. Sixty-seven percent of the sand shiners captured were between 30 - 40 mm (Figure 23).

Spatial distribution of sand shiners in Segments 5 and 6 has been variable. In 2010, 17% of the sand shiners captured were collected in Segment 6 and 83% were captured in Segment 5. In 2006 and 2008 the majority of sand shiners were captured downstream of the Niobrara River confluence with the exception of five fish in 2008. In 2009, a fairly equal number of sand shiners were collect in Segments 5 and 6. However, in 2007 and 2010 nearly all sand shiners were captured upstream of the Niobrara River confluence.

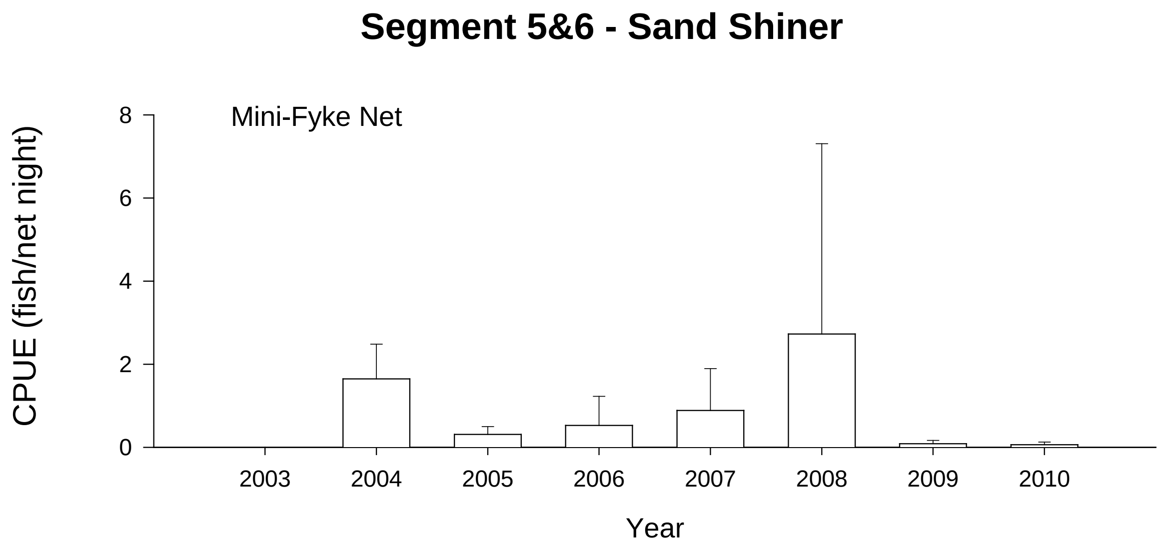

Figure 22. Mean annual catch per unit effort (+/- 2 SE) of sand shiners with mini-fyke nets in Segments 5 & 6 of the Missouri River during fish community season 2003-2010.

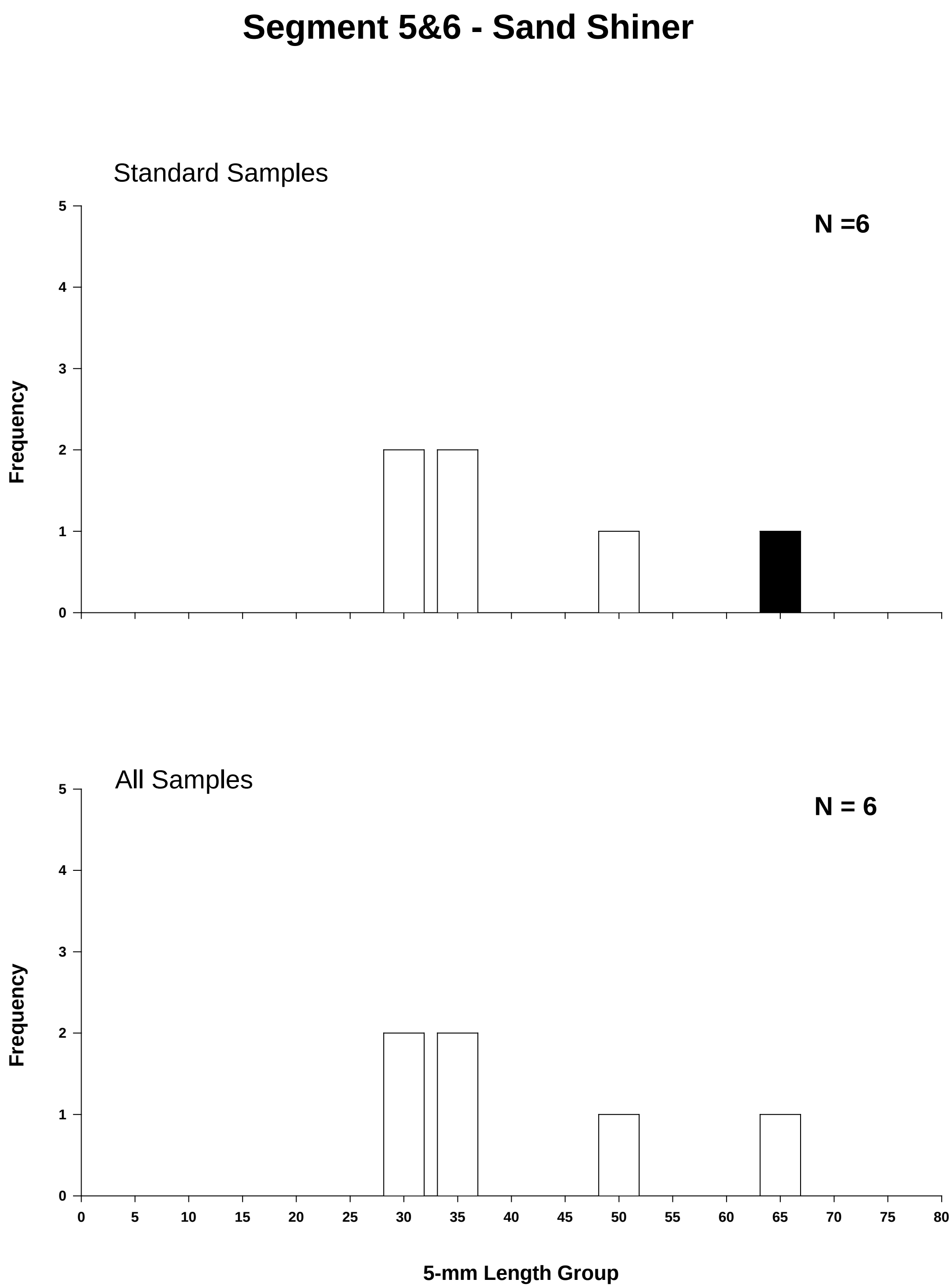

Figure 23. Length frequency of sand shiners during the sturgeon season (black bars) and the fish community season (white bars) in Segments 5 & 6 of the Missouri River during 2010. Standard samples include standard gears, random bends, and random subsamples. All samples include all sampling conducted during 2010.

***Hybognathus* spp**.

The abundance of *Hybognathus* spp. in Segments 5 and 6 was the highest recorded since monitoring began in 2003. A total of 125 *Hybognathus* spp. were captured during the 2010 sampling season. All *Hybognathus* spp. collected in 2010 were identified as brassy minnows. In prior reports (2005 and 2008) brassy minnows were not used to calculate *Hybognathus* spp. CPUE whereas in 2007, 2009, and 2010 they were included (Figure 24). Thirty-seven brassy minnows captured in Segment 5 were not used in CPUE calculations during 2008. All *Hybognathus* spp were captured in mini-fyke nets during the fish community season. Fifteen brassy minnows were collected downstream of the Niobrara River confluence in Segment 6 and 110 fish were collected from Segment 5. Fish collected in Segment 6 were collected from bars in braided channels while fish collected in Segment 5 were collected from bars in inside bend (n = 67), channel crossover (n = 25), outside bend (n = 17), and large secondary connected channel (n = 1) macrohabitats. Mini-fyke net catches from 2003 – 2009 included, one *Hybognathus* spp. collected during 2005 (unidentified), eight fish collected during 2007 (six plains minnow and 2 western silvery minnows), 43 fish collected during 2008 (all brassy minnows except six that were too small to identify to species), and 10 brassy minnows collected during 2009. The length of the majority (72%) of the brassy minnows captured in 2010 ranged between 40 – 59 mm TL (Figure 25). Inclusion of all *Hybognathus* spp. into the relative abundance estimates for previous years will be provided in 2011, thus providing a more accurate CPUE estimate of total *Hybognathus* spp. captured during 2003-2011.

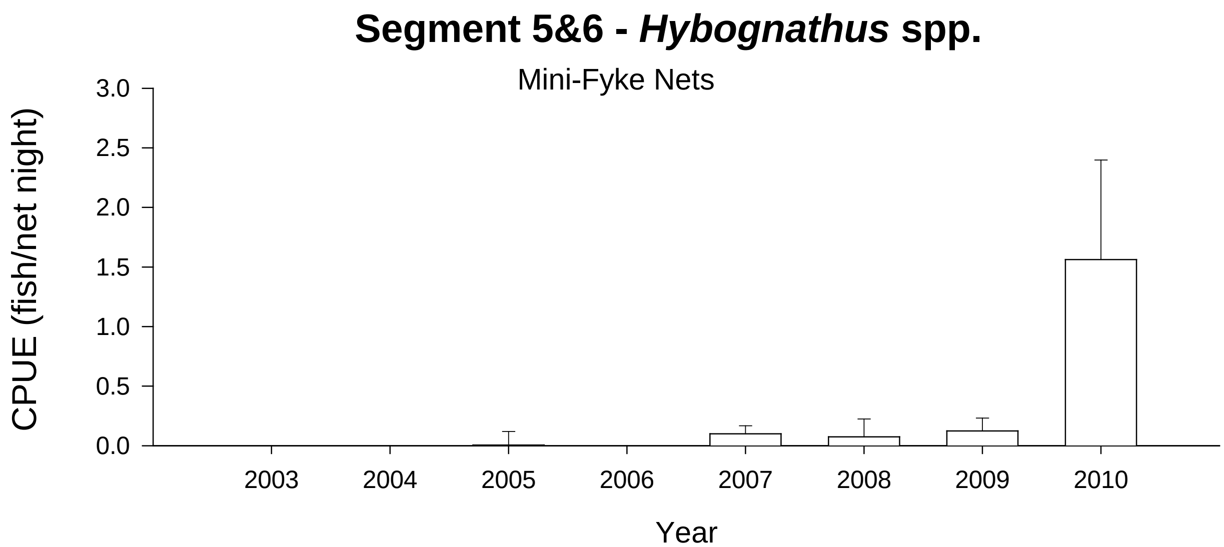

Figure 24. Mean annual catch per unit effort (+/- 2 SE) of *Hybognathus* spp. with mini-fyke nets in Segments 5 & 6 of the Missouri River during fish community season 2003-2010.

Segment 5&6 - *Hybognathus* spp.

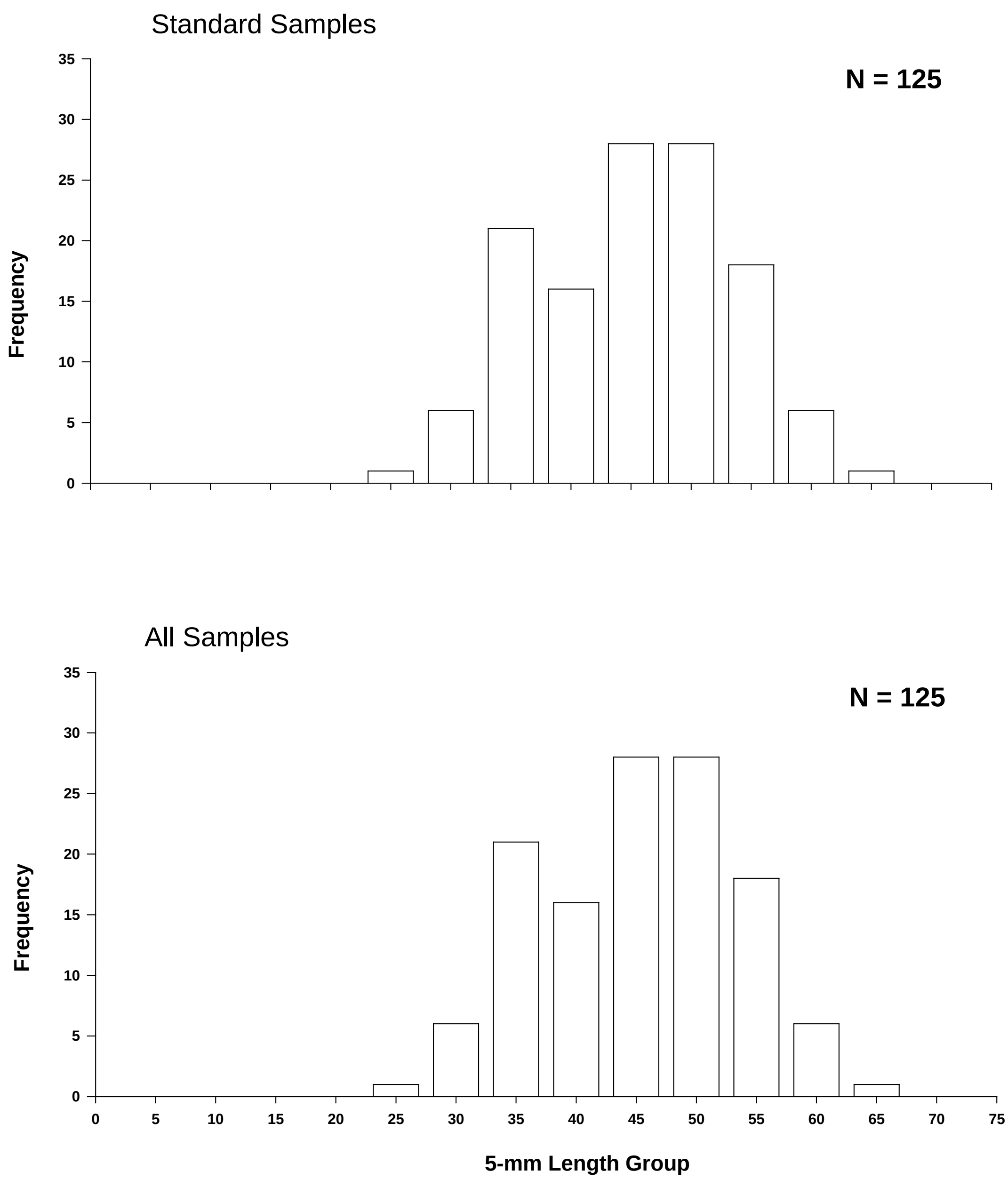

Figure 25. Length frequency of *Hybognathus* spp. caught during the sturgeon season (black bars) and the fish community season (white bars) in Segments 5 & 6 of the Missouri River during 2010. Standard samples include standard gears, random bends, and random subsamples. All samples include all sampling conducted during 2010.

Blue Sucker

The relative abundance of blue suckers in Segments 5 and 6 remained low in 2010. Total catch of blue suckers (n = 4) in standard gears during 2010 increased 33% from 2009 (n = 3) but was 80% lower than our highest catch in 2007 (n = 20). Of the four blue suckers captured in standard sampling gears, three were captured in gill nets and one in a trammel net. Macrohabitats where blue suckers were captured (Table 14) included outside bends (n = 2), inside bend (n = 1), and channel crossover (n = 1). All blue suckers were captured in channel border mesohabitats. During 2010, the relative abundance of blue suckers captured with gill nets (0.015 fish/net night) was lower than the 7 year average (0.027 fish/net night), but increased 200% compared to 2009 (Figure 26). Abundance measured with trammel nets and otter trawls was low in 2010 during both seasons and ranged from 0 to < 0.01 fish/100 m (Figures 27 and 28). Since inception of this monitoring program, no blue suckers have been captured with mini-fyke nets (2003 - 2010). In 2010, all blue suckers captured in Segments 5 and 6 were over 700 mm TL indicating an ageing population lacking consistent recruitment (Figure 29). A similar size structure dominated by large adult fish has been observed in nearly all previous years since monitoring began. However, on June 5, 2007, a single 203 mm TL blue sucker was captured with the otter trawl, providing the first evidence of limited recruitment within Segments 5 and 6 of the Missouri River.

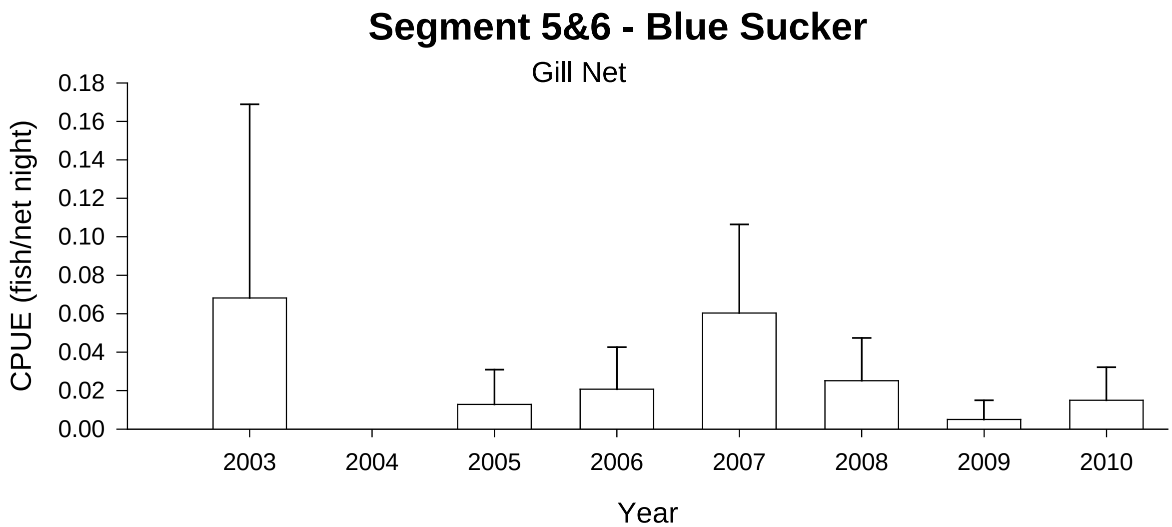

Figure 26. Mean annual catch per unit effort (+/- 2 SE) of blue suckers using gill nets in Segments 5 & 6 of the Missouri River from 2003-2010.

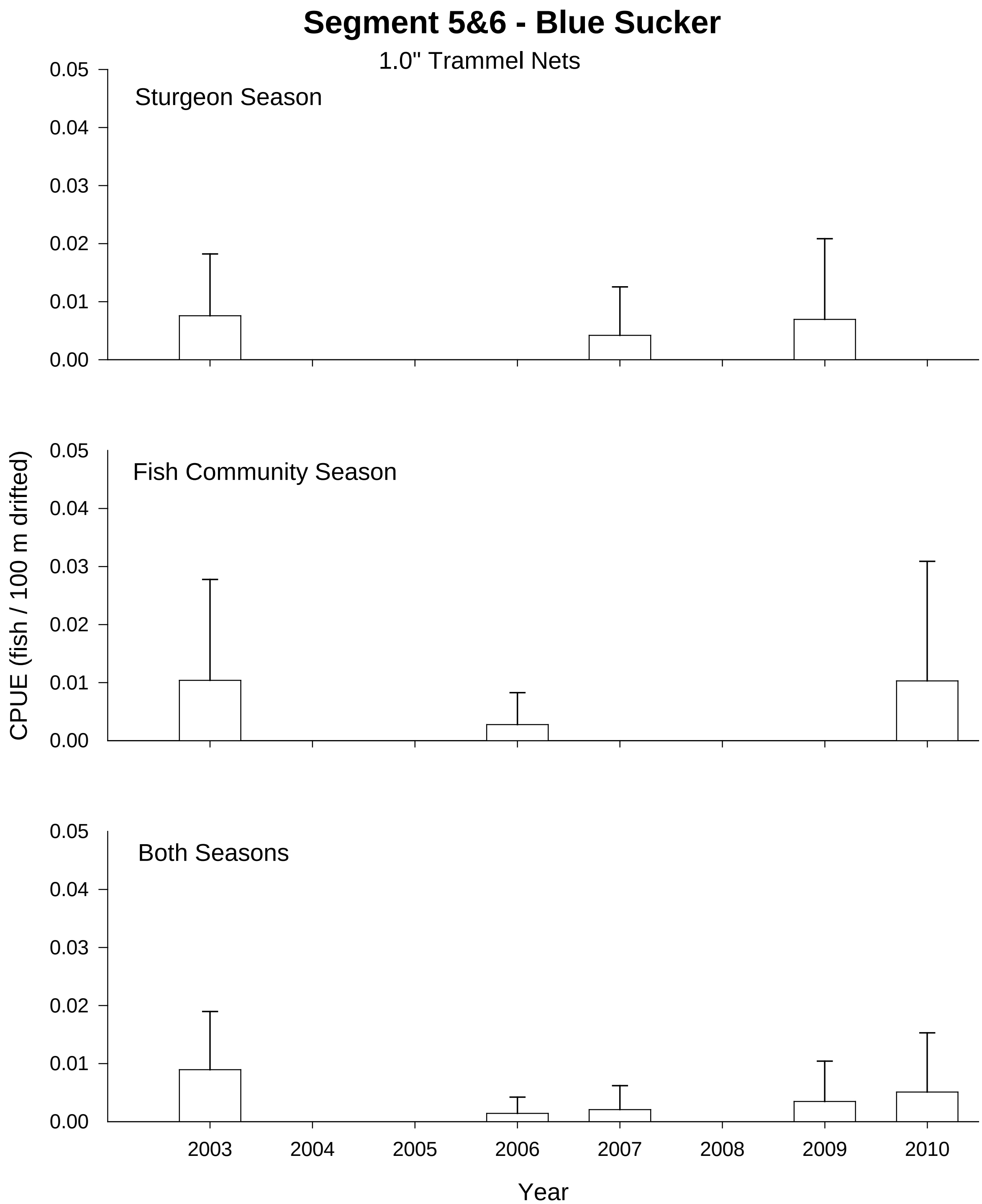

Figure 27. Mean annual catch per unit effort (+/- 2 SE) of blue suckers using 1-inch trammel nets in Segments 5 & 6 of the Missouri River from 2003-2010.

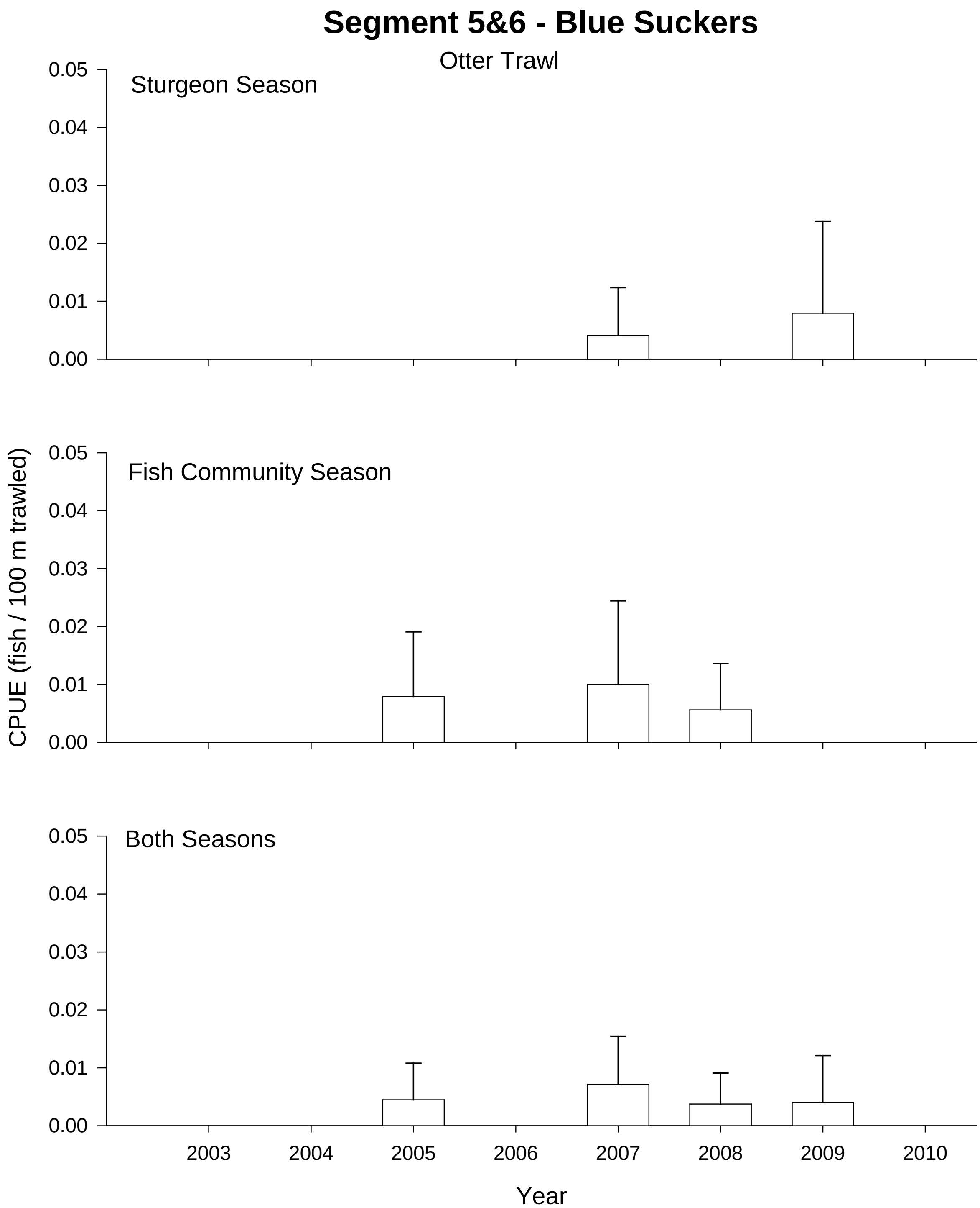

Figure 28. Mean annual catch per unit effort (+/- 2 SE) of blue suckers using otter trawls in Segments 5 & 6 of the Missouri River from 2003-2010.

Table 14. Total number of blue suckers captured for each gear during each season and the proportion caught within each macrohabitat type in Segments 5 & 6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
Sturgeon season (fall through spring)						
1-inch trammel net	0	0	0	0	0	0
		53	14	15	16	2
Gill net	3	0	33	33	33	0
		50	17	15	16	3
Otter trawl	0	0	0	0	0	0
		51	17	16	14	2
Fish community season (summer)						
1-inch trammel net	1	0	0	0	100	0
		53	17	12	16	2
Mini-fyke net	0	0	0	0	0	0
		50	15	16	16	3
Otter trawl	0	0	0	0	0	0
		50	17	15	15	2

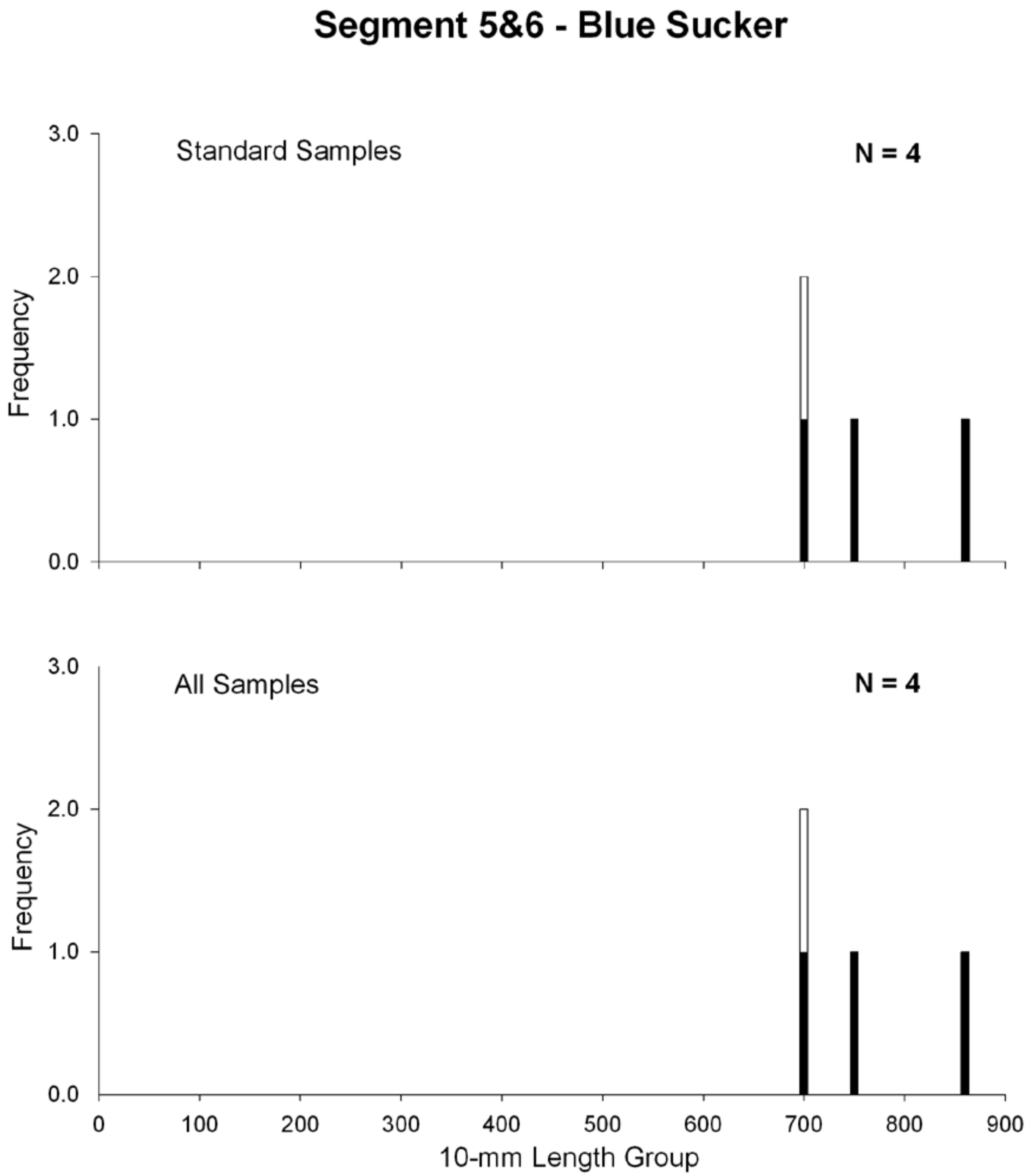

Figure 29. Length frequency of blue suckers during the sturgeon season (black bars) and the fish community season (white bars) in Segments 5 & 6 of the Missouri River during 2010. Standard samples include standard gears, random bends, and random subsamples. All samples include all sampling conducted during 2010.

Sauger

In 2010, 89 saugers were sampled with our standard effort in Segments 5 and 6 with most fish caught with gill nets (n = 52). Remainder of the sauger catch was with trammel nets (n = 14), otter trawls (n = 13), and mini-fyke nets (n = 10). Duplicate passes conducted with trammel nets and otter trawls collected an additional 17 saugers. Gill net mean CPUE in 2010 (0.26 fish/net night) was lower than 2009 (0.39 fish/net night) but was 2.2 times greater than the lowest abundance observed in 2005 (0.12 fish/net night). Sauger relative abundance in gill nets during 2010 was similar to the seven year running average of 0.27 fish/net night (Figure 30) but was 43% lower than the all time high observed in 2003. Seasonal trends in sauger CPUE with trammel nets (Figure 31) declined in both the sturgeon (5%) and fish community seasons (79%) compared to the seven year running average (0.06 fish/100 m for the fish community season and 0.16 fish/100m for the sturgeon season). Relative abundance of saugers during the sturgeon season for the otter trawl (0.03 fish/100 m) has continued to decreased from the all time high of 0.18 fish/100 m observed in 2008 after decreasing each year from 0.05 fish/100 m in 2005 to 0.01 fish/100 m in 2007 (Figure 32). Additionally, sauger catches in otter trawls decreased 19% during the fish community season of 2010 compared to the sturgeon season. During 2010 mean annual relative abundance (sturgeon and fish community season pooled) of saugers decreased for trammel nets (59%) and otter trawls (56%) when compared to the long-term average. Compared to 2009, mean annual CPUE of saugers declined 65% for trammel nets and 67% for otter trawls. Mini-fyke net catches of saugers in 2010 declined 41% from the all time high observed in 2008 and decreased 28% compared to last year (Figure 33).

In Segments 5 and 6 saugers were generally spatially distributed in proximity to the confluence of the Niobrara and Missouri rivers. The majority of saugers (91%) were captured in the channel border mesohabitat. A total of 51 saugers (48%) were captured in the delta downstream of the Niobrara and Missouri river confluence in Segment 6. In Segment 5, an additional 31 fish were captured from bend 15, immediately downstream of the Ponca Creek confluence, with only 24 saugers captured upstream of the Verdel, Nebraska boat landing (54% of the river length in Segment 5). Saugers were captured in the braided channel (48%), outside bend (33%), channel crossover (11%), inside bend (7%), and large secondary connected channel (1%) macrohabitats during 2010 for both seasons collectively (Table 15).

During 2010, the population structure and physical condition of saugers indicated successful spawning and recruitment has occurred in Segments 5 and 6. Over 75% of saugers caught in Segments 5 and 6 of the Missouri River during 2010 were between the 250 - 449 mm TL; however, 8% of fish were < 120 mm TL (Figure 34). Multiple modes (4 - 5) in the length frequency histogram indicated suitable conditions for spawning and recruitment still exist in Segments 5 and 6 (Figure 34). Incremental proportional size distribution (PSD) values for each category during the sturgeon season were: stock–quality = 28, quality–preferred = 34, preferred–memorable = 31, memorable–trophy = 7, and trophy = 0. While the PSD values shifted during the fish community season to: stock–quality = 18, quality–preferred = 68, preferred–memorable = 14, memorable–trophy = 0, with no change in the trophy size class. Incremental PSD during the sturgeon season had higher proportions of stock–quality, preferred–memorable, and memorable–trophy sized saugers compared to the fish community season, while eight sub-stock sized fish captured in the summer indicated some limited recruitment in 2010. Nearly all sub-stock sized saugers were caught with mini-fyke nets. Excluding sub-stock sized fish, mean relative weights during the sturgeon season did not differ from that of the fish community season; the mean relative weights during the sturgeon season and the fish community season were 81 (n = 76; ± 2SE = 2.13) and 80 (n = 22; ± 2SE = 2.56), respectively. The mean condition of sauger decreased 6% in the sturgeon (mean W_r = 86; ± 2SE = 3.58) and 12% in the fish community (mean W_r = 91; ± 2SE = 18.98) seasons when compared to 2009.

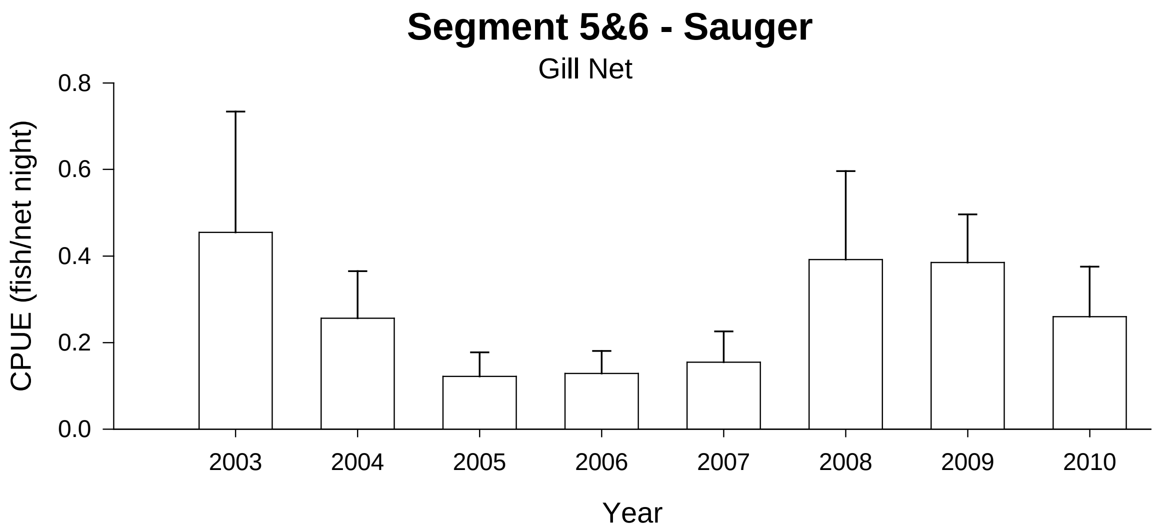

Figure 30. Mean annual catch per unit effort (+/- 2 SE) of saugers using gill nets and in Segments 5 & 6 of the Missouri River from 2003-2010.

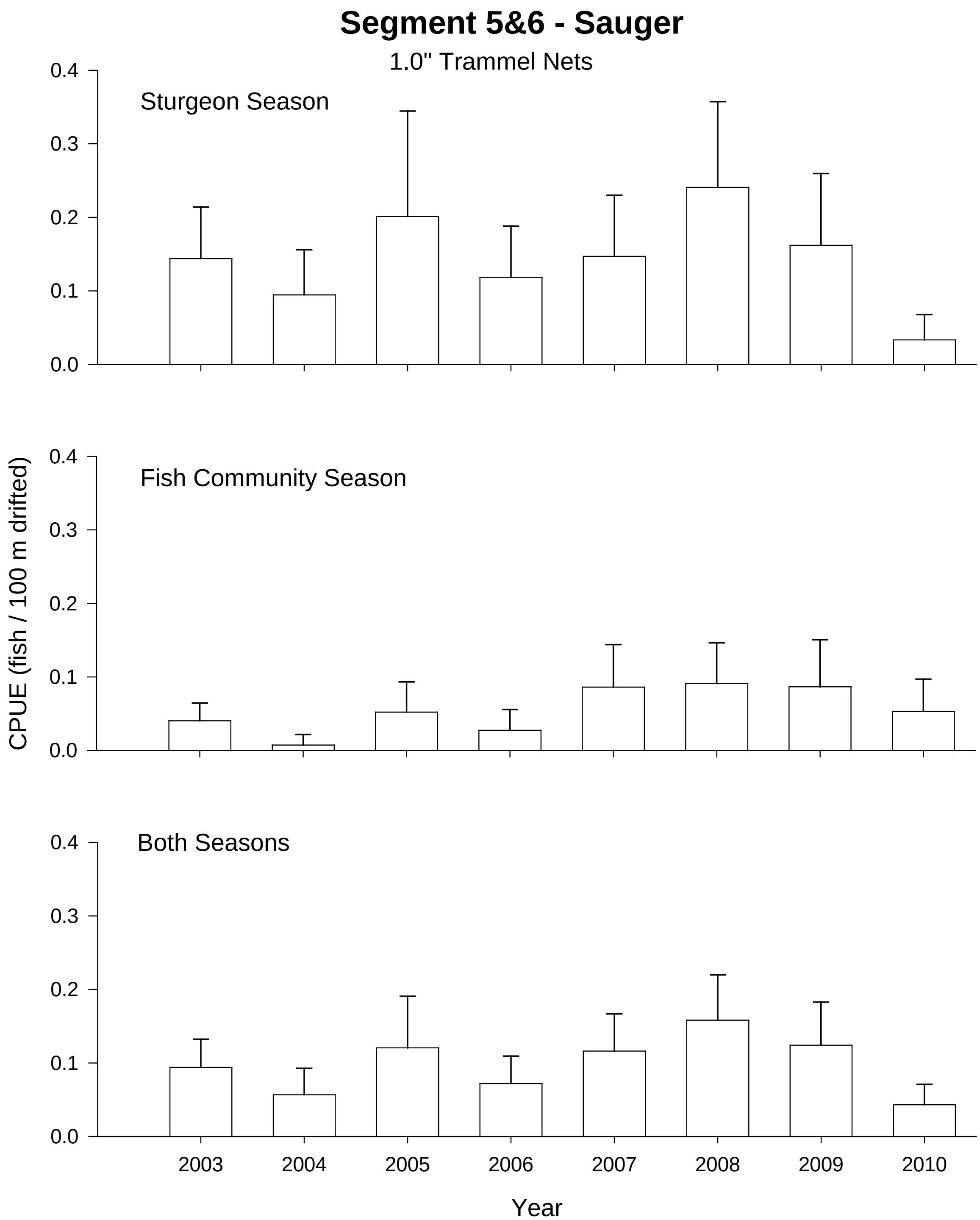

Figure 31. Mean annual catch per unit effort (+/- 2 SE) of saugers using 1-inch trammel nets in Segments 5 & 6 of the Missouri River from 2003-2010.

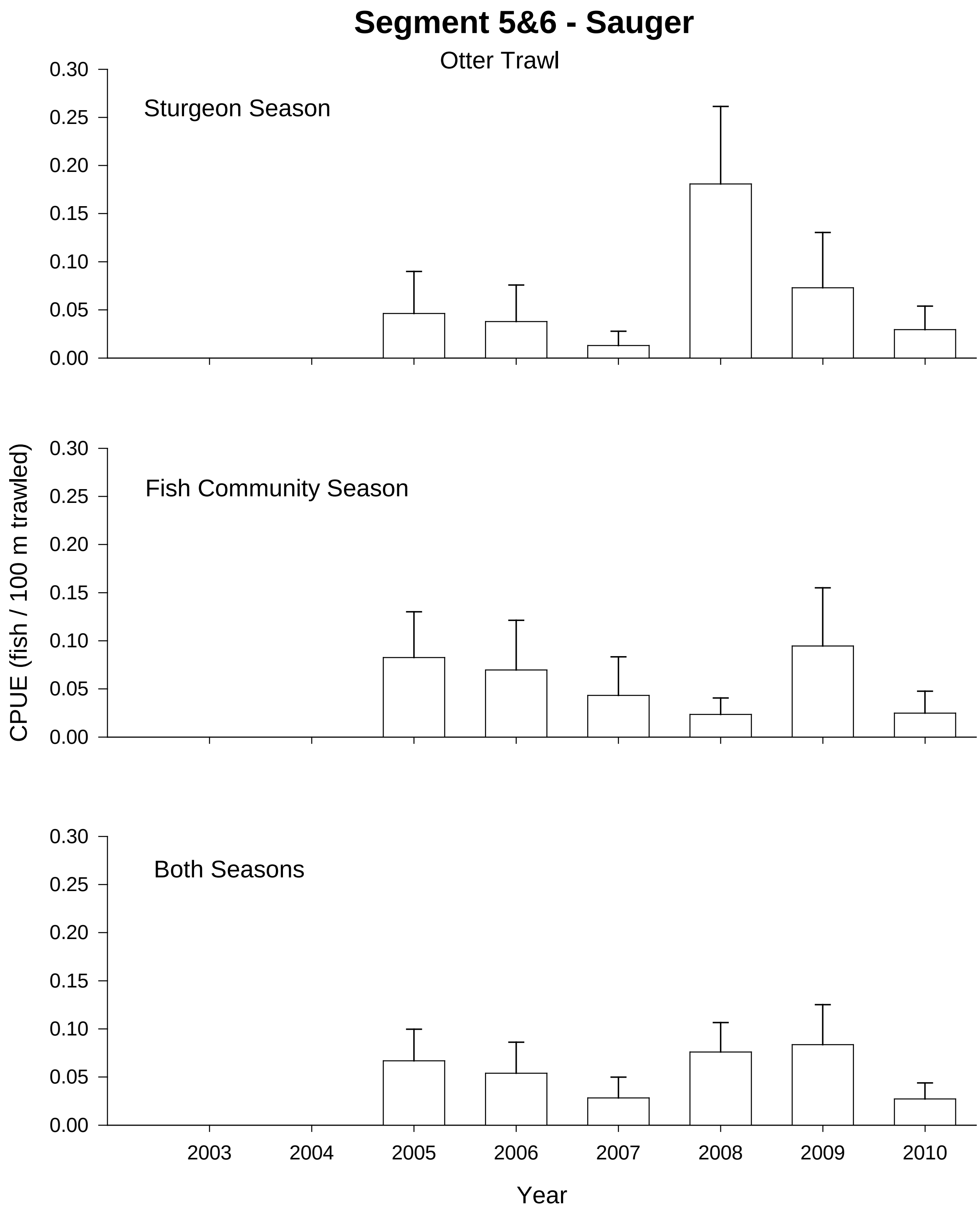

Figure 32. Mean annual catch per unit effort (+/- 2 SE) of saugers using otter trawls in Segments 5 & 6 of the Missouri River from 2003-2010.

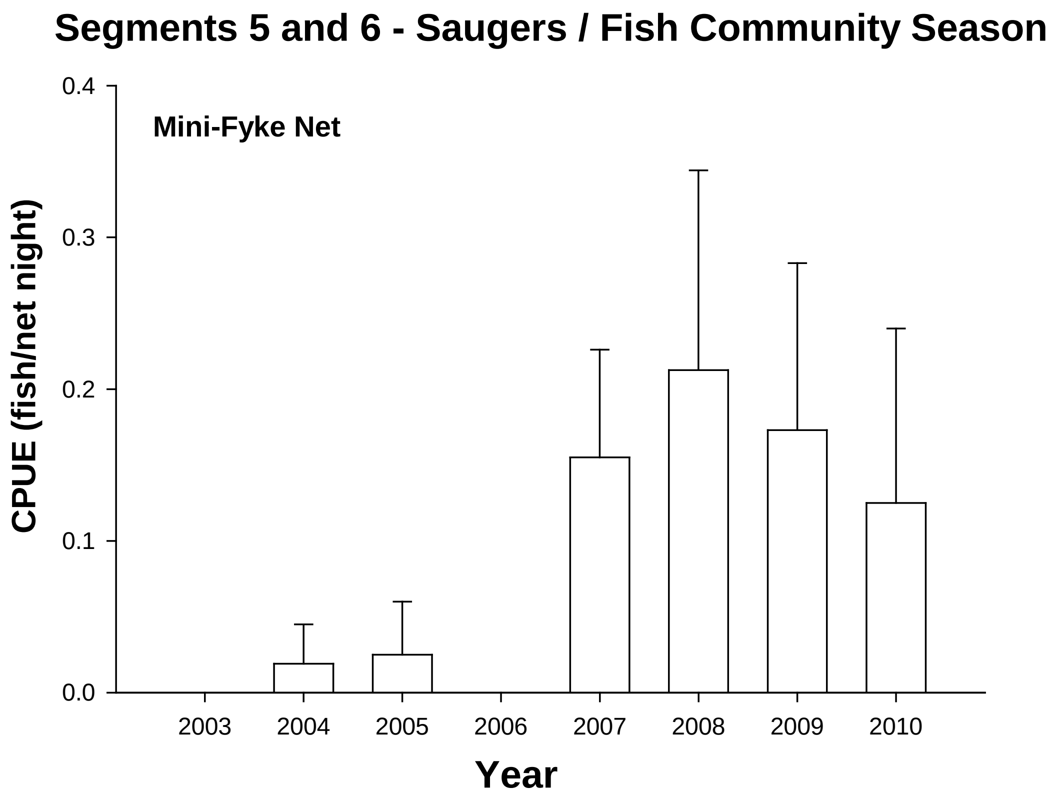

Figure 33. Mean annual catch per unit effort (+/- 2 SE) of saugers using mini-fyke nets in Segments 5 and 6 of the Missouri River during fish community season from 2003-2010.

Table 15. Total number of saugers captured for each gear during each season and the proportion caught within each macrohabitat type in Segments 5 & 6 of the Missouri River during 2010. The percent of total effort for each gear in each habitat is presented on the second line of each gear type.

Gear	N	Macrohabitat[a]				
		BRAD	CHXO	ISB	OSB	SCCL
		Sturgeon season (fall through spring)				
1-inch trammel net	6	17	0	33	50	0
		53	14	15	16	2
Gill net	52	60	15	2	23	0
		50	17	15	16	3
Otter trawl	7	71	0	0	29	0
		51	17	16	14	2
		Fish community season (summer)				
1-inch trammel net	8	0	25	38	25	13
		53	17	12	16	2
Mini-fyke net	10	80	20	0	0	0
		50	15	16	16	3
Otter trawl	6	50	0	17	33	0
		50	17	15	15	2

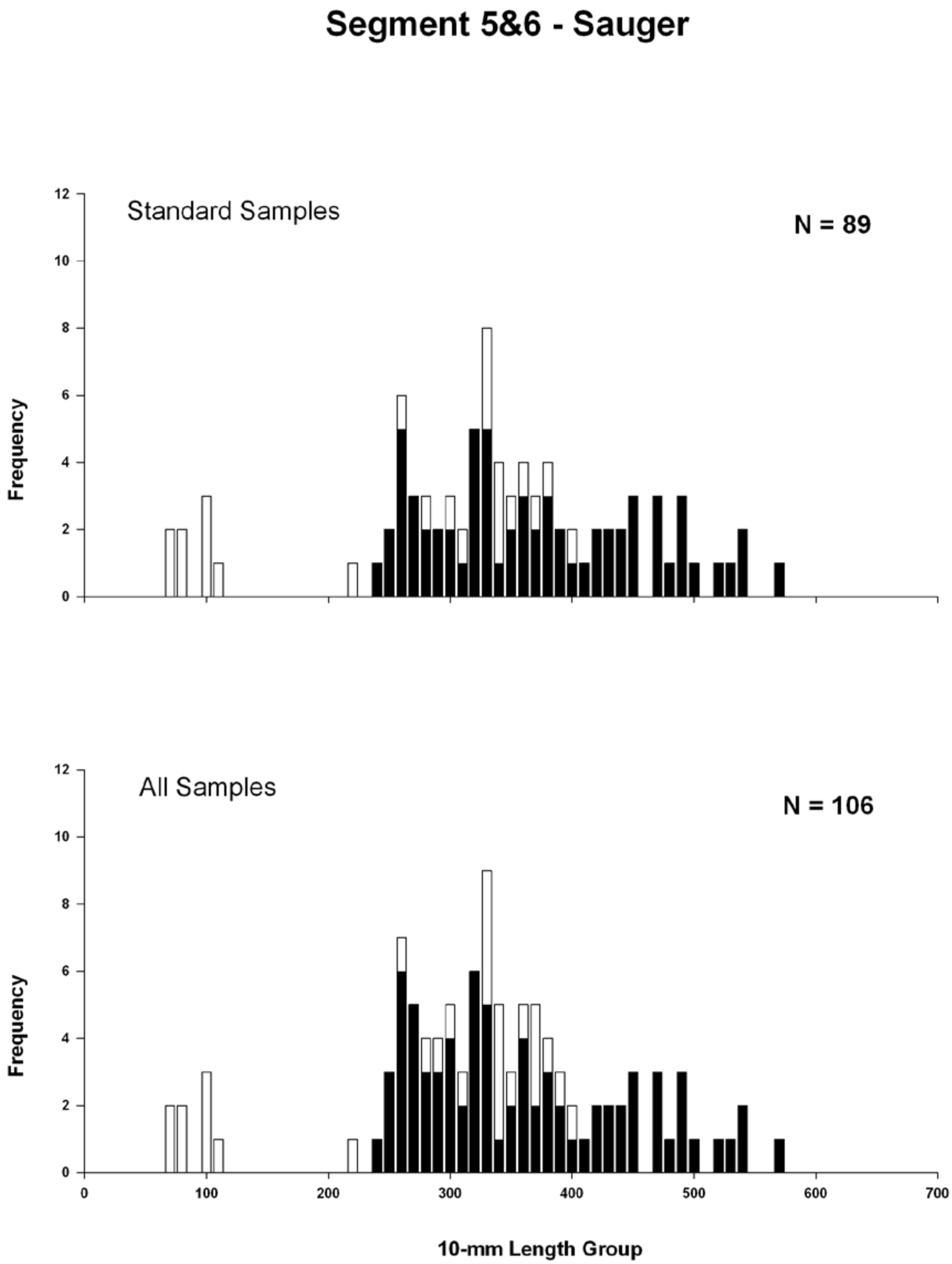

Figure 34. Length frequency of saugers during the sturgeon season (black bars) and the fish community season (white bars) in Segments 5 & 6 of the Missouri River during 2010. Standard samples include standard gears, random bends, and random subsamples. All samples include all sampling conducted during 2010.

Missouri River Fish Community

Objective 6. Document annual results and long-term trends of all non-target species population abundance and geographic distribution throughout the Missouri River system, where sample size is greater than fifty individuals.

A total of 3,503 fish comprised of 48 species and one hybrid, sauger x walleye *S. canadese X S. vitreus,* were captured during the 2010 sampling season in Segments 5 and 6 of the Missouri River (Appendices F1 - F4, and J). A total of 214 random gear deployments contained no fish: gill nets (n = 79: 37%), trammel nets (n = 80: 37%), otter trawls (n = 53: 25%), and mini-fyke nets (n = 2: 1%). Additionally, 22 of 80 trot line deployments contained no fish. We captured eight species during the 2010 season that were not seen in the previous year: bigmouth shiner *Notropis dorsalis* (n = 2), central stoneroller *Campostoma anomalum* (n = 3), fathead minnow *Pimephales promelas* (n = 15), paddlefish *Polyodon spathula* (n = 2), pumpkinseed *Lepomis gibbosus* (n = 1), stonecat *Noturus flavus* (n = 2), longnose dace *R. cataractae* (n = 4), and white sucker *Catostomus commersonii* (n = 2). Two species captured in 2009 but not observed in 2010 were river shiner *Notropis blennius* and yellow bullhead *Ameiurus natalis*. Greatest numbers of fishes (n = 2,180) were captured during the summer with mini-fyke nets and catches consisted mainly of small bodied cyprinids (Appendix F4). Standard gears with the greatest percentage of their total catch comprised of pallid sturgeon and the nine targeted native fish species were: trammel nets (39%), gill nets (41%), otter trawls (10%), and mini-fyke nets (6%). Additionally, 75% of the species captured in trot lines were target species. Target species comprised 6% of the catch in mini-fyke nets in 2010 increasing from 2% in 2009 and 3% in 2006 and 2007. However, all *Hybognathus* spp. and sand shiners in 2010 were captured with mini-fyke nets with the exception of one sand shiner captured in the otter trawl.

Of the 48 species and one hybrid captured with standard gears, 37% had > 50 individuals collectively caught. These species included: spotfin shiner *Cyprinella spiloptera* (n = 580), emerald shiner *N. atherinoides* (n = 329), channel catfish *Ictalurus punctatus* (n = 303), shovelnose sturgeon (n = 198), walleye *S. vitreum* (n = 173), black crappie *Poxomis nigromaculatus* (n = 160), pallid sturgeon (n = 150), silver chub *M. storeriana* (n = 132), brassy minnow (n = 125), bluntnose minnow *Pimephales notatus* (n = 108), sauger (n = 106), shorthead redhorse *Moxostoma macrolepidotum* (n = 92), bluegill *L. macrochirus* (n = 91), largemouth bass *Micropterus salmoides* (n = 86), white bass *Morone chrysops* (n = 83), rainbow smelt *Osmerus mordax* (n = 60), bigmouth buffalo *I. cyprinellus* (n = 57), and creek chub *Semotilus atromaculatus* (n = 55). Six species were represented in the collective catch by ≤ 2 specimens: flathead catfish *Pylodictis olivaris*, pumpkinseed, bigmouth shiner, paddlefish, stonecat, and white sucker. All but four species represented by a cumulative catch of ≥ 50 fish in 2009 were also represented by ≥ 50 individuals in 2010; these species included: river carpsucker *Carpiodes carpio*, freshwater drum *Aplodinotus grunniens*, shortnose gar *Lepisosteus platostomus*, and smallmouth bass *M. dolomieu*.

For gears targeting large fish in deep water habitats (≥ 1.2 m), walleye and channel catfish were the two most common non-targeted species in 2010, which was similar to 2009. Four species, sauger, shorthead redhorse, shovelnose sturgeon, and walleye had an overall gill net mean CPUE ≥ 0.2 fish/net night during 2010 (Appendix F1). During the 2010 sturgeon season, channel catfish had a trammel net mean CPUE of 0.28 fish/100 m, followed by shovelnose sturgeon (0.12 fish/100 m; Appendix H). In contrast, during 2009 channel catfish and sauger were the only species with a mean trammel net CPUE > 0.16 fish/100 m during the sturgeon season. Shovelnose sturgeon, shorthead redhorse, and walleye were the most abundant species captured with trammel nets (mean CPUE 0.06 fish/100 m) during the fish community season (Appendix H), followed by sauger (0.05 fish/100 m). For the otter trawl during the sturgeon season, channel catfish was the only species with a mean CPUE ≥ 0.5 fish/100 m.

Silver chub, channel catfish, and rainbow smelt were the most abundant species captured with the otter trawl (mean CPUE ≥ 0.12 fish/100 m) during the fish community season of 2010 (Appendix H).

The greatest numbers of fish species (n = 42) were captured in shallow water habitats with mini-fyke nets (Appendix F4). The five most abundant species captured in mini-fyke nets were: spotfin shiners (8.6 fish/net night), emerald shiners (4.1 fish/net night), black crappie (2.0 fish/net night), brassy minnows (1.6 fish/net night), and bluntnose minnows (1.4 fish/net night). Additionally, the following 7 species had mean CPUE > 0.5 fish/net night with mini-fyke nets: bluegill, bigmouth buffalo, creek chub, green sunfish *L. cyanellus*, largemouth bass, white crappie *P. annularis* , and white bass.

Additional benefits of this long-term monitoring program are continued determination of the absence of aquatic invasive species in vulnerable waters (e.g. Lewis and Clark Lake) or their early detection if introduced (Conover et al. 2007). Nine exotic fish species were captured in Segments 5 and 6 during 2010 which are sport and bait fishes that were intentionally introduced: common carp *Cyprinus carpio*, rainbow smelt, bluegill, black crappie, white crappie *P. annularis*, pumpkinseed, spottail shiner *Notropis hudsonius*, largemouth bass, and smallmouth bass (Berry and Young 2004). Additionally, Hoagstrom et al. (2007) considered rock bass *Ambloplites rupestris*, northern pike *Esox lucius*, spotfin shiner, and white bass as non- native species of the Missouri Valley in South Dakota (i.e., the main river channel). Based on high mean CPUE in mini-fyke nets (8.56 fish/net night), spotfin shiners were the most abundant non-native fish species captured in Segments 5 and 6 during 2010 followed by black crappie (2.0 fish/net night), bluegill (1.13 fish/net night), and largemouth bass (1.08 fish/net night). None of the four exotic Asian carps, bighead carp *Hypophthalmichthys noblis*, silver carp *H. molitrix*, grass carp *Ctenopharyngodon idella*, or black carp *Mylopharyngodon piceus*, were captured or seen within Segments 5 and 6 during 2003 - 2010. However, bighead carp, silver carp, and grass carp are present in the Missouri River just downstream of Gavins Point Dam in Segment 7 (Conover et al. 2007; Stukel et al. 2010; Wanner and Klumb 2009). Because YOY Asian carps look similar to YOY gizzard shad *Dorosoma cepedianum*, there exists the potential for introduction above Gavins Point Dam by anglers mistakenly using YOY Asian carps as bait.

No zebra mussels *Dreissena polymorpha* were observed while working in Segments 5 and 6 during 2003 – 2010 despite the identification of larval zebra mussels (veligers) collected near the Verdel, Nebraska boat ramp (Figure 1) in 2003 (Lawrence Hesse, River Ecosystems Inc., personal communication). In 2009, Asian clams *Corbicula fluminea* were found in Lewis and Clark Lake which serves as a water source for the USFWS Gavins Point National Fish Hatchery (NFH) in Yankton, South Dakota (USFWS 2010). Asian clams were subsequently found in rearing ponds at Gavins Point Dam NFH in fall of 2009 (USFWS 2010). As part of macroinvertebrate survey, Grohs (2008) captured adult Asian clams in the Missouri River downstream of Fort Randall Dam at Sunshine Bottoms, near the Verdel, Nebraska boat launch, and within the Niobrara Delta in 2006 and 2007. Veligers of Asian clams could have been mistaken for zebra mussels in 2003.

The long-term monitoring program also provides distribution data for turtles. Thirty-seven turtles were captured in mini-fyke nets in 2010 consisting of three species; snapping *Chelydra serpentina* (SNST, n = 5), smooth softshell *Apalone mutica* (SMST, n = 1), and false map *Graptemys pseudogeographica* (FSMT, n = 31, Appendix F).

Discussion

Prior to 2010, general trends of increasing pallid sturgeon annual relative abundance in gill nets, trammel nets, and otter trawls have mirrored increasing stocking numbers, evidence that the population assessment program is meeting its first objective and can effectively describe general changes in the population (Welker and Drobish 2010). Since June 2010, 842 additional age-1 hatchery-reared pallid sturgeon were stocked into Segments 5 and 6 which was an increase of total numbers of nearly 8% (Appendix E). Additionally, 24 age-6 hatchery-reared pallid sturgeon were stocked following completion of the 2010 sampling year. Concomitant with the 8% increase in total fish stocked since 2009, annual (seasons pooled) relative abundance of hatchery-reared pallid sturgeon increased in trammel nets, decreased in gill nets, and was similar in otter trawls compared to the six year average. Decreases in hatchery propagated pallid sturgeon relative abundance was found in otter trawls (23%) during the sturgeon season and otter trawls (41%) and trammel nets (44%) during the fish community season compared to 2009. Gill net CPUE for hatchery-reared pallid sturgeon decreased 72% compared to 2009 and 21% compared to the seven year average (2003 – 2009). The sole exception where relative abundance of hatchery-reared pallid sturgeon increased in 2010, compared to the previous year, was a 2% increase in trammel nets during the sturgeon season. Conformity of trends in annual changes of pallid sturgeon relative abundance for all gears in most seasons and years emphasizes the importance of the multi-gear approach implemented by the population assessment program which provides a "weight of evidence" of population trends over time. However, high water throughout the summer of 2010 may have negatively affected catchability of our gear and/or changed spatial distributions of fish into Lewis and Clark Lake (which is not currently sampled), lowering relative abundance despite the 8% increase in numbers of stocked pallid sturgeon.

Multiple years of monitoring have found areas of high pallid sturgeon recaptures within the Niobrara River Delta formed in Segment 6, illustrating achievement of the second part of Objective One for the population assessment program in RPMA 3, documentation of pallid sturgeon spatial distribution. Although pallid sturgeon were captured in all bends sampled as part of the standard monitoring effort during 2010, there was evidence of fish clustering within three areas (Figure 2). During 2010, 64 pallid sturgeon were captured between rkm 1,335 – 1,342.4 (rm 829.5 – 834.1; Segment 6, bends 8 and 9) upstream of the Santee Indian Reservation boat ramp. Twenty-five fish were also caught between rkm 1,371 – 1,373 (rm 851.7 – 853; Segment 6, bend 12) near the Verdel, Nebraska boat landing, with and an additional 20 fish caught between rkm 1,364.7 – 1,367.5 (rm 848 – 849.7; Segment 6, bend 15) near the Ponca Creek confluence. Clusters of age-3 to age-5 pallid sturgeon were also seen in a telemetry study in Segments 5 and 6 during 2000 to 2002 (Jordan et al. 2006) with most aggregations found at rkm 1,363 (rm 847). River kilometer 1,363 contains one of the deepest habitats (11 m) within Segments 5 and 6 (known as the "pump hole") and is located downstream of the Ponca Creek confluence on the South Dakota side of the main channel. The pump hole, located in bend 16 of Segment 5, was randomly selected for sampling in 2005, 2007 and 2008; with multiple fish (N = 2 – 3) captured each year (Shuman et al. 2006b; Shuman et al. 2008; Shuman et al. 2009). Habitat conditions within and near the pump hole have and continue to change since 2008 due to the erosion of the hard point, shifting the main channel towards the Nebraska (south) side of the river. Synthesizing data for all gears deployed in the Missouri River downstream of Fort Randall Dam from 2003 – 2005 using spatial scan analysis, Spindler et al. (2009) detected three significant clusters of pallid sturgeon presence and two significant clusters of consistent absence. One significant cluster of pallid sturgeon presence was at rkm 1,357 (rm 843) one mile downstream of the Niobrara River confluence. The other locations of significant pallid sturgeon captures found by Spindler et al. (2009) were two locations in different braided channels within the Niobrara River Delta at rkm 1,336 (rm 830) an area where clusters of pallid sturgeon were also captured in 2006 - 2010 (Shuman et al. 2007, Shuman et al. 2008; Shuman et al. 2009).

As in past years, pallid sturgeon were captured in all three continuous macrohabitats and in two discrete macrohabitats (braided channels and large secondary connected channels) with the greatest numbers captured in braided channels. Braided channels were first distinguished as a macrohabitat type in 2004. Since the 2004 sampling season, nearly the entire Missouri River downstream of the Niobrara River was considered a braided channel macrohabitat with the exception of a large secondary connected channel and confluence macrohabitats in Segment 6, bend 1. Since 2003, 62% of all pallid sturgeon were captured in the Niobrara River Delta in Segment 6. Ninety-nine percent of pallid sturgeon captured were within channel border mesohabitats (depth > 1.2 m). Pallid sturgeon captured in 2007 - 2010 corresponded with habitats where fish were relocated during a telemetry study in Segments 5 and 6 during 2000 – 2002 (Jordan et al. 2006). Most sonic-tagged age-3 to age-5 pallid sturgeon were relocated in the main channel (91%) with few fish found in secondary connected channels (4%). In 2009, Wanner et al. (2010b) collected a single age-1 hatchery propagated pallid sturgeon (FL = 388 mm, 109 g) in a trammel net on August 12, 2009 near rkm 7 of the Niobrara River. Additionally, age-3 and age-6 pallid sturgeon were collected in the Niobrara River in 2008 indicating pallid sturgeon use of the lower reaches of the largest tributary in RPMA 3 (Wanner et al. 2009).

Population Assessment Program data has been used to successfully derive juvenile pallid sturgeon survival rates (i.e., Objective 3) for the upper (Hadley and Rotella 2009; Rotella 2010) and middle basins (Steffensen et al. 2010) of the Missouri River. Survival rates two years after release in each basin were generally similar (> 90%), although updated apparent survival for spring and summer yearlings stocked in RPMA 3 was 0.62 and 0.86 respectively (Rotella 2010). First year annual survival rates of pallid sturgeon stocked into RPMA 3 as yearlings were low (0.22 – 0.58) and highly variable but after the second year often exceeded 0.90 with increased precision (Hadley and Rotella 2009). Survival of stocked age-3 pallid sturgeon from 2000 – 2003 was 68% during a telemetry study in RPMA 3 (Jordan et al. 2006). In 2010, pallid sturgeon representing all year classes previously stocked were recaptured (Table 3). With the exception of the 1998 year class during 2006 and the 1999 and 2006 year classes during 2008, all other year classes of pallid sturgeon present have been recaptured annually during the Population Assessment Monitoring Program providing further evidence of good survival in RPMA 3 (Table 3; Appendix K).

Gill nets were an effective gear for capturing pallid sturgeon (n = 14) and relative abundance of hatchery-reared pallid sturgeon generally increased with the increased numbers of fish stocked into Segments 5 and 6 the previous year. Exceptions include decreases in pallid sturgeon relative abundance of 42% from 2004 to 2005, 41% from 2007 to 2008, and 68% from 2009 to 2010. The most substantial increases (> 120%) in all pallid sturgeon CPUE occurred during the 2007 and 2009 sampling years (Figure 5) after large numbers of fish were stocked the previous year (2006; n = 1,008; 2008; n = 4,579). The one year lag for changes in relative abundance in relation to stocking period is due to the fact that gill net sampling occurs prior to most stocking events; therefore, stocked juvenile pallid sturgeon take at least one year to be detected by gill nets. Variability (±2 SE) in gill net CPUE each year was high, often as large or larger than the mean, which likely precludes detecting statistically significant changes in pallid sturgeon abundance within Segments 5 and 6. Under current gill net sampling effort, statistical power (β) to detect a 5% annual decline in pallid sturgeon abundance over 20 years within Segments 5 and 6 of the Missouri River was approximately 0.2 (Bryan et al. 2009). However, this power analysis only use data from 2003 – 2005, when collectively few pallid sturgeon were stocked (Appendix E) and recaptured (n = 123) compared to annual captures > 100 the past three years (Figure 9). Also the high frequency of zeros in the data violated normality (for parametric statistical analyses) thus providing a conservative estimate of power (Bryan et al. 2009).

The trammel net was an effective gear and captured 21 pallid sturgeon in Segments 5 and 6 during 2010 in standard drifts, while non-random duplicate passes captured an additional 12 fish. Relative abundance for hatchery-reared pallid sturgeon in trammel nets during the fish community season decreased 44% in 2010 compared to 2009, 49% compared to the all time high in 2007 (0.084 fish/100 m), and only 3% compared to the 2003 to 2009 running average. Relative abundance of hatchery-reared pallid sturgeon during summer in trammel nets was similar in 2010 (increase of 2%) compared to 2009 and increased 72% compared to the 2003 to 2009 running average. Seasonal differences were found in trammel net mean CPUE for all pallid sturgeon with higher catch rates during the summer (fish community season) compared to the fall through spring (sturgeon season) in 2004 – 2010, with 2008 and 2010 being exceptions while 2003 relative abundance was similar. Guy et al. (2009) reported that trammel nets were relatively efficient at capturing *Scaphirhynchus* spp. and conditional capture probability varied from 0.37 and 0.51 for the first and second attempts, respectively. Wanner et al. (2007b) reported that trammel net mean CPUE was highest and coefficient of variation was lowest during August in Segments 5 and 6. In addition, Schloesser (2008) found detection probabilities with trammel nets for large-bodies fishes in the lower Missouri River were higher in summer compared to fall through spring. With current sampling effort, statistical power to detect a 3 - 5% annual decline in pallid sturgeon abundance over 20 years with trammel nets ranged from 0.2 – 0.4 (Bryan et al. 2009).

The 16-ft otter trawl was an effective active gear for capturing pallid sturgeon. A total of 11 pallid sturgeon were captured in standard tows with an additional 11 fish captured in duplicate passes during 2010. The CPUE trend in seasonal differences for all pallid sturgeon captured in the otter trawl was generally similar to that of the trammel net CPUE; seasonal mean CPUE for all pallid sturgeon was generally highest during the summer (fish community season) in 2005 – 2010, with 2006 and 2007 being exceptions. Wanner et al. (2007b) found otter trawls in October had the highest mean CPUE of pallid sturgeon with the lowest variability and suggested that collectively trammel nets, gill nets, and otter trawls likely captured the true size structure of the population of pallid sturgeon in Segments 5 and 6. In the Mississippi River, Phelps et al. (2009) found generally highest CPUE for shovelnose sturgeon with benthic otter trawls during summer. Current statistical power to detect a 5% annual decline in pallid sturgeon abundance over 20 years with the otter trawl is low ($\beta < 0.2$) based on the analysis by Bryan et al. (2009). However, only one year of trawling data for Segments 5 and 6 (2005) was included in the power analysis. Only 11 pallid sturgeon were caught with the otter trawl in 2005 (Shuman et al. 2006b) with 13 – 23 fish captured annually since 2006 (Shuman et al. 2007, 2008, 2009, 2010).

River discharge can affect catchability, lowering relative abundance independent of actual population size. During 2003 – 2010 higher releases from Ft. Randall Dam were observed during the spring when compared to the fall, with 2007 being the only exception. Pallid sturgeon relative abundance indexed with gill nets demonstrated an inverse relationship to higher discharge occurring during the spring, with lower CPUE estimates observed (D. Shuman, unpublished data). During 2007, discharge from Ft. Randall Dam during late fall was higher compared to early spring resulting in higher CPUE estimates during the spring High flows commonly result in gill nets becoming saturated with detritus and sticks or becoming buried in shifting sand, especially for the four bends in Segment 6 just downstream of the Niobrara confluence. Because of ineffective fishing, associated costs for net repair and, more commonly, replacement, as well as concern for safety of any captured pallid sturgeon, as of 2009 gill nets are no longer set in bends 1 – 4 Segment 6. To assess catchability of pallid sturgeon in Segments 5 and 6 with active gears used in the population assessment program a multi-year telemetry study was initiated in 2010. This mutli-year study will assess various environmental conditions and seasons on the catchability of multiple size classes of pallid sturgeon with drifted trammel nets and otter trawls.

The mean relative condition (K_n) of stocked pallid sturgeon declined after release for nearly all year classes (1997-1998, 2002-2005, and 2007-2008) except the 1998 year class during 2007 - 2010. However, mean length has increased for all year classes since stocking (Table 3; Appendix K). The weight- length equation provided by Shuman et al. (2011) was used to recalculate relative condition for sample years 2003 - 2008 (Appendix K) which was previously calculated using the weight-length equation provided by Keenlyne and Evenson (1993). Shuman et al. (2011) compared the two equations and found weight was overestimated 5 – 21 % for fish 175 – 1,550 mm by the Keenlyne and Evenson (1993) equation.

Condition of most pallid sturgeon was > 1.0 at the time of stocking (Table 3; Appendix K) which may have provided excess energy reserves to better enable the transition from the hatchery to a natural environment, thereby increasing survival. The decrease in condition of hatchery-reared pallid sturgeon may reflect a lack of sufficient prey resources or a stream-lined body form may be more advantageous in the natural lotic environment and hatchery-reared fish were unnaturally fat. Juvenile pallid sturgeon diets in Montana as percent wet weight were 90% fish (Gerrity et al. 2006), while the diets of juvenile pallid sturgeon downstream of Fort Randall Dam were 66% fish and 24% ephemeropterans by dry weight (Grohs et al. 2009). Spindler

(2008) found the abundance of ephemeropterans and dipterans in the drift were significantly higher (1.6 – 1.8 fold) in areas where juvenile pallid sturgeon were captured compared to areas where fish were not captured. Shuman et al. (2011) found basin wide K_n of juvenile pallid sturgeon declined since stocking but stabilized around 0.9 within two years. Consistency of pallid sturgeon K_n from 2003 – 2010 for stock–quality and quality–preferred sized fish indicates availability of sufficient prey resources within in Segments 5 and 6 (Figure 4). Consistent high relative condition of juvenile pallid sturgeon also indicates the current annual stocking rate of 600 age-1 fish appears adequate. However, relative condition of preferred-memorable sized pallid sturgeon has declined from 2008 – 2010 potentially indicating the onset of sexual maturity for the oldest year classes (1997-1999) aged 11-13 years and/or limited fish prey.

Gill nets, trammel nets, and otter trawls were all effective at capturing shovelnose sturgeon. Gill net mean CPUE for shovelnose sturgeon greater than stock length decreased to its lowest level since 2005, and was substantially lower (52%) in 2010 compared to 2009 (Figure 10). Yearly relative abundance of shovelnose sturgeon in trammel nets substantially decreased from an all time high in 2008, but was similar to 2003 – 2007 and 2009, which continues to indicate a stable population with high survival of adults with low spawning success and/or recruitment. Trammel net mean CPUE was the highest during the summer fish community season for shovelnose sturgeon during 2003 – 2010 with the exception of 2008 and 2010, which corresponded with pallid sturgeon seasonal catch rates. Shovelnose sturgeon relative abundance in otter trawls decreased during the sturgeon season and fish community seasons compared to 2009, and yearly relative abundance continued to decline from the high during 2006 possibly indicating a stable to declining population. Statistical power (β) to detect a 5% annual decline in shovelnose sturgeon abundance over 20 years was ≥ 0.7 for trammel nets and otter trawls under current levels of sampling effort and ranged from 0.4 – 0.8 for gill nets (Bryan et al. 2009).

Shovelnose sturgeon were individually marked with floy tags during 2006 (n = 161), 2007 (n = 411), 2008 (n = 273), 2009 (n = 260), and 2010 (n = 176). Except for 2010, the percent of recaptured floy-tagged shovelnose sturgeon has increased each year since tagging began in 2006: 3, 7 and 13% respectively from 2007 - 2009. Although recaptures declined in 2010 to 10%, this high proportion indicates that a large proportion of the total shovelnose sturgeon population has been tagged since 2006.

The low number of shovelnose sturgeon within the stock–quality (n = 2) and no fish within the quality–preferred length categories indicates low levels of recruitment have occurred within Segments 5 and 6 of the Missouri River. The catch of two stock–quality fish in 2010 provides the first indication of past recruitment in Segments 5 and 6 but transcription errors occurred while taking length or (more likely) weight measurements. Jordan and Willis (2001) during 1998 and 1999 as well as Pierce et al. (2003) reported only capturing preferred length and larger sized shovelnose sturgeon in RPMA 3. Shovelnose sturgeon within the preferred–memorable and ≥ memorable length classes were in good relative condition in 2010, thus these fish should be physically capable of reproduction. Personal observations in 2008 – 2010 identified female shovelnose sturgeon in later stages of egg development within Segments 5 and 6. Secondary analysis of black eggs collected from a static gill net on November 13, 2006 downstream of the Bazile Creek confluence, which was previously confirmed genetically as sturgeon eggs, were determined to be northern leopard frog *Rana pipiens* eggs (Heist 2010). Standardized gears (gill nets, otter trawl, and trammel nets) have captured small shovelnose sturgeon (i.e., < 249 mm FL) from the channelized and unchannelized Missouri River (Eder and Steffensen 2010; Herman et al. 2010; Horner et al. 2010; Plauck et al. 2010; Steffensen 2010; Wilson et al. 2010). These catches in other segments further indicate that shovelnose sturgeon in

Segments 5 and 6 are failing to either spawn due lack of habitat or have poor larval and juvenile survival.

Failure to capture sturgeon chubs, sicklefin chubs, and shoal chubs with the otter trawl is likely due to lack of recruitment in Segments 5 and 6. None of these three chub species have been captured in Segments 5 and 6 since monitoring began in 2003 suggesting that these chub species are either extirpated or at such a low abundance that we were unable to detect them. In Segments 5 and 6, the otter trawl captured 130 silver chubs during 2010 with > 60 captured each year from 2005 – 2009. This same trawl has captured sturgeon chubs, sicklefin chubs, and shoal chubs in Segments 7 – 10 (Steffensen 2010; Horner et al. 2010; Eder and Steffensen 2010; Stukel et al. 2010) and 13 - 14 (Plauck et al. 2010; Herman et al. 2010) in 2009 in South Dakota, Iowa, Nebraska, Kansas, and Missouri downstream of Gavins Point Dam. In Montana and North Dakota, sicklefin and sturgeon chubs were also captured with the otter trawl in Segments 2 (Haddix et al. 2010a), 3 (Haddix et al. 2010b), and 4 (Wilson et al. 2010) of the Missouri River in 2009. Additionally, this same trawl was used to collect shoal chubs from the Kanasas River during 2009 (Niswonger et al. 2010). Capture of these three chubs in other segments of the Missouri River and large tributaries indicated that we should capture these species if present in Segments 5 and 6. These three chub species have also not been found in the Niobrara River (Wanner et al. 2009; Wanner et al. 2010b) though flathead chubs *Platygobio gracilis* were commonly collected, a species only encountered during 2005 in Segments 5 and 6 (Shuman et al. 2006b). Predation could also explain the lack of presence of these four minnow species in Segments 5 and 6. Relative abundance of saugers in Segments 5 and 6 are similar to levels seen at many locations downstream in Segments 7 – 14 (Oldenburg et al.2010). In contrast, smallmouth bass catches are generally highest immediately downstream of Fort Randall and Gavins Point dams (Berry et al. 2004) in Segments 5 - 7.

Since 2003, all three *Hybognathus* spp. were at low abundance in Segments 5 and 6. One hundred-ten brassy minnows were captured in Segment 6 with mini-fyke nets in 2010 and 15 brassy minnows were captured in Segment 5. Prior to 2010 a total of 66 *Hybognathus* spp. were captured since sampling began in 2003. Ten of the 66 total captures were brassy minnows collected in 2009 (Shuman et al. 2010). Prior to 2009, four *Hybognathus* spp. in 2003, one *Hybognathus* spp. in 2005, and 6 plains minnows and 2 western silvery minnows in 2007, and six *Hybognathus spp.* and 37 brassy minnows in 2008 were captured in Segments 5 and 6 (Shuman et al 2006b; Shuman et al. 2008; Shuman et al. 2009). *Hybognathus* spp. were captured primarily with mini-fyke nets throughout the Missouri River during 2009 (Haddix et al. 2010a; Haddix et al. 2010b; Wilson et al. 2010; Herman et al. 2010; Horner et al. 2010; Eder and Steffensen 2010; Plauck et al. 2010; Steffensen 2010; Stukel et al. 2010; Wilson et al. 2010).

The first record of blue sucker recruitment in Segments 5 and 6 was documented in 2007 with the capture of a 203 mm total length fish. No small blue suckers < 600 mm TL were captured in Segments 5 and 6 during 2003 – 2006 and 2008 – 2010. Five blue sucker yolk-sac larvae (approximate mean length of 10 mm) were collected in Segment 5 near Sunshine Bottoms on June 6, 2003 at a water temperatures ranging between 15.5 – 16 °C (R. Klumb, USFWS, unpublished data). At present, blue suckers appear to have difficulty recruiting in Segments 5 and 6. Few small (< 250 mm TL) blue suckers have been captured in other segments of the Missouri River (Eder and Steffensen 2010; Haddix et al. 2010a, 2010b; Horner et al. 2010; Niswonger et al. 2010; Steffensen 2010; Stukel et al. 2010; Wilson et al. 2010) with the exception of downstream of the Big Sioux River in Segment 8 during 2006 (Hamel and Steffensen 2007). These low catch rates of small blue suckers in the channelized and unchannelized segments of the Missouri River highlight that habitats used by early life stages are poorly known or that suitable spawning conditions in the Missouri River have been limited.

Gill nets, trammel nets, and otter trawls were effective at capturing saugers in Segments 5 and 6. Gill net mean CPUE declined during 2003 – 2005 during a period of drought, leveled off during 2005 – 2007, increased in 2007 – 2008, leveled off again in 2008 – 2009 and declined in 2009 – 2010. Trammel net mean CPUE during the sturgeon season is consistently higher than that of the fish community season except during 2010, while otter trawl CPUE was consistently higher during the fish community season, except during 2008 and 2010. Under current sampling effort, statistical power (β) in Segments 5 and 6 to detect a 5% annual decline in sauger abundance over 20 years with trammel nets was about 0.8 and ranged from 0.6 – 0.7 for gill nets (Bryan et al. 2009). Yearly trends in relative abundance for saugers in otter trawls, gill nets, and trammel nets demonstrates a stable or slightly decreasing population since 2008 after drought conditions lessened. Decreases in CPUE for saugers may also be attributed to a decrease in sampling efficacy during recent years (2009 and 2010) of increased discharge from Fort Randall Dam.

Multiple modes in the length frequency of saugers indicate consistent recruitment (Figure 33). Graeb (2006) found that radio-tagged ripe saugers only spawned in the delta (Segment 6) and not in the Missouri River upstream of the Niobrara River confluence. Total catch of YOY saugers,, (< 150 mm) in mini-fyke nets during summer in 2010 (n = 8) increased from 2004 (n = 2) and 2005 (n = 1) was similar to 2009 (n = 6) and decreased from 2008 (n = 15). Despite a 88% decrease in total number of YOY sauger captured in 2010 compared to 2008 adequate spawning conditions and larval survival existed in Segments 5 and 6 during 2010 (Figure 33). Although saugers can spawn and recruit in Segments 5 and 6, the population’s long term viability could still be at risk due to hybridization with walleye. Hybridization rates of sauger with walleye in Lewis and Clark Lake were 21%; hybrids were comprised of multiple year classes indicating hybridization occurred regularly (Graeb 2006). The delta formed in the headwaters of Lewis and Clark Lake has been found to be an increasing important habitat for spawning by saugers in RPMA 3 compared to clear colder waters upstream of the delta (Graeb et al. 2009).

The collective total catch of all fish in Segments 5 and 6 has been highly variable from 2003 to 2010 (range: 2,842 – 14,622). These observed fluctuations among years in total catch may be attributed to disparate levels of effort with gears targeting small bodied fishes such as the use of the bag siene as a standard gear in 2004 and 2005, the evaluation of the small mesh otter trawl in 2006 and push trawl in 2007 (Appendix C). We can not be certain that the fluctuations in total fish captures represented a decrease in overall fish relative abundance in Segments 5 and 6 during 2009 and 2010 or a decrease in sampling efficiency due to reductions in sandbar habitat available or flooded shoreline vegetation due to high water levels. The fish community season extended from July 1st to October 31st. Because different fish species may become more abundant during different times of the year (increase in YOY), sampling during the fish community season should be systematically spread throughout the four month period. However, Klumb (2007) noted little variation in the monthly mean relative abundance of overall fish catches in mini-fyke nets from June – August within the Segments 5 and 6, but peaks for individual species were observed.

We captured 48 fish species and one hybrid (saugeye) downstream of Fort Randall Dam during 2010. During 1996 – 1998, Berry and Young (2004) captured 45 fish species and one hybrid (walleye x sauger). We captured nine species not observed in the Fort Randall reach by Berry and Young (2004): bigmouth shiner, blue sucker, creek chub, grass pickerel, orange-spotted sunfish, pallid sturgeon, central stoneroller, longnose dace, and pumpkinseed. Species encountered by Berry and Young (2004) but not observed during standardized monitoring in Segments 5 and 6 during 2010 included: burbot *Lota lota*, flathead chub, golden shiner

Notemigonus crysoleucas, mimic shiner *Notropis volucellus*, goldeye *Hioden alosoides*, and river shiner *Notropis blennius*. River shiners, flathead chubs, and goldeyes have been captured in past years of monitoring in Segments 5 and 6 but since 2003 no burbots, golden shiners, and mimic shiners have been observed. Flathead chubs were commonly collected in the Niobrara River in 2008 - 2010 (Wanner et al. 2009; Wanner et al. 2010b).

The pallid sturgeon population assessment program is adaptive, allowing for changes in standard gear types and experimentation with the effectiveness of new gears (Appendix C). Since the monitoring program began in 2003, the beam trawl, small mesh otter trawl, hoop net, setline, bag seine, and push trawl have been evaluated and are no longer used as standard gears due to low catch rates and similar species composition captured in comparison to current standard gears. In 2006 and 2007 a comparison of white and green mesh gill nets and trammel nets were evaluated and Wanner at al. (2010a) reported no significant differences in catch rates due to mesh color for gill nets with significance only noted for 5 of 25 species in trammel nets. Therefore, green and white mesh gill nets and trammel nets can be pooled for future analyses. In 2009 and 2010 the trotline was initiated as an evaluation gear to determine its effectiveness in capturing pallid sturgeon (Appendix J).

Tissue samples (fin clips) collected from sturgeon during 2009 from Segments 5 and 6 indicated the presence of the pallid sturgeon iridovirus. A total of 38 tissue samples were collected from pallid (n = 9) and shovelnose (n = 29) sturgeon. One pallid sturgeon, from the 2003 year class produced at Gavins Point National Fish Hatchery and stocked in 2004 near Sunshine Bottoms tested positive for the presence of the disease while all shovelnose tested negative (Linda Vannest, USFWS Bozeman Fish Health Center, personal communication). From stocking to recapture the virus positive pallid sturgeon added more weight and length compared to the mean, while relative condition decreased from above average at stocking to slightly below the mean at recapture. Fork length (300 mm) and weight (92 g) of this virus positive fish at stocking was less than the mean (324 mm, range = 277 – 370 mm, 113 g, range = 70 – 163 g, n = 17) while fork length (564 mm) and weight (560 g) at recapture was greater than the mean for this year class (518 mm, range = 465 – 575, 436 g, range = 290 – 580 g, n = 14). Also, relative condition at stocking (1.15) of the virus positive fish was greater than the mean relative condition (1.09) of the other 14 pallid sturgeon of the 2003 year class recaptured during 2009, while the relative condition at recapture (0.88) was slightly less than the mean 0.90. Based on the information collected from this single fish, virus positive pallid sturgeon appear to increase in length and weight similar to fish from the same year class as well as exhibit similar condition.

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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 (1991). Asterisks and bold type denote targeted native Missouri River species. Letter codes for turtles found in the Missouri River are also listed.

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 silvery 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	American 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. Three habitat scales were used in the hierarchical habitat classification system: Macrohabitats, Mesohabitats, and Microhabitats.

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
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. List of standard and wild gears (type), their corresponding codes in the database, seasons deployed, years used, and catch per unit effort units for collection of Missouri River fishes in Segments 5 and 6 for the long-term pallid sturgeon and associated fish community sampling program. Long-term monitoring began in 2003 for Segments 5 and 6. Two seasons are sampled: 1) the sturgeon season (ST) extends from fall through spring (October 1 – June 30) and 2) fish community season (FC) in summer (July 1 – September 30). Detailed gear descriptions and specifications provided in Welker and Drobish (2010).

Gear	Code	Type	Season	Years	CPUE units
Trammel net – 1 inch inner mesh	TN	STD	Both	2003 - present	fish/100 m
Gill net – 4 meshes, small mesh set upstream	GN14	STD	ST	2003 - present	fish/net night
Gill net – 4 meshes, large mesh set upstream	GN41	STD	ST	2003 - present	fish/net night
Otter trawl – 16 ft head rope	OT16	STD	Both	2005 - present	fish/100 m
Otter trawl – 16 ft SKT 4mm x 4mm HB2 MOR	OT01	WILD	FC	2005 - 2006	fish/100 m
Beam trawl	BT	STD[a]	Both	2003-2004	fish/100 m
Push Trawl – 8 ft 4mm x 4mm	POT02	WILD	FC	2006 - 2007	fish/ m
Mini-fyke net	MF	STD	FC	2003 - present	fish/net night
Bag Seine – quarter arc method pulled upstream	BSQU	WILD[b]	FC	2003 – 2005	fish/100 m^2
Bag Seine – quarter arc method pulled downstream	BSQD	WILD[b]	FC	2003 – 2005	fish/100 m^2
Bag Seine – half arc method pulled upstream	BSHU	WILD[b]	FC	2003 – 2005	fish/100 m^2
Bag Seine – half arc method pulled downstream	BSHD	WILD[b]	FC	2003 – 2005	fish/100 m^2
Bag seine – rectangular method pulled upstream	BSRU	WILD[b]	FC	2003 – 2005	fish/100 m^2
Bag seine – rectangular method pulled downstream	BSRD	WILD[b]	FC	2003 – 2005	fish/100 m^2
Hoopnets	HN	WILD[c]	Both	2003 - 2005	fish/ net night
Setlines	SL	WILD	Both	2003 – 2005	fish/ hook night
Trot Line	TL	Evaluation	ST	2009 - 2010	fish / hook night

[a]Beam trawls were a standard gear from 2003 - 2004 and dropped as a standard gear in 2005.
[b]Bag seines were a standard gear from 2003 – 2005 and dropped as a standard gear in 2006.
[c]Hoop nets were a standard gear from 2003 – 2004 and dropped as a standard gear in 2005 but still used in Segments 5 and 6.

Appendix D. Stocking locations and codes for pallid sturgeon by Recovery Priority Management Area (RPMA) in the Missouri River Basin. RM = river mile.

State(s)	RPMA	Site name	Code	River	RM
MT	2	Forsyth	FOR	Yellowstone	253.2
MT	2	Cartersville	CAR	Yellowstone	235.3
MT	2	Miles City	MIC	Yellowstone	181.8
MT	2	Fallon	FAL	Yellowstone	124.0
MT	2	Intake	INT	Yellowstone	70.0
MT	2	Sidney	SID	Yellowstone	31.0
MT	2	Big Sky Bend	BSB	Yellowstone	17.0
ND	2	Fairview	FRV	Yellowstone	9.0
MT	2	Milk River	MLK	Milk	11.5
MT	2	Mouth of Milk	MOM	Missouri	1761.5
MT	2	Grand Champs	GRC	Missouri	1741.0
MT	2	Wolf Point	WFP	Missouri	1701.5
MT	2	Poplar	POP	Missouri	1649.5
MT	2	Brockton	BRK	Missouri	1678.0
MT	2	Culbertson	CBS	Missouri	1621.0
MT	2	Nohly Bridge	NOB	Missouri	1590.0
ND	2	Confluence	CON	Missouri	1581.5
SD/NE	3	Sunshine Bottom	SUN	Missouri	866.2
SD/NE	3	Verdel Boat Ramp	VER	Missouri	855.0
SD/NE	3	Standing Bear Bridge	STB	Missouri	845.0
SD/NE	3	Running Water	RNW	Missouri	840.1
SD/NE	4	St. Helena	STH	Missouri	799.0
SD/NE	4	Mullberry Bend	MUL	Missouri	775.0
NE/IA	4	Ponca State Park	PSP	Missouri	753.0
NE/IA	4	Sioux City	SIO	Missouri	732.6
NE/IA	4	Sloan	SLN	Missouri	709.0
NE/IA	4	Decatur	DCT	Missouri	691.0
NE/IA	4	Boyer Chute	BYC	Missouri	637.4
NE/IA	4	Bellevue	BEL	Missouri	601.4
NE/IA	4	Rulo	RLO	Missouri	497.9
MO/KS	4	Kansas River	KSR	Missouri	367.5
NE	4	Platte River	PLR	Platte	5.0
KS/MO	4	Leavenworth	LVW	Missouri	397.0
MO	4	Parkville	PKV	Missouri	377.5
MO	4	Kansas City	KAC	Missouri	342.0
MO	4	Miami	MIA	Missouri	262.8
MO	4	Grand River	GDR	Missouri	250.0
MO	4	Boonville	BOO	Missouri	195.1
MO	4	Overton	OVT	Missouri	185.1
MO	4	Hartsburg	HAR	Missouri	160.0
MO	4	Jefferson City	JEF	Missouri	143.9
MO	4	Mokane	MOK	Missouri	124.7
MO	4	Hermann	HER	Missouri	97.6
MO	4	Washington	WAS	Missouri	68.5
MO	4	St. Charles	STC	Missouri	28.5

Appendix E. Juvenile and adult pallid sturgeon stocking summary for Segments 5 and 6 of the Missouri River (RPMA 3).

Year	Stocking site[a]	Number stocked	Year class	Stocking date	Age at stocking	Primary mark	Secondary mark
2000	VER	416	1997	6/6/2000	Age - 3	PIT	Elastomer / Dangler
2000	VER	22	1997	8/2/2000	Age - 3	Sonic tag[b]	PIT
2000	VER	98	1998	9/20/2000	Age - 2	PIT	
2000	VER	4	Adults[c,]	7/6/00	Unknown - Adult	Sonic tag[d]	PIT
2000	VER	3	Adults[c,]	9/20/00	Unknown - Adult	2 w/ sonic tags[d]	PIT
2000	RNW	2	Adults[c]	7/6/00	Unknown - Adult	PIT	
2002	VER	558	2001	4/21/2002	Age - 1	PIT	Elastomer
2002	SUN	181	1999	4/27/2002	Age - 3	PIT	Elastomer
2003	STB	300	2002	7/26/2003	Age - 1	PIT	Elastomer
2003	SUN	301	2002	7/26/2003	Age - 1	PIT	Elastomer
2004	SUN	244	2003	10/7/2004	Age - 1	PIT	Elastomer
2004	STB	271	2003	10/7/2004	Age - 1	PIT	Elastomer
2005	RNW	868	2004	8/30/2005	Age - 1	PIT	Elastomer
2006	STB	1,005	2005	8/25/2006	Age - 1	PIT	Elastomer
2006	Sand Creek	3	Adults[c]	12/8/2006	Unknown - Adult	PIT	
2007	STB	600	2006	5/9/2007	Age - 1	3rd right scute	Elastomer
2008	STB	600	2007	4/17/2008	Age - 1	PIT	4th left scute
2008	SUN	569	2007	5/8/2008	Age - 1	PIT	3rd and 4th left scute[e]
2008	STB	3,410	2008	9/14/2008	Age - 0	Elastomer[f]	
2009	STB	340	2008	4/13/2009	Age - 1	4th right scute	Elastomer
2009	VER	297	2008	5/28/2009	Age - 1	PIT	4th right scute
2010	VER	491	2009	4/15/2010	Age - 1	PIT	5th Left scute
2010	VER	3	2009	4/15/2010	Age - 1	5th left scute	
2010	VER	144	2009	4/22/2010	Age - 1	PIT	5th left scute

Appendix E. (continued).

Year	Stocking site[a]	Number stocked	Year class	Stocking date	Age at stocking	Primary mark	Secondary mark
2010	VER	210	2009	4/22/2010	Age - 1	5th left scute	Elastomer
2010	VER	12	2004	10/29/2010	Age - 6	Sonic tag[g]	PIT
2010	RNW	12	2004	10/29/2010	Age - 6	Sonic tag[g]	PIT

[a]Stocking site abbreviation presented in Appendix D.
[b]Stocked for telemetry study by Jordan et al. (2006).
[c] Translocated fish from Lake Sharpe, South Dakota.
[d]Stocked for telemetry study by Wanner et al. (2007c).
[e]Only about 100 fish had wrong scute removed (3rd left) and had correct scute (4th left) also removed.
[f]2008 year class had approximately 300 fish (< 10%) incorrectly tagged with purple elastomer on left and yellow on right.
Yellow last used as year class designation in 2005.
[g]Stocked for new catchability/detectability study.

Appendix F

Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/100 m) by mesohabitat within a macrohabitat for all species caught with each gear type combining the sturgeon (fall through spring) and fish community (summer) seasons for Segments 5 & 6 of the Missouri River during 2010. 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 and definitions are presented in Appendix B. Standard Error was not calculated when N < 2.

Appendix F1. Gill net catch, relative abundance (CPUE as fish/net night) with variation (± 2 SE in parentheses) segment wide and for habitats sampled in Segments 5 and 6 of the Missouri River during 2010.

Species	Total catch	Overall CPUE	BRAD	CHXO	CONF	ISB	OSB	SCCL
			CHNB	CHNB	CHNB	CHNB	CHNB	CHNB
BUSK	**3**	**0.015 (0.017)**	**0 (0)**	**0.03 (0.061)**		**0.033 (0.067)**	**0.032 (0.065)**	**0 (0)**
CARP	5	0.025 (0.022)	0.04 (0.039)	0 (0)		0.033 (0.067)	0 (0)	0 (0)
CNCF	15	0.075 (0.06)	0.03 (0.034)	0.061 (0.084)		0.3 (0.361)	0.032 (0.065)	0 (0)
GZSD	1	0.005 (0.01)	0 (0)	0 (0)		0 (0)	0 (0)	0.167 (0.333)
NTPK	4	0.02 (0.02)	0.02 (0.028)	0.03 (0.061)		0 (0)	0 (0)	0.167 (0.333)
PDFH	1	0.005 (0.01)	0.01 (0.02)	0 (0)		0 (0)	0 (0)	0 (0)
PDSG	**14**	**0.07 (0.036)**	**0.09 (0.058)**	**0.03 (0.061)**		**0 (0)**	**0.129 (0.122)**	**0 (0)**
RKBS	3	0.015 (0.022)	0.03 (0.045)	0 (0)		0 (0)	0 (0)	0 (0)
RVCS	4	0.02 (0.028)	0.02 (0.04)	0 (0)		0.067 (0.133)	0 (0)	0 (0)
SGER	**52**	**0.26 (0.115)**	**0.31 (0.15)**	**0.242 (0.195)**		**0.033 (0.067)**	**0.387 (0.522)**	**0 (0)**
SGWE	3	0.015 (0.017)	0.01 (0.02)	0 (0)		0 (0)	0.065 (0.09)	0 (0)
SHRH	39	0.195 (0.066)	0.09 (0.064)	0.273 (0.157)		0.333 (0.2)	0.258 (0.227)	0.5 (0.683)
SMBF	2	0.01 (0.014)	0.01 (0.02)	0 (0)		0.033 (0.067)	0 (0)	0 (0)
SMBS	2	0.01 (0.02)	0 (0)	0 (0)		0.067 (0.133)	0 (0)	0 (0)
SNGR	3	0.015 (0.017)	0 (0)	0.061 (0.084)		0 (0)	0.032 (0.065)	0 (0)
SNSG	**95**	**0.475 (0.143)**	**0.54 (0.249)**	**0.636 (0.312)**		**0.233 (0.157)**	**0.323 (0.234)**	**0.5 (0.683)**
WLYE	149	0.745 (0.469)	0.84 (0.689)	0.121 (0.145)		0.233 (0.403)	1.742 (1.991)	0 (0)
YWPH	1	0.005 (0.01)	0 (0)	0 (0)		0.033 (0.067)	0 (0)	0 (0)

Appendix F2. 1-inch trammel net catch and relative abundance (CPUE as fish/100 m) with variation (± 2 SE in parentheses) segment wide and for habitats sampled in Segments 5 and 6 of the Missouri River during 2010.

Species	Total catch	Overall CPUE	BRAD	CHXO	CONF	ISB	OSB	SCCL
			CHNB	CHNB	CHNB	CHNB	CHNB	CHNB
BLGL	1	0.004 (0.007)	0 (0)	0 (0)		0 (0)	0.02 (0.041)	0 (0)
BMBF	3	0.009 (0.011)	0.018 (0.023)	0 (0)		0 (0)	0 (0)	0 (0)
BUSK	**1**	**0.005** **(0.01)**	**0** **(0)**	**0** **(0)**		**0** **(0)**	**0.029** **(0.057)**	**0** **(0)**
CARP	8	0.026 (0.02)	0.028 (0.025)	0.022 (0.043)		0.04 (0.08)	0 (0)	0.112 (0.225)
CNCF	59	0.159 (0.06)	0.194 (0.086)	0.156 (0.128)		0.16 (0.217)	0.09 (0.11)	0 (0)
FWDM	3	0.008 (0.01)	0.017 (0.021)	0 (0)		0 (0)	0 (0)	0 (0)
PDFH	1	0.003 (0.007)	0 (0)	0.022 (0.044)		0 (0)	0 (0)	0 (0)
PDSG	**21**	**0.059** **(0.032)**	**0.045** **(0.035)**	**0.098** **(0.082)**		**0.027** **(0.053)**	**0.1** **(0.13)**	**0** **(0)**
RVCS	8	0.022 (0.019)	0 (0)	0.06 (0.092)		0.04 (0.056)	0.038 (0.055)	0 (0)
SGER	**14**	**0.043** **(0.028)**	**0.01** **(0.02)**	**0.039** **(0.055)**		**0.105** **(0.105)**	**0.067** **(0.094)**	**0.138** **(0.276)**
SGWE	1	0.002 (0.004)	0 (0)	0 (0)		0 (0)	0.011 (0.023)	0 (0)
SHRH	22	0.071 (0.038)	0.036 (0.038)	0.035 (0.05)		0.167 (0.14)	0.127 (0.129)	0 (0)
SMBF	8	0.022 (0.016)	0.042 (0.031)	0 (0)		0 (0)	0.012 (0.023)	0 (0)
SNSG	**33**	**0.088** **(0.033)**	**0.098** **(0.048)**	**0.087** **(0.073)**		**0.027** **(0.053)**	**0.091** **(0.091)**	**0.238** **(0.298)**
WLYE	11	0.033 (0.03)	0 (0)	0.039 (0.055)		0.04 (0.081)	0.117 (0.147)	0 (0)
WTBS	1	0.003 (0.006)	0.006 (0.013)	0 (0)		0 (0)	0 (0)	0 (0)

Appendix F3. Otter trawl catch and relative abundance (CPUE as fish/100 m) with variation (± 2 SE in parentheses) segment wide and for habitats sampled in Segments 5 and 6 of the Missouri River during 2010.

Species	Total catch	Overall CPUE	BRAD	CHXO	CONF	ISB	OSB	SCCL
			CHNB	CHNB	CHNB	CHNB	CHNB	CHNB
CARP	3	0.01 (0.014)	0 (0)	0 (0)		0.038 (0.076)	0 (0)	0.143 (0.286)
CNCF	152	0.356 (0.13)	0.528 (0.242)	0.121 (0.077)		0.131 (0.142)	0.298 (0.196)	0.226 (0.279)
ERSN	1	0.002 (0.004)	0.004 (0.008)	0 (0)		0 (0)	0 (0)	0 (0)
FWDM	15	0.032 (0.033)	0 (0)	0 (0)		0.08 (0.135)	0.122 (0.163)	0 (0)
GZSD	2	0.004 (0.006)	0.008 (0.012)	0 (0)		0 (0)	0 (0)	0 (0)
JYDR	1	0.002 (0.004)	0 (0)	0 (0)		0 (0)	0.013 (0.027)	0 (0)
PDSG	**11**	**0.024 (0.017)**	**0.025 (0.028)**	**0.027 (0.037)**		**0 (0)**	**0.043 (0.047)**	**0 (0)**
QLBK	1	0.004 (0.007)	0 (0)	0 (0)		0 (0)	0.024 (0.047)	0 (0)
RBST	47	0.104 (0.066)	0 (0)	0.206 (0.272)		0.289 (0.221)	0.165 (0.198)	0 (0)
RVCS	1	0.004 (0.007)	0 (0)	0 (0)		0 (0)	0.024 (0.047)	0 (0)
SFSN	6	0.012 (0.01)	0 (0)	0.038 (0.042)		0.013 (0.027)	0.027 (0.037)	0 (0)
SGER	**13**	**0.027 (0.017)**	**0.034 (0.026)**	**0 (0)**		**0.013 (0.027)**	**0.053 (0.063)**	**0 (0)**
SHRH	8	0.018 (0.036)	0 (0)	0 (0)		0.116 (0.233)	0 (0)	0 (0)
SMBS	4	0.01 (0.015)	0 (0)	0 (0)		0.067 (0.094)	0 (0)	0 (0)
SNSG	**9**	**0.02 (0.014)**	**0.031 (0.022)**	**0 (0)**		**0.029 (0.058)**	**0 (0)**	**0 (0)**
SNSN	**1**	**0.004 (0.007)**	**0 (0)**	**0 (0)**		**0 (0)**	**0 (0)**	**0.143 (0.286)**
STSN	3	0.007 (0.009)	0.004 (0.008)	0 (0)		0.034 (0.048)	0 (0)	0 (0)
SVCB	111	0.258 (0.134)	0.136 (0.13)	0.093 (0.081)		0.385 (0.349)	0.736 (0.629)	0 (0)
UCY	1	0.002 (0.004)	0.004 (0.008)	0 (0)		0 (0)	0 (0)	0 (0)
WLYE	5	0.012 (0.011)	0.011 (0.015)	0 (0)		0.028 (0.039)	0.013 (0.027)	0 (0)
WTBS	4	0.01 (0.01)	0.006 (0.013)	0 (0)		0.03 (0.041)	0.013 (0.027)	0 (0)

Appendix F4. Mini-fyke net catch and relative abundance (CPUE as fish/net night) with variation (± 2 SE in parentheses) segment wide and for habitats sampled in Segments 5 and 6 of the Missouri River during 2010.

Species	Total catch	Overall CPUE	BRAD	CHXO	CONF	ISB	OSB	SCCL
			BARS	BARS	BARS	BARS	BARS	BARS
BKBH	12	0.15 (0.124)	0.175 (0.213)	0 (0)		0.077 (0.154)	0.308 (0.35)	0 (0)
BKCP	160	2 (1.632)	3.575 (3.18)	0.333 (0.284)		0.154 (0.208)	0.846 (1.216)	0 (0)
BLGL	90	1.125 (0.65)	0.75 (0.647)	3.167 (3.427)		0.462 (0.537)	0.769 (0.647)	3 (6)
BMBF	52	0.65 (0.789)	1.3 (1.561)	0 (0)		0 (0)	0 (0)	0 (0)
BMSN	2	0.025 (0.035)	0.025 (0.05)	0 (0)		0.077 (0.154)	0 (0)	0 (0)
BNMW	108	1.35 (0.55)	1.5 (0.911)	1.167 (0.772)		1.385 (1.561)	1.231 (0.938)	0 (0)
BSMW	**125**	**1.563** **(0.836)**	**0.375** **(0.211)**	**2.083** **(1.359)**		**5.154** **(4.302)**	**1.308** **(1.366)**	**0.5** **(1)**
CARP	25	0.313 (0.157)	0.425 (0.267)	0.083 (0.167)		0.154 (0.208)	0.385 (0.426)	0 (0)
CKCB	55	0.688 (0.348)	0.275 (0.202)	1.083 (1.424)		0.615 (0.482)	1.692 (1.403)	0.5 (1)
CLSR	3	0.038 (0.043)	0 (0)	0.083 (0.167)		0 (0)	0.154 (0.208)	0 (0)
CNCF	10	0.125 (0.09)	0.075 (0.084)	0.083 (0.167)		0 (0)	0.231 (0.332)	1.5 (1)
ERSN	328	4.1 (2.493)	2.675 (1.197)	1.167 (1.573)		5.462 (4.876)	10.462 (13.856)	0 (0)
FHMW	15	0.188 (0.257)	0.025 (0.05)	0.167 (0.333)		0.846 (1.533)	0.077 (0.154)	0 (0)
FSMT	31	0.388 (0.267)	0 (0)	1 (1.015)		0.538 (0.738)	0.923 (1.049)	0 (0)
FWDM	14	0.175 (0.188)	0.325 (0.368)	0.083 (0.167)		0 (0)	0 (0)	0 (0)
GNSF	49	0.613 (0.439)	0.075 (0.084)	2.333 (2.274)		0.692 (1.228)	0.692 (0.797)	0 (0)
GSPK	10	0.125 (0.14)	0.25 (0.275)	0 (0)		0 (0)	0 (0)	0 (0)
GZSD	5	0.063 (0.054)	0.125 (0.106)	0 (0)		0 (0)	0 (0)	0 (0)
JYDR	38	0.475 (0.318)	0.25 (0.224)	1.167 (1.823)		0.769 (0.647)	0.308 (0.35)	0 (0)
LMBS	86	1.075 (0.929)	1.9 (1.824)	0.417 (0.386)		0.231 (0.332)	0.154 (0.208)	0 (0)
LNDC	4	0.05 (0.079)	0 (0)	0 (0)		0 (0)	0.308 (0.474)	0 (0)
NTPK	1	0.013 (0.025)	0 (0)	0 (0)		0 (0)	0.077 (0.154)	0 (0)

Appendix F4. Mini-fyke net catch and relative abundance (CPUE as fish/net night) with variation (± 2 SE in parentheses) segment wide and for habitats sampled in Segments 5 and 6 of the Missouri River during 2010.

Species	Total catch	Overall CPUE	BRAD	CHXO	CONF	ISB	OSB	SCCL
			BARS	BARS	BARS	BARS	BARS	BARS
OSSF	32	0.4 (0.381)	0.025 (0.05)	0.917 (1.336)		0 (0)	1.538 (1.903)	0 (0)
PNSD	1	0.013 (0.025)	0.025 (0.05)	0 (0)		0 (0)	0 (0)	0 (0)
QLBK	1	0.013 (0.025)	0.025 (0.05)	0 (0)		0 (0)	0 (0)	0 (0)
RBST	6	0.075 (0.078)	0.125 (0.147)	0 (0)		0 (0)	0.077 (0.154)	0 (0)
RDSN	24	0.3 (0.22)	0.225 (0.308)	0.583 (0.833)		0 (0)	0.615 (0.579)	0 (0)
RKBS	9	0.113 (0.087)	0.075 (0.111)	0.333 (0.376)		0.154 (0.208)	0 (0)	0 (0)
RVCS	9	0.113 (0.142)	0.2 (0.279)	0 (0)		0.077 (0.154)	0 (0)	0 (0)
SFSN	685	8.563 (4.403)	5.5 (2.525)	11.667 (10.291)		20.231 (23.605)	4.769 (2.91)	0 (0)
SGER	**10**	**0.125** **(0.115)**	**0.2** **(0.217)**	**0.167** **(0.225)**		**0** **(0)**	**0** **(0)**	**0** **(0)**
SHRH	1	0.013 (0.025)	0 (0)	0.083 (0.167)		0 (0)	0 (0)	0 (0)
SMBS	22	0.275 (0.133)	0.2 (0.147)	0.5 (0.461)		0.462 (0.487)	0.154 (0.208)	0 (0)
SMST	1	0.013 (0.025)	0.025 (0.05)	0 (0)		0 (0)	0 (0)	0 (0)
SNGR	29	0.363 (0.214)	0.325 (0.195)	0.25 (0.359)		0 (0)	1 (1.086)	0 (0)
SNSN	**5**	**0.063** **(0.065)**	**0.025** **(0.05)**	**0.083** **(0.167)**		**0.154** **(0.308)**	**0.077** **(0.154)**	**0** **(0)**
SNST	5	0.063 (0.054)	0.125 (0.106)	0 (0)		0 (0)	0 (0)	0 (0)
STCT	2	0.025 (0.035)	0.05 (0.07)	0 (0)		0 (0)	0 (0)	0 (0)
STSN	14	0.175 (0.15)	0.325 (0.29)	0 (0)		0.077 (0.154)	0 (0)	0 (0)
SVCB	1	0.013 (0.025)	0.025 (0.05)	0 (0)		0 (0)	0 (0)	0 (0)
UCS	5	0.063 (0.054)	0.05 (0.07)	0 (0)		0.077 (0.154)	0.154 (0.208)	0 (0)
UCY	5	0.063 (0.054)	0.1 (0.096)	0 (0)		0 (0)	0.077 (0.154)	0 (0)
WLYE	1	0.013 (0.025)	0.025 (0.05)	0 (0)		0 (0)	0 (0)	0 (0)

Appendix F4. Mini-fyke net catch and relative abundance (CPUE as fish/net night) with variation (± 2 SE in parentheses) segment wide and for habitats sampled in Segments 5 and 6 of the Missouri River during 2010.

Species	Total catch	Overall CPUE	BRAD	CHXO	CONF	ISB	OSB	SCCL
			BARS	BARS	BARS	BARS	BARS	BARS
WTBS	78	0.975 (0.758)	0.375 (0.293)	2.25 (3.183)		2.385 (3.475)	0.385 (0.281)	0 (0)
WTCP	42	0.525 (0.37)	0.65 (0.643)	0.75 (1.019)		0.154 (0.208)	0.077 (0.154)	2 (4)
WTSK	2	0.025 (0.035)	0 (0)	0 (0)		0 (0)	0.154 (0.208)	0 (0)
YWPH	4	0.05 (0.061)	0 (0)	0.25 (0.359)		0 (0)	0.077 (0.154)	0 (0)

Appendix G. Hatchery names, locations, and abbreviations.

Hatchery	State	Abbreviation
Blind Pony State Fish Hatchery	MO	BYP
Neosho National Fish Hatchery	MO	NEO
Gavins Point National Fish Hatchery	SD	GAV
Garrison Dam National Fish Hatchery	ND	GAR
Miles City State Fish Hatchery	MT	MCH
Blue Water State Fish Hatchery	MT	BLU
Bozeman Fish Technology Center	MT	BFT
Fort Peck State Fish Hatchery	MT	FPH

Appendix H. Alphabetic list of Missouri River fishes with total catch per unit effort by gear type for the sturgeon (fall through spring) and the fish community (summer) seasons during 2010 for Segments 5 & 6 of the Missouri River. Species codes are located in Appendix A. Asterisks and bold type denote targeted native Missouri River species.

Species	Sturgeon season			Fish community season		
	1-inch trammel net	Gill net	Otter trawl	1-inch trammel net	Mini-fyke net	Otter trawl
BKBH	0.000	0.000	0.000	0.000	0.150	0.000
BKCP	0.000	0.000	0.000	0.000	2.000	0.000
BLGL	0.007	0.000	0.000	0.000	1.125	0.000
BMBF	0.018	0.000	0.000	0.000	0.650	0.000
BMSN	0.000	0.000	0.000	0.000	0.025	0.000
BNMW	0.000	0.000	0.000	0.000	1.350	0.000
BSMW	**0.000**	**0.000**	**0.000**	**0.000**	**1.563**	**0.000**
BUSK	**0.000**	**0.015**	**0.000**	**0.010**	**0.000**	**0.000**
CARP	0.039	0.025	0.019	0.014	0.313	0.000
CKCB	0.000	0.000	0.000	0.000	0.688	0.000
CLSR	0.000	0.000	0.000	0.000	0.038	0.000
CNCF	0.283	0.075	0.538	0.031	0.125	0.174
ERSN	0.000	0.000	0.000	0.000	4.100	0.004
FHCF	0.000	0.000	0.000	0.000	0.000	0.000
FHMW	0.000	0.000	0.000	0.000	0.188	0.000
FSMT	0.000	0.000	0.000	0.000	0.388	0.000

Species	Sturgeon season			Fish community season		
	1-inch trammel net	Gill net	Otter trawl	1-inch trammel net	Mini-fyke net	Otter trawl
FWDM	0.012	0.000	0.000	0.005	0.175	0.063
GNSF	0.000	0.000	0.000	0.000	0.613	0.000
GSPK	0.000	0.000	0.000	0.000	0.125	0.000
GZSD	0.000	0.005	0.000	0.000	0.063	0.008
JYDR	0.000	0.000	0.000	0.000	0.475	0.004
LMBS	0.000	0.000	0.000	0.000	1.075	0.000
LNDC	0.000	0.000	0.000	0.000	0.050	0.000
NTPK	0.000	0.020	0.000	0.000	0.013	0.000
OSSF	0.000	0.000	0.000	0.000	0.400	0.000
PDFH	0.007	0.005	0.000	0.000	0.000	0.000
PDSG	**0.074**	**0.070**	**0.022**	**0.043**	**0.000**	**0.025**
PNSD	0.000	0.000	0.000	0.000	0.013	0.000
QLBK	0.000	0.000	0.007	0.000	0.013	0.000
RBST	0.000	0.000	0.085	0.000	0.075	0.124
RDSN	0.000	0.000	0.000	0.000	0.300	0.000
RKBS	0.000	0.015	0.000	0.000	0.113	0.000
RVCS	0.043	0.020	0.007	0.000	0.113	0.000
SFSN	0.000	0.000	0.008	0.000	8.563	0.017

Species	Sturgeon season			Fish community season		
	1-inch trammel net	Gill net	Otter trawl	1-inch trammel net	Mini-fyke net	Otter trawl
SGER	**0.033**	**0.260**	**0.030**	**0.053**	**0.125**	**0.025**
SGWE	0.004	0.015	0.000	0.000	0.000	0.000
SHRH	0.081	0.195	0.000	0.060	0.013	0.036
SMBF	0.039	0.010	0.000	0.005	0.000	0.000
SMBS	0.000	0.010	0.012	0.000	0.275	0.009
SMST	0.000	0.000	0.000	0.000	0.013	0.000
SNGR	0.000	0.015	0.000	0.000	0.363	0.000
SNSG	**0.115**	**0.475**	**0.018**	**0.061**	**0.000**	**0.022**
SNSN	**0.000**	**0.000**	**0.007**	**0.000**	**0.063**	**0.000**
SNST	0.000	0.000	0.000	0.000	0.063	0.000
STCT	0.000	0.000	0.000	0.000	0.025	0.000
STSN	0.000	0.000	0.011	0.000	0.175	0.004
SVCB	0.000	0.000	0.194	0.000	0.013	0.323
UCS	0.000	0.000	0.000	0.000	0.063	0.000
UCY	0.000	0.000	0.000	0.000	0.063	0.004
WLYE	0.008	0.745	0.015	0.058	0.013	0.009
WTBS	0.006	0.000	0.000	0.000	0.975	0.020
WTCP	0.000	0.000	0.000	0.000	0.525	0.000

Species	Sturgeon season			Fish community season		
	1-inch trammel net	Gill net	Otter trawl	1-inch trammel net	Mini-fyke net	Otter trawl
WTSK	0.000	0.000	0.000	0.000	0.025	0.000
YWPH	0.000	0.005	0.000	0.000	0.050	0.000

Appendix I. Comprehensive list of bend numbers (randomly selected) and corresponding bend river miles for Segments 5 & 6 of the Missouri River sampled from 2003-2010 during the sturgeon (ST) and fish community (FC) seasons.

Segment-bend number	Bend river mile	Year							
		2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
5 - 1	880.0								
5 - 2	878.9						ST, FC		
5 - 3	875.7			FC				ST, FC	
5 - 4	873.2		ST				ST, FC		
5 - 5	871.9		ST			ST	ST, FC		
5 - 6	870.7	ST, FC	FC		ST, FC	ST, FC			ST, FC
5 - 7	869.2	ST, FC	ST, FC	ST, FC	ST, FC	ST, FC			
5 - 8	865.7				ST, FC				ST, FC
5 - 9	864.4								ST, FC
5 - 10	863.2	ST, FC	ST	ST		ST, FC		ST, FC	
5 - 11	861.5	ST (W)		FC	ST, FC	ST, FC			
5 - 12	853.0		ST, FC	ST,FC				ST, FC	ST, FC
5 - 13	851.7	ST (W)	FC						
5 - 14	851.0				ST, FC		ST, FC		
5 - 15	849.5	ST, FC	ST	ST				ST, FC	ST, FC
5 - 16	847.9	ST (W)	ST	FC	(W)	ST, FC	ST, FC		
5 - 17	845.5	ST, FC	FC	ST				ST, FC	
6 - 1	844.0		ST, FC	ST	ST,FC	ST, FC		ST, FC	
6 - 2	843.2	ST, FC	ST	ST		ST			
6 - 3	842.5	ST (W)	FC				ST, FC		
6 - 4	841.2	ST, FC	ST,FC	ST, FC	ST, FC				ST, FC
6 - 5	840.3	ST, FC	ST,FC	ST					ST, FC
6 - 6	836.9	ST, FC	ST		ST, FC	ST, FC		ST, FC	
6 - 7	834.9	ST (W)	ST	ST, FC	ST, FC	ST, FC	ST, FC		ST, FC
6 - 8	832.5	ST, FC		FC	ST, FC	ST, FC		ST, FC	ST, FC
6 - 9	830.5	ST (W)	ST,FC	FC			ST, FC		ST, FC
6 - 10	829.5	ST (W)		FC			ST, FC	ST, FC	
6 - 11	828.5	ST (W)				ST, FC	ST, FC	ST, FC	

Appendix J. Evaluation of the trotline as a standard gear

Trotlines were deployed in all macrohabitat-mesohabitat combinations present within the 10 randomly selected bends (n = 8 subsamples) after gill netting was completed in spring. The main rope of each trotline was 32 m long and contained 20 droppers (0.5 m long) spaced about 1.5 m apart. Each dropper had a single 2/0 circle hook baited with a single night crawler and was anchored at both ends parallel to the current. Mean water temperature at time of deployment was 7.7 ºC and ranged from 5.3 – 10.5 ºC. A total of 80 trotlines were set in braided channel (50%), outside bend (17.5%), inside bend (12.5%), channel crossover (17.5%), and large secondary connected channel (2.5%) macrohabitats. All trotlines were deployed in the channel boarder mesohabitat.

A total of 81 pallid sturgeon were captured with trotlines during the April 19-20, 2010 during the spring sturgeon season. Mean length of pallid sturgeon captured was 559 mm and ranged between 378 – 904 mm, while mean weight was 589 g and ranged from 155 – 2,500 g. Sixty-five percent of the pallid sturgeon captured with trotlines were collected in braided macrohabitat (n = 53), 17% in the channel crossovers (n = 14), 11% in outside bends (n = 9), 4% from inside bends (n = 3), and 2% in large secondary connected channels (n = 2). Spatially, pallid sturgeon were captured in all 10 bends sampled (Appendix I.). During 2009, a single pallid sturgeon collected in bend 3 of Segment 5 was the furthest upstream recapture in RPMA 3 since monitoring began in 2003.

In addition to pallid sturgeon, trotlines captured a total of 90 fish from 9 species and one hybrid. Trotlines effectively captured one targeted species, the shovelnose sturgeon (n = 48). Non-target species captured include: channel catfish (n = 20), shorthead redhorse (n = 12), walleye (n = 3), fresh water drum (n = 2), smallmouth buffalo (n = 1), black bullhead (n = 1), silver chub (n = 1), and flathead catfish (n = 1). Three sauger X walleye hybrids were also collected. A total of 22 of 80 trotlines collected no fish. The trotline will again be implemented in the spring of 2011.

Appendix K. Amended pallid sturgeon length and weights at stocking and recapture, with recalculated growth rates and relative condition factors ($K_{n,}$) for 2003 – 2009 reports in Segments 5 and 6 of the Missouri River. Condition was recalculated using a new weight-length relation specific for the Missouri River presented in Shuman et al. (2011); whereas, previous reports used the equation from Keenlyne and Evenson (1993).

		Stocking data			Recapture data			Growth rate	
Year class	N	Length (mm)	Weight (g)	K_n	Length (mm/d)	Weight (g/d)	K_n	Length (mm/d)	Weight (g/d)
					2003				
1997	26	532	654.2	1.249	647	811.0	0.804	0.099	0.134
		(12)	(52.3)	(0.094)	(13)	(53.9)	(0.024)	(0.013)	(0.040)
1998	3	499	459.7	1.029	566	530.0	0.794	0.062	0.066
		(69)	(222.3)	(0.101)	(75)	(256.6)	(0.084)	(0.027)	(0.094)
1999	6	465	426.0	1.213	514	429.0	0.866	0.108	0.023
		(40)	(126.5)	(0.248)	(64)	(151.3)	(0.032)	(0.077)	(0.207)
2001	6	210			392	187.0	0.958	0.374	
		(16)			(25)	(37.7)	(0.042)	(0.065)	
2002	1	294	91.0	1.220	385	143.0	0.789	1.000	0.571
					2004				
1997	8	554	705.0	1.158	656	857.0	0.803	0.075	0.114
		(17)	(118.7)	(0.107)	(21)	(156.3)	(0.090)	(0.016)	(0.122)
1998	1	487	491.0	1.249	546	420.0	0.733	0.045	-0.054
1999	6	477	518.5	1.293	540	478.0	0.851	0.101	-0.080
		(52)	(173.2)	(0.199)	(45)	(102.5)	(0.052)	(0.026)	(0.122)
2001	3	213			402	204.0	0.926	0.238	
		(7)			(58)	(121.7)	(0.144)	(0.067)	
2002	3	234	51.7	1.421	350	133.0	0.992	0.318	0.219
		(24)	(18.7)	(0.082)	(27)	(31.9)	(0.060)	(0.103)	(0.057)
					2005				
1997	3	558	806.7	1.296	664	1034.0	0.932	0.058	0.125
		(30)	(183.3)	(0.059)	(70)	(349.5)	(0.074)	(0.025)	(0.096)
1998	2	508	484.5	1.076	580	530.0	0.759	0.043	0.028
		(3)	(7.0)	(0.005)	(10)	(20.0)	(0.072)	(0.001)	(0.135)
1999	2	426	266.5	1.023	470	385.0	1.026	0.045	0.127
		(64)	(147.0)	(0.072)	(79)	(330.0)	(0.366)	(0.021)	(0.203)
2001	5	182			422	227.0	0.925	0.202	
		(10)			(26)	(37.1)	(0.118)	(0.016)	
2002	6	235	52.0	1.424	443	326.0	1.049	0.289	0.364
		(16)	(12.2)	(0.058)	(73)	(146.4)	(0.132)	(0.056)	(0.148)
2003	10	332	157.8	1.322	415	223.0	0.910	0.252	0.187
		(32)	(43.5)	(0.099)	(39)	(66.8)	(0.088)	(0.058)	(0.137)
2004	7	302	111.1	1.362	351	145.0	1.082	1.253	0.873
		(11)	(13.3)	(0.055)	(11)	(18.3)	(0.090)	(0.084)	(0.388)

Appendix K (continued).

Year class	N	Stocking data Length (mm)	Stocking data Weight (g)	Stocking data K_n	Recapture data Length (mm/d)	Recapture data Weight (g/d)	Recapture data K_n	Growth rate Length (mm/d)	Growth rate Weight (g/d)
2006									
1997	7	498	532.7	1.176	688	1096.0	0.889	0.088	0.262
		(55)	(185.4)	(0.161)	(19)	(112.8)	(0.050)	(0.024)	(0.098)
1999	1	393	200.0	1.03	606	710.0	0.879	0.140	0.335
2001	6	210			542	523.0	0.930	0.224	
		(15)			(28)	(69.3)	(0.058)	(0.023)	
2002	8	253	68.4	1.49	498	401.0	0.933	0.226	0.306
		(19)	(13.0)	(0.22)	(34)	(72.1)	(0.056)	(0.030)	(0.060)
2003	4	308	121.5	1.30	413	215.0	0.933	0.206	0.182
		(52)	(62.3)	(0.17)	(26)	(38.7)	(0.052)	(0.022)	(0.057)
2004	8	278	89.4	1.41	348	127.0	0.978	0.321	0.158
		(16)	(16.1)	(0.09)	(19)	(17.7)	(0.074)	(0.133)	(0.089)
2007									
1997	9	543	681.7	1.10	755	1526.0	0.897	0.084	0.333
		(38)	(134.2)	(0.11)	(49)	(310.1)	(0.070)	(0.022)	(0.133)
1998	2	472	331.0	0.88	554	765.0	1.377	0.033	0.174
		(90)	(254.0)	(0.16)	(87)	(200.0)	(1.024)	(0.000)	(0.177)
1999	1	453	328.0	1.06	593	725.0	0.964	0.084	0.239
2001	5	224			541	521.0	0.930	0.169	
		(14)			(32)	(97.4)	(0.078)	(0.021)	
2002	16	243	57.6	1.38	501	437.0	0.979	0.185	0.272
		(12)	(10.2)	(0.10)	(26)	(75.2)	(0.029)	(0.017)	(0.051)
2003	17	319	127.2	1.26	490	386.0	0.939	0.179	0.269
		(19)	(21.7)	(0.06)	(23)	(51.7)	(0.044)	(0.013)	(0.041)
2004	18	294	103.3	1.33	435	253.0	0.909	0.212	0.223
		(15)	(15.8)	(0.09)	(23)	(39.2)	(0.058)	(0.035)	(0.058)
2005	12	322	147.1	1.45	396	210.0	1.024	0.225	0.180
		(23)	(33.6)	(0.11)	(26)	(49.7)	(0.074)	(0.041)	(0.102)
2006*	8	189	26.7	1.54	321	94	0.94	0.854	0.437
		(5)	(2.7)	(0.29)	(10)	(16)	(0.110)	(0.068)	(0.103)
2008									
1997	12	534	610.3	1.169	792	1959.6	0.975	0.089	0.465
		(21)	(88.6)	(0.119)	(42)	(360.4)	(0.045)	(0.010)	(0.106)
1998	1	427	208.0	0.832	677	1000.0	0.86	0.087	0.277
		.	.		.	.	.	.	.
2001	18	194	.	.	617	811.9	0.953	0.184	.
		(12)		.	(25)	(83.0)	(0.067)	(0.018)	.
2002	20	248	62.7	1.339	541	529.8	0.918	0.161	0.253
		(11)	(8.3)	(0.054)	(22)	(82.3)	(0.048)	(0.013)	(0.044)
2003	10	318	110.2	1.216	523	452.5	0.908	0.161	0.268
		(30)	(32.0)	(0.056)	(20)	(55.5)	(0.063)	(0.015)	(0.031)

Appendix K (continued).

Year class	N	Stocking data Length (mm)	Weight (g)	K_n	Recapture data Length (mm/d)	Weight (g/d)	K_n	Growth rate Length (mm/d)	Weight (g/d)
2008									
2004	12	322	139.1	1.326	480	342.8	0.900	0.150	0.195
		(18)	(26.4)	(0.094)	(24)	(57.7)	(0.041)	(0.025)	(0.055)
2005	10	314	142.4	1.361	444	257.5	0.871	0.215	0.191
		(21)	(25.0)	(0.105)	(23)	(51.4)	(0.112)	(0.063)	(0.096)
2007	4	262	61.0	1.130	265	56.8	1.01	0.132	-.279
		(26)	(29.7)	(0.186)	(27)	(40.8)	(0.579)	(0.053)	(1.053)
2009									
1997	16	541	684.9	1.203	804	1901.0	0.902	0.086	0.405
		(18)	(107.3)	(0.129)	(33)	(239.2)	(0.022)	(0.012)	(0.084)
1998	3	460	309.3	0.915	540	515.0	0.932	0.026	0.065
		(37)	(150.7)	(0.179)	(30)	(50.0)	(0.077)	(0.001)	(0.030)
1999	4	426	258.3	0.98	653	933.3	0.888	0.090	0.267
		(41)	(101)	(0.127)	(44)	(228.6)	(0.070)	(0.015)	(0.059)
2001	22	203	.	.	603	773.3	0.936	0.155	.
		(11)	.	.	(28)	(108.2)	(0.025)	(0.017)	.
2002	20	252	62.2	1.361	592	700.3	0.919	0.166	0.311
		(10)	(7.7)	(0.053)	(23)	(89.3)	(0.029)	(0.011)	(0.042)
2003	18	322	126.6	1.232	521	443.1	0.896	0.124	0.198
		(12)	(14.9)	(0.033)	(16)	(39.6)	(0.022)	(0.014)	(0.029)
2004	30	296	106.8	1.409	485	372.3	0.938	0.136	0.188
		(10)	(7.1)	(0.075)	(14)	(36.9)	(0.027)	(0.013)	(0.025)
2005	22	315	132.8	1.358	457	305.4	0.947	0.143	0.175
		(14)	(22.1)	(0.080)	(16)	(31.8)	(0.031)	(0.020)	(0.034)
2006*	8	189	26.7	1.54	454	297.1	0.933	0.334	0.339
		(5)	(2.7)	(0.29)	(23)	(54.6)	(0.067)	(0.024)	(0.061)
2007	5	231	40.0	1.075	402	199.0	0.949	0.465	0.441
		(25)	(22.3)	(0.311)	(14)	(22.7)	(0.025)	(0.148)	(0.167)
2008	3	263	55.0	1.059	299	87.3	1.058	0.473	0.193
		(22)	(14.0)	(0.021)	(42)	(41.3)	(0.122)	(0.176)	(0.540)

*Mean length and weight at stocking derived from subsample (n = 81) of fish measured at tagging. All other year classes were PIT tagged and observed growth rates derived from individual fish.