Shallow water fish communities in the Missouri River downstream of Fort Randall and Gavins Point dams in 2003 and 2004 with emphasis on Asian carps

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EXECUTIVE SUMMARY

In 2003 and 2004, fish were collected during late-spring through summer with conical minnow traps (two mesh sizes), bag seines, and mini-fyke nets in shallow water habitats in the unchannelized Missouri River downstream of Fort Randall and Gavins Point dams in South Dakota and Nebraska. Presence of three Asian carp species, bighead carp *Hypophthalmichthys nobilis,* silver carp *H. molitrix,* and grass carp *Ctenopharyngodon idella*, have been documented in the Missouri River downstream of Gavins Point Dam but have not been found upstream of this barrier. Whether Asian carps are reproducing in this reach of the Missouri River in South Dakota and Nebraska is also unknown. Adult silver carp were observed downstream of Gavins Point Dam in the mouth of the James River, South Dakota in 2003 and 2004, but no young-of-the-year (YOY) for all three Asian carp species were captured downstream of either dam. Lack of YOY captures potentially resulted from: 1) adult Asian carps migrating in summer to feed but, as of yet, are not reproducing in the South Dakota and Nebraska waters of the Missouri River downstream of Gavins Point Dam, 2) have only recently become established in this part of the Missouri River, 3) gears used in this study were deployed in habitats not inhabited by YOY Asian carps or 4) gears used were ineffective to capture this life stage. The number of species captured during this study was similar downstream of each dam; 43 and 40 species were captured downstream of Fort Randall and Gavins Point dams respectively. Greater than 5,100 fish were captured each year in each reach. Emerald shiners *Notropis atherinoides*, spotfin shiners *Cyprinella spiloptera*, sand shiners *N. stramineus*, YOY redhorses *Moxostoma* spp., and YOY carpsuckers *Carpiodes* spp. were commonly collected with one or more gears downstream of each dam. Smallmouth bass *Micropterus dolomieu* were only common downstream of Fort Randall Dam while bigmouth shiners *N. dorsalis* and YOY gizzard shad *Dorosoma cepedianum*

were more commonly collected only downstream of Gavins Point Dam. The unchannelized Missouri River reaches downstream of Fort Randall and Gavins Point dams still retain natural riverine habitat features such as shifting sand bars, side channels, and the presence of large woody debris, but flow regimes differ due to operation of the respective dams. Fort Randall Dam releases can fluctuate water depths > 0.75 m/d for peak power generation; whereas, daily Gavins Point Dam outflows are relatively constant. As a result of these releases, thermal regimes differed downstream of each dam. Spatially, overall fish abundance differed more between reaches than within each reach. With few exceptions, in both years the monthly median relative abundance of fishes caught in minnow traps and bag seines was significantly greater for the Gavins Point Reach compared to the Fort Randall Reach. Median mini-fyke net CPUE of all fishes was significantly greater in the Gavins Point Reach during August 2003 and September 2003 and 2004 with no differences detected in the other months. Although median minnow trap, bag seine and mini-fyke net catches generally did not significantly differ between upstream and downstream sites within each reach, highest fish abundance was often seen at the site within each reach in proximity to a major tributary (Niobrara and James rivers) and Lewis and Clark Lake. Length frequencies of emerald shiners, spotfin shiners, and sand shiners were significantly wider downstream of Gavins Point Dam, few shiners < 45 mm total length were collected downstream of Fort Randall Dam. Compared to the Missouri River downstream of Gavins Point Dam, high diel water fluctuations from peak hydropower generation at Fort Randall Dam appears to be lessening overall fish abundance in the Missouri River either by desiccation of fish eggs and fry or reduced productivity. However, differences in the fish community between reaches may also influence overall fish abundance through increased predation.

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INTRODUCTION

The bighead carp *Hypophthalmichthys nobilis* and silver carp *H. molitrix*, cyprinids from China, were introduced to the United States by aquaculturists in the mid-1970's (Henderson 1980) and have since escaped into the Missouri, Mississippi, and Ohio rivers (Fuller et al. 1999; Kolar et al. 2005). The attractiveness of bighead and silver carps for use in polyculture operations was that grazing on phytoplankton by these species improved water quality, without competing with commercial catfish species (Henderson 1980). Bighead carp are also sold live as a food fish in specialty ethnic markets (Kolar et al. 2005); however, silver carp are not cultured in the United States and were recently listed under the "injurious wildlife provision" of the Lacey Act (Fowler et al. 2007). A third Asian carp species, the grass carp *Ctenopharyngodon idella,* was introduced into the United States in 1963 by the U. S. Fish and Wildlife Service (FWS) as a biological control agent for nuisance aquatic macrophytes, has been extensively stocked, and is now reported in 45 states (Mitchell and Kelly 2006), including South Dakota and Nebraska (Guillory and Gasaway 1978; Fuller et al. 1999). Black carp *Mylopharyngodon piceus* have reportedly escaped from a flooded aquaculture facility into the Osage River in the state of Missouri (Conover et al. 2007) but have not yet been reported in South Dakota and Nebraska. Concern by resource agencies of negative effects on native fisheries due to the spread of Asian carps throughout the United States led to formation in 2002 of an Asian Carp Workgroup by the Aquatic Nuisance Species Task Force of the FWS tasked to develop a nationwide management and control plan (Conover et al. 2007).

Bighead and silver carp have expanded their range in the Missouri River upstream to Gavins Point Dam but have not yet been found above this barrier (Kolar et al. 2005; Shuman et al. 2005; Shuman et al. 2006; Shuman et al. 2007). To date, no grass carp have been observed

upstream of Gavins Point Dam (Shuman et al. 2005; Shuman et al. 2006; Shuman et al. 2007). Expansion of bighead and silver carp into South Dakota and Nebraska waters of the Missouri River up to Gavins Point Dam near Yankton, South Dakota is recent with no records reported in either state by Fuller et al. (1999). First records of bighead carp in South Dakota were in 1998 with additional sightings reported in 2002 and 2003 (Kolar et al. 2005; FWS Great Plains FWMAO no date). Adult silver carp were first documented in South Dakota waters at the Missouri River and James River confluence in 2003 (This study) and have subsequently been observed in 2004 in the Big Sioux River near Canton, South Dakota (Kolar et al. 2003). Grass carp have been present in South Dakota and Nebraska since the mid-1970's (Guillory and Gasaway 1978).

Bighead, silver, and grass carps are successfully reproducing in the lower Missouri River (Shrank et al. 2001; Reeves and Galat 2004) and their high fecundity and rapid growth has created concern regarding the potential for competition with native fishes for limited phytoplankton and zooplankton resources (Fuller et al. 1999; Shrank et al. 2003). Mean fecundity of female bighead carp in the Missouri River was 226,213 eggs and bimodal egg diameters in the ovary indicated potential for protracted spawning (Shrank and Guy 2002). Silver carp also have protracted spawning periods with some fish spawning multiple times within a year (Papoulias et al. 2006). By age-3, bighead carp and silver carp attained total lengths > 500 mm (Johal et al. 2001; Shrank and Guy 2002) which likely precludes these species from predation by native Missouri River piscivores. At present, it is unknown if bighead, silver, and grass carps are reproducing in the upper Missouri River within South Dakota and Nebraska. The preponderance of scientific literature regarding bighead and silver carp biology summarized by Jennings (1988) and Kolar et al. (2005) has originated from Asia or focused on propagation and

growth for aquaculture. How larval and juvenile Asian carp interact with the native Missouri River fishes in the wild is currently unknown.

Ideally, historic community composition and densities of young-of-the-year (YOY) fishes in the Missouri River are required to assess any changes that may have occurred since establishment of Asian carp. Long term data sets are required to attempt assessment of ecological effects of exotic species introductions. Existence of a > 40 year fisheries database in conjunction with over 20 years of limnological data in Oneida Lake, New York elucidated lower trophic level responses (Idrisi et al. 2001) and changes in abundance, diet, and behavior of an important game fish species (Mayer et al. 2000; Mayer et al. 2001) after colonization and establishment of zebra mussels *Dreissena polymorpha*. In the Missouri River downstream of Fort Randall and Gavins Point dams, limited data exists on shallow water fish communities and their abundance. A three year study from 1996-1998 primarily targeted benthic fishes in the main channel of the Missouri River although shoreline seining and electrofishing were also used (Berry and Young 2001). The preponderance of fisheries data in the Missouri River downstream of Fort Randall and Gavins Point dams is directed at game fishes such as paddlefish *Polyodon spathula*, saugers *Sander canadense,* and walleyes *S. vitreum* or occurred primarily in dam tailwaters or the reservoir, Lewis and Clark Lake (Bouchard et al. 2006). This study concurrently assessed shallow water fish assemblages and abundance in the Missouri River downstream of Fort Randall and Gavins Point dams because Gavins Point Dam physically restricts the natural upstream expansion of Asian carps. In lieu of long term fisheries data for these sections of the Missouri River, sampling reaches above and below this dam will be used to compare potential differences in fish community composition and abundance in areas with and without Asian carp.

Adult Asian carp are difficult to capture with traditional fisheries gear (FWS Great Plains FWMAO no date) and gears that effectively capture juvenile Asian carps are not known. Therefore, this study used passive and active gears to assess the shallow water fish community of the Missouri River downstream of Fort Randall and Gavins Point dams. Passive gears used to collect fish included four minnow trap types as well as small meshed trap nets (herein called mini-fyke nets) which allowed deployment in varied habitat types. Bag seines were the only active gear used in this study.

Summer shallow water fish surveys in this study began assessment of bighead and silver carp ecology required to assess the potential affect of these species on the native fishes of the Missouri River in South Dakota and Nebraska. Principal objectives of this project included: 1) ascertain if Asian carps are reproducing downstream of Gavins Point dam, 2) document nursery habitats used by juvenile Asian carps, 3) assess spatial distributions of YOY Asian carps, and 4) compare shallow water fish assemblages in areas with and without Asian carps. Additionally, this project compared effectiveness of minnow traps, bag seines, and mini-fyke nets to sample shallow water fishes in the unchannelized Missouri River. This project addressed the following six recommendations listed in the draft Asian carp management and control plan (Conover et al. 2007): 1) Develop and conduct routine early detection monitoring programs in locations where risk of introductions or range expansions of Asian carps exist, 2) Determine life history parameters of Asian carps in the Mississippi River Basin, 3) Describe current and temporal changes in distribution to better understand the invasion and colonization process, 4) Develop and evaluate effective methods for sampling feral populations of Asian carps, 5) Assess the ecological effects of bighead, black, and silver carps on individual aquatic species and aquatic ecosystems, and 6) Document actual ecological effects of bighead, black, grass, and silver carps.

This project also sampled larval fishes during 2003 and 2004 in the Missouri River downstream Fort Randall and Gavins Point dams with surface drift nets and those results will be reported separately.

STUDY AREA

Six main stem dams on the Missouri River have converted most lotic habitats to reservoirs (Hesse 1987; NRC 2002); however, two free-flowing, unchannelized segments of the Missouri River still exist in South Dakota and Nebraska downstream of Fort Randall and Gavins Point dams (Figures 1 and 2). Fort Randall Dam at Pickstown, South Dakota was built in 1952 and formed Lake Francis Case. Downstream of Fort Randall Dam (river kilometer [rkm] 1,416), the Missouri River becomes free flowing and unchannelized for approximately 75 km until it reaches the head waters of Lewis and Clark Lake (rkm 1,327). Lewis and Clark Lake, the most downstream reservoir, was formed after closure of the Missouri River by Gavins Point Dam (rkm 1,305) near Yankton, South Dakota in 1955. Natural fish passage upstream past each dam is impossible.

The Missouri River downstream of each dam still encompasses many natural characteristics such as a meandering river channel, sandbars, sandbar pools, side channels, backwater areas, islands, eroding banks, old growth riparian forest and year round flows. Maximum depth in the Fort Randall Reach is about 12 m and channel width ranges from 230 – 1,500 m. The Gavins Point Reach has a maximum depth of about 15 m and channel width varies from 300 – 1,400 m (Stukel et al. 2006). Both reaches are influenced by a major tributary (watershed > 25,000 km^2), the Niobrara River in the Fort Randall Reach and the James River in the Gavins Point Reach. Sedimentation from the Niobrara River has formed a large braided delta and cattail (*Thypha* spp.) marsh that starts near rkm 1,351 and is progressively expanding

downriver into Lewis and Clark Lake. Width of the delta ranges 2.4 – 4.7 km and has two main channels of flow along the bluffs in Nebraska and South Dakota that comprised the former shoreline of Lewis and Clark Lake. Braided sand bar complexes, characterized by an ill-defined main channel, are common in the Gavins Point Reach. Channelization of the Missouri River for navigation begins downstream of Ponca State Park in Nebraska just upstream of Sioux City, Iowa (rkm 1,196).

Although many natural riverine characteristics persist downstream of Fort Randall and Gavins Point dams, the presence and operations of each dam have greatly modified water temperature, sediment, and flow (Hesse and Sheets 1993; NRC 2002; Pegg et al. 2002). Both dams are operated by the U. S. Army Corps of Engineers (USACE). Fort Randall Dam generates electricity using a peaking power mode that results in diel water level fluctuations of > 0.75 m with lowest daily flows at 0600 hours and peak flows occurring between 1200 to 1900 hours (USACE 1994). In contrast, the primary function of Gavins Point Dam is to level out release fluctuations from the five upstream dams to serve downstream purposes such as navigation, water supply, and flood control.

METHODS

Fish collections and habitat

The Missouri River shallow water fish community was sampled at an upstream and downstream site within each reach during May through September of 2003 and 2004. Each site encompassed about 8 - 17 rkm. The upstream site in the Fort Randall Reach was located at Sunshine Bottoms (rkm 1,400 – 1,389) while the downstream site was above and below the

confluence of the Missouri and Niobrara rivers (rkm 1,369 – 1,352). For the Gavins Point reach the upstream site was above and below the confluence of the Missouri and James rivers (rkm 1,290 – 1,278) while the downstream site was located from Goat Island to just upstream of Mulberry Bend (rkm 1,262 – 1,250).

Passive and active gears were deployed to assess the shallow water fish community in each reach of the Missouri River during 2003 and 2004. Gears were fished in shallow bars (depth < 1.2 m) located in four different habitats as classified in Drobish (2006): inside bends (i.e., the convex side of the river channel), outside bends (i.e., the concave side of the river channel), secondary connected channels, and non-connected secondary channels (i.e. backwaters). Four types of minnow traps, baited with a handful of dog food, were set overnight in each habitat within approximately 5 – 15 m of each other during May to September (Figure 3). Two traps were conical shaped wire traps (length 416 mm, diameter 194 mm) with a 19-mm opening on each side at the end of a 108-mm conical throat. The two conical "Gee" traps only differed in mesh size: 6.4 mm (1/4 in) and 3.2 mm (1/8 in) which are herein respectively referred to as 1/4-inch mesh and 1/8-inch mesh conical traps (Figure 3a and 3b). One minnow trap was a box-shaped collapsible trap (length 432 mm, width and height 248 mm) constructed of soft nylon mesh (3.2 mm) with a 51-mm opening on each end of a 127-mm conical throat herein referred to as the "nylon box trap" (Figure 3c). The largest minnow trap was a four-sided wire mesh (25 x 13 mm) box shaped trap (height 292 mm, length and width 610 mm) with two 64 mm x 25 mm openings on each side. The openings on the four sides of the wire box trap, herein referred to as the "4-way box trap", were recessed 140 mm resulting in the actual cage for captured fish being "x" shaped (Figure 3d). A brick was tied to all minnow traps to hold them in place and a small wooden block float was tied on the trap to aide with retrieval while remaining inconspicuous to

prevent theft. Mini-fyke nets constructed of 3 mm "ACE" type nylon mesh consisted of a 4.5 m long x 0.6 m high lead set at the bankline with two 1.2 m wide x 0.6 m high rectangular steel frames that formed the cab and two 0.6-m diameter circular hoops that funneled fish towards the cod-end. All passive gears were fished overnight with catch-per-unit-effort (CPUE) recorded for minnow traps as fish per trap night while CPUE for mini-fyke nets was fish per net night. On a few occasions, inclement weather prevented retrieval of minnow traps or mini-fyke nets the next day, so the catch was divided by the total number of nights fished. Fyke net catch rates were proportional to soak time and standardization of effort by net night was appropriate because soak times varied by < 1 d (Breen and Ruetz 2006). A bag seine, constructed of 6.4 mm "ACE" type mesh, was the only active gear used in this study. Seine dimensions were 9.1 m long, 1.8 m high, with a 1.8 m x 1.8 m x 1.8 m bag attached at the center. Seines swept a quarter arc or rectangular shaped area with CPUE recorded as fish/m^2. Seining and mini-fyke nets were only used from July to September and had the same specifications as those employed by the Missouri River Pallid Sturgeon Population Assessment Team (Drobish 2006).

All fish collected in the field were kept on ice and then frozen for identification and measurement in the laboratory. All fish captured were enumerated and total lengths (TL) of at least 20 individuals per species from the catch of each gear deployment were measured to the nearest mm. For excessively large catches of cyprinids and catastomids, all other species were counted and measured and then a random subsample of about 25 or 50% of the total cyprinids and catastomids were identified and measured.

Water temperature, dissolved oxygen (DO), and turbidity were recorded in each habitat on each date. Water temperature and DO were measured when gears were deployed or retrieved with an YSI Model 57 temperature-DO meter (Yellow Springs Instruments, Yellow Springs,

Ohio). In addition, water temperatures at all sites were recorded to the nearest 0.01 °C every 30 min with submersible data loggers (Onset Computer Corporation, Bourne, Massachusetts) placed in each habitat: inside bends, outside bends, and secondary connected channels. Turbidity was recorded to the nearest nephalometric turbidity unit (NTU) with either a Hanna Model 93703 meter (Hanna Instruments Incorporated, Woonsocket, Rhode Island) or a Hach 2100P Turbidimeter (Hach Company, Loveland, Colorado).

Statistical analyses

Median relative abundance of all fish species caught with each gear between the Fort Randall and Gavins Point reaches and between upstream and downstream sites within each reach were compared separately for each month in each year using the Mann-Whitney *U* test (Zar 1999). For a given gear, each monthly measurement of relative abundance in each year was considered an independent estimate of summer fish abundance. Consistency of spatial differences in fish relative abundance between reaches or within a reach over the two years of study reinforces the effect of differing habitat conditions on fish productivity due to presence of Asian carps or differing management of flow out of Fort Randall and Gavins Point dams. Size distributions of principal species captured in Fort Randall and Gavins Point reaches of the Missouri River were compared with Kolmogorov-Smirnov tests (K-S).

Comparisons of catches in the two conical traps and between fish captured in seines and mini-fyke nets were possible because all gears were fished side-by-side in the same habitat on the same dates. Kolmogorov-Smirnov tests assessed whether length frequency distributions of captured cyprinid species differed between 1/4-inch mesh and 1/8-inch mesh conical minnow traps. Length distributions of principal species captured in seines and mini-fyke-nets were

compared separately for each site in each year. Because a pair of minnow traps was set in each habitat on each date, median CPUE was compared with the Wilcoxon Signed-Rank test (Zar 1999). Additionally, the number of species captured in seines and mini-fyke-nets was compared with Mann-Whitney *U* test using only deployments that captured fish. Statistical analyses were performed using Number Cruncher Statistical Software (Hintze 2005) and significance for all statistical tests was set to $\alpha = 0.1$ unless otherwise stated.

RESULTS

Discharge, water temperature, turbidity, and dissolved oxygen

In both reaches during this study, discharge remained fairly consistent during summer (range 600 to 800 m^3/s) and then was reduced by over 30% in late fall, winter, and early spring (Figures 4 and 5). Daily mean discharge out of Fort Randall Dam during May through September of 2003 and 2004 was 708 m^3/s and the average daily range was from 171 – 1,045 m^3/s. Mean daily discharge out of Gavins Point Dam during May through September of 2003 and 2004 was 741 m^3/s and the average daily range was 735 – 748 m^3/s. Below both dams in April and early May of 2004, mean daily discharge fluctuated about 175 m^3/s to prevent endangered least tern *Sternula antilarum* and piping plover *Charadrius melodus* from nesting on sand bars at low water elevations (i.e., harassment flows) that would otherwise be inundated when flows increased in May to sustain navigation on the lower Missouri River.

Water temperatures differed between reaches. Summer temperatures (June – September) rarely exceeded 25 °C in the Fort Randall Reach compared to the Gavins Point Reach (Figures 6 – 13). Mean summer water temperatures only exceeded 20 °C in secondary connected channels in the Fort Randall Reach; whereas, mean summer temperatures in all habitats and locations in the Gavins Point Reach exceeded 20.5 °C (Table 1). Mean summer water temperatures in 2003

were consistently warmer in all habitats compared to 2004 in the Gavins Point Reach (Table 1). The mean differences in summer water temperatures between 2003 and 2004 were lessened or reversed in the Fort Randall Reach but water temperatures never exceeded 25 °C in any habitat during 2004 (Figures 6 – 9).

Summer turbidity in the Missouri River downstream of Fort Randall and Gavins Point dams ranged from 0 – 77 NTU during 2003 and 2004 (N = 53 – 121 readings per site each year). Turbidity at both study locations downstream of Fort Randall Dam was significantly lower (95% confidence interval) than sites downstream of Gavins Point Dam (Figure 14). In both years, turbidity was significantly higher at the downstream site in the Fort Randall Reach but did not differ between upstream and downstream locations in the Gavins Point Reach. The downstream study site in the Fort Randall Reach was at and just below the confluence of the Niobrara and Missouri rivers; whereas, both study sites in the Gavins Point Reach were at or downstream of the confluence of the James and Missouri rivers. Differences in summer mean turbidity among macrohabitat types in both reaches were low (< 4 NTU).

Average summer DO concentrations were > 8 mg/L in surface waters at both sites within the Fort Randall and Gavins Point reaches of the Missouri River during 2003 and 2004 based on 36 – 58 readings per site each year (Figure 14). Minimum DO readings at each site within both reaches always exceeded 6.0 mg/L.

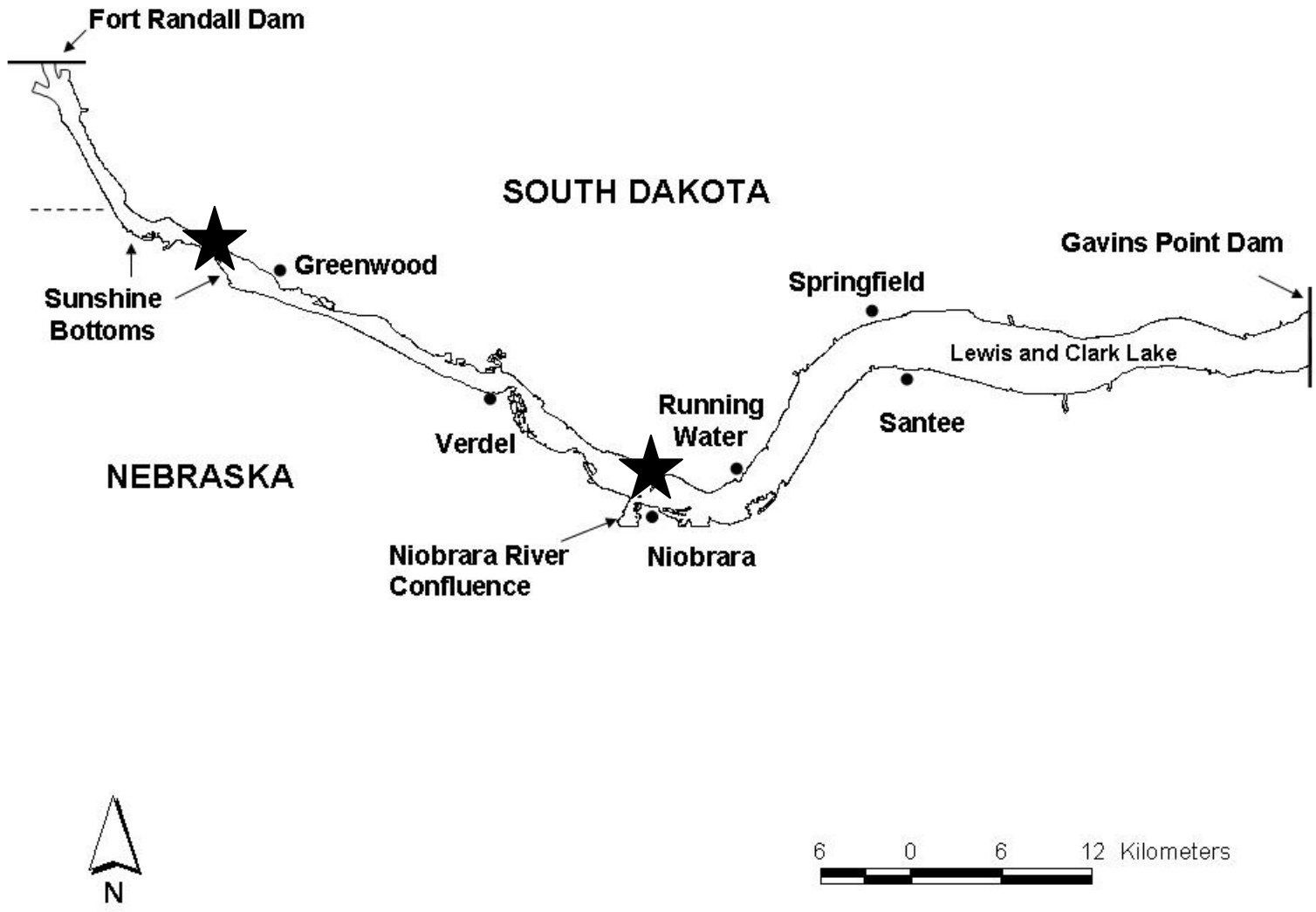


Figure 1. Map of the unchannelized Missouri River downstream of Fort Randall Dam, stars indicate upstream and downstream sampling sites for shallow water fishes during 2003 and 2004.

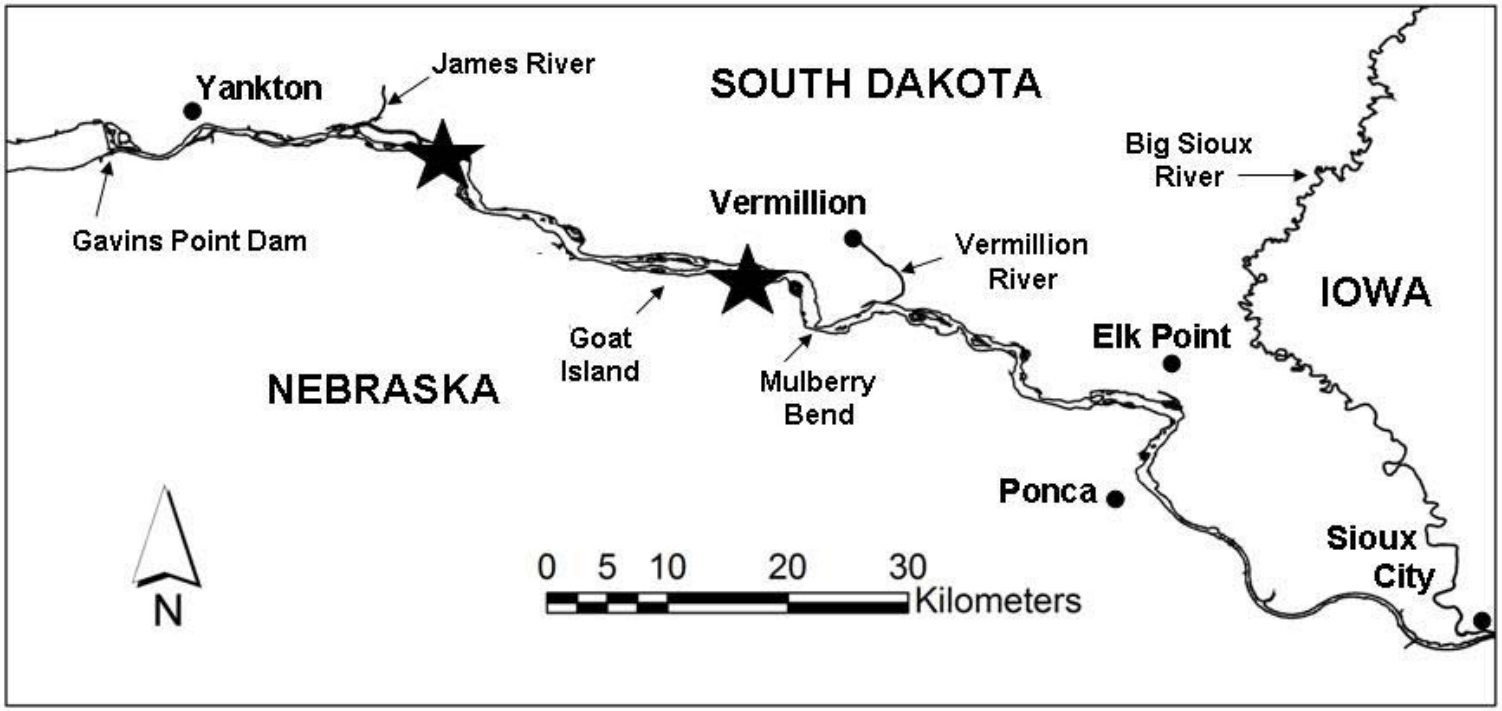


Figure 2. Map of the unchannelized Missouri River downstream of Gavins Point Dam, stars indicate upstream and downstream sampling sites for shallow water fishes during 2003 and 2004.

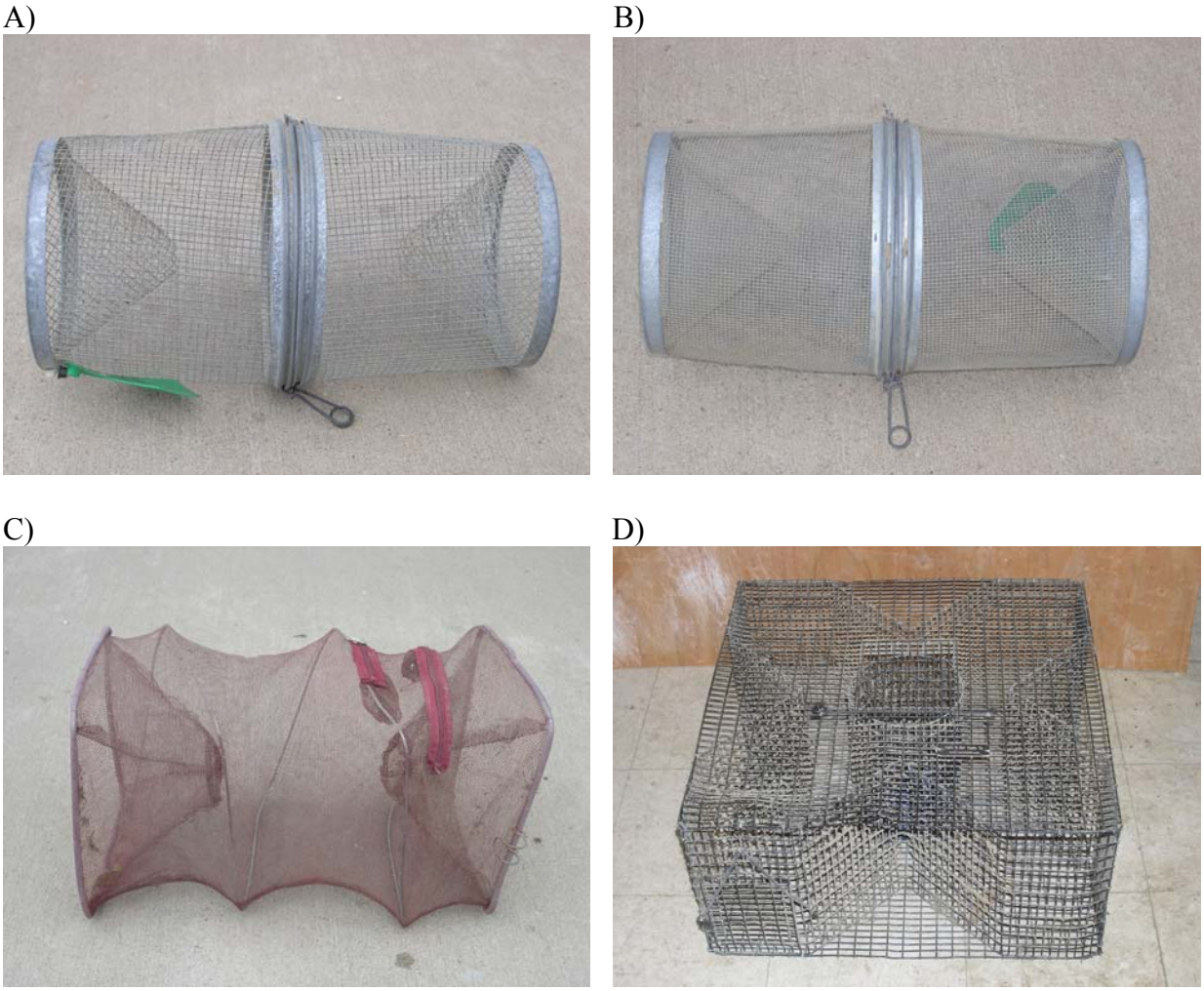


Figure 3. Four minnow trap types used to sample small, shallow water fishes in the Missouri River: A) 1/8-inch wire mesh conical "Gee" trap, B) 1/4-inch wire mesh conical "Gee" trap, C) 1/8-inch nylon mesh, collapsible square trap, and D) 0.5 x 1 inch wire mesh, four-opening box trap. Conical Gee type traps were fished in 2003 and 2004 while the square and box traps were only used during 2003.

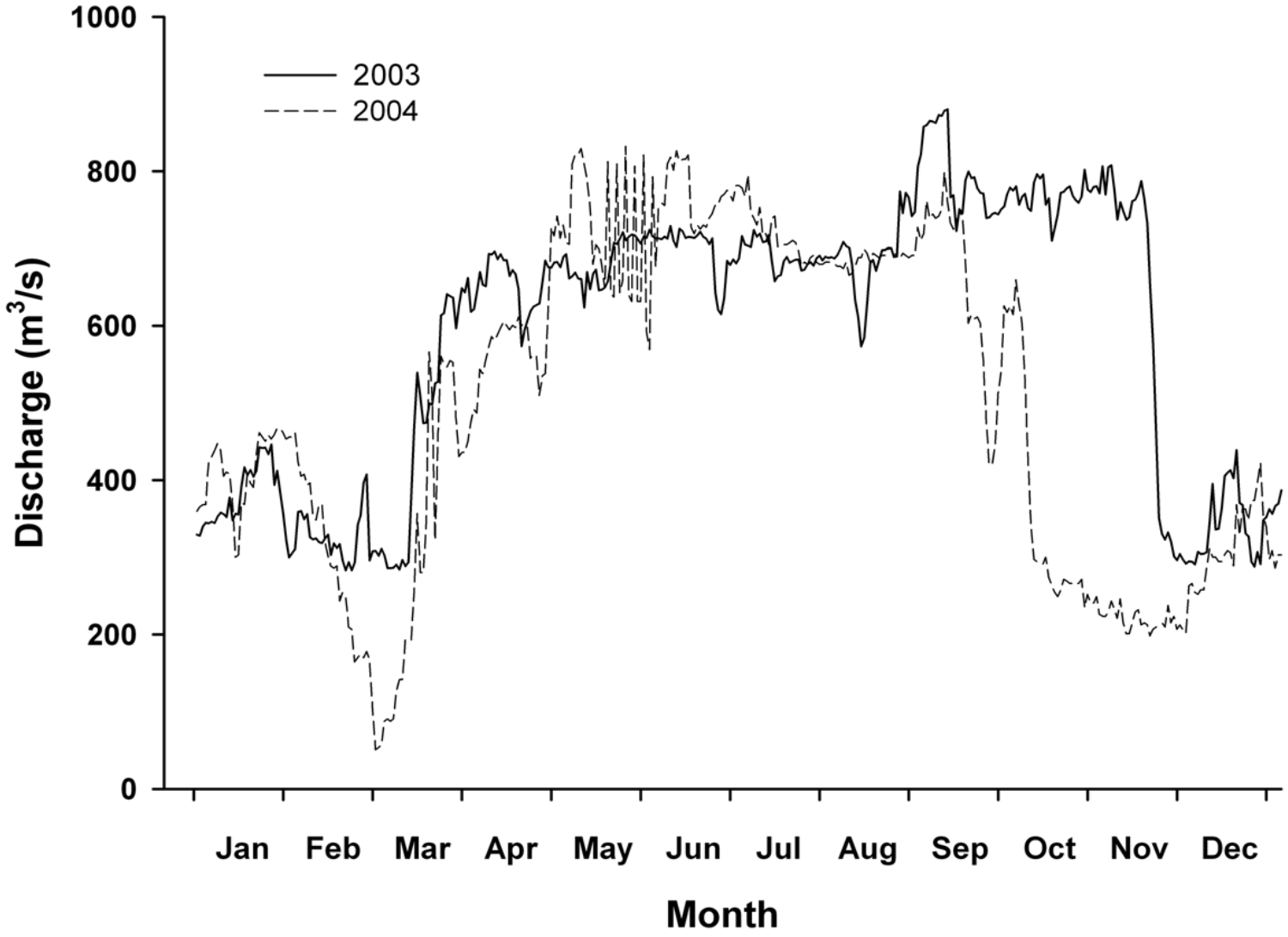


Figure 4. Missouri River mean daily discharge out of Fort Randall Dam, South Dakota during 2003 and 2004. Discharge data were provided by the U.S. Army Corps of Engineers, Northwestern Division, Missouri River Basin Water Management Division, Omaha, Nebraska.

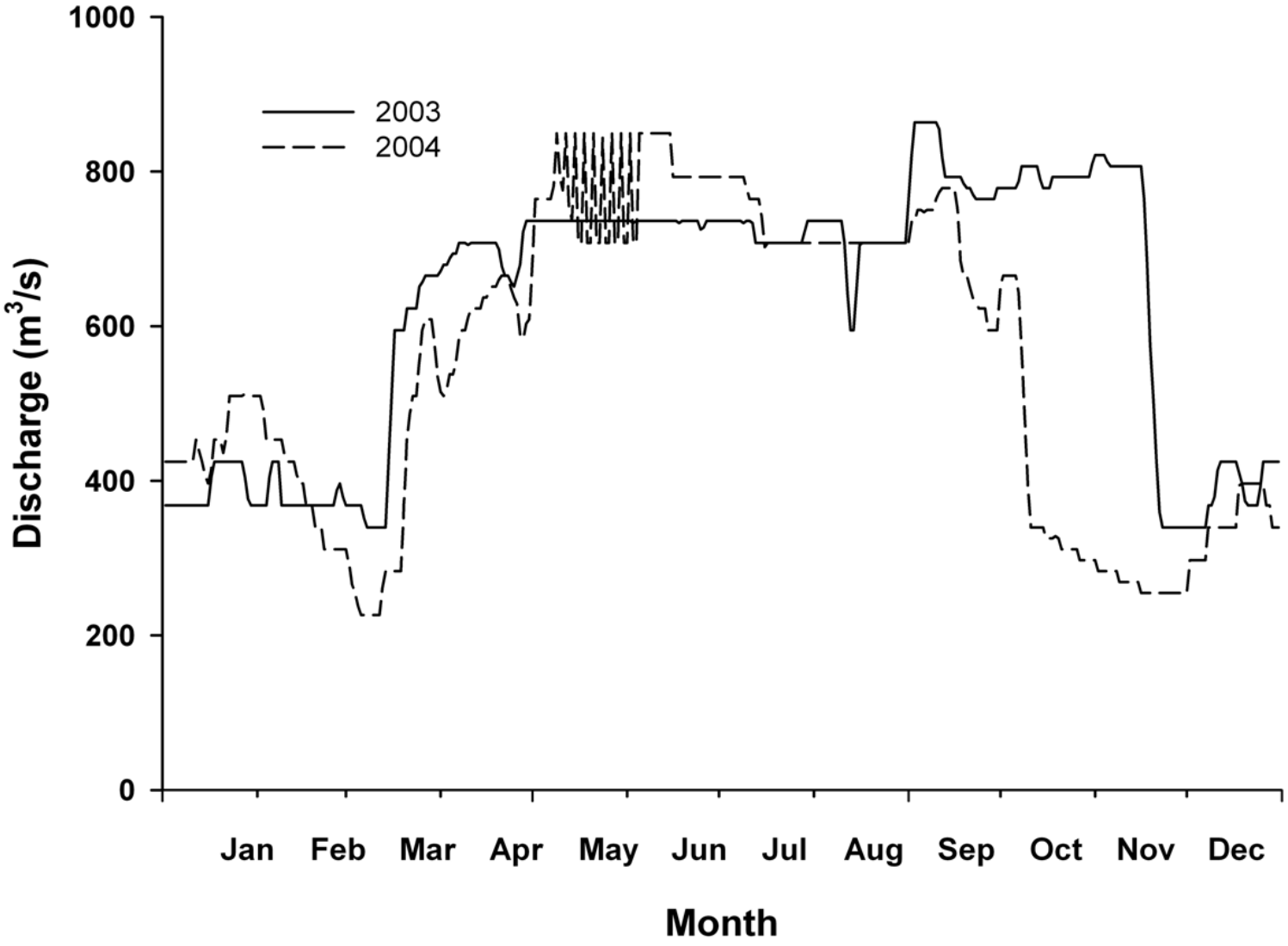


Figure 5. Missouri River mean daily discharge out of Gavins Point Dam, Nebraska during 2003 and 2004. Discharge data were provided by the U.S. Army Corps of Engineers, Northwestern Division, Missouri River Basin Water Management Division, Omaha, Nebraska.

Table 1. Mean (± 2 SE) summer (May through September) water temperatures (°C) at upstream and downstream locations in the Fort Randall and Gavins Point reaches of the Missouri River during 2003 and 2004 along with the mean summer difference in water temperatures between habitats, years and locations. Water temperature differences between habitats calculated as outside bends (OSB) – inside bends (ISB) and OSB – secondary connected channels (SCC). Differences in summer water temperature between years calculated as 2004 – 2003 and between locations as upstream – downstream.

Location	Year	Dates	Habitat	Mean summer temperature	Mean difference by habitat from OSB	Mean difference: 2004 - 2003	Mean difference Upstream - downstream
				Fort Randall Reach			
Upstream	2003	May 8 - Nov 18	ISB	19.1 (0.8)	0.1 (0.1)	1.1 (0.3)	-1.5 (0.2)
Upstream	2003	May 8 - Nov 19	OSB	19.1 (0.7)	-	-0.2 (0.2)	-0.6 (0.2)
Upstream	2003	Jun 18 - Nov 18[a]	SCC	22.2 (0.6)	-0.7 (0.1)	-1.4 (0.3)	-0.7 (0.2)
Downstream	2003	May 6 - Sep 2	ISB	19.6 (0.9)	-0.2 (0.1)	0.8 (0.4)	-
Downstream	2003	May 6 - Nov 20	OSB	19.5 (0.7)	-	-0.2 (0.3)	-
Downstream	2003	May 6 - Sep 2	SCC	20.2 (0.9)	-0.8 (0.1)	-1.5 (0.2)	-
Upstream	2004	May 14 - Aug 6	ISB	18.1 (0.6)	-0.3 (0.1)	-	-1.3 (0.2)
Upstream	2004	May 15 - Dec 31	OSB	19.4 (0.5)	-	-	-0.5 (0.1)
Upstream	2004	May 14 - Sep 16	SCC	19.7 (0.5)	-0.5 (0.1)	-	-0.4 (0.1)
Downstream	2004	May 11 - Jul 24	ISB	18.5 (0.7)	-0.7 (0.1)	-	-
Downstream	2004	May 11 - Dec 31	OSB	19.6 (0.5)	-	-	-
Downstream	2004	Jun 18 - Dec 31[b]	SCC	21.7 (0.3)	-0.4 (< 0.05)	-	-

Table 1. (continued).

Location	Year	Dates	Habitat	Mean summer temperature	Mean difference by habitat from OSB	Mean difference: 2004 - 2003	Mean difference Upstream – downstream
				Gavins Point Reach			
Upstream	2003	May 18 – Sep 25	ISB	22.3 (0.6)	0.3 (0.1)	-0.9 (0.3)	-0.3 (0.1)
Upstream	2003	Jun 26 – Sep 25	OSB	24.1 (0.5)	-	-1.5 (0.4)	-0.2 (0.1)
Upstream	2003	Jun 1 – Sep 25	SCC	24.1 (0.6)	-0.8 (0.2)	-0.4 (0.4)	0.9 (0.1)
Downstream	2003	Jun 25 – Aug 7[c]	ISB	24.9 (0.6)	0.5 (0.1)	-1.1 (0.3)	-
Downstream	2003	Jun 24 – Sep 22	OSB	24.4 (0.5)	-	-1.6 (0.4)	-
Downstream	2003	May 17 – Sep 23	SCC	22.6 (0.6)	0.2 (0.1)	-1.7 (0.3)	-
Upstream	2004	May 5 – Dec 31[d]	ISB	20.8 (0.5)	0.2 (<0.05)	-	-0.4 (0.1)
Upstream	2004	May 5 – Oct 26	OSB	20.9 (0.5)	-	-	-0.2 (0.1)
Upstream	2004	May 6 – Oct 26	SCC	22.5 (0.5)	-1.5 (0.2)	-	1.4 (0.2)
Downstream	2004	May 4 – Dec 3	ISB	21.1 (0.5)	0.5 (0.1)	-	-
Downstream	2004	Jun 15 – Dec 4	OSB	22.4 (0.4)	-	-	-
Downstream	2004	Jun 15 – Sep 10	SCC	23.0 (0.4)	< -0.1 (0.2)	-	-

[a]No data from Jul 18 to Aug 3, 2003.
[b]No data from Sep 22 to Nov 2, 2004.
[c]No data from Jul 3 to Jul 16, 2003.
[d]No data from Oct 6 to Oct 30, 2004.

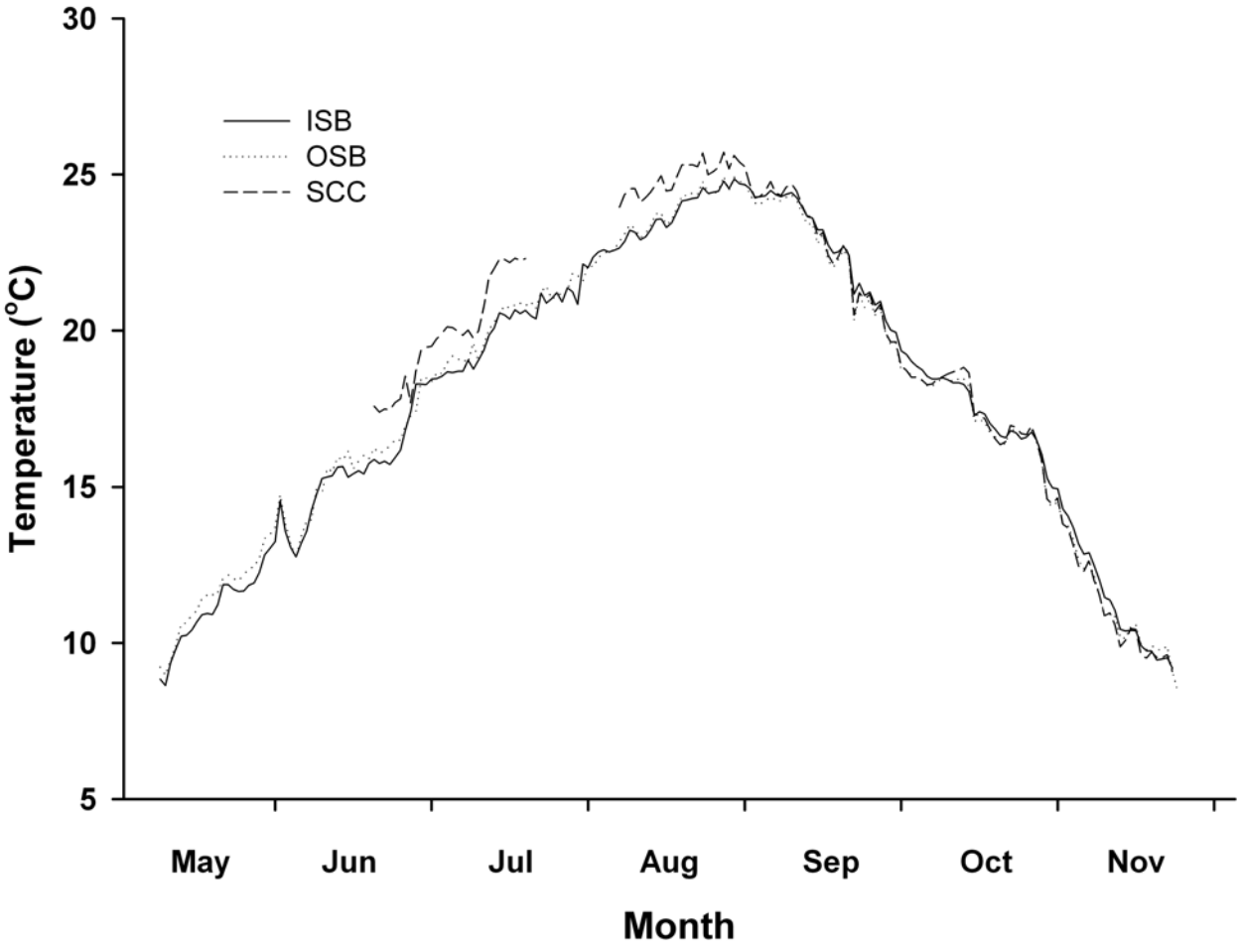


Figure 6. Missouri River mean daily water temperatures at the upstream site of the Fort Randall Reach, Sunshine Bottoms, during 2003 in three habitats: inside bend (ISB), outside bend (OSB), and secondary connected channel (SCC).

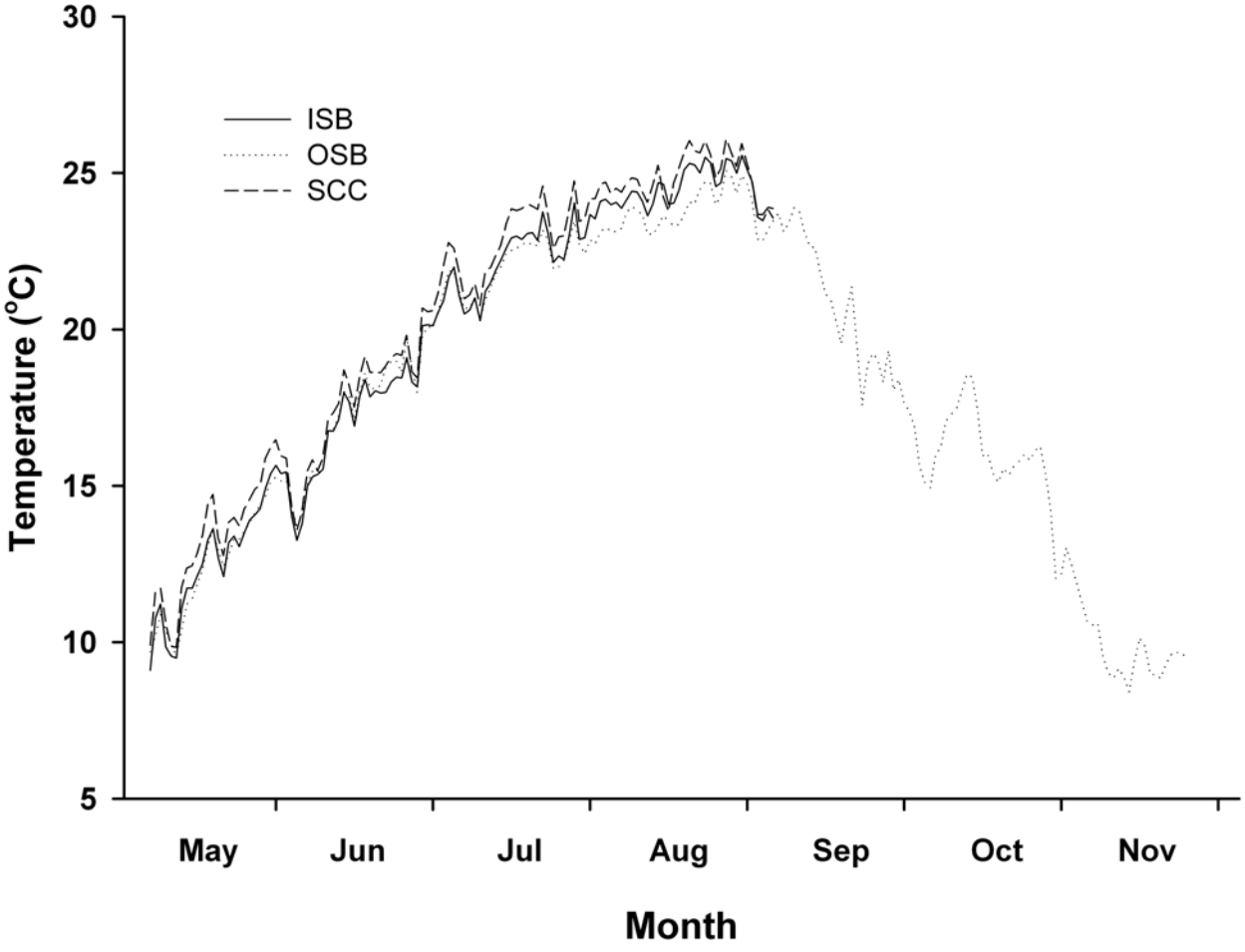


Figure 7. Missouri River mean daily water temperatures at the downstream site of the Fort Randall Reach, the Niobrara River confluence, during 2003 in three habitats: inside bend (ISB), outside bend (OSB), and secondary connected channel (SCC).

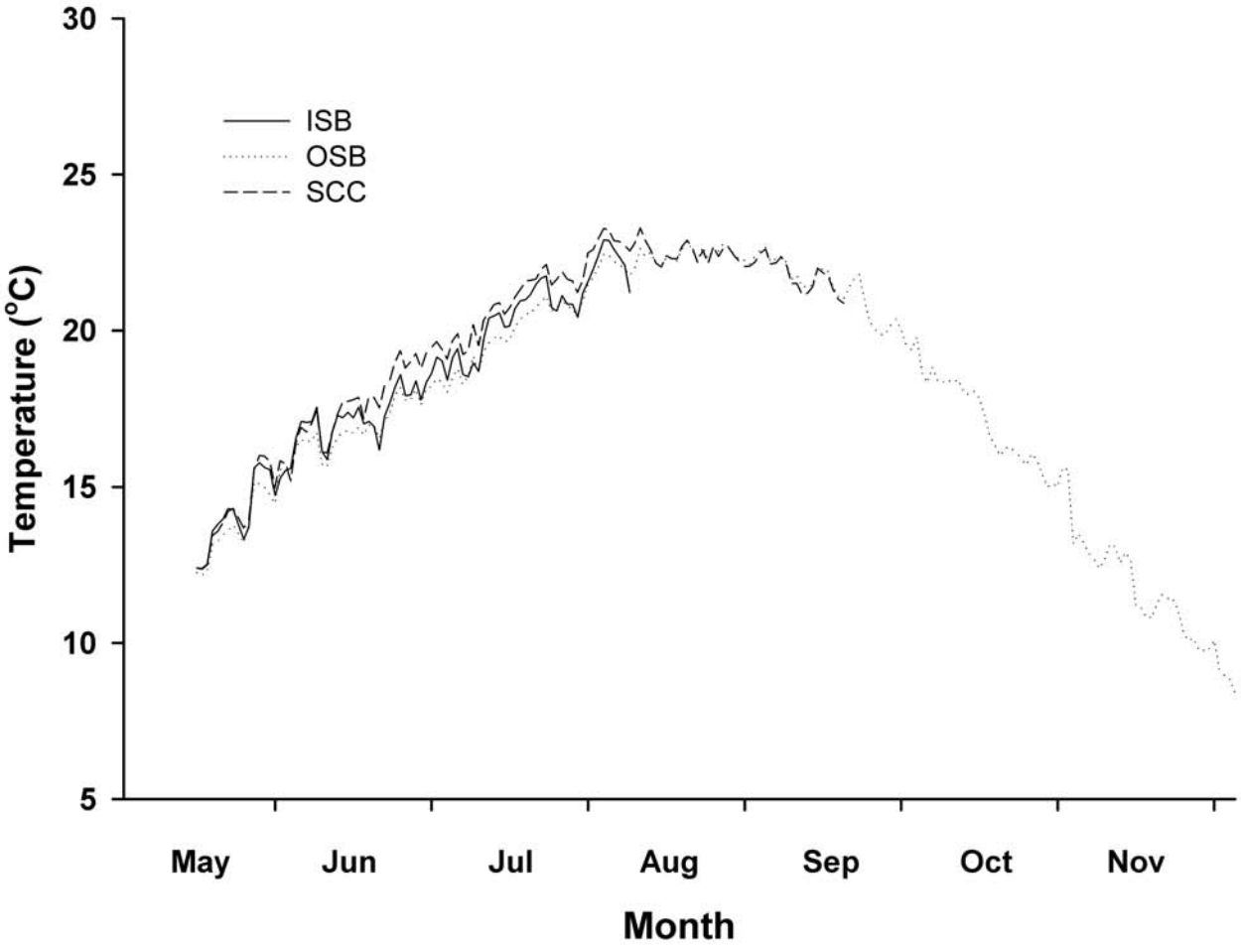


Figure 8. Missouri River mean daily water temperatures at the upstream site of the Fort Randall Reach, Sunshine Bottoms, during 2004 in three habitats: inside bend (ISB), outside bend (OSB), and secondary connected channel (SCC).

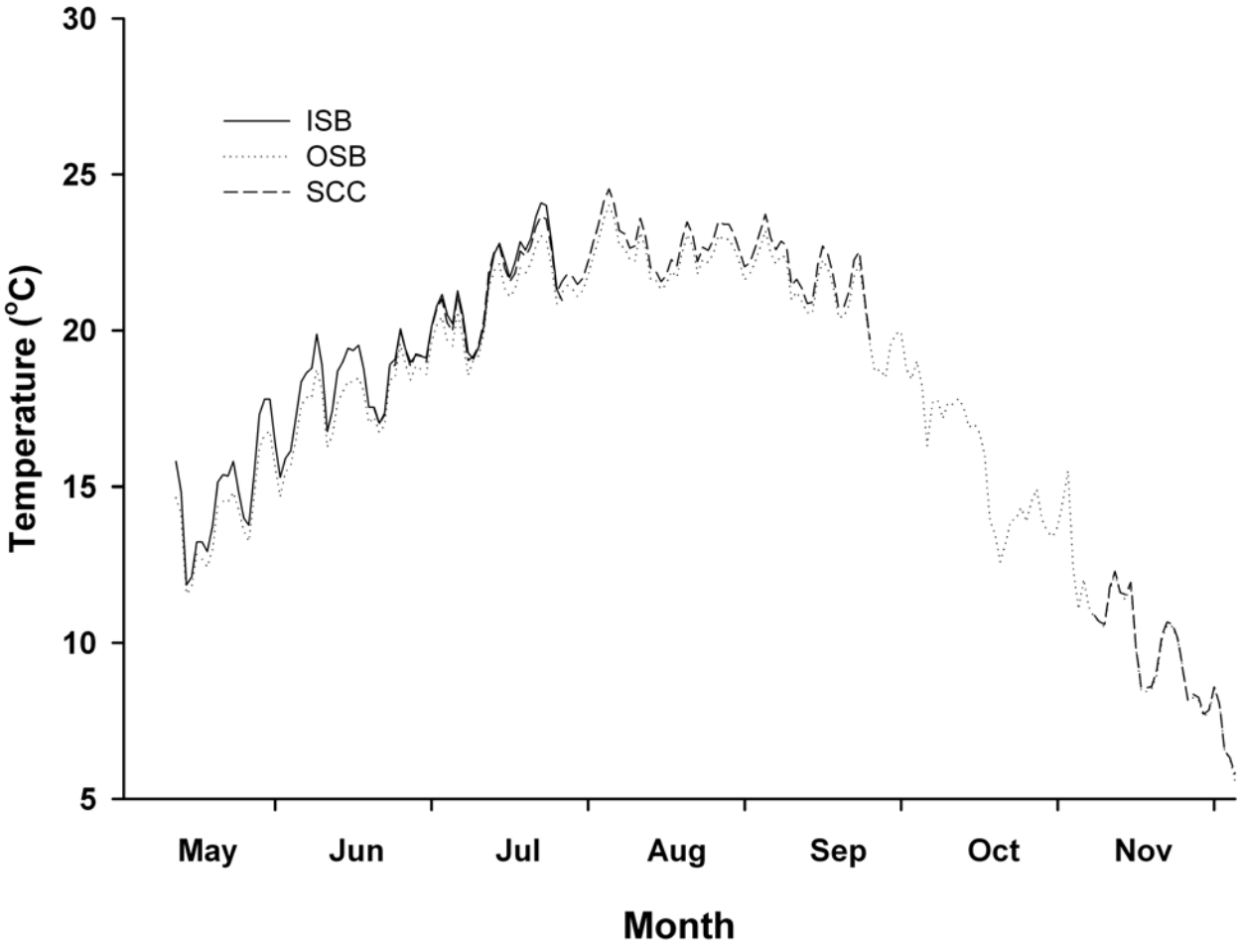


Figure 9. Missouri River mean daily water temperatures at the downstream site of the Fort Randall Reach, the Niobrara River confluence, during 2004 in three habitats: inside bend (ISB), outside bend (OSB), and secondary connected channel (SCC).

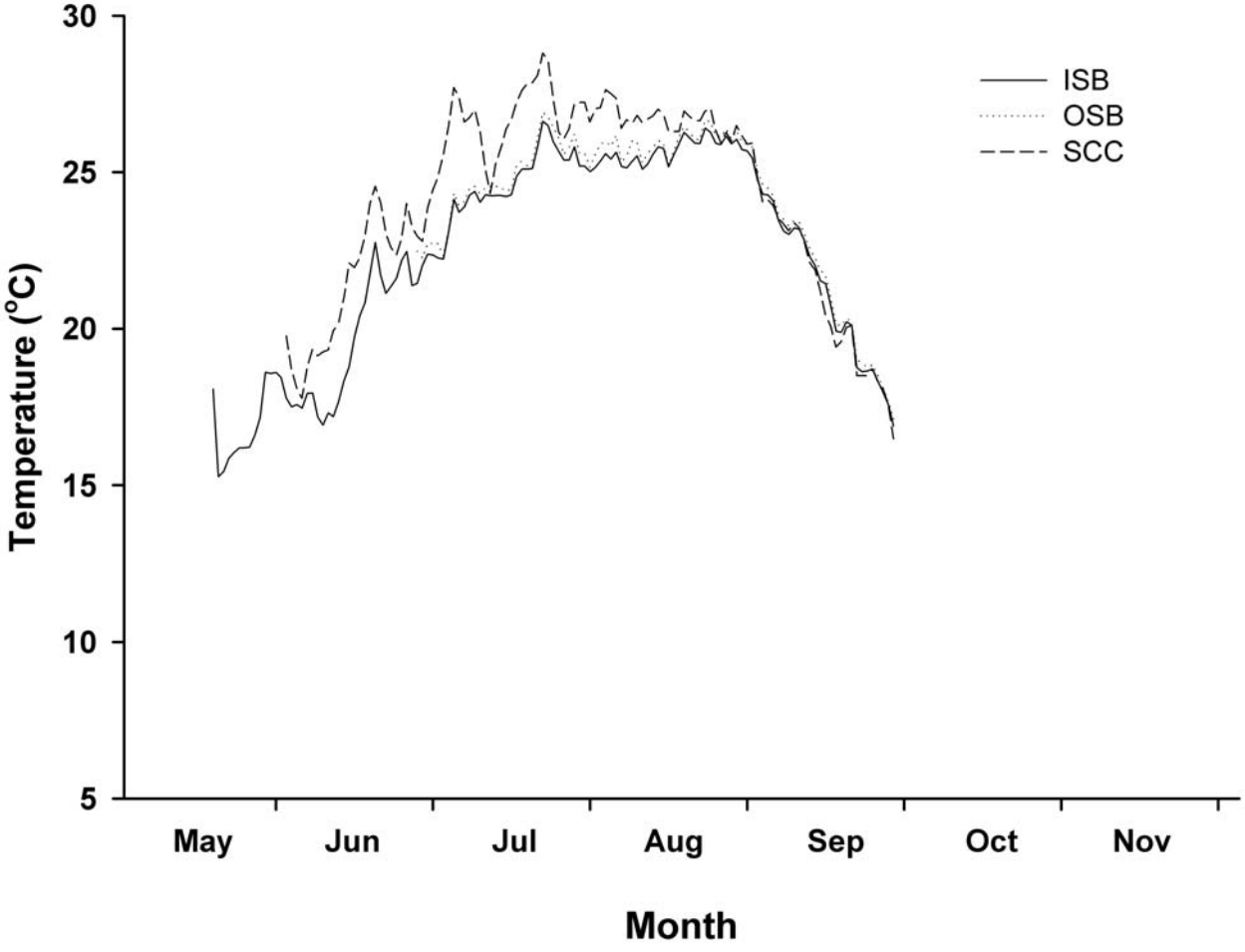


Figure 10. Missouri River mean daily water temperatures at the upstream site of the Gavins Point Reach, the James River confluence, during 2003 in three habitats: inside bend (ISB), outside bend (OSB), and secondary connected channel (SCC).

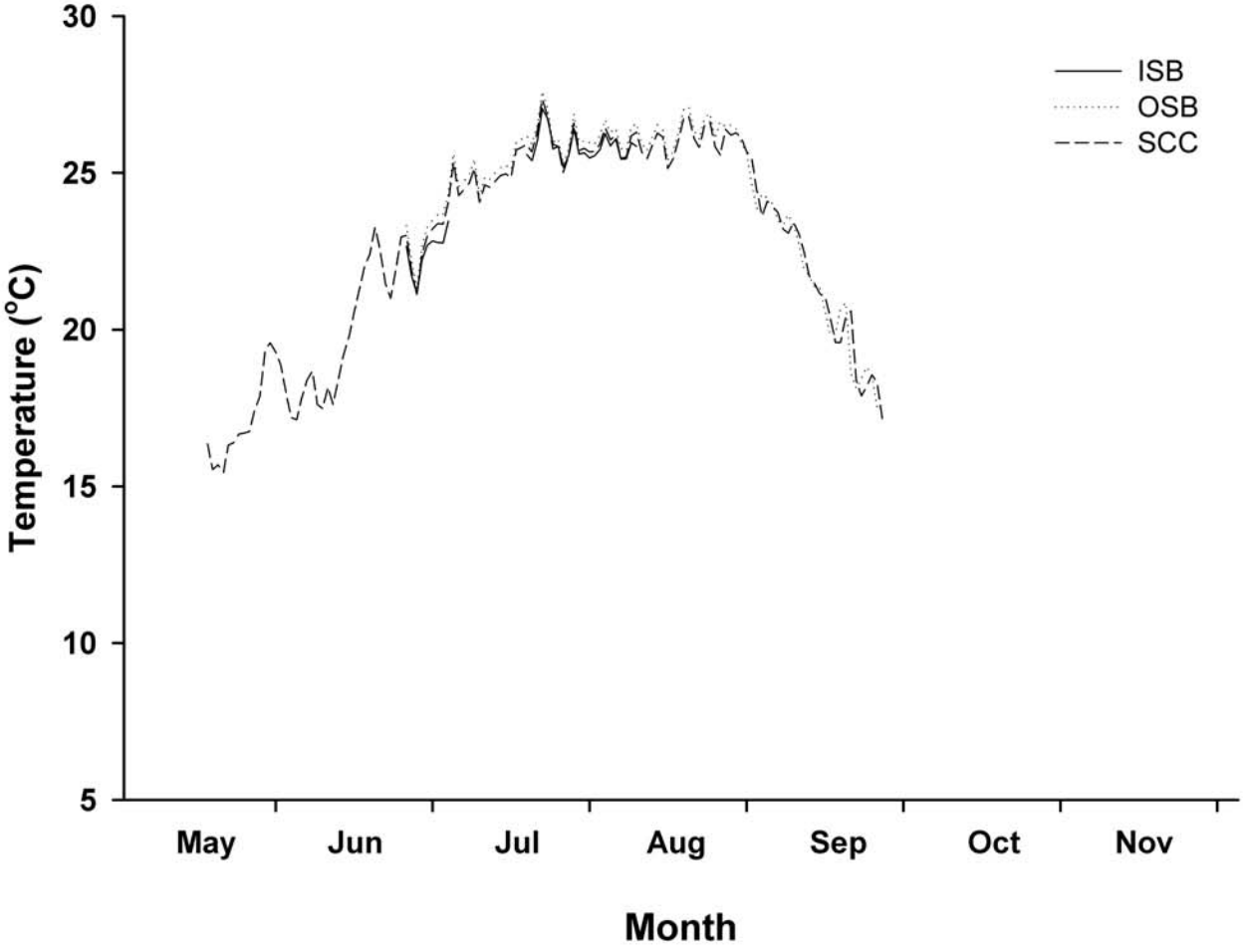


Figure 11. Missouri River mean daily water temperatures at the downstream site of the Gavins Point Reach, Goat Island, during 2003 in three habitats: inside bend (ISB), outside bend (OSB), and secondary connected channel (SCC).

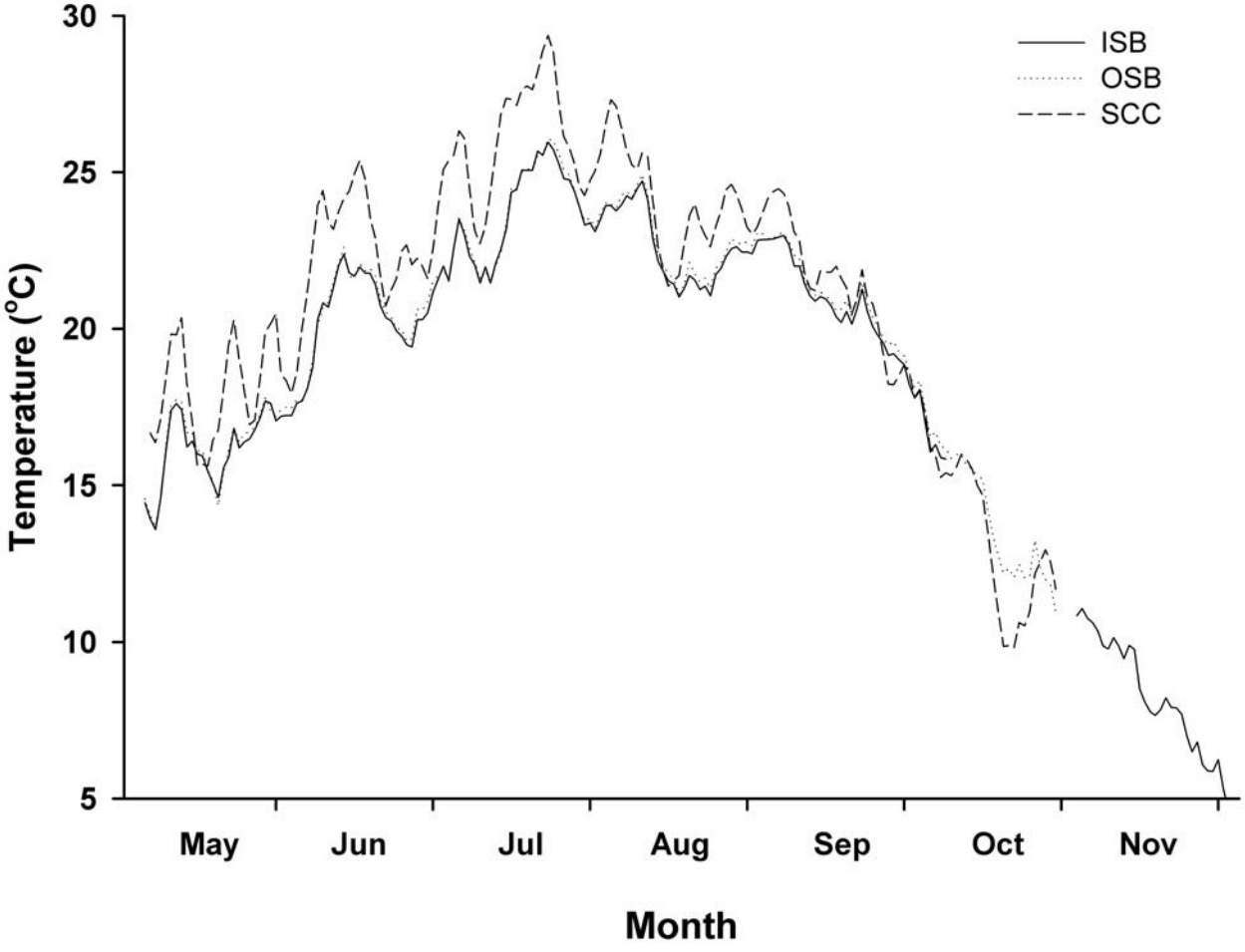


Figure 12. Missouri River mean daily water temperatures at the upstream site of the Gavins Point Reach, the James River confluence, during 2004 in three habitats: inside bend (ISB), outside bend (OSB), and secondary connected channel (SCC).

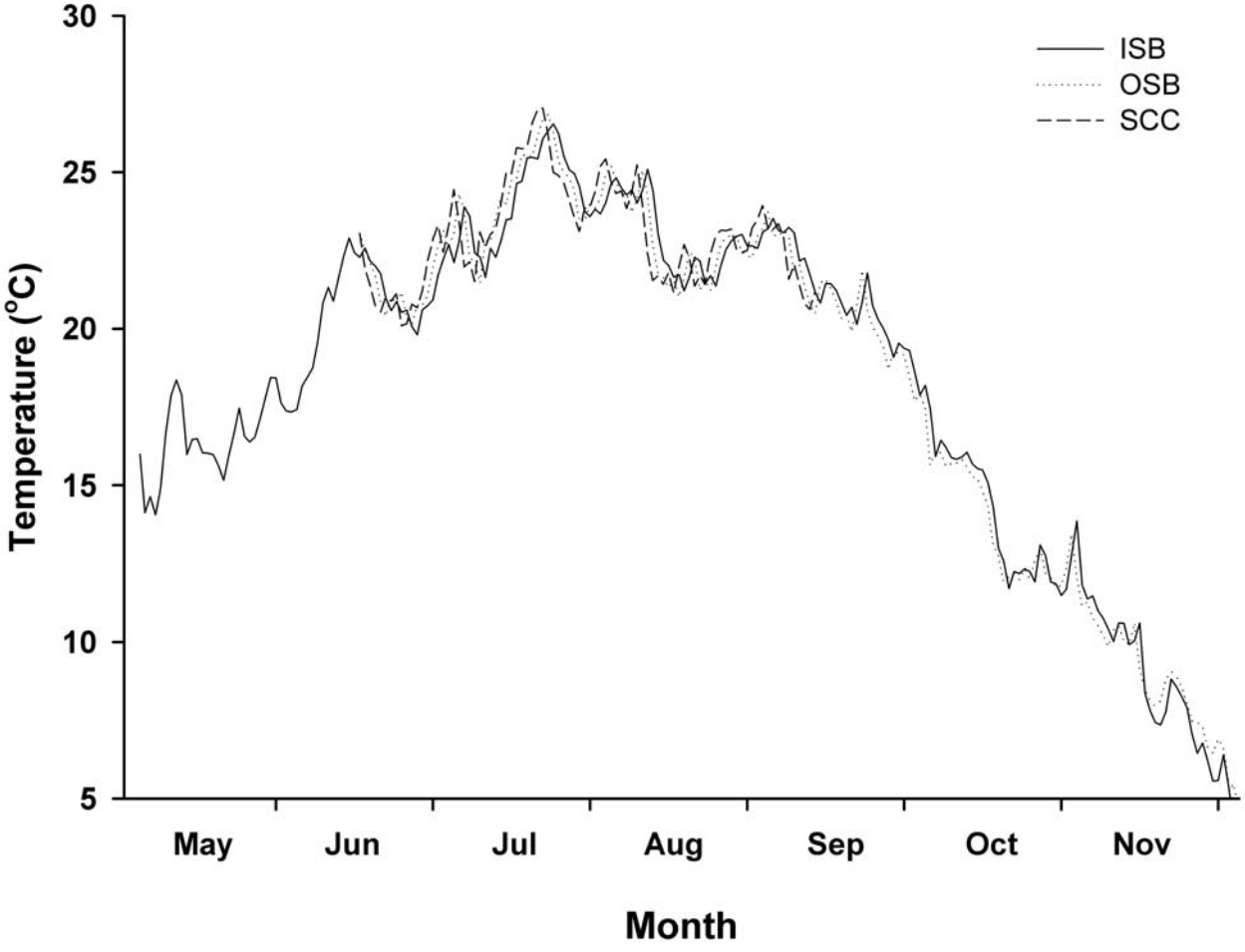


Figure 13. Missouri River mean daily water temperatures at the downstream site of the Gavins Point Reach, Goat Island, during 2004 in three habitats: inside bend (ISB), outside bend (OSB), and secondary connected channel (SCC).

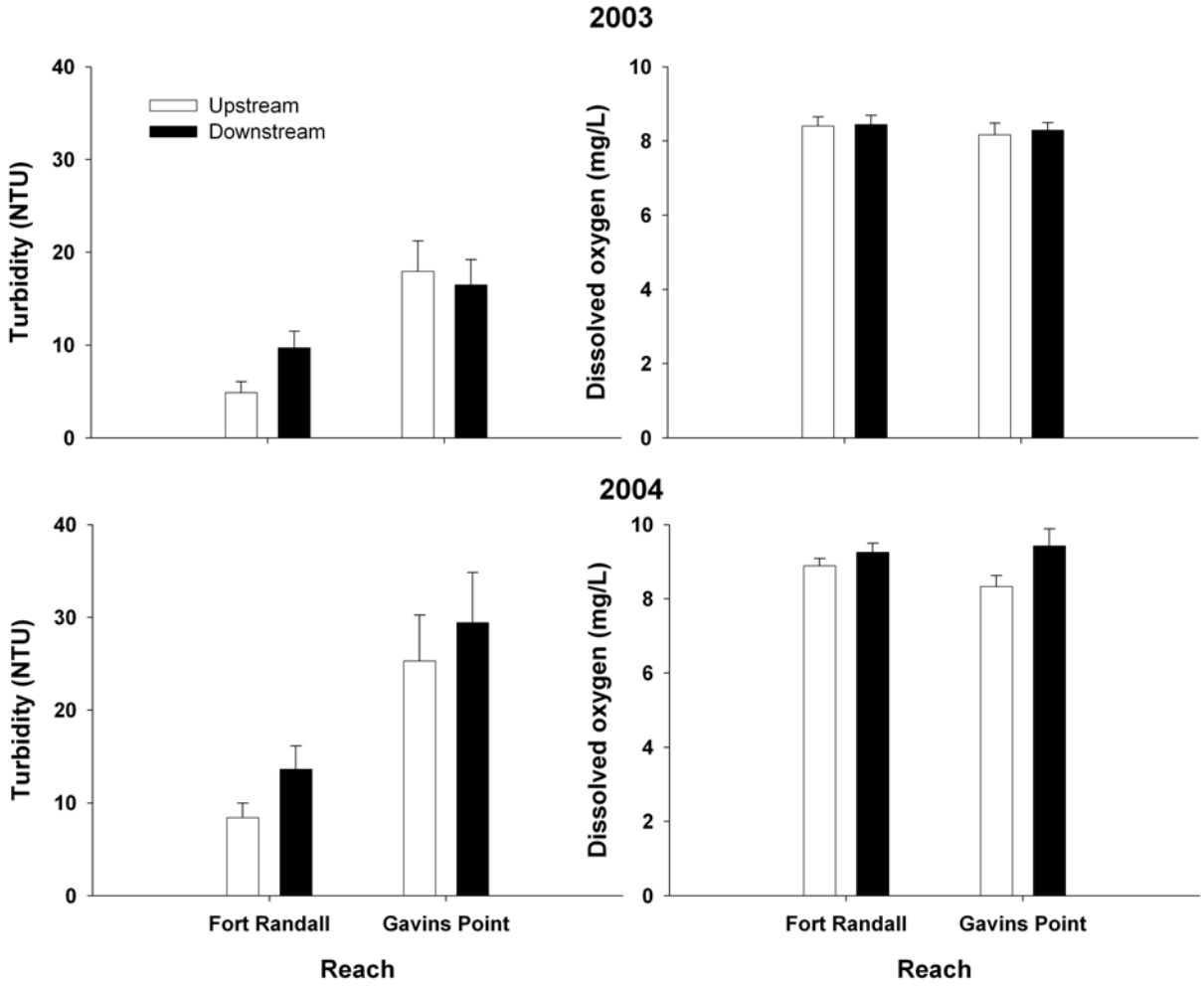


Figure 14. Mean and 95% confidence intervals for summer turbidity as nephalometric turbidity units (NTU) and dissolved oxygen concentrations at upstream and downstream study sites in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004.

Fish collections

Over 100 minnow trap sets of each type of trap, > 150 seine hauls and > 60 mini-fyke net sets were used to collect fishes in shallow waters of the Missouri River during 2003 and 2004 downstream of Fort Randall and Gavins Point dams (Tables 2 and 3). For all gears, a total of 39,454 fish were collected from the Missouri River during 2003 and 2004 with > 5,100 fish collected from the Fort Randall Reach and > 9,400 fish collected from the Gavins Point Reach in each year (Appendices A – J). Effort between years remained fairly consistent for the minnow traps and mini-fyke nets while seining effort was increased 46% in the Fort Randall Reach and 27% in the Gavins Point Reach during 2004 (Tables 2 and 3). Effort for each gear was generally equal for the upstream and downstream study sites within the Fort Randall and Gavins Point reaches.

Effectiveness of gears to capture fish differed. Over 96% of mini-fyke net sets captured fish compared to 59 – 92% of seine hauls and 8 – 59% of minnow trap sets. Among the four minnow trap types used in 2003, the 1/4-inch and 1/8-inch mesh conical traps more frequently captured fish (25 – 59% of deployments) compared to the nylon box trap (15 – 38%) and the 4-way box trap (8 – 15%). Due to low capture success with the nylon box trap and 4-way box trap in 2003, these two designs were not used during 2004. The percent of 1/4-inch and 1/8-inch mesh conical minnow trap deployments that captured fish increased seasonally from generally < 40% in May and June to > 40% in July through September (Figure 15) after water temperatures reached 18 – 20 °C (Figures 6 – 13). In both years, the percent of seine hauls that captured fish was lower in the Fort Randall Reach (< 67%) compared to the Gavins Point Reach (> 82%).

Fish assemblages

During 2003 and 2004, over 40 fish species were collected in the Missouri River downstream of Fort Randall and Gavins Point dams (Table 4; Appendices A - J). Emerald shiners, sand shiners, and spotfin shiners were abundant with > 200 individuals collected in both reaches in both years. Smallmouth bass were abundant in the Fort Randall Reach in 2003 and 2004 but fewer than 50 individuals were captured in either year downstream of Gavins Point Dam. Bigmouth shiners and white bass were abundant in the Gavins Point Reach during 2003 and 2004 whereas < 50 individuals of these species were collected downstream of Fort Randall Dam. Non-native species collected downstream of both Fort Randall and Gavins Point dams included common carp, largemouth bass, rainbow smelt, smallmouth bass, and white bass. Northern pike were only collected downstream of Fort Randall Dam.

About 25% of the species captured in the Missouri River downstream of Fort Randall and Gavins Point dams were classified as rare having < 10 individuals found in only one year of the study. This rarity is due to low actual abundance, low frequency of inhabiting shallow waters, or low susceptibility to capture with the minnow traps, seine, and mini-fyke nets. In the Fort Randall Reach, 14 fish species were represented by < 10 individuals in one year of this study: blacknose dace, bigmouth buffalo, blacknose shiner, freshwater drum, *Hybognathus* spp., Iowa darter, longnose gar, pumpkinseed, rainbow smelt, river shiner, smallmouth buffalo, shovelnose sturgeon, stonecat, and silver chub. In the Gavins Point Reach, 12 fish species had < 10 individuals collected in one year of this study: bluntnose minnow, creek chub, flathead catfish, *Hybognathus* spp., longnose gar, pumpkinseed, quillback, rainbow smelt, sauger, smallmouth buffalo, and stonecat. The following species were found during this study only in the Fort Randall Reach: blacknose dace, blacknose shiner, Iowa darter, northern pike, rock bass, and shovelnose sturgeon, while creek chub

and quillback were only collected in the Gavins Point Reach. In both reaches during 2003 and 2004, YOY *Carpiodes* spp. which cannot be reliably identified to species at small size were commonly collected and would include quillback and river carpsuckers, two species categorized as rare due to collection of few definitive specimens. No YOY of the four Asian carp species were found in either reach in both years of this study despite confirmed presence of adult bighead carp, silver carp, and grass carp, downstream of Gavins Point Dam.

Bag seines and mini-fyke nets captured more species than the 1/4-inch and 1/8- inch mesh conical minnow traps during May through September 2003 and 2004 in the Missouri River downstream of Fort Randall and Gavins Point dams (Appendices A – J). Similar numbers of species were captured with the bag seine (24 – 29) and mini-fyke net (27 – 31 species) in both reaches. Although the conical minnow traps captured a greater number of species downstream of Gavins Point Dam (8 – 17 species) compared to the Fort Randall Reach (6 – 12 species), the two meshes generally captured a similar number of species within each reach. For deployments that captured fish, the median number of species caught per deployment in mini-fyke nets was significantly greater (Mann-Whitney U Test, $U \geq 1{,}079$, $P < 0.001$) compared to the bag seine downstream of Fort Randall and Gavins Point dams during 2003 and 2004 (Figure 16).

In most months from May through September during 2003 and 2004, the principal cyprinid species caught with the 1/4-inch and 1/8-inch conical minnow traps downstream of Fort Randall and Gavins Point dams was spotfin shiners (Figures 17 and 18). After catches increased in July for both mesh sizes, the preponderance of the catch (> 75%) at both sites in both years was comprised of four species: emerald shiners, red shiners, sand shiners, and spotfin shiners. The exception was for the 1/8-inch mesh conical minnow trap in the Gavins Point Reach in September of 2003 where bigmouth shiners comprised over 55% of the catch.

Table 2. Monthly effort (as number of deployments) expended collecting shallow water fishes in the Missouri River with four types of minnow traps, bag seines, and mini-fyke nets downstream of Fort Randall and Gavins Point dams during 2003. Within each reach samples were colleted at an upstream (U) and downstream (D) location. Seines and mini-fyke nets were not used until after July 1.

Gear	N	Percent with fish	Monthly deployments				
			May	June	July	Aug	Sept
Fort Randall Reach							
1/8-inch mesh conical minnow trap	101	40.6	5U, 4D	15U, 14D	8U, 8D	16U, 15D	8U, 8D
1/4-inch mesh conical minnow trap	100	38.0	4U, 4D	16U, 14D	7U, 8D	15U, 16D	8U, 8D
4-way Box minnow trap	101	6.9	4U, 4D	16U, 14D	8U, 8D	16U, 16D	8U, 7D
1/8-inch mesh square minnow trap	97	15.5	4U, 4D	16U, 14D	8U, 8D	16U, 11D	8U, 8D
Bag seine	151	58.9	-	-	14U, 12D	34U, 42D	25U, 24D
Mini-fyke net	64	96.8	-	-	8U, 8D	16U, 16D	8U, 8D
Gavins Point Reach							
1/8-inch mesh conical minnow trap	106	55.7	7U, 14D	16U, 7D	8U, 8D	16U, 16D	8U, 8D
1/4-inch mesh conical minnow trap	107	46.7	8U, 15D	16U, 6D	8U, 8D	15U, 15D	8U, 8D
4-way Box minnow trap	106	15.1	8U, 14D	16U, 8D	8U, 8D	15U, 15D	7U, 7D
1/8-inch mesh square minnow trap	108	38.0	7U, 14D	16U, 8D	8U, 8D	15U, 16D	8U, 8D
Bag seine	181	91.7	-	-	20U, 10D	56U, 45D	28U, 22D
Mini-fyke net	62	98.4	-	-	8U, 8D	16U, 15D	8U, 7D

Table 3. Monthly effort (as number of deployments) expended collecting shallow water fishes in the Missouri River with two types of minnow traps, bag seines, and mini-fyke nets downstream of Fort Randall and Gavins Point dams during 2004. Within each reach samples were colleted at an upstream (U) and downstream (D) location. Seines and mini-fyke nets were not used until after July 1.

Gear	N	Percent with fish	Monthly deployments				
			May	June	July	Aug	Sept
Fort Randall Reach							
1/8-inch mesh conical minnow trap	116	27.6	8U, 8D	14U, 20D	17U, 16D	7U, 8D	8U, 10D
1/4-inch mesh conical minnow trap	121	24.8	8U, 10D	15U, 20D	17U, 17D	8U, 8D	8U, 10D
Bag seine	220	66.4	-	-	52U, 63D	23U, 34D	24U, 24D
Mini-fyke net	79	100	-	-	17U, 20D	8U, 16D	8U, 10D
Gavins Point Reach							
1/8-inch mesh conical minnow trap	108	59.3	8U, 10D	15U, 16D	13U, 17D	7U, 7D	8U, 7D
1/4-inch mesh conical minnow trap	104	45.2	4U, 9D	15U, 16D	15U, 16D	7U, 7D	8U, 7D
Bag seine	229	83	-	-	64U, 64D	24U, 24D	24U, 29D
Mini-fyke net	61	98.4	-	-	15U, 14D	8U, 8D	8U, 8D

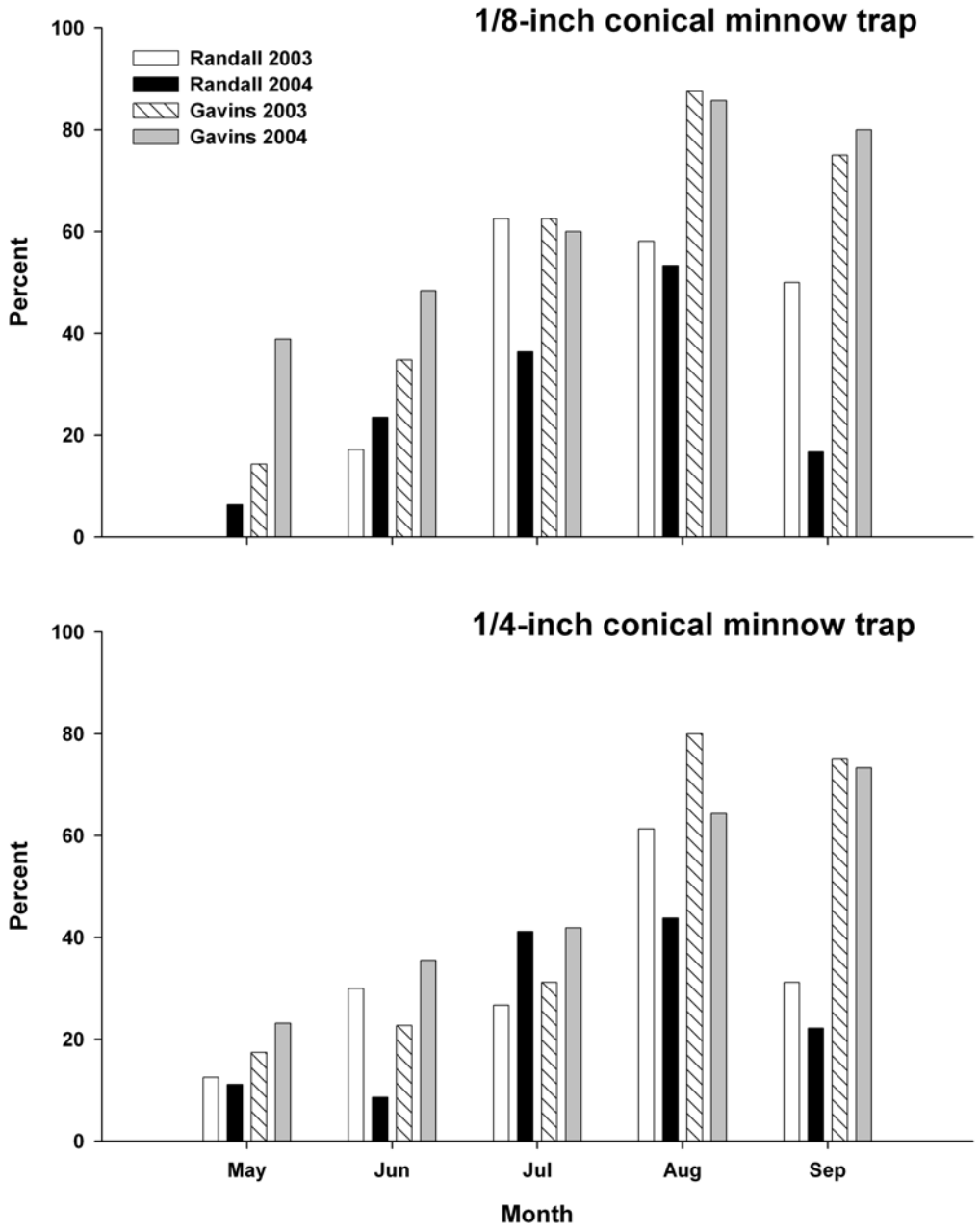


Figure 15. Monthly percent of minnow trap deployments that captured fish in shallow water habitats of the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004.

Table 4. Fish species captured with minnow traps, bag seines, and mini-fyke nets in shallow waters of the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004. An "X" indicates presence of a species at a site with occurrence categorized as abundant (> 200 fish), common (50 – 200 fish), uncommon (10 – 49 fish), rare (< 10 fish) or absent based on the largest number of individuals collectively captured with these gears in either 2003 or 2004.

Common name	Scientific name	Fort Randall Reach			Gavins Point Reach		
		2003	2004	Occurrence	2003	2004	Occurrence
Blacknose dace	*Rhinichthys atratulus*	X		Rare			Absent
Black crappie	*Pomoxis nigromaculatus*	X	X	Uncommon	X	X	Rare
Black bullhead	*Ameiurus melas*	X	X	Rare	X	X	Rare
Bluegill	*Lepomis macrochirus*	X	X	Uncommon	X	X	Common
Bigmouth buffalo	*Ictiobus cyprinellus*		X	Rare	X	X	Rare
Bigmouth shiner	*Notropis dorsalis*	X	X	Rare	X	X	Abundant
Bluntnose minnow	*Pimephales notatus*	X	X	Common	X		Rare
Blacknose shiner	*Notropis heterolepsis*	X		Rare			Absent
Channel catfish	*Ictalurus punctatus*	X	X	Rare	X	X	Uncommon
Common carp	*Cyprinus carpio*	X	X	Rare	X	X	Common
Creek chub	*Semotilus atromaculatus*			Absent	X		Rare
Emerald shiner	*Notropis atherinoides*	X	X	Abundant	X	X	Abundant
Flathead catfish	*Pylodictis olivaris*			Absent	X		Rare
Fathead minnow	*Pimephales promelas*	X	X	Common	X	X	Uncommon
Freshwater drum	*Aplodinotus grunniens*	X		Rare	X	X	Common
Green sunfish	*Lepomis cyanellus*	X	X	Common	X	X	Rare
Gizzard shad	*Dorosoma cepedianum*	X	X	Common	X	X	Abundant
Hybognathus species	*Hybognathus* spp.	X		Rare	X		Rare
Iowa darter	*Etheostoma exile*	X		Rare			Absent
Johnny darter	*Etheostoma nigrum*	X	X	Common	X	X	Uncommon
Largemouth bass	*Micropterus salmoides*	X	X	Common	X	X	Rare
Longnose gar	*Lepisosteus osseus*		X	Rare		X	Rare
Northern pike	*Esox lucius*	X	X	Rare			Absent
Orangespotted sunfish	*Lepomis humilis*	X	X	Uncommon	X	X	Uncommon

Table 4. (continued).

Common name	Scientific name	Fort Randall Reach			Gavins Point Reach		
		2003	2004	Occurrence	2003	2004	Occurrence
Pumpkinseed	*Lepomis gibbosus*	X		Rare	X		Rare
Quillback	*Carpiodes cyprinus*			Absent	X		Rare
Rainbow smelt	*Osmerus mordax*		X	Rare		X	Rare
Red shiner	*Cyprinella lutrensis*	X	X	Common	X	X	Abundant
Rock bass	*Ambloplites rupestris*	X	X	Uncommon			Absent
River carpsucker	*Carpiodes carpio*	X	X	Rare	X	X	Rare
River shiner	*Notropis blennius*		X	Rare	X	X	Uncommon
Spotfin shiner	*Cyprinella spiloptera*	X	X	Abundant	X	X	Abundant
Sauger	*Sander canadense*	X	X	Rare	X		Rare
Shorthead redhorse	*Moxostoma macrolepidotum*	X	X	Uncommon	X	X	Common
Smallmouth buffalo	*Ictiobus bubalus*	X		Rare	X		Rare
Smallmouth bass	*Micropterus dolomieu*	X	X	Abundant	X	X	Uncommon
Shortnose gar	*Lepisosteus platostomus*	X	X	Uncommon	X	X	Uncommon
Shovelnose sturgeon	*Scaphirhynchus platorynchus*		X	Rare			Absent
Sand shiner	*Notropis stramineus*	X	X	Abundant	X	X	Abundant
Stonecat	*Noturus flavus*		X	Rare	X		Rare
Spottail shiner	*Notropis hudsonius*	X	X	Common	X	X	Uncommon
Silver chub	*Macrhybopsis storeriana*		X	Rare	X	X	Rare
Unidentified carpsucker	*Carpiodes* spp.	X	X	Common	X	X	Abundant
Unidentified redhorse	*Moxostoma* spp.	X	X	Common	X		Uncommon
Walleye	*Sander vitreus*	X	X	Rare	X	X	Uncommon
White bass	*Morone chrysops*	X	X	Uncommon	X	X	Abundant
White crappie	*Pomoxis annularis*	X	X	Uncommon	X	X	Uncommon
Yellow perch	*Perca flavescens*	X	X	Common	X	X	Rare

The fish assemblage collected in shallow waters of the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004 with bag seines and mini-fyke nets was comprised mainly of cyprinids (> 50%); however, differences were observed between reaches and gears (Figures 19 and 20). In both years, seine and mini-fyke catches in the Fort Randall Reach had a greater proportion of centrarchids (19 – 35%) compared to the Gavins Point Reach (< 5%). Smallmouth bass YOY were the most common centrarchid captured in the Fort Randall Reach with bag seines (Appendix E) and mini-fyke nets (Appendix G) during 2003 and 2004. In both reaches during 2003 and 2004, bag seine catches of catastomids (mainly *Carpiodes* spp.) and gizzard shad YOY generally comprised a greater percentage of the catch compared to mini-fyke nets. Based on bag seine and mini-fyke net catches, the proportion of YOY gizzard shad and white bass in the shallow water fish assemblage downstream of Gavins Point Dam was generally greater compared to the Fort Randall Reach during 2003 and 2004.

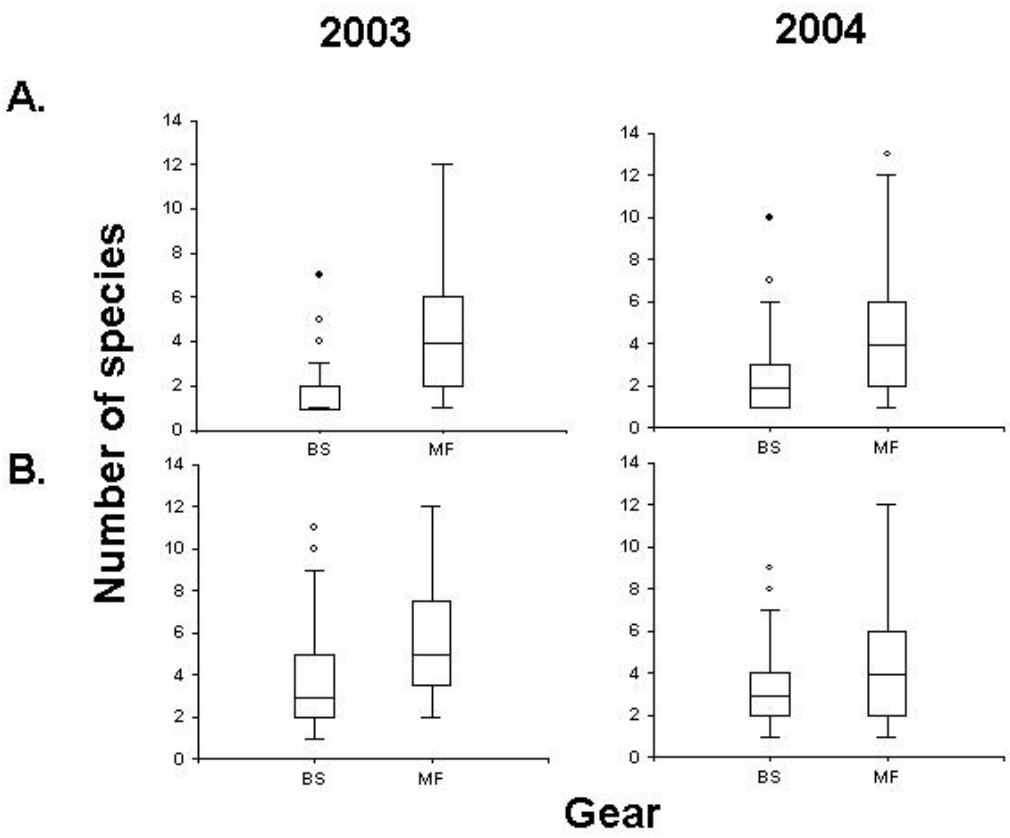


Figure 16. Boxplots showing the number of species captured per deployment using bag seines (BS) and mini-fyke nets (MF) in the Missouri River during 2003 and 2004 downstream of A) Fort Randall Dam and B) Gavins Point Dam, South Dakota and Nebraska. Box shows the interquartile range (IQR) bounded by 25th and 75th percentiles while the whiskers are delineated as the largest and smallest observation within the IQR plus 1.5 times the IQR. Open and closed circles are outliers > 3 times the IQR.

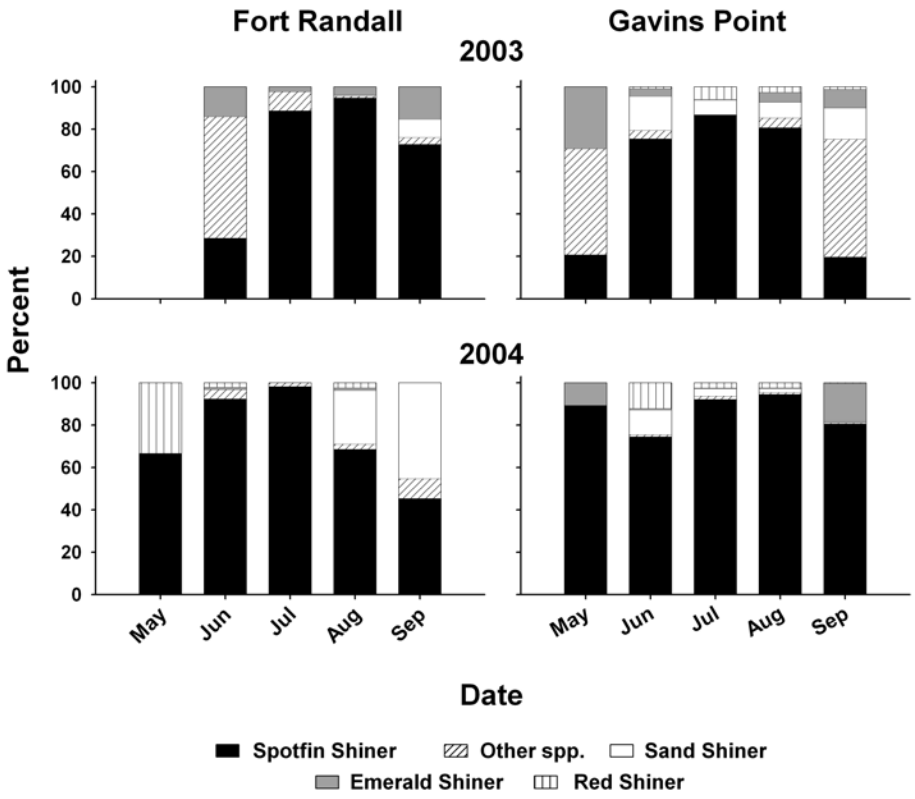


Figure 17. Monthly composition (as percent of total catch) of fishes captured with 1/8-inch mesh conical minnow traps set in shallow waters of the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004.

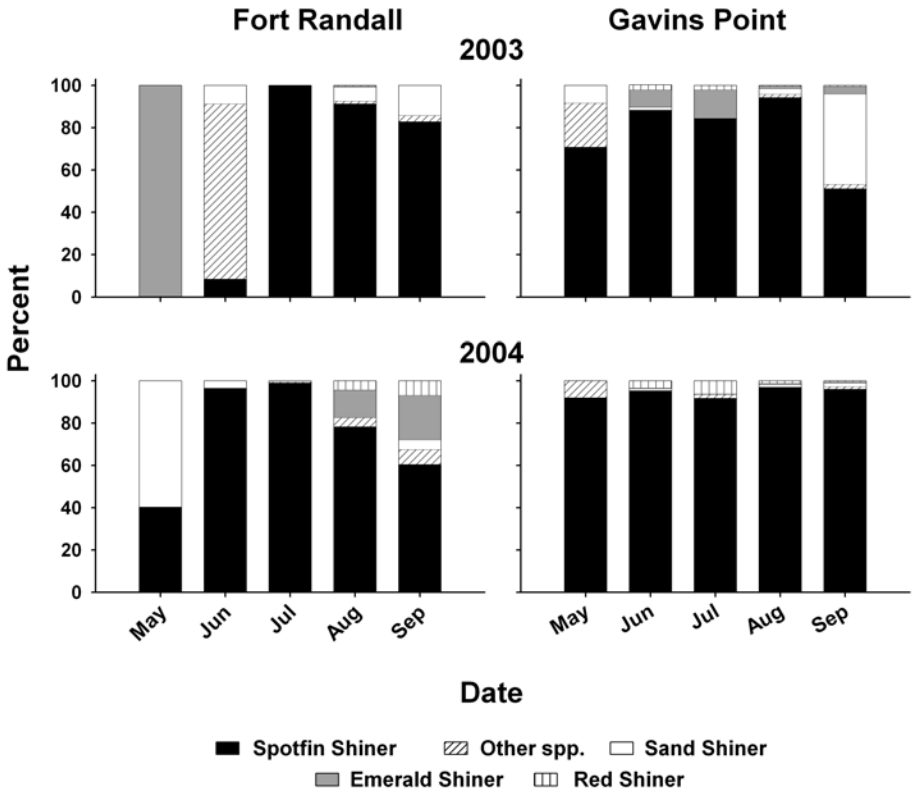


Figure 18. Monthly composition (as percent of total catch) of fishes captured with 1/4-inch mesh conical minnow traps set in shallow waters of the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004.

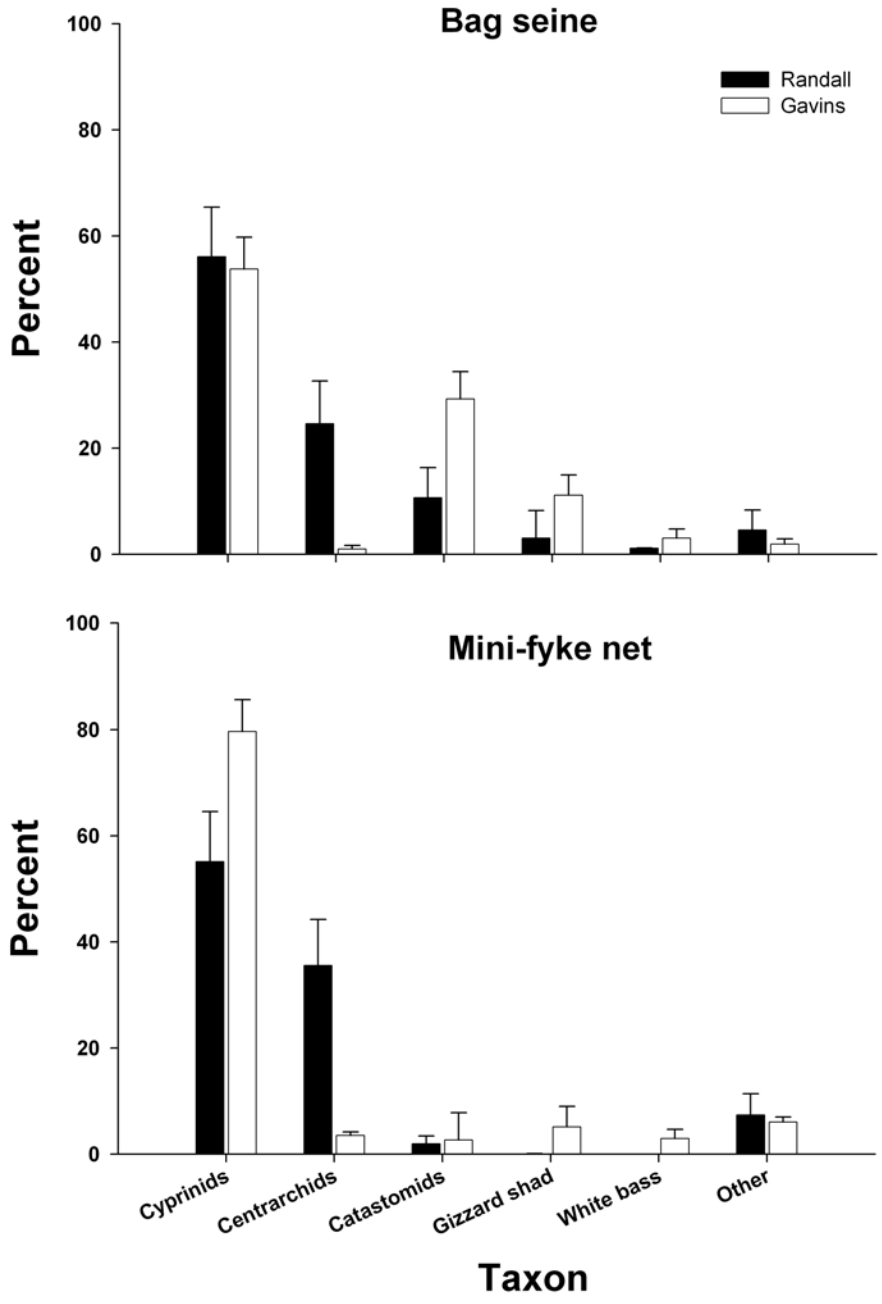


Figure 19. Mean (± 2 SE) summer fish assemblage composition of catches in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 with bag seines and mini-fyke nets.

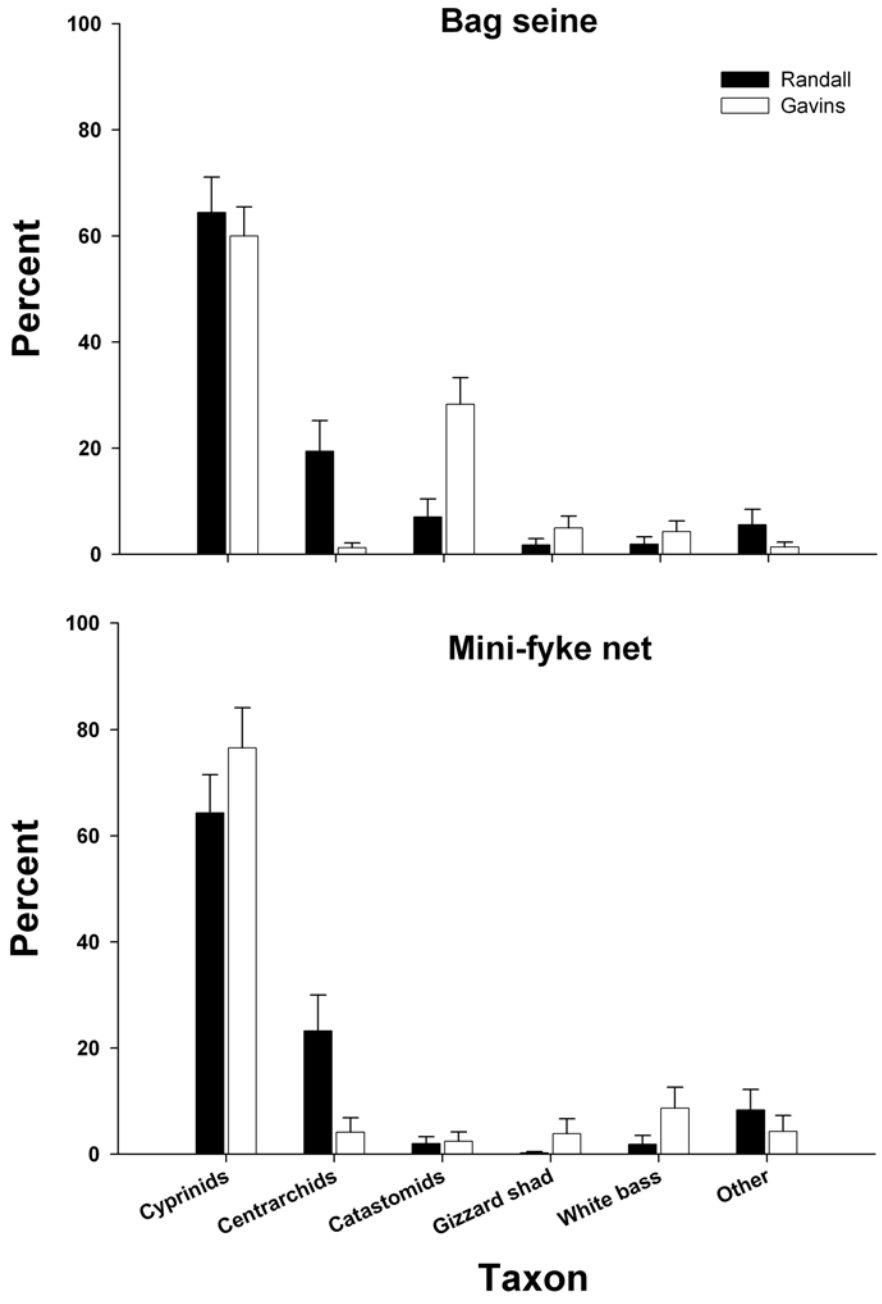


Figure 20. Mean (± 2 SE) summer fish assemblage composition of catches in the Missouri River downstream of Fort Randall and Gavins Point dams during 2004 with bag seines and mini-fyke nets.

Fish relative abundance – minnow traps

Relative abundance of total fishes captured with 1/8-inch and 1/4-inch mesh conical minnow traps were generally higher in the Gavins Point Reach compared to the Fort Randall Reach during 2003 and 2004 (Figure 21). For the 1/8-inch mesh minnow trap, mean relative abundance ranged from 0 – 15.5 fish/trap night in the Fort Randall Reach and 0.5 – 129 fish/trap night in the Gavins Point Reach during 2003 and 2004. Relative abundance of fishes during 2003 and 2004 based on 1/4-inch mesh minnow traps ranged from 0.2 – 5.1 fish/trap night in the Fort Randall Reach and 0.2 – 26.9 fish/trap night in the Gavins Point Reach. Due to the high incidence of zero catches for both traps (Figure 15), CPUE could not be transformed to achieve normality (log10, reciprocal, square root, and arcsine) which necessitated using non-parametric statistics. With few exceptions, monthly median relative abundance of fishes in both trap types was significantly greater for the Gavins Point Reach compared to the Fort Randall Reach during both years (Table 5). No statistical comparisons were done for May due to low catch rates.

In general, relative abundance of fish captured with the 1/8-inch and 1/4-inch mesh conical minnow traps within each reach differed more seasonally than inter-annually (Figure 21). For both minnow traps, highest relative abundance was generally seen in July or August in the Fort Randall Reach and in August and September in the Gavins Point Reach. In general, total fish relative abundance captured with both trap types within each reach was similar in 2003 and 2004 except for September catches in the 1/8-inch traps in the Gavins Point Reach. The high September catch rate in 2003 for the 1/8-inch mesh traps in the Gavins Point Reach resulted from a catch of 948 bigmouth shiners in a single trap.

The effect of mesh size on catch rate was equivocal for the conical minnow traps. Median catch rates between the 1/8-inch and 1/4-inch meshes were not significantly different

during 2003 or 2004 in the Fort Randall Reach (Wilcoxon Signed-Rank Test: 2003: z = 0.852, *P* = 0.39; 2004: z = 0.911, *P* = 0.36). In contrast, median catch rates of fish in the 1/8-inch mesh were significantly higher in both 2003 and 2004 in the Gavins Point Reach compared to 1/4-inch mesh (Wilcoxon Signed-Rank Test: 2003: z = 2.056, *P* = 0.04; 2004: z = 3.037, *P* < 0.01). However, the preponderance of zero catches for both trap types was generally greater in the Fort Randall Reach compared to the Gavins Point Reach, especially in August and September (Figure 15).

In general, relative abundance of fishes based on minnow trap catches for each mesh size did not differ appreciably between upstream and downstream locations within each reach during 2003 and 2004 (Figures 22-25). For the 1/8-inch conical minnow trap in the Fort Randall Reach, mean relative abundance of all fishes ranged from 0 – 9.7 fish/trap night at the upstream site and 0 – 21.7 fish/trap night at the downstream site (Figure 22) while 1/4-inch mesh conical minnow trap catches within this reach ranged from 0.1 – 4.8 and 0 – 11.5 fish/trap night at the upstream and downstream sites respectively (Figure 23). Mean relative abundance of fishes caught with the 1/8-inch mesh traps in the Gavins Point Reach ranged from 0.3 – 218 fish/trap night at the upstream site and 0.2 – 51.1 fish/trap night at the downstream site (Figure 24) while 1/4-inch mesh trap mean catches in this reach ranged from 0.3 – 42.5 and 0 – 17.6 fish/trap night at the upstream and downstream sites respectively (Figure 25). Sand shiners were consistently caught in June through September during 2003 and 2004 in the Gavins Point Reach compared to sporadic occurrence in the Fort Randall Reach. Median catch rates were significantly higher in September at the downstream site in the Fort Randall Reach in both years for the 1/8-inch mesh conical traps and only in 2004 for the 1/4-inch mesh conical traps (Table 6). All other comparisons between CPUE at the upstream and downstream sites in the Fort Randall Reach

were not significantly different. Median catch rates between the upstream and downstream sites were only significantly different on one occasion for the Gavins Point Reach, August of 2004 for the 1/4-inch mesh conical traps (Table 7).

Catches in both minnow traps did not differ appreciably among macrohabitats when compared to effort expended in each habitat type (Figures 26 and 27). The percentage of the total catch in the 1/8-inch mesh conical minnow traps was higher than the percentage of effort expended within secondary non-connected channels for both reaches (Figure 26) but this trend was not evident for the 1/4-inch mesh traps (Figure 27).

Catches in the nylon mesh box traps and the 4-way box traps during 2003 in both reaches of the Missouri River were low (Appendices E and F). However, for the nylon mesh box traps, the overall mean summer catch rate for all fish species was over three times higher for the Gavins Point Reach (1.49 fish/trap night) compared to the Fort Randall Reach (0.45 fish/trap night). Catch rate with the 4-way box traps was also three times higher in the Gavins Point Reach compared to the Fort Randall Reach; however, the total fish captured in both reaches combined was only 38 fish.

Length frequencies – minnow traps

Compared to the Gavins Point Reach, few cyprinids < 45 mm TL were captured in the Fort Randall Reach in 2003 and 2004 in both mesh sized minnow traps (Figures 28 and 29). For the 1/8-inch conical mesh minnow traps, significantly more small sized cyprinids were captured downstream of Gavins Point Dam in 2003 (K-S: $D = 0.436$, $P < 0.001$) and 2004 (K-S: $D = 0.409$, $P < 0.001$). Similarly, compared to the Fort Randall Reach, the 1/4-inch conical minnow

trap also captured significantly more small sized cyprinids in the Gavin Reach during 2003 (K-S: $D = 0.302$, $P < 0.001$) and 2004 (K-S: $D = 0.193$, $P = 0.04$).

The cumulative length frequencies of cyprinids generally differed between meshes for the conical minnow traps. The 1/8-inch mesh captured greater numbers of fish < 50 mm total length. For the Fort Randall Reach, cumulative length frequency distributions of cyprinids caught in each mesh sized minnow trap significantly differed in 2003 (K-S: $D = 0.132$, $P = 0.002$) and was marginally insignificant in 2004 (K-S: $D = 0.098$, $P = 0.102$); the majority of fish in both trap types ranged from 50 – 70 mm TL (Figure 28). In both years in the Gavins Point Reach (Figure 29), the cumulative frequency distributions for cyprinids captured in the 1/8-inch and 1/4-inch mesh traps significantly differed from each other in 2003 (K-S: $D = 0.316$, $P < 0.001$) and 2004 (K-S: $D = 0.283$, $P = 0.002$).

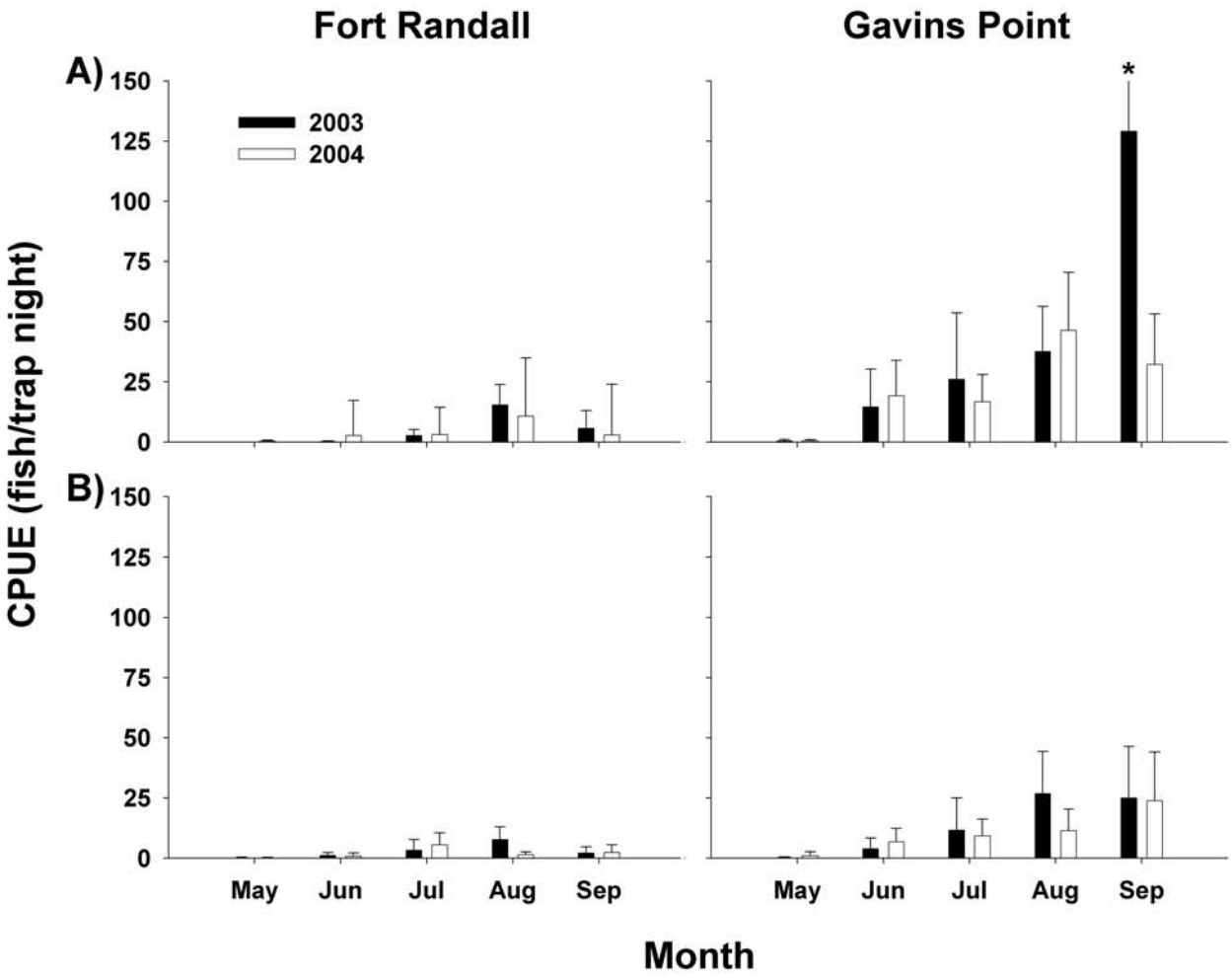


Figure 21. Mean (± 2SE) monthly catch-per-unit-effort (CPUE) of all fish species captured with: A) 1/8-inch mesh conical minnow traps and B) 1/4-inch mesh conical minnow traps set in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004. The upper bound for September 2003 CPUE with the 1/8-inch conical minnow trap in the Gavins Point Reach was 169 fish/trap night.

Table 5. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between the Fort Randall and Gavins Point reaches of the Missouri River caught with minnow traps during 2003 and 2004. Minnow trap CPUE was fish/trap night.

Month	Year	Fort Randall Reach		Gavins Point Reach		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
1/8-inch mesh conical minnow trap							
Jun	2003	29	0 (0, 0)	23	0 (0, 8)	258.5	0.07
Jul	2003	16	1 (0, 1.8)	16	1.5 (0, 40.5)	102.5	0.32
Aug	2003	31	3 (0, 26)	32	13 (2.2, 60.5)	334	0.02
Sep	2003	14	0.5 (0,3)	14	6.5 (0, 37)	72	0.09
Jun	2004	34	0 (0, 0.2)	31	0 (0, 14)	369	0.02
Jul	2004	33	0 (0, 2.5)	30	1 (0, 21.2)	354.5	0.04
Aug	2004	15	1 (0, 24)	14	43.5 (3.5, 75)	44.5	0.01
Sep	2004	18	0 (0, 0)	15	16 (1, 45)	44.5	< 0.01
1/4-inch mesh conical minnow trap							
Jun	2003	30	0 (0, 1)	22	0 (0, 0.5)	321	0.83
Jul	2003	15	0 (0, 1)	16	0 (0, 6.5)	109.5	0.60
Aug	2003	31	1 (0, 9)	30	0 (1, 29.5)	331.5	0.05
Sep	2003	16	0 (0, 2.5)	16	4.5 (0.2, 36)	62	0.01
Jun	2004	31	0 (0, 0)	35	0 (0, 3)	392.5	< 0.01
Jul	2004	34	0 (0, 8.25)	31	0 (0, 5)	510.5	0.81
Aug	2004	16	0 (0, 2)	14	3.5 (0, 15.5)	70.5	0.07
Sep	2004	18	0 (0, 0.2)	15	4 (0, 38)	59	< 0.01

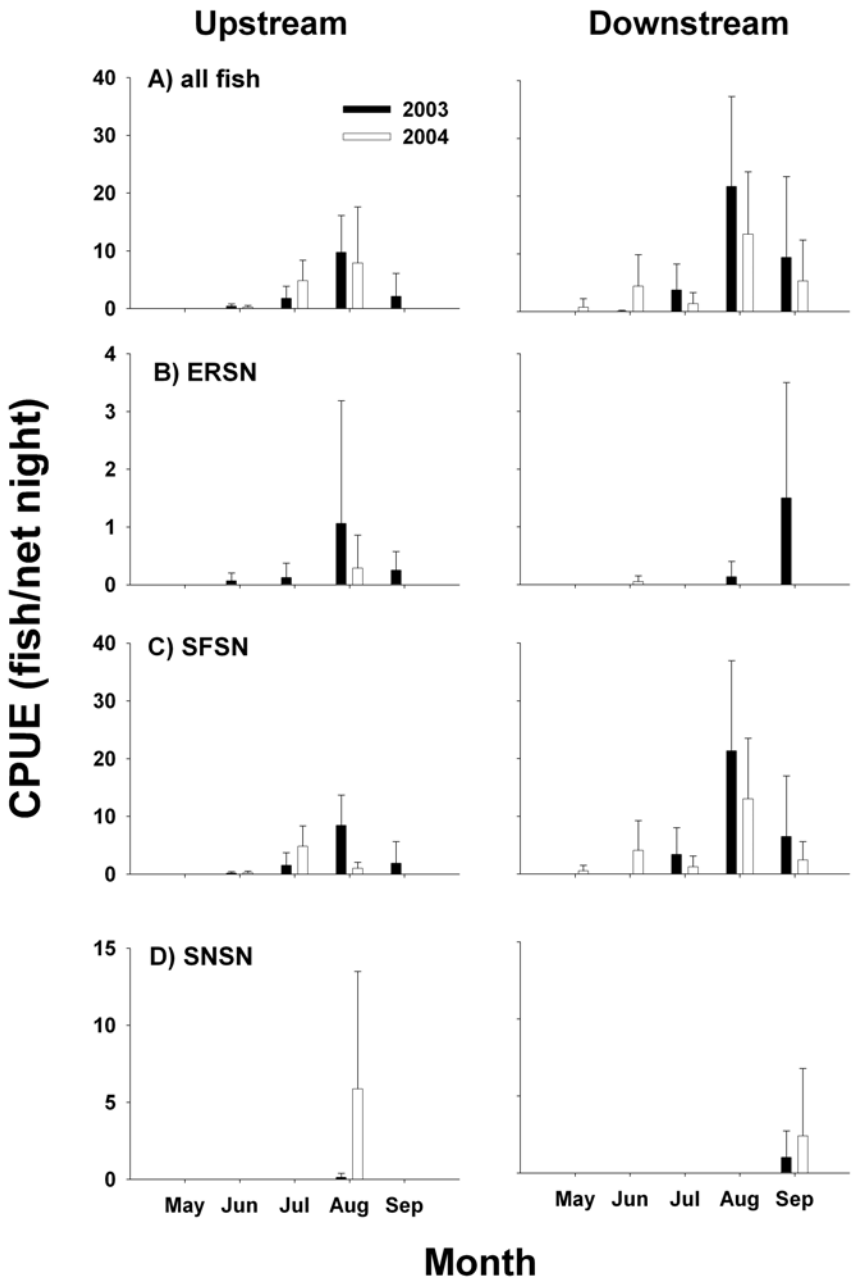


Figure 22. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with 1/8-inch mesh conical minnow traps set at upstream and downstream locations in the Missouri River downstream of Fort Randall Dam during 2003 and 2004 for: A) all fish species, B) emerald shiners (ERSN), C) spotfin shiners (SFSN), and D) sand shiners (SNSN). Note differing y-axis scales.

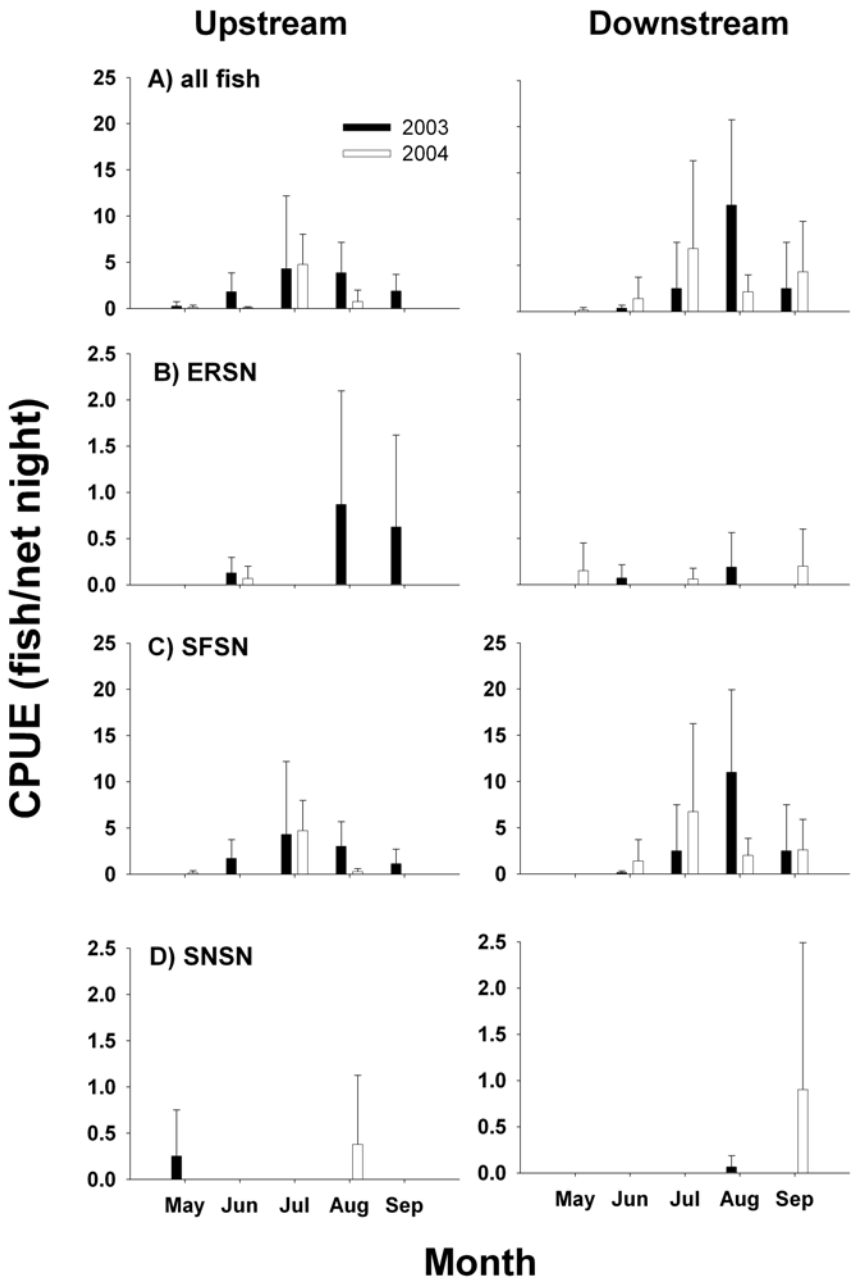


Figure 23. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with 1/4-inch mesh conical minnow traps set at upstream and downstream locations in the Missouri River downstream of Fort Randall Dam during 2003 and 2004 for: A) all fish species, B) emerald shiners (ERSN), C) spotfin shiners (SFSN), and D) sand shiners (SNSN). Note differing y-axis scales.

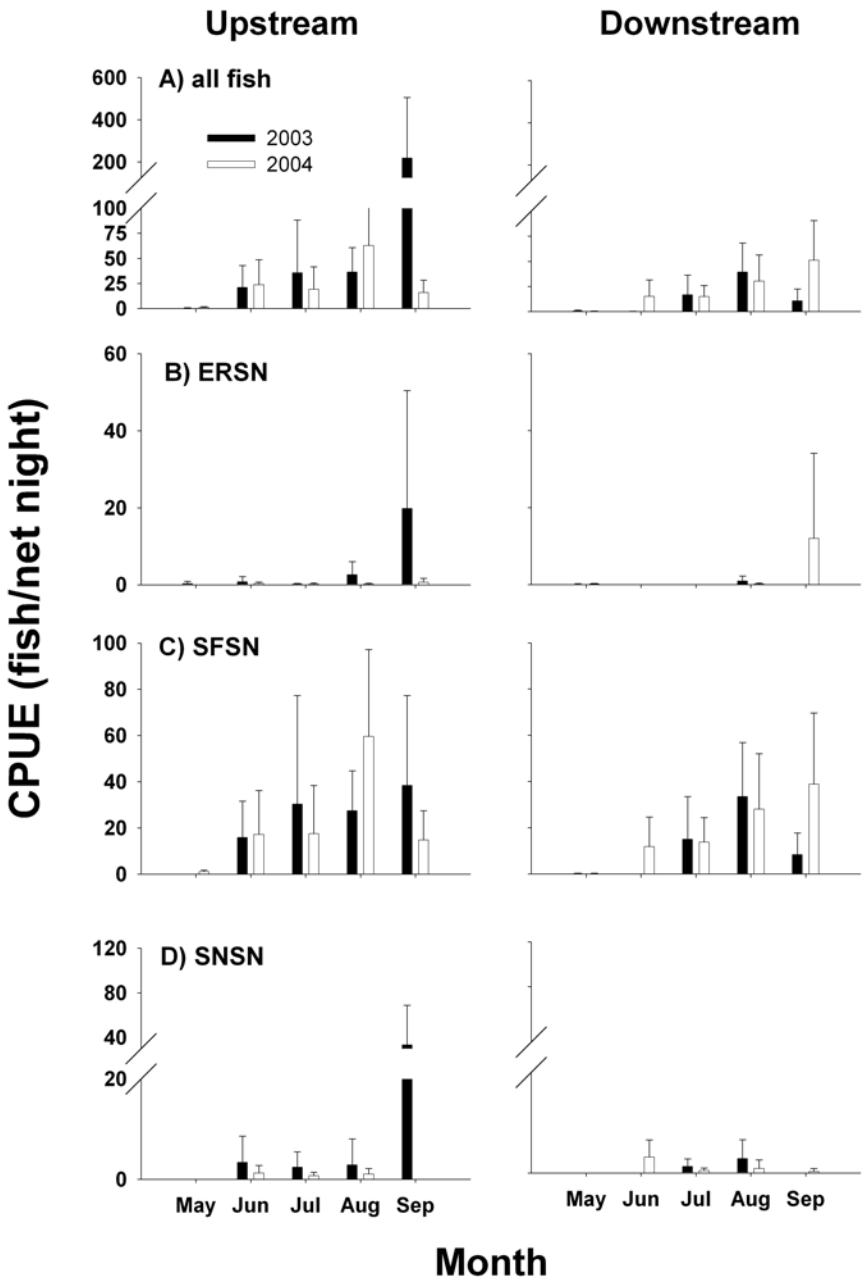


Figure 24. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with 1/8-inch mesh conical minnow traps set at upstream and downstream locations in the Missouri River downstream of Gavins Point Dam during 2003 and 2004 for: A) all fish species, B) emerald shiners (ERSN), C) spotfin shiners (SFSN), and D) sand shiners (SNSN). Note differing y-axis scales.

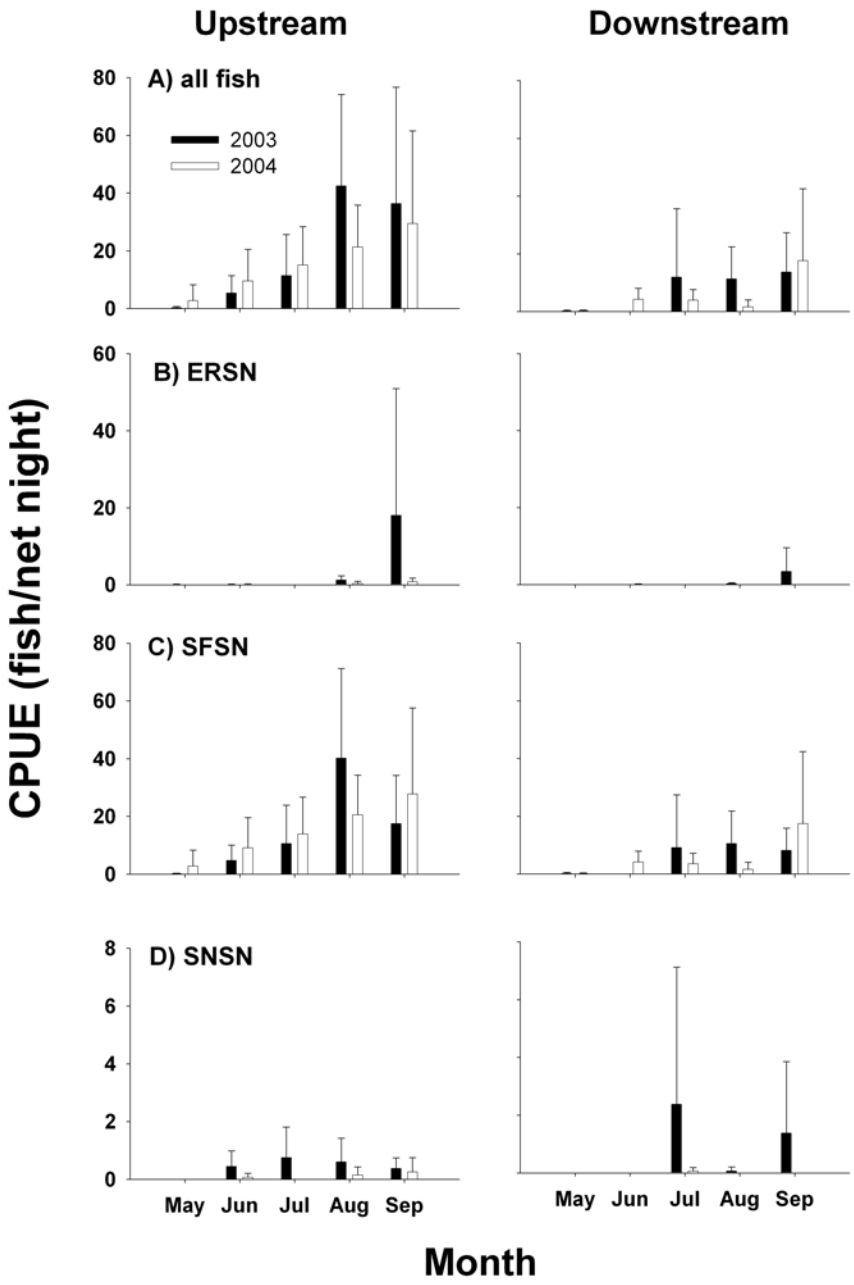


Figure 25. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with 1/4-inch mesh conical minnow traps set at upstream and downstream locations in the Missouri River downstream of Gavins Point Dam during 2003 and 2004 for: A) all fish species, B) emerald shiners (ERSN), C) spotfin shiners (SFSN), and D) sand shiners (SNSN). Note differing y-axis scales.

Table 6. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between upstream and downstream locations within the Fort Randall Reach of the Missouri River caught with minnow traps during 2003 and 2004. Minnow trap CPUE was fish/trap night.

Month	Year	Upstream		Downstream		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
1/8-inch mesh conical minnow trap							
June	2003	15	0 (0, 0)	15	0 (0, 1)	83.5	0.15
July	2003	8	1 (0, 1.8)	8	1 (0, 7.8)	30	0.82
August	2003	16	2.5 (0, 21.8)	15	3 (0, 44)	106.5	0.58
September	2003	8	0 (0, 0.8)	8	2 (0.3, 6.5)	16	0.07
June	2004	14	0 (0, 0)	20	0 (0, 1)	115	0.24
July	2004	17	0 (0, 9.5)	18	0 (0, 0.8)	99	0.12
August	2004	7	0 (0, 24)	8	10.5 (0, 24)	23	0.54
September	2004	8	0 (0, 0)	10	0 (0, 6)	28	0.10
1/4-inch mesh conical minnow trap							
June	2003	16	0 (0, 1)	14	0 (0, 1)	104	0.68
July	2003	7	0 (0, 1)	8	0 (0, 0)	20	0.23
Aug	2003	15	1 (0, 4)	16	1.5 (0, 19.5)	93	0.27
September	2003	8	0.5 (0, 3.8)	8	0 (0, 0)	22	0.20
June	2004	15	0 (0, 0)	20	0 (0, 0)	144	0.68
July	2004	17	0 (0, 9.5)	17	0 (0, 4.5)	125	0.45
August	2004	8	0 (0, 0.8)	8	1.5 (0, 4.3)	19	0.13
September	2004	8	0 (0, 0)	10	0 (0, 5.5)	24	0.05

Table 7. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between upstream and downstream locations within the Gavins Point Reach of the Missouri River caught with minnow traps during 2003 and 2004. Minnow trap CPUE was fish/trap night.

Month	Year	Upstream		Downstream		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
1/8-inch mesh conical minnow trap							
June	2003	16	0 (0, 12)	7	0 (0, < 0.0001)	36	0.12
July	2003	8	2 (0.2, 40.5)	8	0.5 (0, 45.8)	25.5	0.48
August	2003	16	6 (2.3, 76.8)	16	17.5 (2.5, 50)	119.5	0.75
September	2003	8	19 (0.3, 341.8)	6	6 (0, 20.5)	17.5	0.40
June	2004	15	3 (0, 14)	16	0 (0, 19.8)	106.5	0.57
July	2004	13	1 (0, 16)	17	2 (0, 23)	108	0.91
August	2004	7	68 (5, 84)	7	26 (0, 55)	13	0.14
September	2004	8	9.5 (0.3, 33.8)	7	24 (7, 119)	17.5	0.22
1/4-inch mesh conical minnow trap							
June	2003	16	0 (0, 2.8)	6	0 (0, 0)	33	0.13
July	2003	8	1 (0, 20)	8	0 (0, 0)	22	0.20
August	2003	15	5 (0, 95)	15	3 (1, 7)	97	0.52
September	2003	8	10 (2, 61.5)	8	3.5 (0, 32.3)	20	0.20
June	2004	15	0 (0, 2)	16	0 (0, 9)	110.5	0.66
July	2004	15	0 (0,39)	16	0 (0, 5)	102.5	0.44
August	2004	7	12 (6, 46)	7	0 (0, 1)	6	0.02
September	2004	8	11 (0.3, 39.5)	7	4 (0, 24)	23.5	0.60

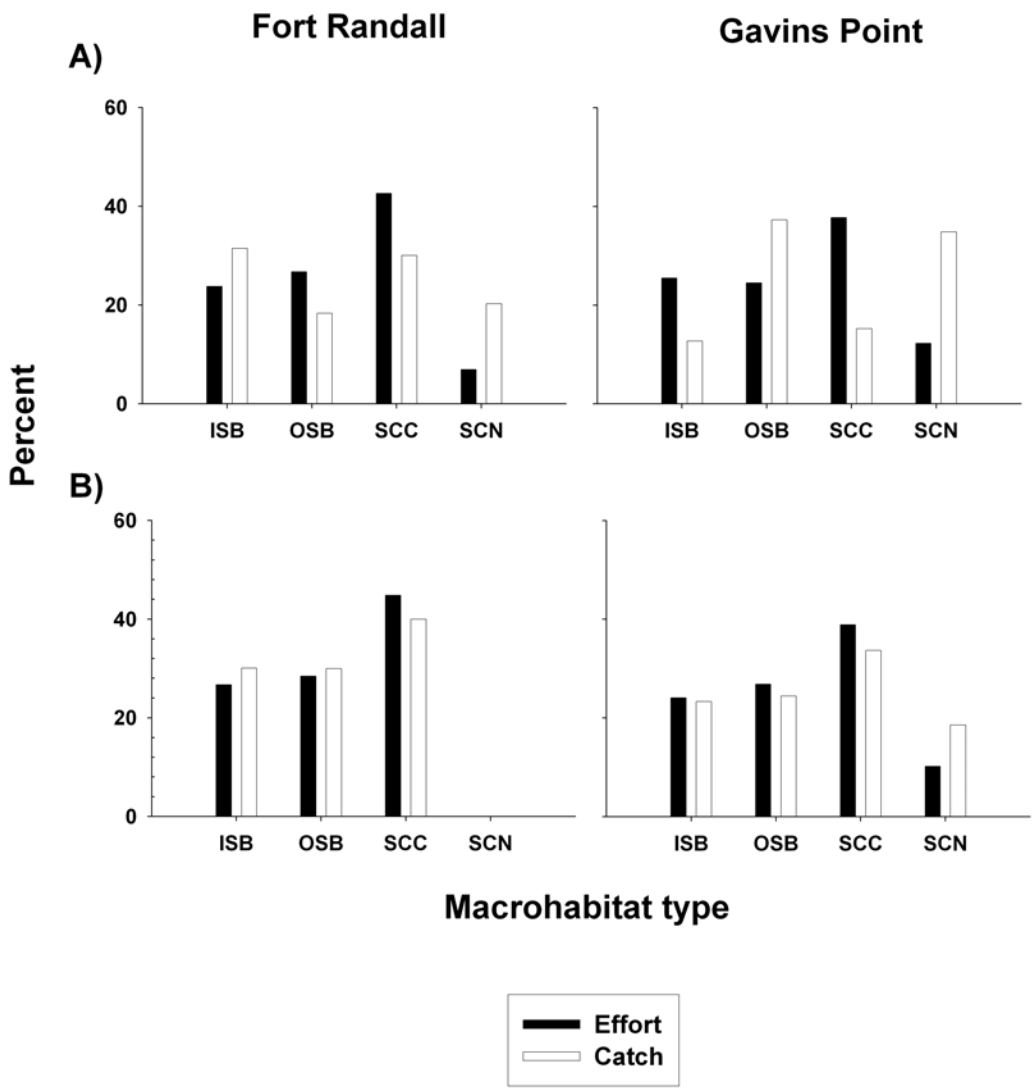


Figure 26. Proportion of 1/8-inch mesh conical minnow trap effort (as deployments) and catch for all fish species in four macrohabitat types, inside bends (ISB), outside bends (OSB), secondary connected channels (SCC), and secondary non-connected channels (SCN), in the Missouri River downstream of Fort Randall and Gavins Point dams during: A) 2003 and B) 2004.

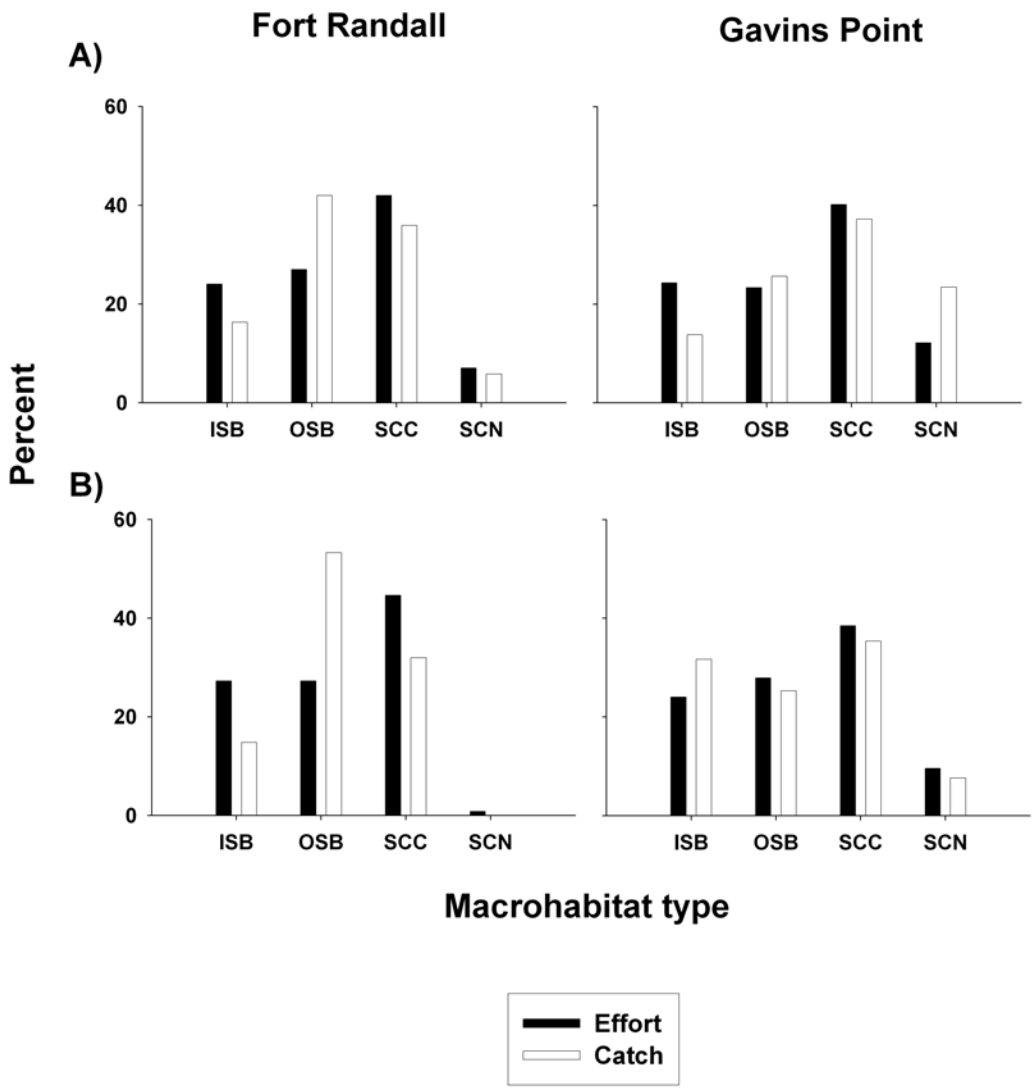


Figure 27. Proportion of 1/4-inch mesh conical minnow trap effort (as deployments) and catch for all fish species in four macrohabitat types, inside bends (ISB), outside bends (OSB), secondary connected channels (SCC), and secondary non-connected channels (SCN), in the Missouri River downstream of Fort Randall and Gavins Point dams during: A) 2003 and B) 2004.

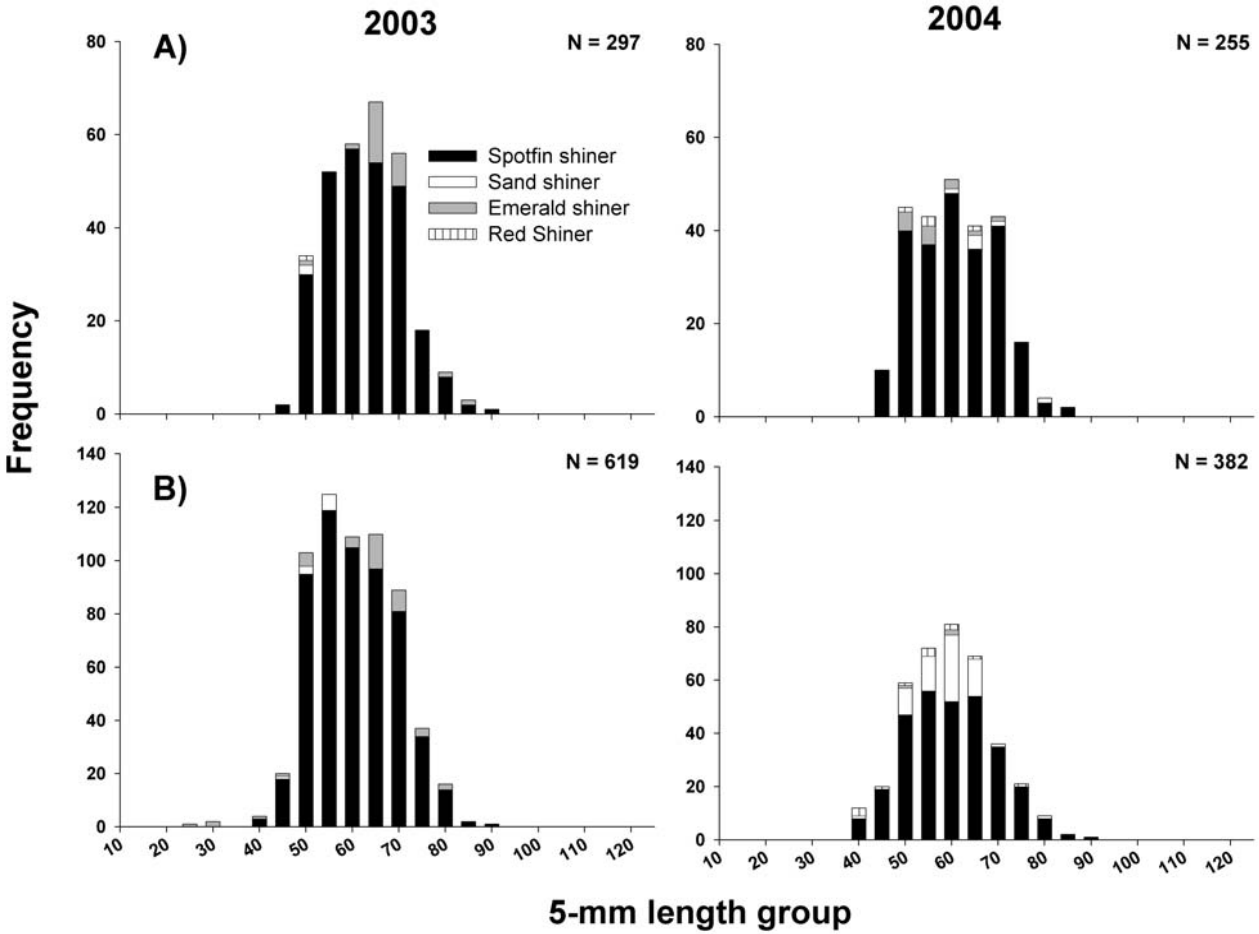


Figure 28. Length frequency of cyprinids caught with A) 1/4-inch mesh conical minnow traps and B) 1/8-inch mesh conical minnow traps in the Missouri River downstream of Fort Randall Dam during 2003 and 2004.

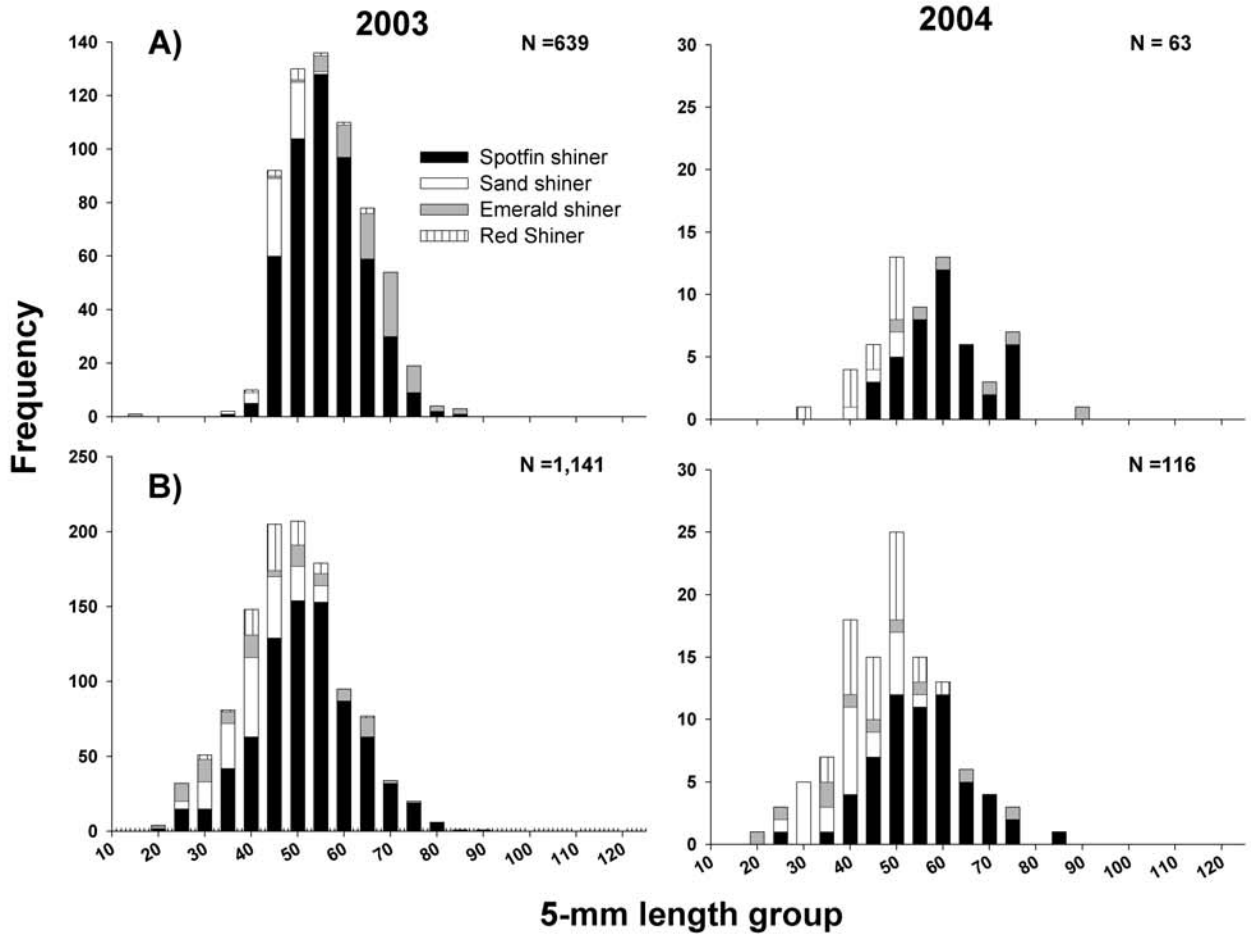


Figure 29. Length frequency of cyprinids caught with A) 1/4-inch mesh conical minnow traps and B) 1/8-inch mesh conical minnow traps in the Missouri River downstream of Gavins Point Dam during 2003 and 2004.

Fish relative abundance – bag seines

In 2003 and 2004, the mean relative abundance of all fishes captured with bag seines in the Missouri River was greater downstream of Gavins Point Dam compared to the Fort Randall Reach (Figure 30). For both years, mean abundance of all fishes ranged from 0.028 - 0.244 fish/m^2 in the Fort Randall Reach; whereas, fish abundance in the Gavins Point Reach was > 0.275 fish/m^2 in all months except for July of 2004. Due to the high incidence of zero catches with bag seines, especially in the Fort Randall Reach, mean CPUE of fish could not be transformed to achieve normality (log10, reciprocal, square root, and arcsine) and necessitated use of non-parametric statistics. Compared to the Fort Randall Reach, median abundance of all fishes was significantly greater downstream of Gavins Point Dam in all months during 2003 and 2004 (Table 8). Seasonal trends in relative abundance differed in 2003 and 2004 in the Fort Randall Reach; collective catches declined from July to September of 2003 while catches remained fairly uniform during 2004. In contrast, collective bag seine catches peaked during August of both years in the Gavins Point Reach.

Relative abundance of nine species that were commonly captured with bag seines in the Missouri River in the Fort Randall or Gavins Point reaches differed between reaches except for emerald shiners and spotfin shiners (Figure 30). During 2003 and 2004, emerald shiners were the most abundant species captured downstream of Fort Randall Dam (Appendix G) while unidentified carpsuckers (*Carpiodes* spp.) were the most abundant species captured in the Gavins Point Reach (Appendix H). Bigmouth shiners, sand shiners, *Carpiodes* spp., YOY gizzard shad, and white bass relative abundance was generally greater downstream of Gavins Point Dam compared the Fort Randall Reach. Smallmouth bass (mainly YOY) relative abundance was generally greater throughout the summer in 2003 and 2004 in the Fort Randall Reach compared

to the Gavins Point Reach and peaked in August. Relative abundance of catastomids (carp suckers and redhorses) generally peaked in August in both reaches in both years.

The relative abundance of shallow water fishes caught in the Missouri River during summer of 2003 and 2004 with the bag seine was generally greater at sites in proximity to the major tributary within each reach. However, the study location with the major tributary in both reaches, the Niobrara River at the downstream site in the Fort Randall Reach and the James River at the upstream site in the Gavins Point Reach, was also the Missouri River sites closest to the reservoir, Lewis and Clark Lake (Figures 1 and 2). Mean monthly bag seine CPUE of all fishes in the Fort Randall Reach during 2003 and 2004 ranged from 0.02 – 0.29 fish/m^2 at the upstream site and ranged from 0.03 – 0.31 fish/m^2 at the downstream site (Figure 31). Mean monthly relative abundance of fishes in the Gavins Point Reach (Figure 32) at the upstream site ranged from 0.18 – 0.52 fish/m^2 compared to the downstream site (range 0.10 – 0.38 fish/m^2). For both reaches, the monthly median CPUE of all fish species in the Missouri River was either similar or significantly greater at the location associated with a major tributary and nearest to Lewis and Clark Lake (Tables 9 and 10).

Spatial relative abundance of species common in one or both reaches of the Missouri River differed in relation to the combined proximity of the major tributary and reservoir (Figures 31 and 32). In both years, bigmouth shiners in both reaches were more abundant at the site with a major tributary confluence nearest to Lewis and Clark Lake. In general, monthly CPUE of gizzard shad and smallmouth bass in both reaches was highest at the site in proximity to a tributary confluence and Lewis and Clark Lake. Spatial patterns for sand shiners, spotfin shiners,

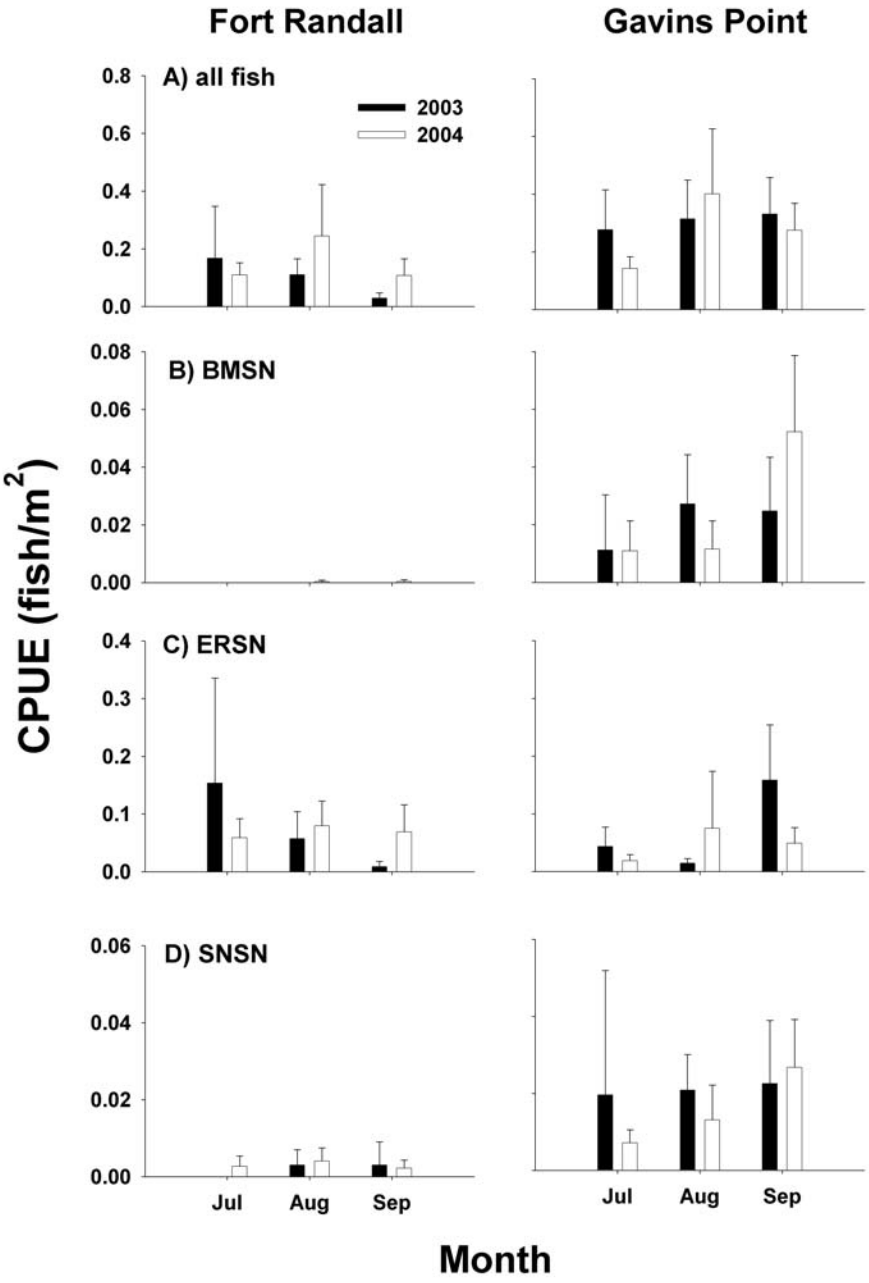


Figure 30. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with bag seines in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004 for: A) all fish species, B) bigmouth shiners (BMSN), C) emerald shiners (ERSN), D) sand shiners (SNSN), E) spotfin shiners (SFSN), F) unidentified carpsuckers, i.e., *Carpiodes* spp. (UCS), G) unidentified redhorses, i.e., *Moxostoma* spp. (URH), H) gizzard shad (GZSD), I) smallmouth bass (SMBS), and J) white bass (WTBS). Note differing y-axis scales among species.

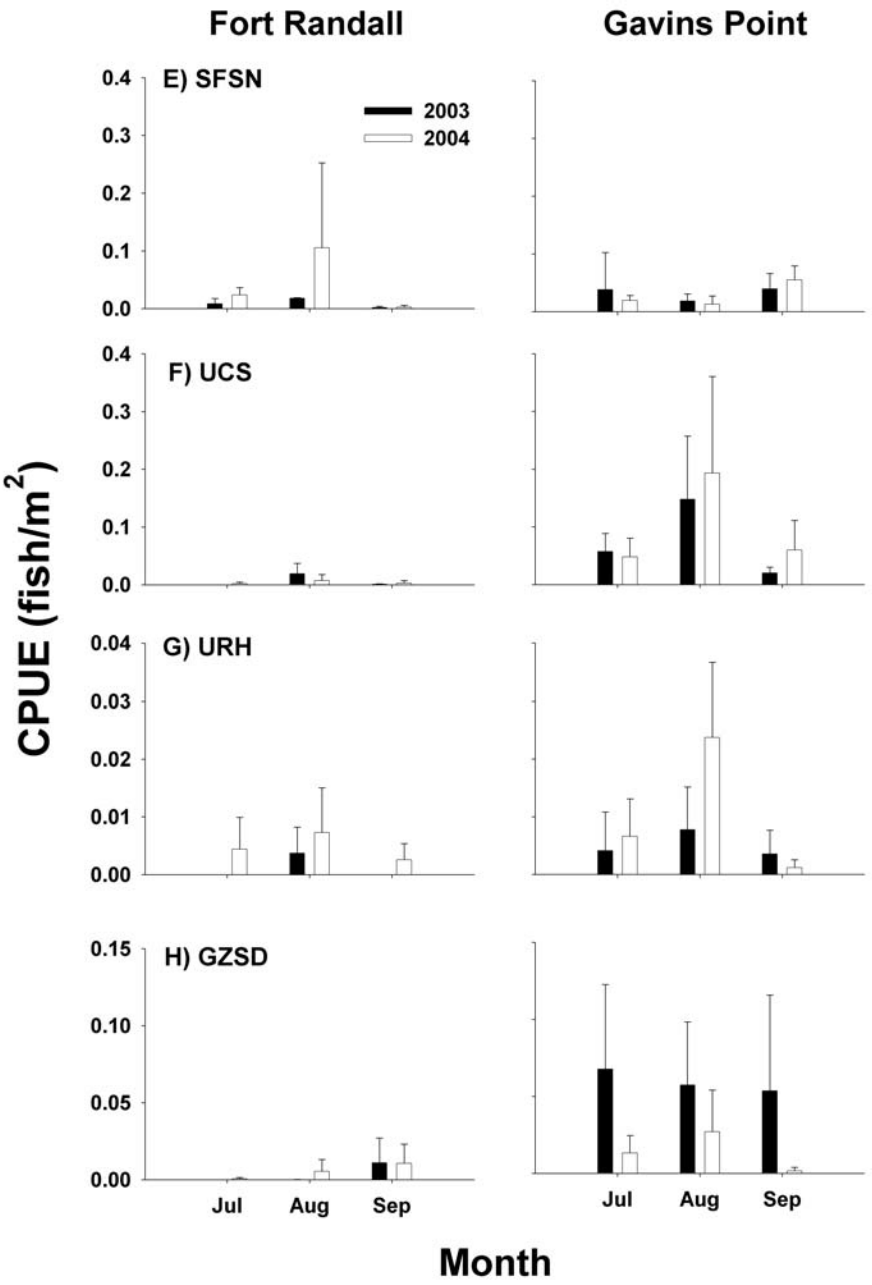


Figure 30. (continued).

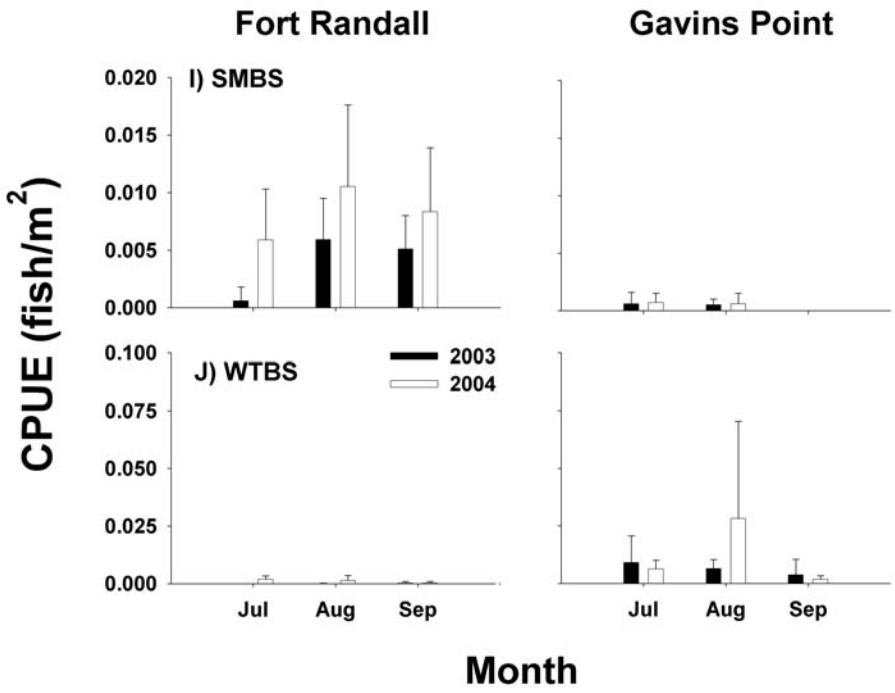


Figure 30. (continued).

Table 8. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between the Fort Randall and Gavins Point reaches of the Missouri River caught with bag seines during 2003 and 2004. Bag seine CPUE was fish/m^2.

Month	Year	Fort Randall Reach		Gavins Point Reach		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
Jul	2003	26	0.011 (0, 0.109)	30	0.192 (0.045, 0.377)	205	< 0.01
Aug	2003	76	0.027 (0, 0.101)	101	0.108 (0.031, 0.313)	2267	< 0.01
Sep	2003	49	0.015 (0, 0.023)	50	0.160 (0.058, 0.431)	307	< 0.01
Jul	2004	115	0.031 (0, 0.108)	128	0.046 (0.055, 0.185)	6080.5	0.02
Aug	2004	57	0.077 (0, 0.246)	48	0.146 (0.050, 0.361)	959	0.01
Sep	2004	48	0.046 (0, 0.138)	53	0.138 (0.038, 0.338)	798.5	< 0.01

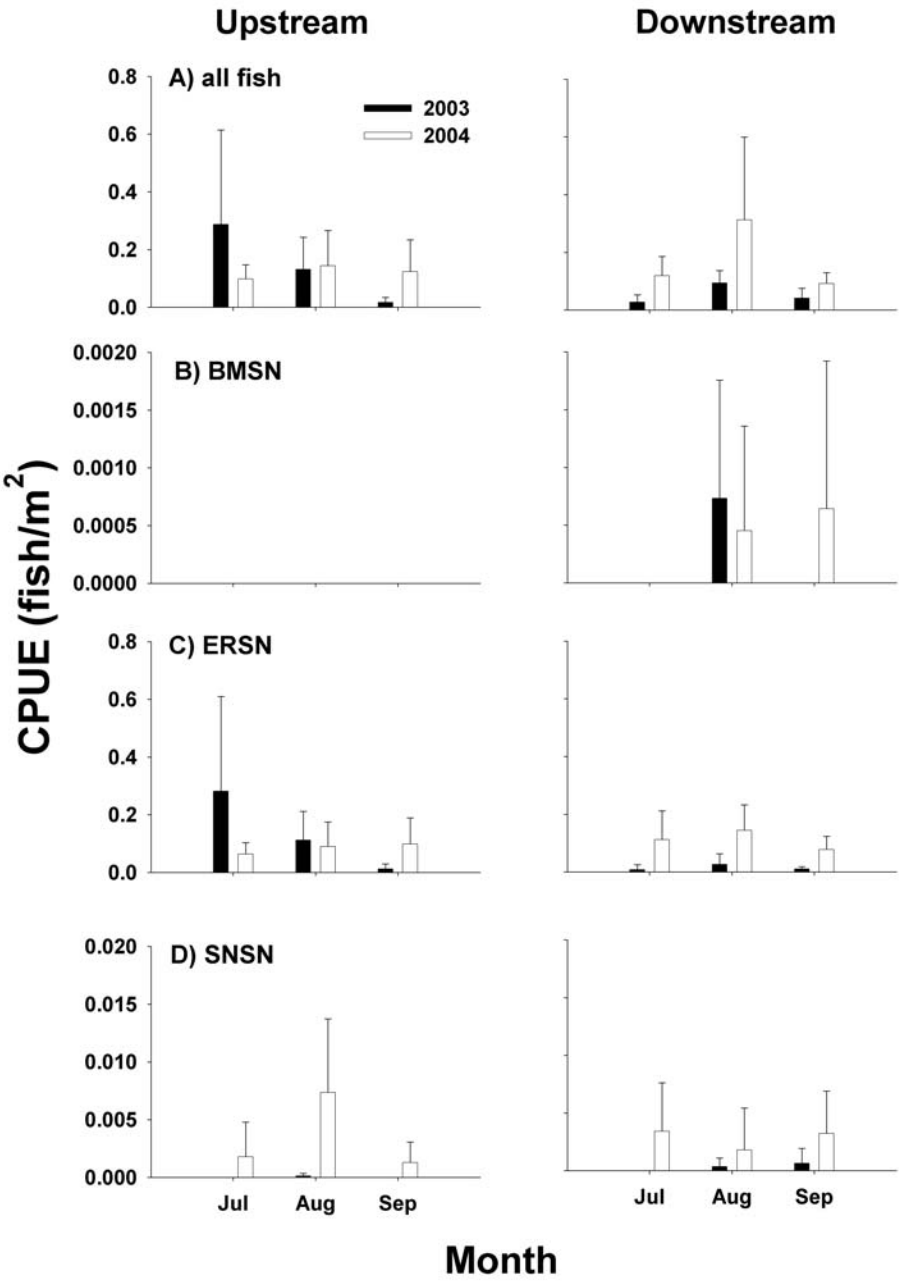
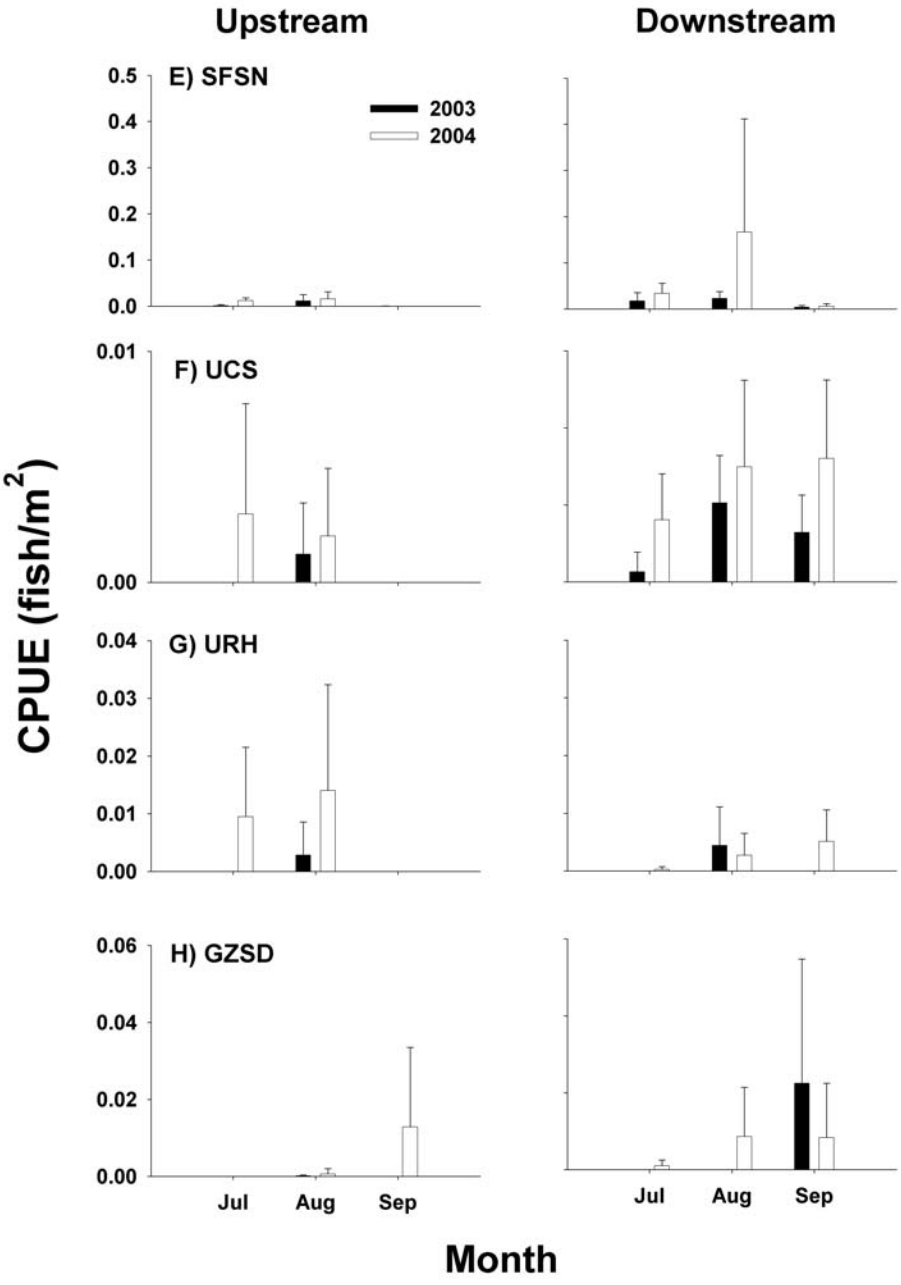


Figure 31. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with bag seines at upstream and downstream locations in the Missouri River downstream of Fort Randall Dam during 2003 and 2004 for: A) all fish species, B) bigmouth shiners (BMSN), C) emerald shiners (ERSN), D) sand shiners (SNSN), E) spotfin shiners (SFSN), F) unidentified carpsuckers, i.e., *Carpiodes* spp. (UCS), G) unidentified redhorses, i.e., *Moxostoma* spp. (URH), H) gizzard shad (GZSD), I) smallmouth bass (SMBS), and J) white bass (WTBS). Note differing y-axis scales among species.



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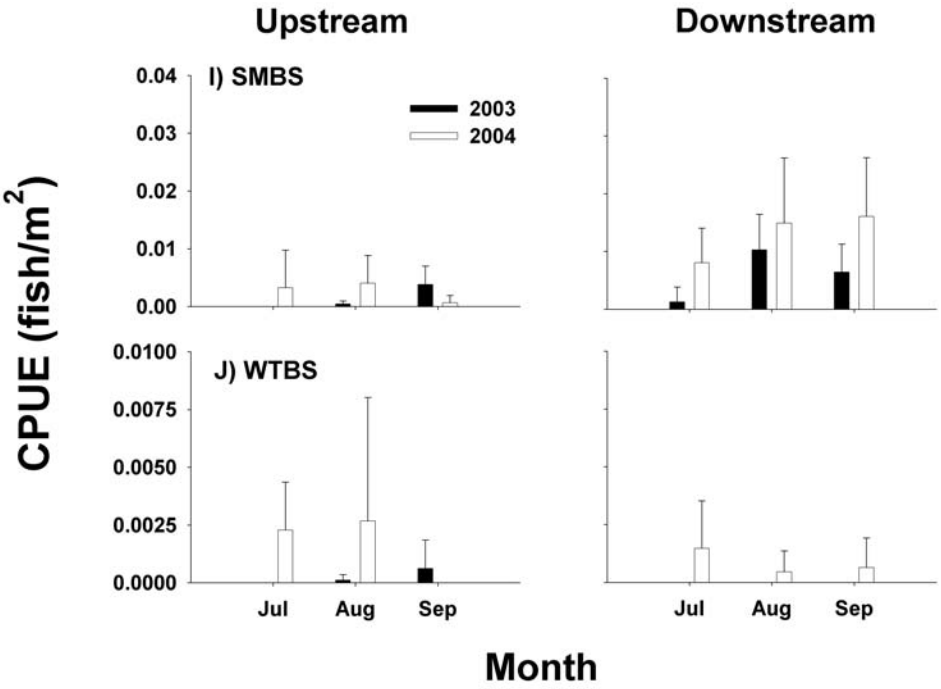

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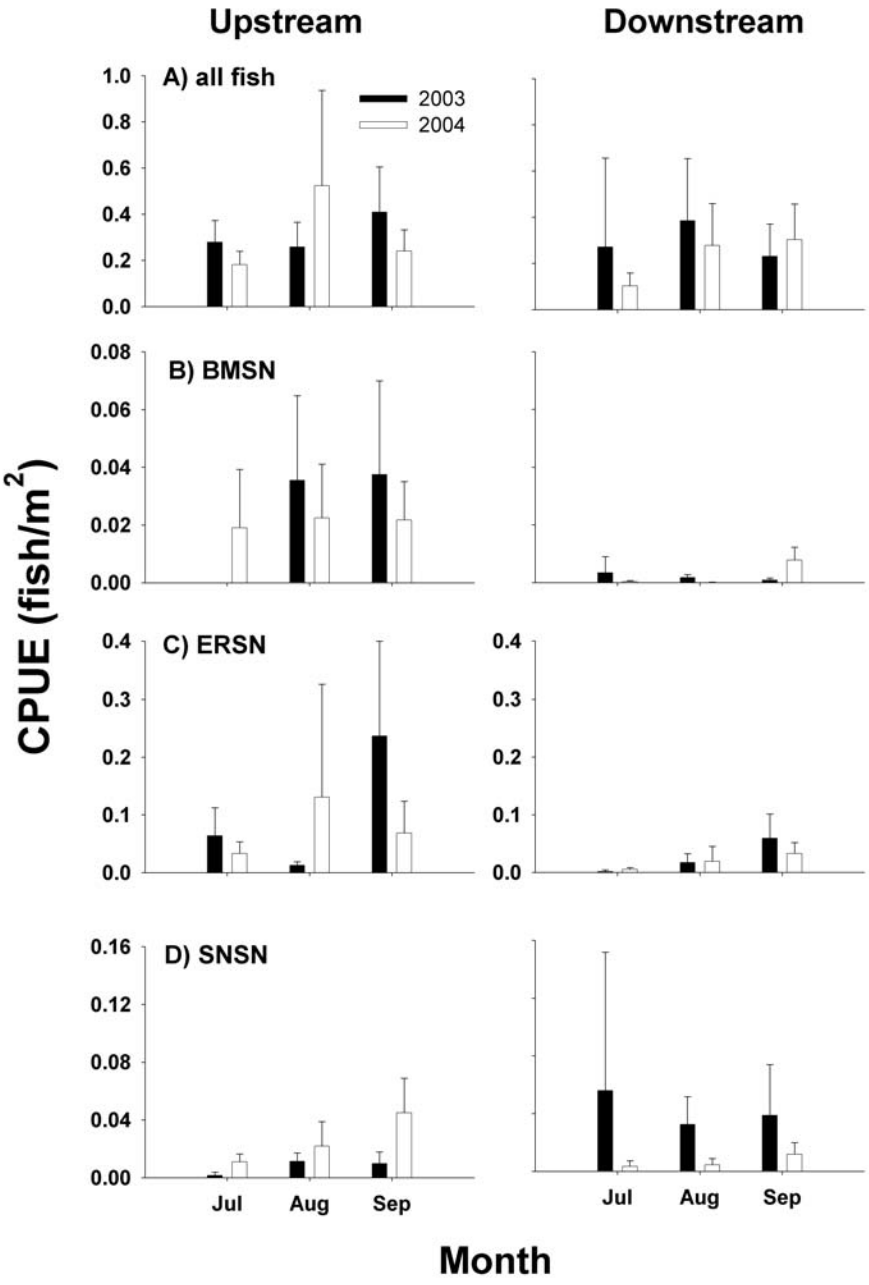
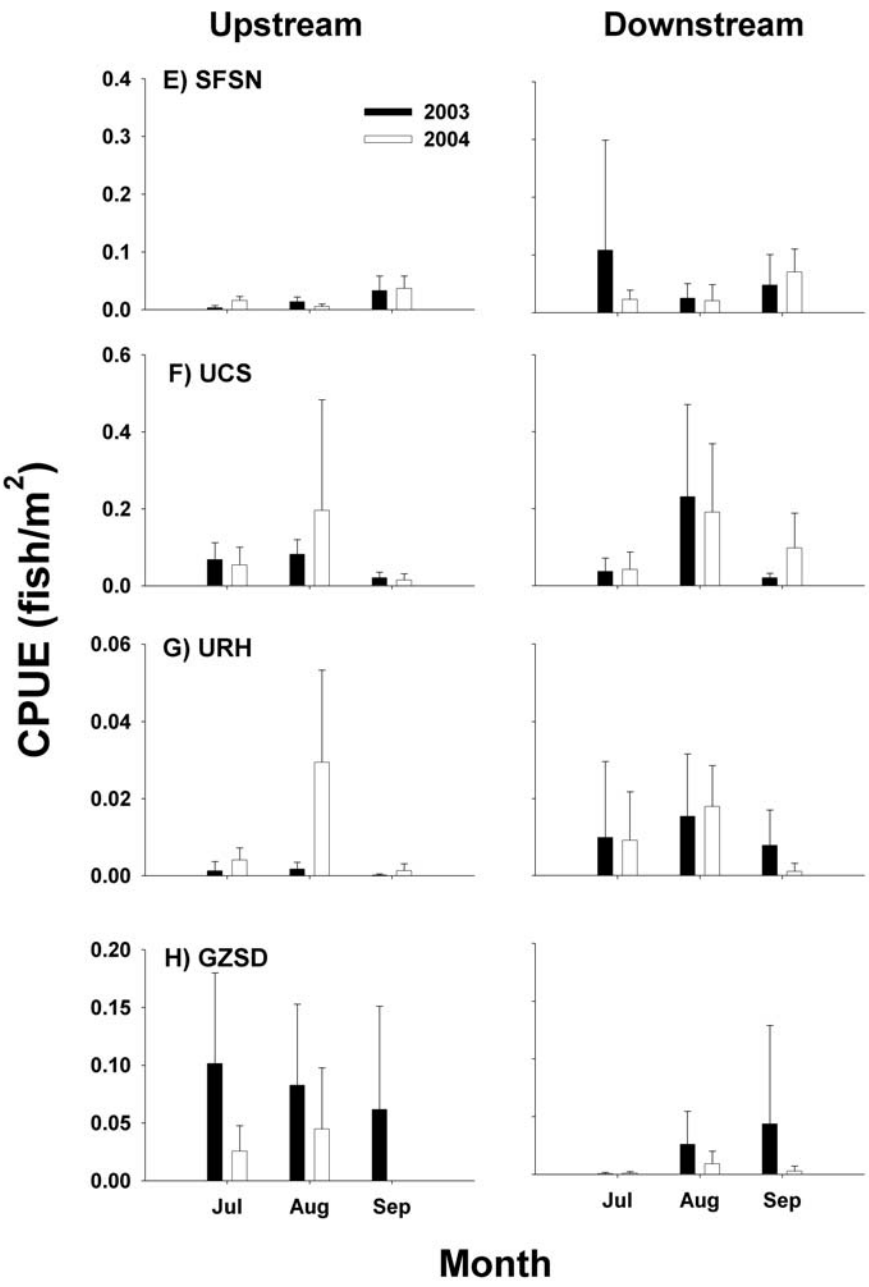


Figure 32. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with bag seines at upstream and downstream locations in the Missouri River downstream of Gavins Point Dam during 2003 and 2004 for: A) all fish species, B) bigmouth shiners (BMSN), C) emerald shiners (ERSN), D) sand shiners (SNSN), E) spotfin shiners (SFSN), F) unidentified carpsuckers, i.e., *Carpiodes* spp. (UCS), G) unidentified redhorses, i.e., *Moxostoma* spp. (URH), H) gizzard shad (GZSD), I) smallmouth bass (SMBS), and J) white bass (WTBS). Note differing y-axis scales among species.



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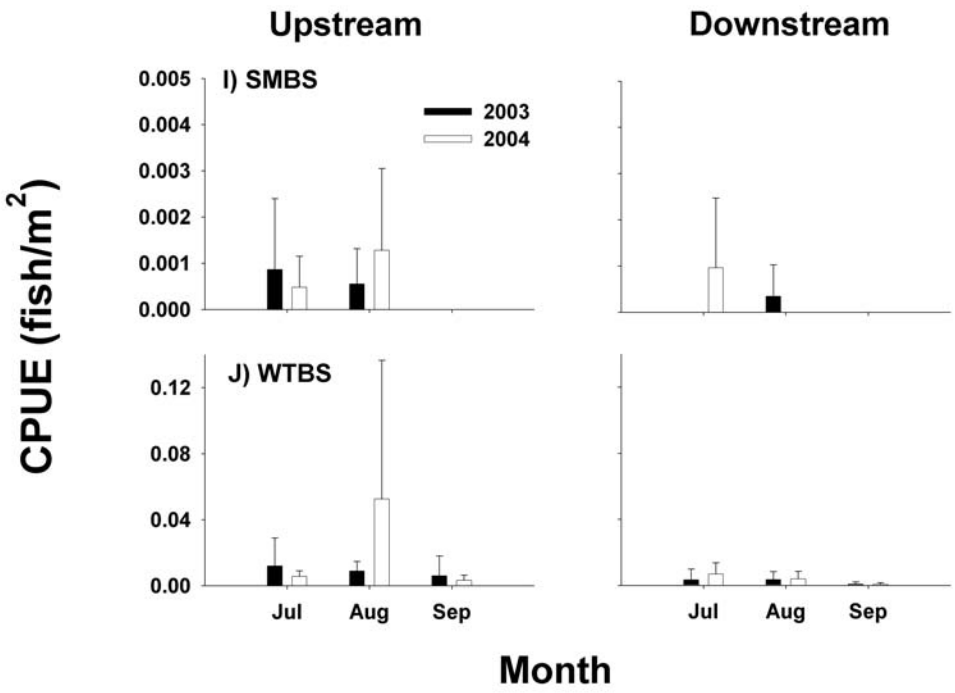


Figure 32. (continued).

Table 9. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between upstream and downstream locations within the Fort Randall Reach of the Missouri River caught with bag seines during 2003 and 2004. Bag seine CPUE was fish/m^2.

Month	Year	Upstream		Downstream		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
July	2003	14	0.031 (0, 0.269)	12	0.003 (0, 0.062)	58	0.16
August	2003	34	0 (0, 0.080)	42	0.031 (0.015, 0.115)	487	0.01
September	2003	25	0 (0, 0.015)	24	0.015 (0, 0.046)	202	0.04
July	2004	53	0.015 (0, 0.108)	62	0.031 (0, 0.096)	1510.5	0.45
August	2004	23	0.031 (0, 0.138)	34	0.085 (0.012, 0.258)	304.5	0.15
September	2004	24	0.015 (0, 0.131))	24	0.062 (0.019, 0.138	222.5	0.17

Table 10. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between upstream and downstream locations within the Gavins Point Reach of the Missouri River caught with bag seines during 2003 and 2004. Bag seine CPUE was fish/m^2.

Month	Year	Upstream		Downstream		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
July	2003	20	0.227 (0.111, 0.434)	10	0.091 (0, 0.214)	54.5	0.05
August	2003	56	0.115 (0.031, 0.313)	45	0.077 (0.034, 0.315)	1244	0.11
September	2003	28	0.192 (0.076, 0.548)	22	0.123 (0.023, 0.273)	223	0.10
July	2004	64	0.123 (0.031, 0.246)	64	0.015 (0, 0.108)	1239.5	< 0.01
August	2004	24	0.200 (0.085, 0.381)	24	0.085 (0.031, 0.308)	207.5	0.10
September	2004	24	0.192 (0.046, 0.346)	29	0.108 (0.031, 0.354)	315.5	0.56

Carpiodes spp., *Moxostoma* spp., and white bass relative abundance were not consistent between upstream and downstream sites within each reach. Emerald shiners were generally more abundant at the upstream site within the Gavins Point Reach but did not appreciably differ spatially within the Fort Randall Reach.

Total fish caught with bag seines did not differ appreciably among macrohabitats in the Missouri River when compared to effort expended (as deployments) in each habitat type during 2003 and 2004 (Figures 33). The only macrohabitat where the difference in the percentage of the total catch was > 15% of the effort expended in that habitat was for inside bends in the Fort Randall Reach during 2003. The percentage of effort exceeded the total catch by > 15% only in secondary connected channels in the Fort Randall Reach during 2004 and in outside bends of the Gavins Point Reach during 2003.

Fish relative abundance – mini-fyke nets

Mean relative abundance of shallow water fishes within the Fort Randall and Gavins Point reaches of the Missouri River were generally similar in 2003 and 2004 but timing of a large peak in abundance during 2003 differed in each reach (Figure 34). In the Fort Randall Reach, mean relative abundance of fishes caught with mini-fyke nets ranged from 18 – 269 fish/net night while abundance in the Gavins Point Reach ranged from 28 – 209 fish/net night during this study. Large peaks of mean relative abundance in 2003 occurred in the Fort Randall Reach during July and in September for the Gavins Point Reach. These peaks in both reaches were composed primarily of emerald shiners and spotfin shiners. Other than the large peak in total fish abundance observed in each reach during 2003, mean relative abundance for the other months within each reach was generally similar for 2003 and 2004. Compared to the Fort

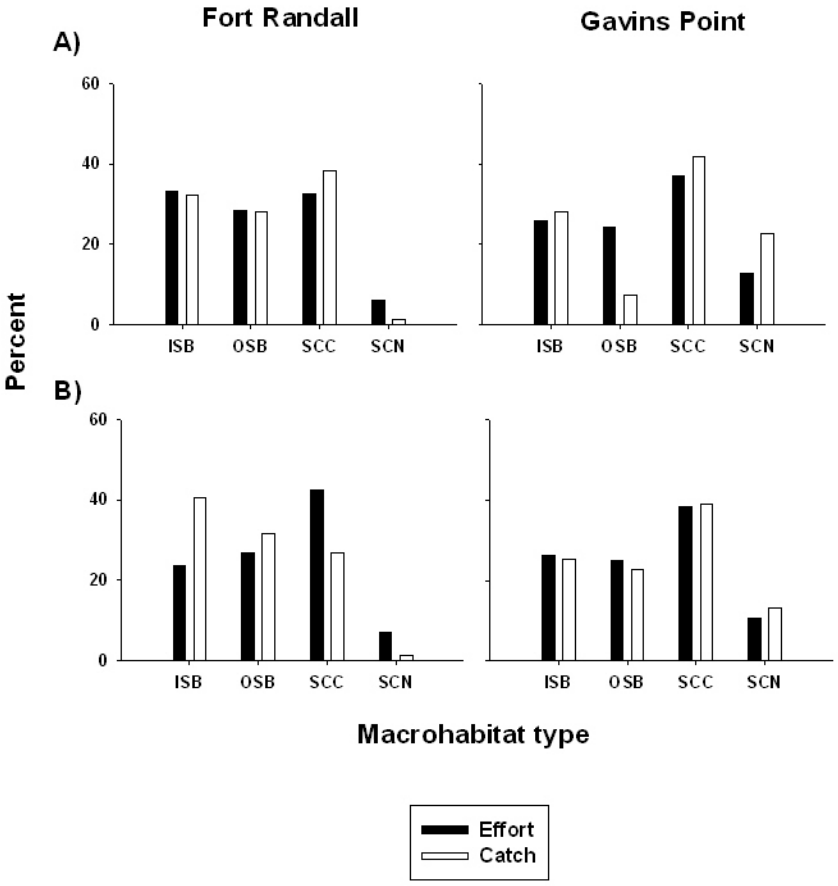


Figure 33. Proportion of bag seine effort (as hauls) and catch for all fish species in four macrohabitat types, inside bends (ISB), outside bends (OSB), secondary connected channels (SCC), and secondary non-connected channels (SCN), in the Missouri River downstream of Fort Randall and Gavins Point dams during: A) 2003 and B) 2004.

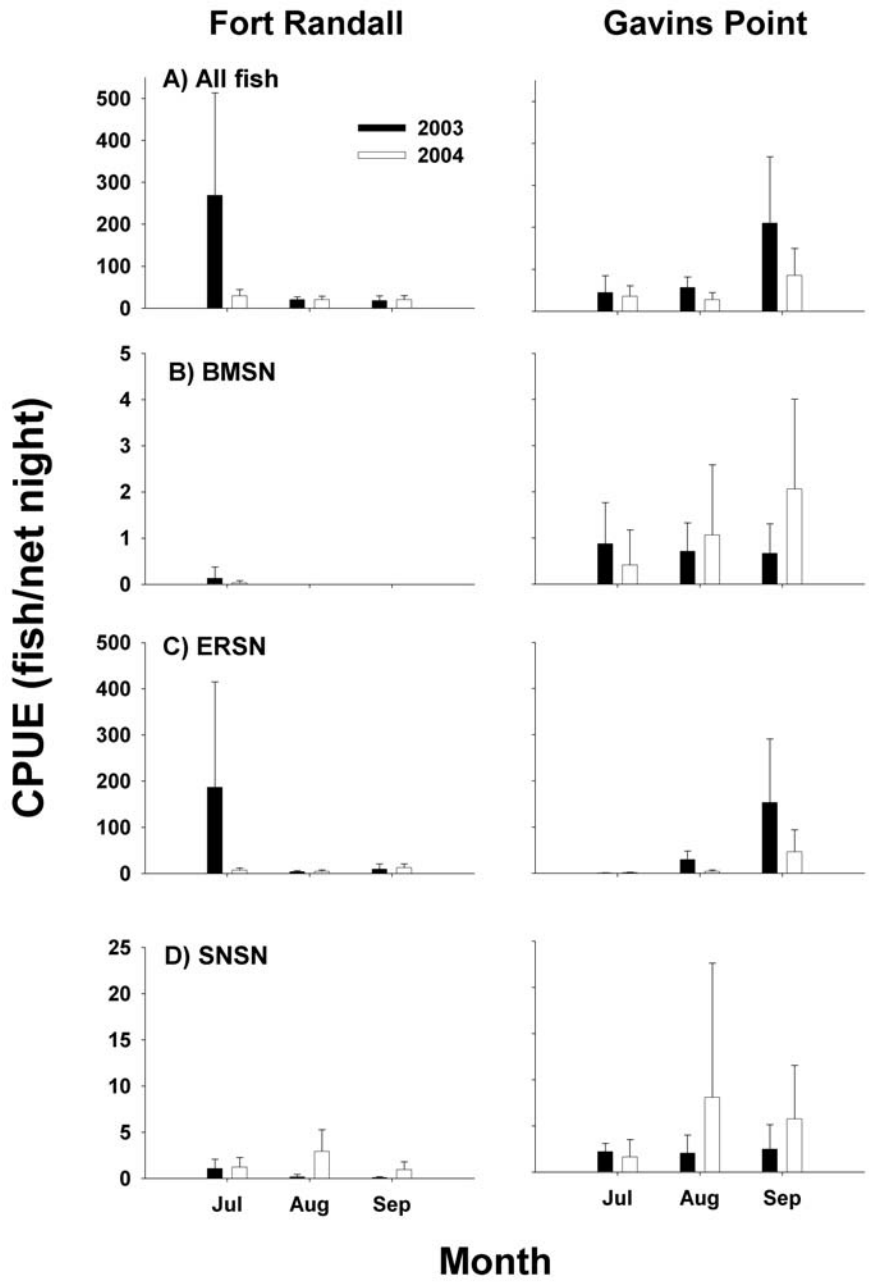
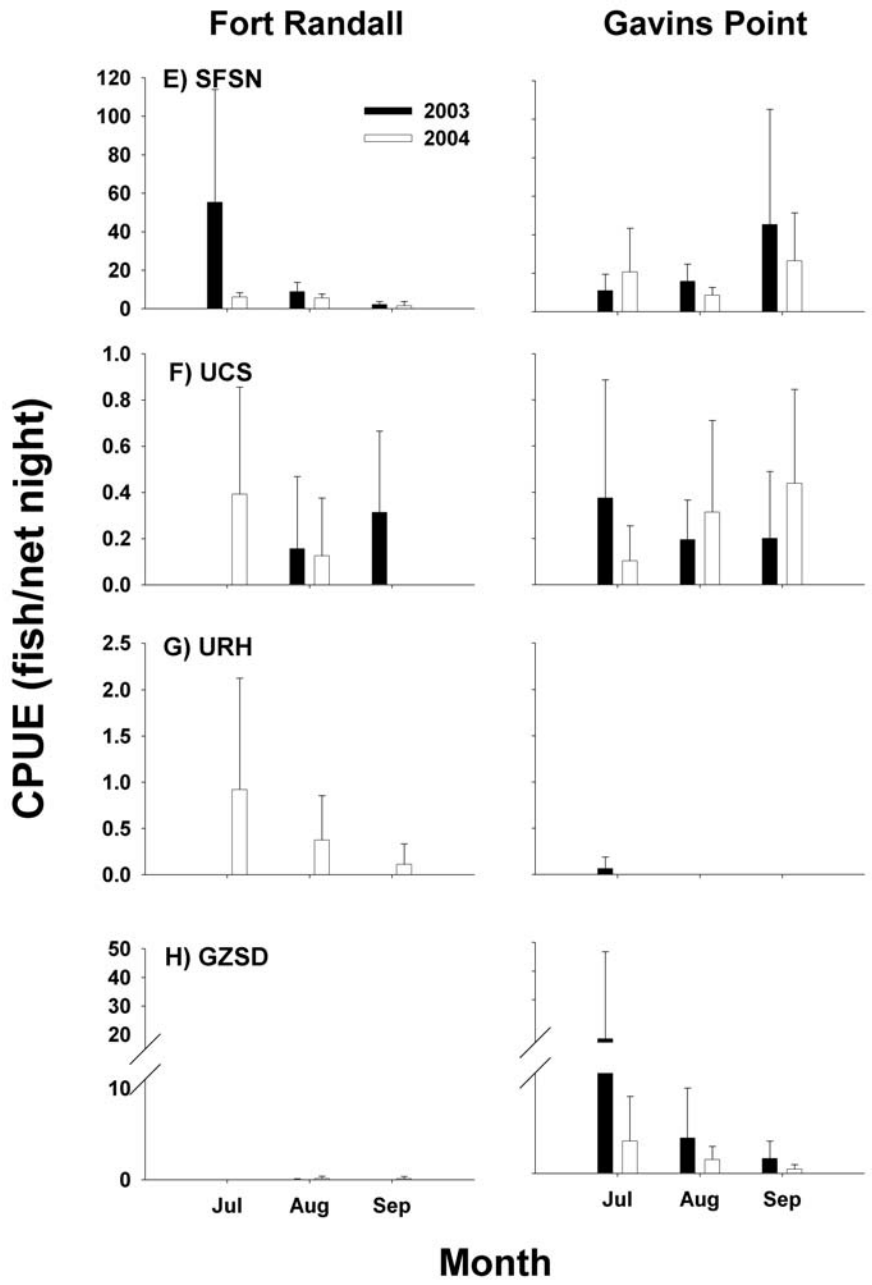


Figure 34. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with mini-fyke nets in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004 for: A) all fish species, B) bigmouth shiners (BMSN), C) emerald shiners (ERSN), D) sand shiners (SNSN), E) spotfin shiners (SFSN), F) unidentified carpsuckers, i.e., *Carpiodes* spp. (UCS), G) unidentified redhorses, i.e., *Moxostoma* spp. (URH), H) gizzard shad (GZSD), I) smallmouth bass (SMBS), and J) white bass (WTBS). Note differing y-axis scales among species.



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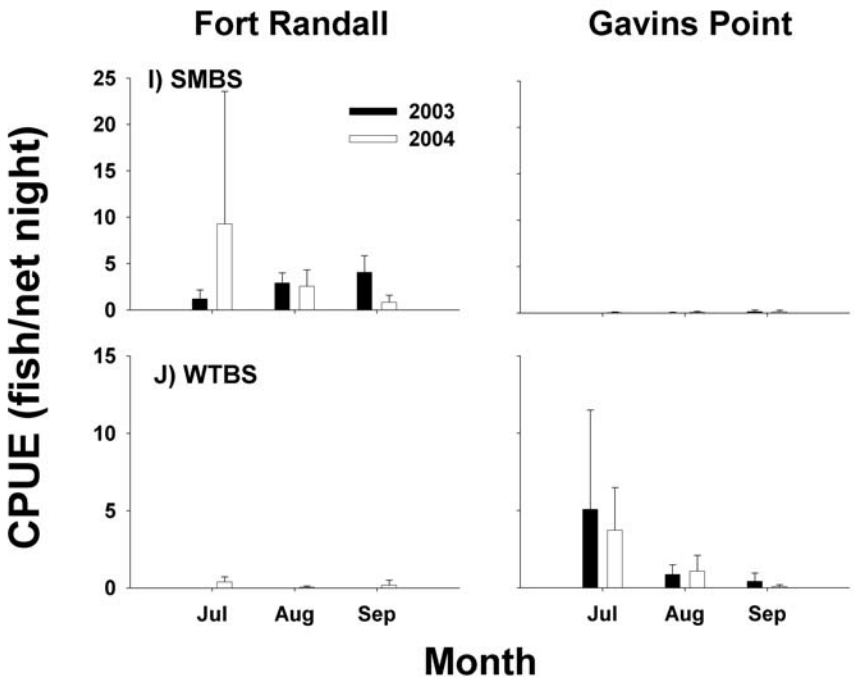


Figure 34. (continued).

Randall Reach, median fish abundance was significantly greater downstream of Gavins Point Dam in August and September of 2003 and September of 2004 and were not significantly different between reaches on all other dates (Table 11).

Relative abundance of nine commonly collected species or taxons within the Fort Randall and Gavins Point reaches generally differed between reaches except for *Carpiodes* spp. (Figure 34). During 2003 and 2004, emerald shiners were the most abundant species captured downstream of Fort Randall Dam while they were the most abundant species captured downstream of Gavins Point Dam only in 2003 (Appendices I and J). For both reaches, emerald shiner abundance generally declined from 2003 to 2004. Spotfin shiners in 2004 were the most abundant species captured with mini-fyke nets in the Gavins Point Reach (mean 19.0 fish/net night) and this species was also in high abundance during 2003 (mean 18.8 fish/net night) and 2004 (mean 4.8 fish/net night) in the Fort Randall Reach. Relative abundance of sand shiners was generally higher in the Gavins Point Reach (1.6 – 8.1 fish/net night) compared to the Fort Randall Reach (0.06 – 2.9 fish/net night). Bigmouth shiners, gizzard shad, and white bass were more abundant in the Gavins Point Reach during 2003 and 2004 compared to the Fort Randall Reach; whereas, smallmouth bass were in greater abundance in the Fort Randall Reach in both years. Gizzard shad relative abundance was lower in the Gavins Point Reach during 2004 compared to 2003. *Moxostoma* spp. were in higher abundance in the Fort Randall Reach during 2004 compared to the Gavins Point Reach but none were collect downstream of Fort Randall Dam during 2003.

The relative abundance of shallow water fishes caught with mini-fyke nets was generally similar between upstream and downstream sites within the Fort Randall and Gavins Point reaches of the Missouri River during 2003 and 2004 (Figures 35 and 36). Mean monthly mini-

fyke net CPUE of all fishes in the Fort Randall Reach during 2003 and 2004 ranged from 20 – 452 fish/net night at the upstream site and ranged from 11 – 85 fish/net night at the downstream site. Monthly mean relative abundance did not vary greatly except for the high peak observed at the upstream site in the Fort Randall Reach during July 2003, which partially resulted from a single net capturing 1751 emerald shiners. For the Gavins Point Reach during 2003 and 2004, upstream monthly mean CPUE of all fishes ranged from 26 – 250 fish/net night while downstream CPUE ranged from 21 – 112 fish/net night. Similar to the Fort Randall Reach, monthly CPUE of all fishes generally did not vary greatly during summer except for one large peak observed at the upstream site in September of 2003, which partially resulted from a single net capturing 968 emerald shiners. Median CPUE of shallow water fishes did not significantly differ between upstream and downstream sites in the Fort Randall Reach during 2003 and 2004 (Table 12). Only in July 2004 was median mini-fyke net CPUE significantly greater at the upstream site in the Gavins Point Reach (Table 13).

In contrast to bag seine catches, the spatial relative abundance of species common in one or both reaches of the Missouri River did not differ in relation to the combined proximity of a major tributary and Lewis and Clark Lake (Figures 35 and 36). In both reaches, only gizzard shad CPUE was greatest at sites nearest the tributary and reservoir. However, peak gizzard shad abundance occurred in late summer for the Fort Randall Reach and early summer for the Gavins Point Reach. Emerald shiner relative abundance in the Fort Randall Reach was generally greatest at the upstream sites in proximity to Lake Francis Case. Smallmouth bass CPUE in the Fort Randall Reach generally did not differ between upstream and downstream sites in 2003 and

Table 11. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between the Fort Randall and Gavins Point reaches of the Missouri River caught with mini-fyke nets during 2003 and 2004. Mini-fyke net CPUE was fish/net night.

Month	Year	Fort Randall Reach		Gavins Point Reach		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
Jul	2003	16	24.5	16	18.5	113	0.57
Aug	2003	32	14.0	31	27.0	301.5	0.01
Sep	2003	16	11.0	15	40.0	53	0.01
Jul	2004	37	26.0	29	15.0	451	0.27
Aug	2004	24	14.0	16	17.5	177	0.68
Sep	2004	18	13.5	16	29.5	84	0.04

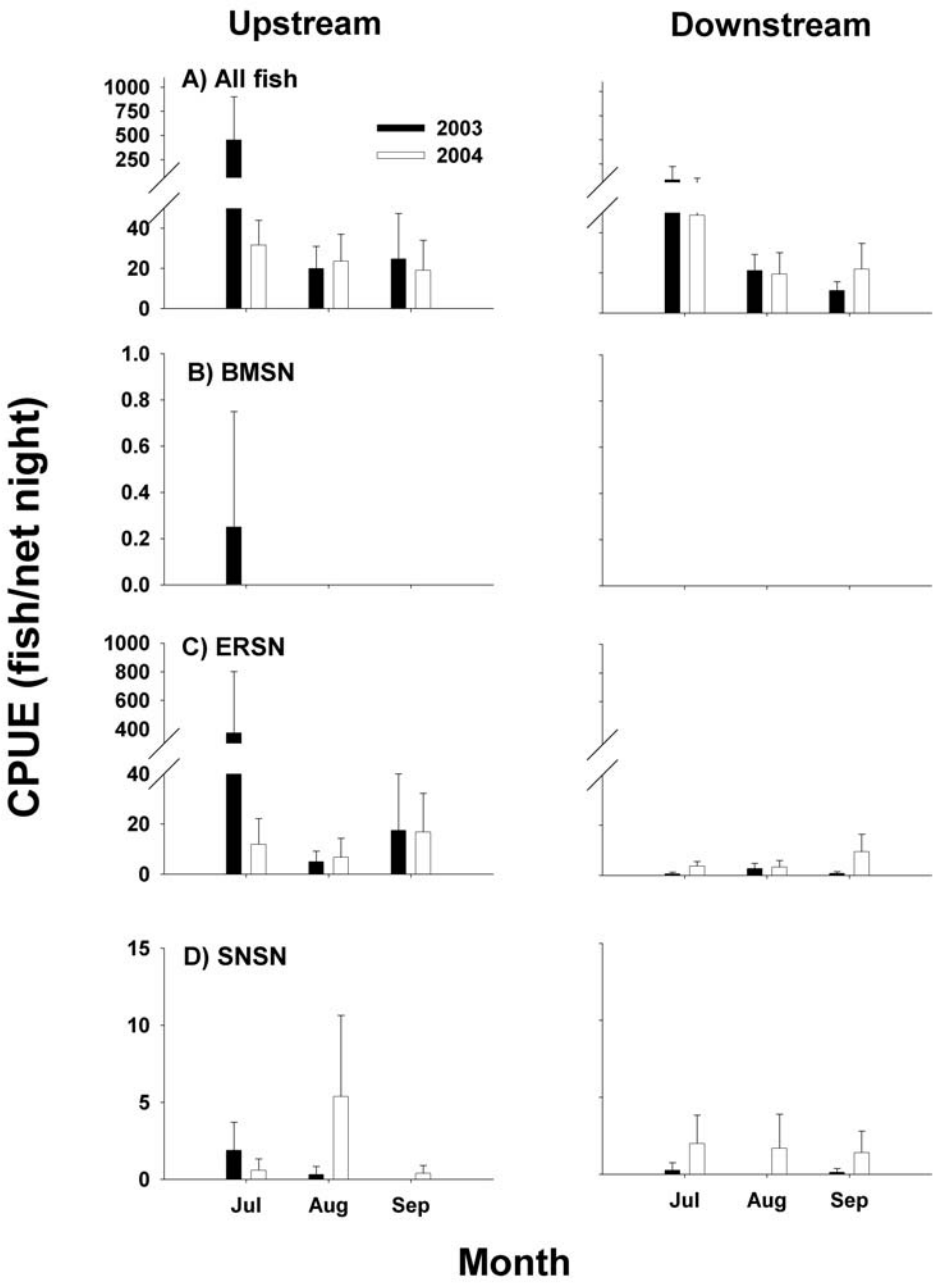


Figure 35. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with mini-fyke nets at upstream and downstream locations in the Missouri River downstream of Fort Randall Dam during 2003 and 2004 for: A) all fish species, B) bigmouth shiners (BMSN), C) emerald shiners (ERSN), D) sand shiners (SNSN), E) spotfin shiners (SFSN), F) unidentified carpsuckers, i.e., *Carpiodes* spp. (UCS), G) unidentified redhorses, i.e., *Moxostoma* spp. (URH), H) gizzard shad (GZSD), I) smallmouth bass (SMBS), and J) white bass (WTBS). Note differing y-axis scales among species.

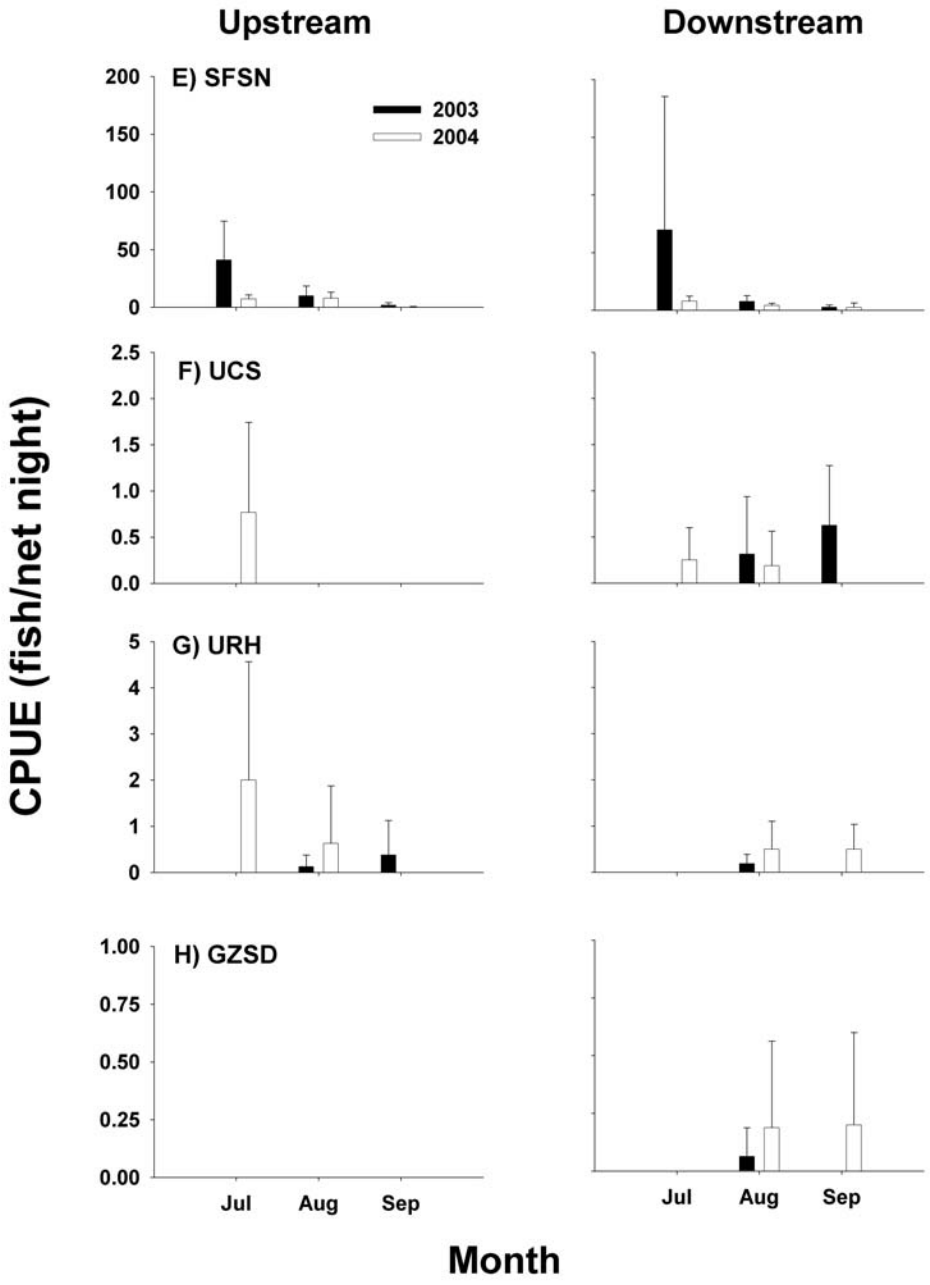


Figure 35. (continued).

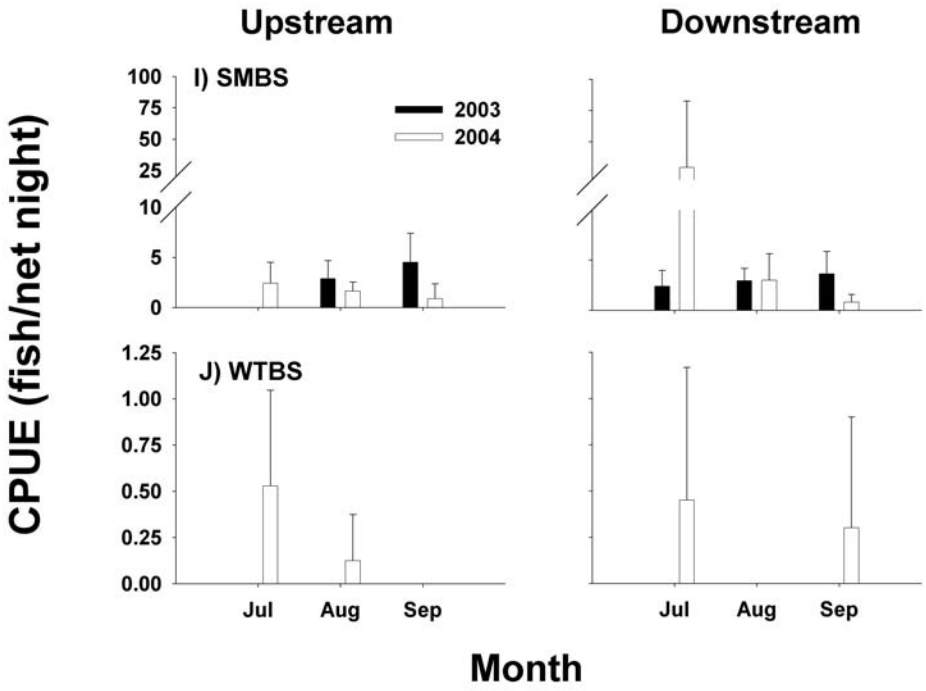


Figure 35. (continued).

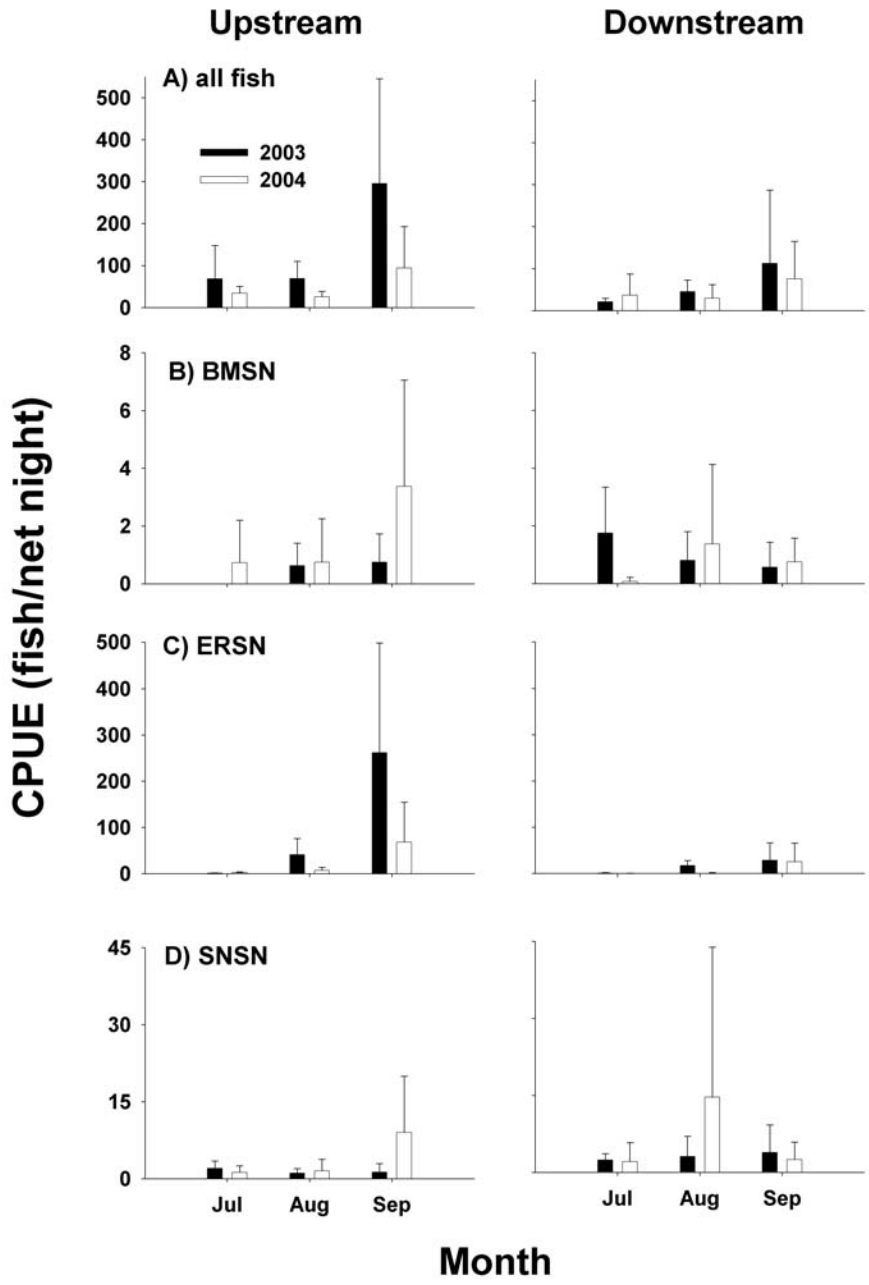
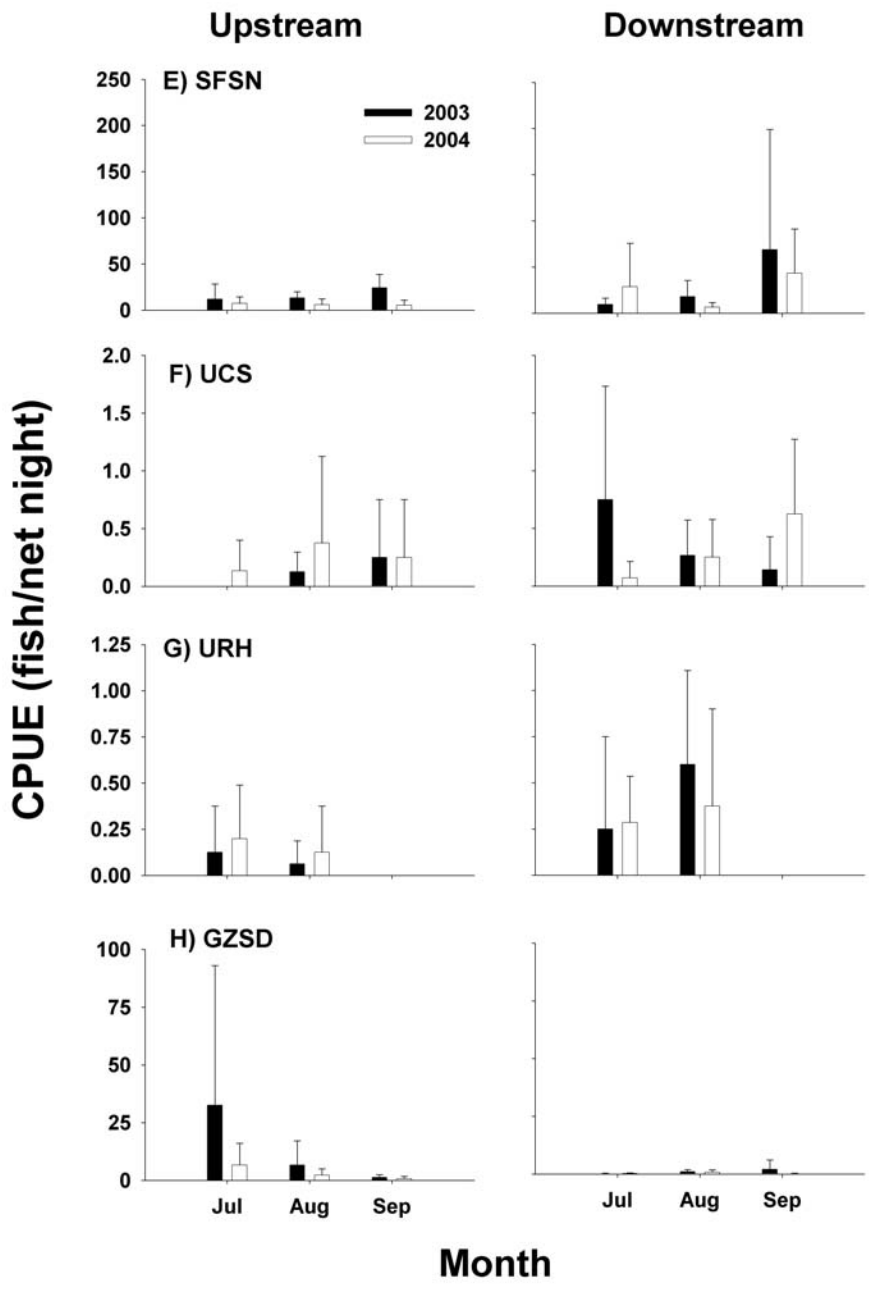


Figure 36. Mean (± 2 SE) monthly catch-per-unit-effort (CPUE) with mini-fyke nets at upstream and downstream locations in the Missouri River downstream of Gavins Point Dam during 2003 and 2004 for: A) all fish species, B) bigmouth shiners (BMSN), C) emerald shiners (ERSN), D) sand shiners (SNSN), E) spotfin shiners (SFSN), F) unidentified carpsuckers, i.e., *Carpiodes* spp. (UCS), G) unidentified redhorses, i.e., *Moxostoma* spp. (URH), H) gizzard shad (GZSD), I) smallmouth bass (SMBS), and J) white bass (WTBS). Note differing y-axis scales among species.



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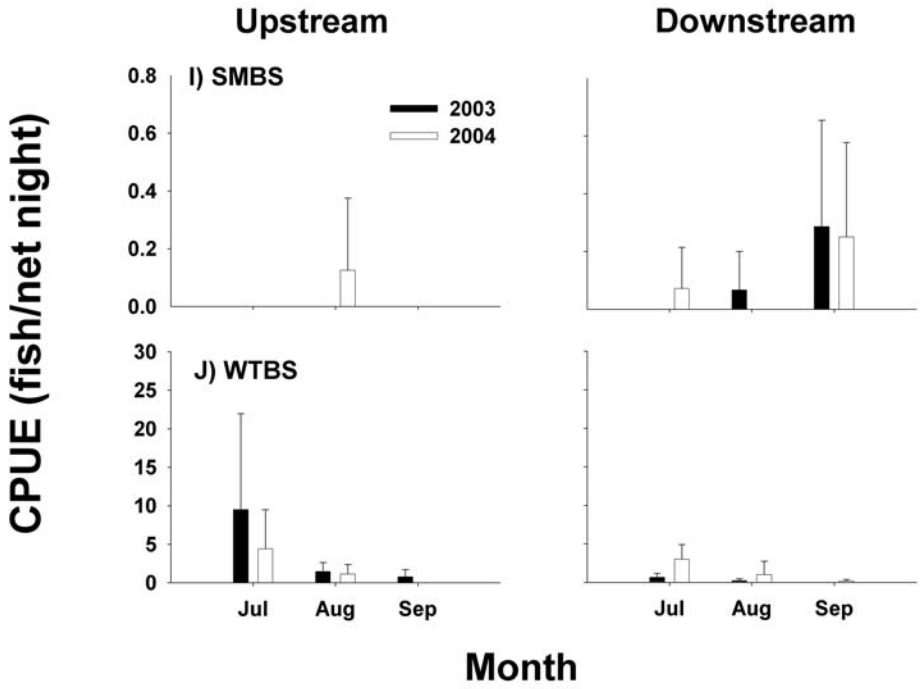

Figure 36. (continued).

Table 12. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between upstream and downstream locations within the Fort Randall Reach of the Missouri River caught with mini-fyke nets during 2003 and 2004. Mini-fyke net CPUE was fish/net night.

Month	Year	Upstream		Downstream		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
July	2003	8	20 (8, 28.3)	8	194 (5, 731)	22	0.29
August	2003	16	12 (5.3, 30.3)	16	19.5 (9.5, 26.5)	106	0.41
September	2003	8	16 (7.3, 27.3)	8	9.5 (6.3, 17.8)	24	0.40
July	2004	17	28 (10.5, 44)	20	23 (10.5, 39.3)	151	0.56
August	2004	8	18 (6.8, 40.5)	16	14 (4.8, 24)	55	0.58
September	2004	8	11 (5.3, 30.5)	10	19 (5, 31.3)	36.5	0.76

Table 13. Mann-Whitney *U* test results comparing monthly median catch-per-unit-effort (CPUE) of all fish species (25th and 75th percentiles in parentheses) between upstream and downstream locations within the Gavins Point Reach of the Missouri River caught with mini-fyke nets during 2003 and 2004. Mini-fyke net CPUE was fish/net night.

Month	Year	Upstream		Downstream		*U*	*P*
		N	Median CPUE (25th, 75th percentile)	N	Median CPUE (25th, 75th percentile)		
July	2003	8	18.5 (5.8, 75.5)	8	24.5 (9, 33))	29.5	0.79
August	2003	16	41 (19, 81.5)	15	21 (10, 72)	87	0.19
September	2003	8	143 (36.5, 494.3)	7	36 (2, 72)	14.5	0.12
July	2004	15	24 (8, 54)	14	9.5 (3.8, 20.5)	62	0.06
August	2004	8	25 (14.3, 34.8)	8	8 (4.3, 41)	23.5	0.37
September	2004	8	29.5 (10.5, 137.8)	8	27.5 (7.5, 83)	26	0.53

2004 except for a large peak in July 2004 at the downstream site. White bass relative abundance in the Gavins Point Reach was generally greatest at the upstream site in July with spatial differences lessened in August and September.

Trends in total fish catch with mini-fyke nets set in particular macrohabitats in the Missouri River were apparent when compared to effort expended (as deployments) in each habitat type during 2003 and 2004 (Figure 37). Generally 30-40% of the total deployments were set in each macrohabitat except for SCN. In both reaches the proportion of the total catch of fishes (5 – 15%) for 2003 and 2004 was lower in ISB compared to the proportion of mini-fyke nets set in that habitat. For both years in the Fort Randall Reach, nearly 50% of the total catch occurred in OSB. The proportion of the total catch in SCN was 30 – 50% in the Gavins Point Reach despite < 20% of sets being expended in that habitat.

Length frequencies – bag seines and mini-fyke nets

In general, bag seines and mini-fyke nets sampled different size ranges of Missouri River cyprinids (Table 14). Shorter cyprinids were more commonly captured in mini-fyke nets while larger fishes were more commonly sampled with bag seines. A significantly wider length distribution of bigmouth shiners was caught with seines compared to mini-fyke nets (Figure 38) downstream of Gavins Point Dam in 2003 and 2004. Length distributions of emerald shiners (Figure 39) caught with bag seines significantly differed from those caught with mini-fyke nets downstream of Fort Randall and Gavins Point dams during 2003 and for only Gavins Point reach during 2004. Sand shiner length frequencies (Figure 40) did not differ between bag seine and mini-fyke net catches in the Fort Randall Reach during 2003 but did differ in the Gavins Point Reach during 2003 and 2004. Differences in the length distribution of spotfin shiners

Table 14. Mean (±2 SE) and median (90% confidence interval) total lengths (TL) and results of Kolmogorov-Smirnov tests comparing length frequency distributions of Missouri River fishes captured with bag seines (BS) and mini-fyke nets (MF) downstream of Fort Randall and Gavins Point dams during 2003 and 2004.

Reach	Year	Gear	N	Mean TL	Median TL	*D*	*P*
				Bigmouth shiner			
Gavins Point	2003	BS	325	45 (0.9)	45 (45, 46)	0.599	< 0.001
		MF	43	35 (1.6)	34 (33, 37)		
Gavins Point	2004	BS	270	44 (1.1)	45 (42, 47)	0.240	0.005
		MF	61	40 (1.8)	39 (37, 42)		
				Emerald shiner			
Fort Randall	2003	BS	311	72 (0.9)	71 (70, 72)	0.423	< 0.001
		MF	476	65 (0.9)	64 (63, 65)		
Fort Randall	2004	BS	557	68 (0.6)	67 (66, 67)	0.065	0.278
		MF	381	67 (1.0)	68 (67, 68)		
Gavins Point	2003	BS	683	51 (1.3)	47 (46, 49)	0.321	0.001
		MF	573	39 (1.0)	36 (35, 37)		
Gavins Point	2004	BS	393	55 (1.4)	59 (57, 60)	0.462	0.001
		MF	228	43 (1.8)	37.5 (36, 39)		
				Sand shiner			
Fort Randall	2004	BS	34	58 (2.2)	57.5 (55, 60)	0.214	0.149
		MF	120	56 (1.5)	54 (53, 56)		
Gavins Point	2003	BS	335	42 (1.0)	42 (41, 43)	0.212	0.001
		MF	117	40 (1.2)	39 (38, 40)		
Gavins Point	2004	BS	199	43 (1.2)	44 (43, 46)	0.180	0.013
		MF	120	40 (1.2)	40 (38, 42)		

Table 14 (continued).

Reach	Year	Gear	N	Mean TL	Median TL	*D*	*P*
				Spotfin shiner			
Fort Randall	2003	BS	131	61 (1.2)	61 (59, 62)	0.129	0.056
		MF	508	60 (0.9)	59 (58, 60)		
Fort Randall	2004	BS	220	59 (1.1)	58 (57, 60)	0.209	< 0.001
		MF	316	63 (1.0)	63 (62, 65)		
Gavins Point	2003	BS	336	53 (1.2)	54 (53, 55)	0.137	0.001
		MF	577	50 (1.1)	51 (50, 52)		
Gavins Point	2004	BS	370	48 (1.1)	49 (48, 50)	0.275	< 0.001
		MF	515	54 (1.1)	54 (53, 55)		
				Gizzard shad			
Gavins Point	2003	BS	640	59 (1.6)	52 (50, 54)	0.270	< 0.001
		MF	109	52 (4.4)	43 (41, 45)		
				Smallmouth bass			
Fort Randall	2003	BS	49	67 (6.0)	62 (59, 68)	0.218	0.042
		MF	185	75 (5.8)			
Fort Randall	2004	BS	82	56 (3.9)	57 (54, 59)	0.434	< 0.001
		MF	132	50 (6.8)	38.5 (36, 41)		
				White bass			
Gavins Point	2003	BS	106	63 (4.7)	54 (51, 59)	0.363	< 0.001
		MF	82	50 (5.0)	43.5 (40, 47)		
Gavins Point	2004	BS	100	49 (2.6)	45.5 (43, 48)	0.509	< 0.001
		MF	110	36 (2.0)	34.5 (32, 37)		

(Figure 41) caught with bag seines and mini-fyke nets were less clear, median TLs were larger in bag seines in 2003 but were larger in mini-fyke nets in 2004 in both reaches.

Multiple size classes of common cyprinids were captured with the bag seine in the Gavins Point Reach during 2003 and 2004 with fish < 50 mm TL prevalent in that reach compared to more truncated length frequency distributions for the same commonly caught species in the Fort Randall Reach (Figures 38 – 41). The bag seine commonly caught bigmouth shiners, emerald shiners, sand shiners, and spotfin shiners down to 30 mm TL with individuals as small as 20 mm TL captured. Significantly greater numbers of small emerald shiners and spotfin shiners were captured in the Gavins Reach in 2003 and 2004 (Table 15) while in the Fort Randall Reach only larger sized fish (> 65 mm TL) were caught (Figures 39 and 41). Sand shiner length distributions also included significantly more smaller fish in the Gavins Point Reach than the Fort Randall Reach during 2004 (Table 15). Mean TLs of emerald shiners, sand shiners, and spotfin shiners were 8 – 21 mm shorter in the Gavins Point Reach compared to the Fort Randall Reach. Presence of multiple modes in the length distribution of bigmouth shiners, emerald shiners, sand shiners, and spotfin shiners in the Gavins Point Reach during 2003 and 2004 indicated a higher level of spawning success and recruitment or lower mortality for these four species compared to the Fort Randall Reach.

Multiple size classes of the two common catastomid genera were evident in bag seine catches in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004 (Figures 42 and 43). *Carpiodes* spp. and *Moxostoma* spp. down to 25 mm TL were commonly captured with the bag seines in both reaches in both years. Length distributions of Moxostoma spp. in 2004 did not significantly differ between reaches (Table 15). Presence of multiple modes and a wide size distribution indicated that *Carpiodes* spp. and *Moxostoma* spp

Table 15. Mean (±2 SE) and median (90% confidence interval) total lengths (TL) and results of Kolmogorov-Smirnov tests comparing length frequency distributions of Missouri River fishes downstream of Fort Randall and Gavins Point dams during 2003 and 2004 captured with bag seines.

Year	Reach	N	Mean TL	Median TL	*D*	*P*
			Emerald shiner			
2003	Fort Randall	311	72 (0.9)	71 (70, 72)	0.637	< 0.001
	Gavins Point	683	51 (1.3)	47 (46, 49)		
2004	Fort Randall	557	68 (0.6)	67 (66, 67)	0.459	< 0.001
	Gavins Point	390	55 (1.4)	59 (57, 60)		
			Sand shiner			
2004	Fort Randall	34	58 (2.2)	57.5 (55, 60)	0.650	< 0.001
	Gavins Point	196	43 (1.2)	44 (42, 45)		
			Spotfin shiner			
2003	Fort Randall	131	61 (1.2)	61 (59, 62)	0.348	< 0.001
	Gavins Point	336	53 (1.2)	54 (53, 55)		
2004	Fort Randall	220	59 (1.2)	58 (57, 60)	0.493	< 0.001
	Gavins Point	370	48 (1.0)	49 (48, 50)		
			Redhorses (*Moxostoma* spp.)			
2004	Fort Randall	46	43 (4.6)	36 (34, 38)	0.207	0.097
	Gavins Point	123	39 (1.8)	38 (35, 41)		

had protracted spawning seasons downstream of Fort Randall and Gavins Point dams during 2003 and 2004.

The length frequencies of gizzard shad, smallmouth bass and white bass caught with bag seines in the Missouri River downstream of Fort Randall and Gavins Point dams had multiple modes and a wide distribution indicating successful spawning over an extended season during 2003 and 2004 (Figures 44 – 46). However, each of these three species was only commonly collected in 2003 and 2004 from one reach, gizzard shad and white bass in the Gavins Point Reach and smallmouth bass in the Fort Randall Reach. Gizzard shad, smallmouth bass and white bass were commonly collected down to 35 mm TL with the bag seine.

Like the bag seine, multiple size classes of common cyprinids were captured in the mini-fyke nets in the Gavins Point Reach during 2003 and 2004 with fish < 50 mm TL prevalent in that reach compared to more truncated length frequency distributions for the same commonly caught species in the Fort Randall Reach (Figures 39 – 41). Greater numbers of small emerald shiners, sand shiners, and spotfin shiners were captured in the Gavins Point Reach while in the Fort Randall Reach larger sized fish (> 65 mm TL) were caught. Mean TLs of these three cyprinids caught in the Fort Randall reach were 9 – 26 mm smaller than those caught in the same year in the Gavins Point Reach (Table 16).

Differences existed in the prevalence of catastomids and gizzard shad based on bag seine and mini-fyke net catches. Compared to bag seines, few individuals of the two common catastomids, *Carpiodes* spp. and *Moxostoma* spp. as well as gizzard shad were captured with mini-fyke nets in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003 and 2004 (Figures 38 and 39). A wide size range of the catastomids and gizzard shad down to 25 mm TL were commonly captured with the bag seines in both reaches in both years.

Table 16. Mean (±2 SE) and median (90% confidence interval) total lengths (TL) and results of Kolmogorov-Smirnov tests comparing length frequency distributions of Missouri River fishes downstream of Fort Randall and Gavins Point dams during 2003 and 2004 captured with mini-fyke nets.

Year	Reach	N	Mean TL	Median TL	*D*	*P*
			Emerald shiner			
2003	Fort Randall	476	65 (0.9)	64 (63, 65)	0.808	< 0.001
	Gavins Point	573	39 (1.0)	36 (35, 37)		
2004	Fort Randall	381	67 (1.0)	68 (67, 68)	0.734	< 0.001
	Gavins Point	228	43 (1.8)	37.5 (36, 39)		
			Sand shiner			
2003	Fort Randall	21	49 (3.5)	48 (46, 50)	0.600	< 0.001
	Gavins Point	105	40 (1.3)	39 (38, 40)		
2004	Fort Randall	120	56 (1.5)	54 (53, 56)	0.775	< 0.001
	Gavins Point	120	40 (1.3)	40 (38, 42)		
			Spotfin shiner			
2003	Fort Randall	508	60 (0.9)	59 (58, 60)	0.337	< 0.001
	Gavins Point	577	50 (1.1)	51 (50, 52)		
2004	Fort Randall	316	63 (1.0)	63 (62, 65)	0.335	< 0.001
	Gavins Point	515	54 (1.1)	54 (53, 55)		

The length frequencies of smallmouth bass and white bass caught with mini-fyke nets in the Missouri River downstream of Fort Randall and Gavins Point dams had multiple modes and a wide distribution indicating successful spawning over an extended spawning season occurred during 2003 and 2004 (Figures 40 – 42). However, each of these species was only commonly collected in 2003 and 2004 from one reach, white bass in the Gavins Point Reach and smallmouth bass in the Fort Randall Reach. Smallmouth bass and white bass were commonly collected down to 25 mm TL with the mini-fyke net.

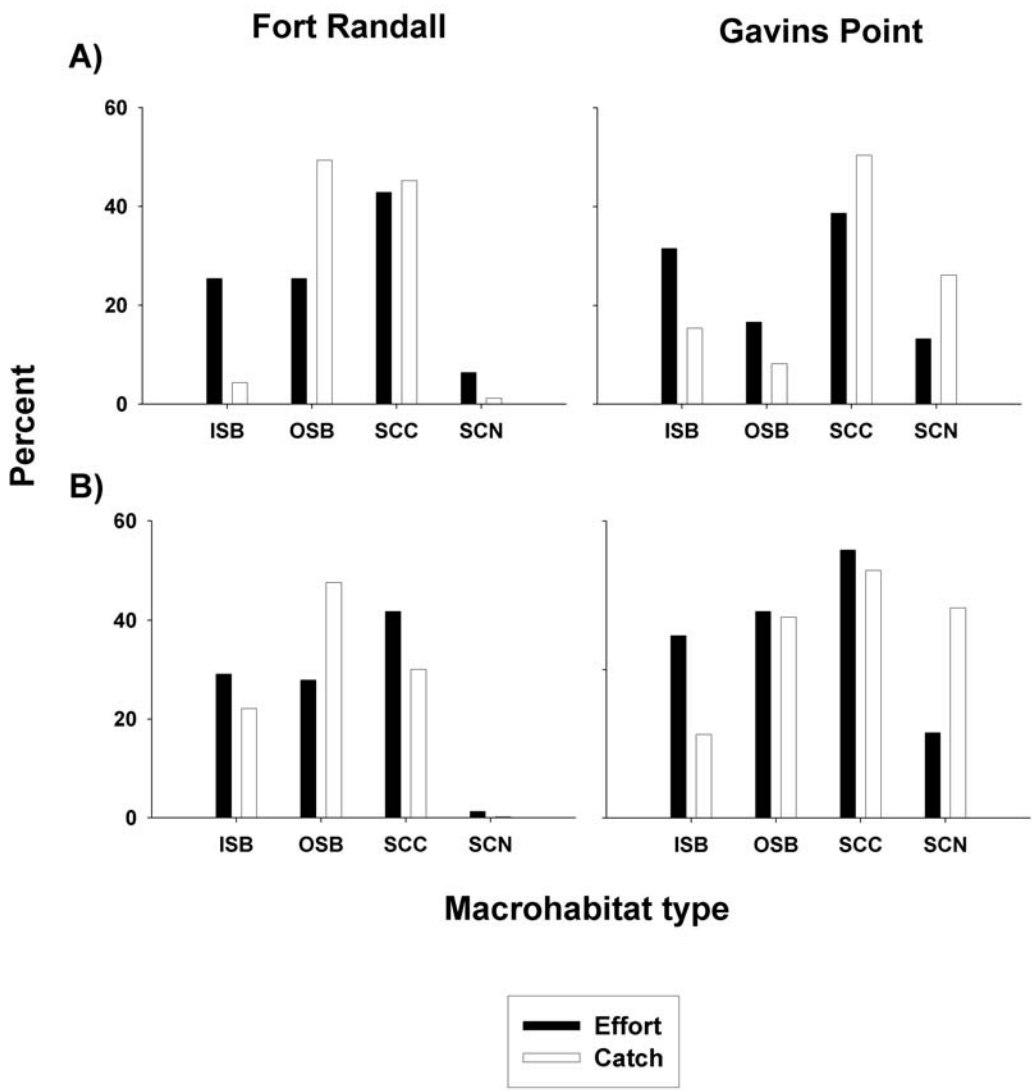

Figure 37. Proportion of mini-fyke effort (as deployments) and catch for all fish species in four macrohabitat types, inside bends (ISB), outside bends (OSB), secondary connected channels (SCC), and secondary non-connected channels (SCN), in the Missouri River downstream of Fort Randall and Gavins Point dams during: A) 2003 and B) 2004.

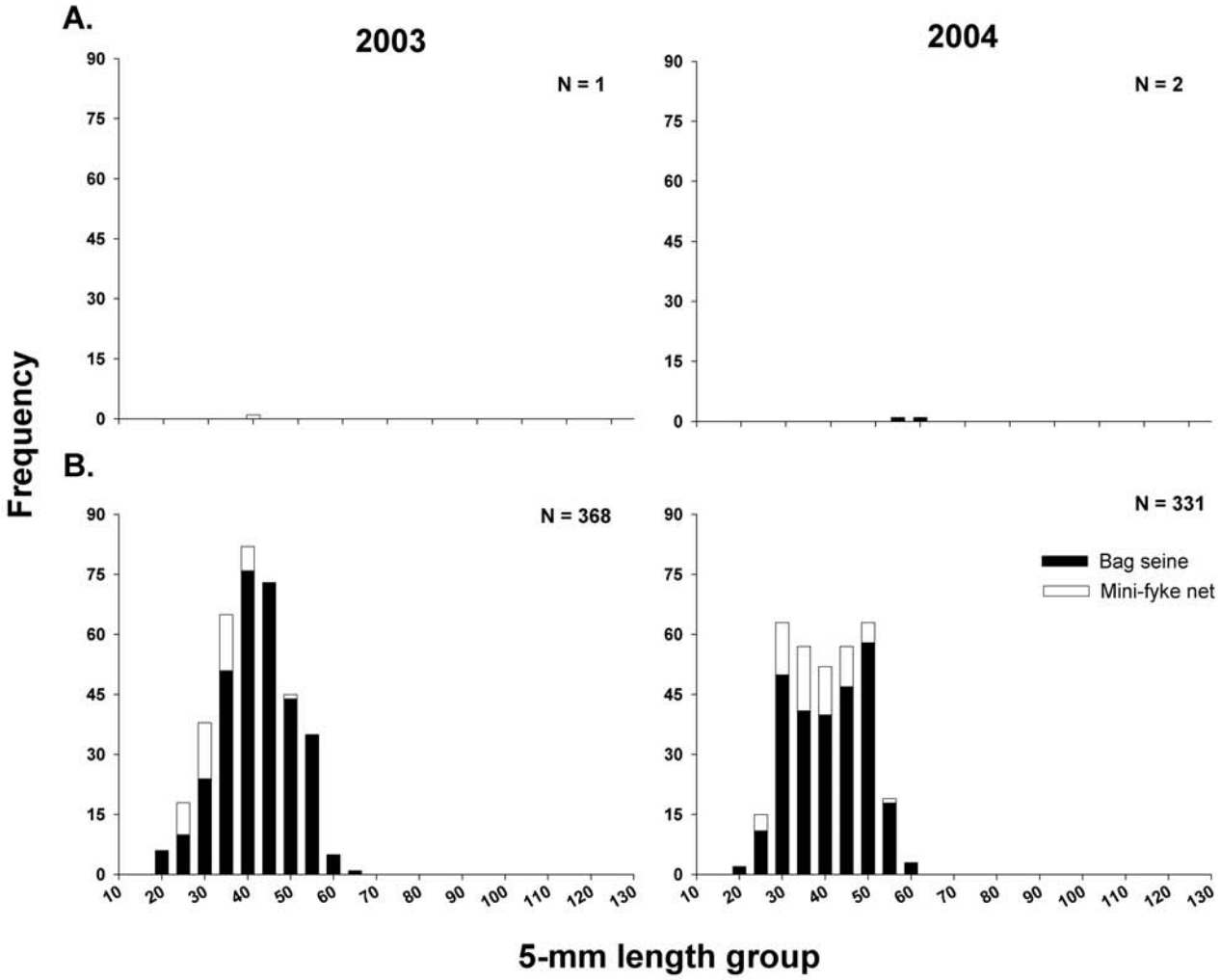

Figure 38. Frequency distribution of total lengths of bigmouth shiners captured with bag seines and mini-fyke nets in the Missouri River downstream of: A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

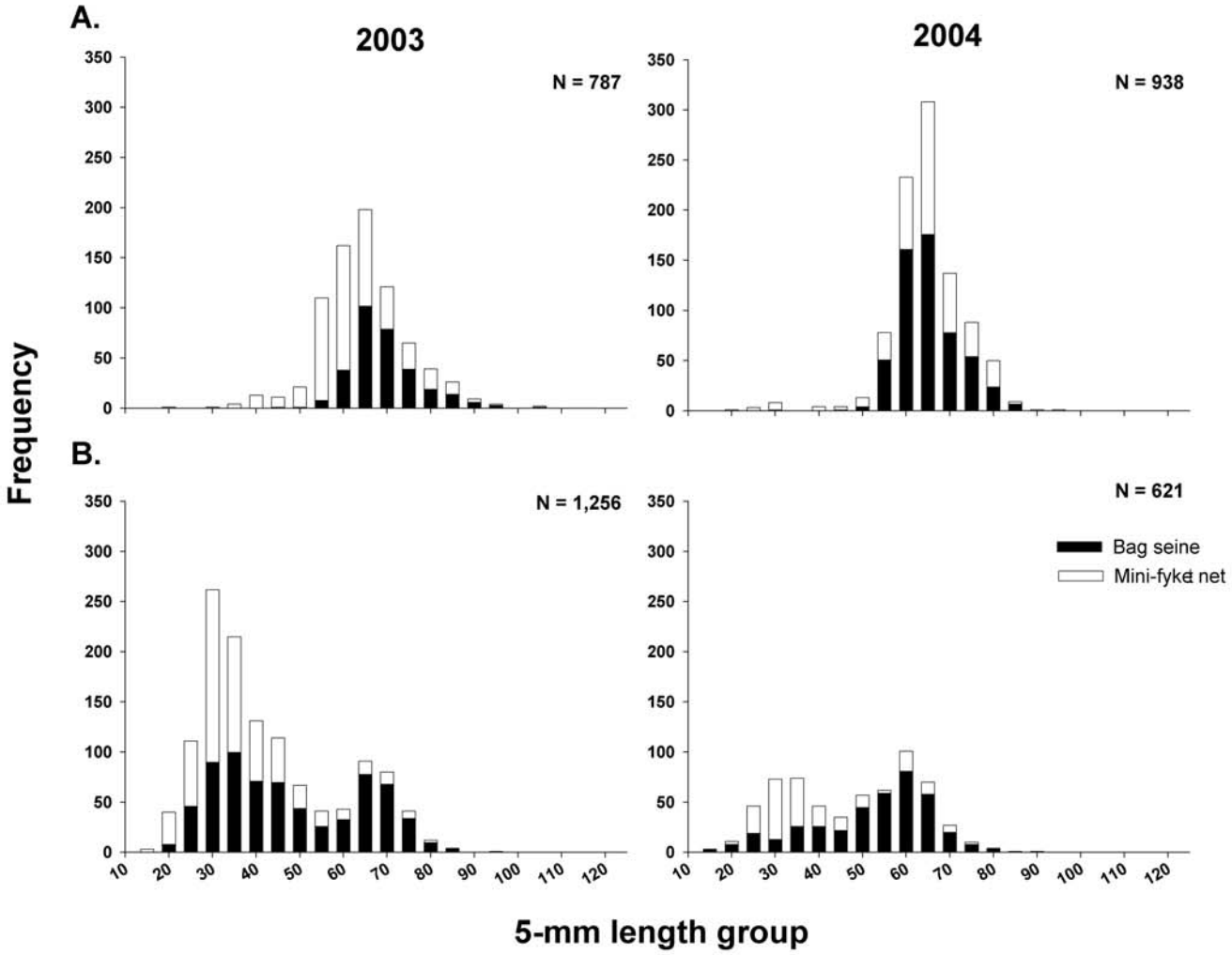

Figure 39. Frequency distribution of total lengths of emerald shiners captured with bag seines and mini-fyke nets in the Missouri River downstream of: A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

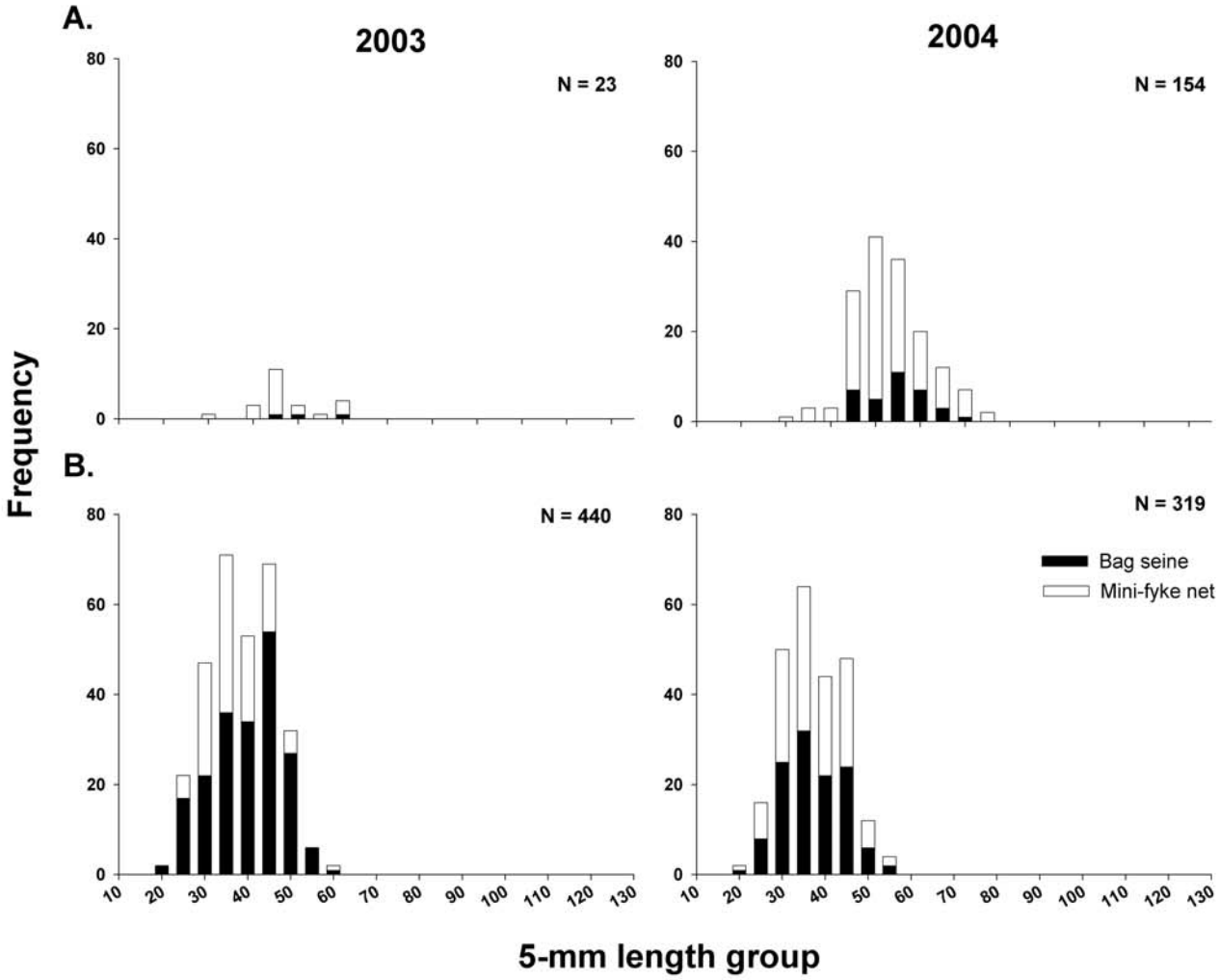

Figure 40. Frequency distribution of total lengths of sand shiners captured with bag seines and mini-fyke nets in the Missouri River downstream of: A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

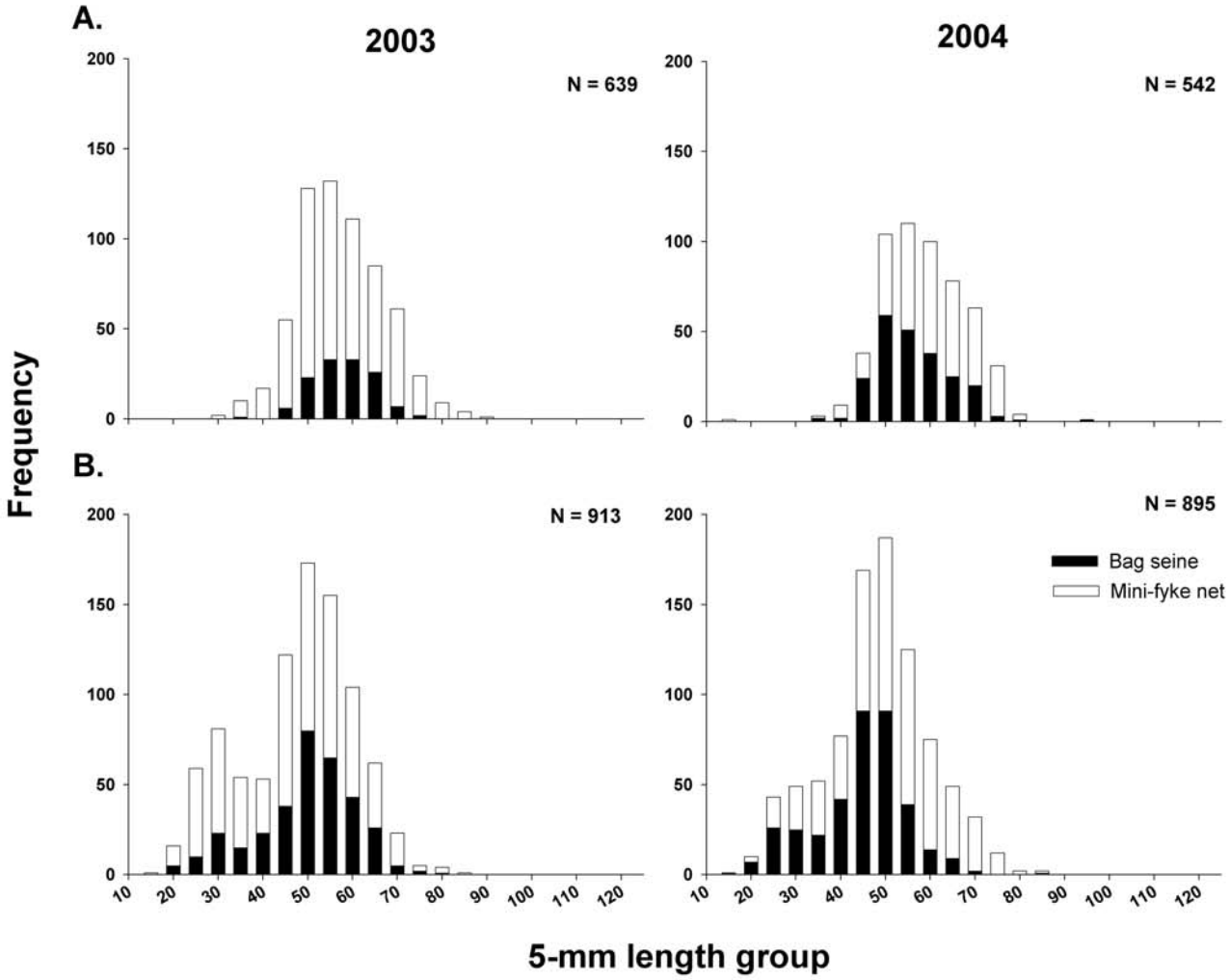

Figure 41. Frequency distribution of total lengths of spotfin shiners captured with bag seines and mini-fyke nets in the Missouri River downstream of: A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

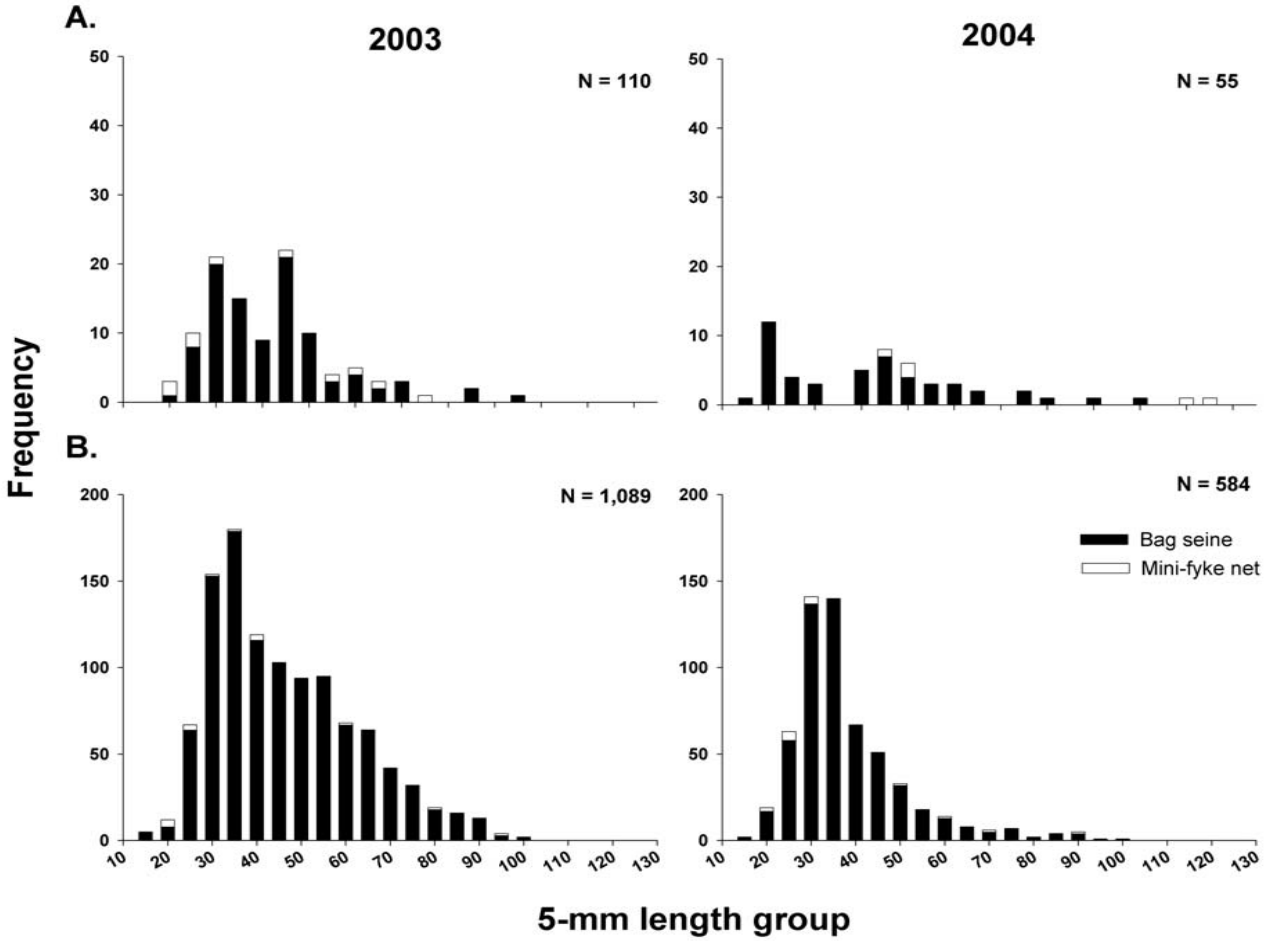

Figure 42. Frequency distribution of total lengths of *Carpiodes* spp. captured with bag seines and mini-fyke nets in the Missouri River downstream of: A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

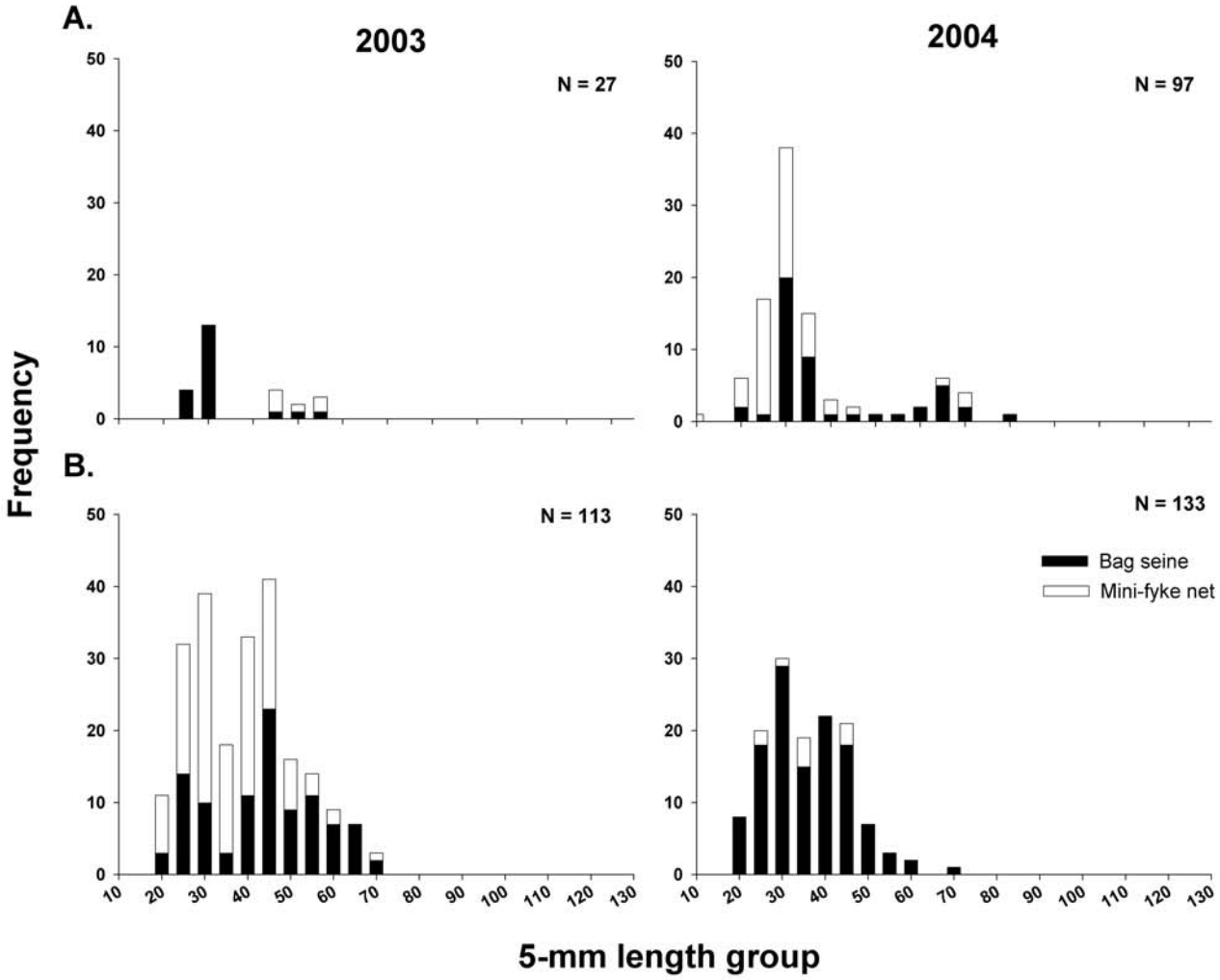

Figure 43. Frequency distribution of total lengths of *Moxostoma* spp. captured with bag seines and mini-fyke nets in the Missouri River downstream of: A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

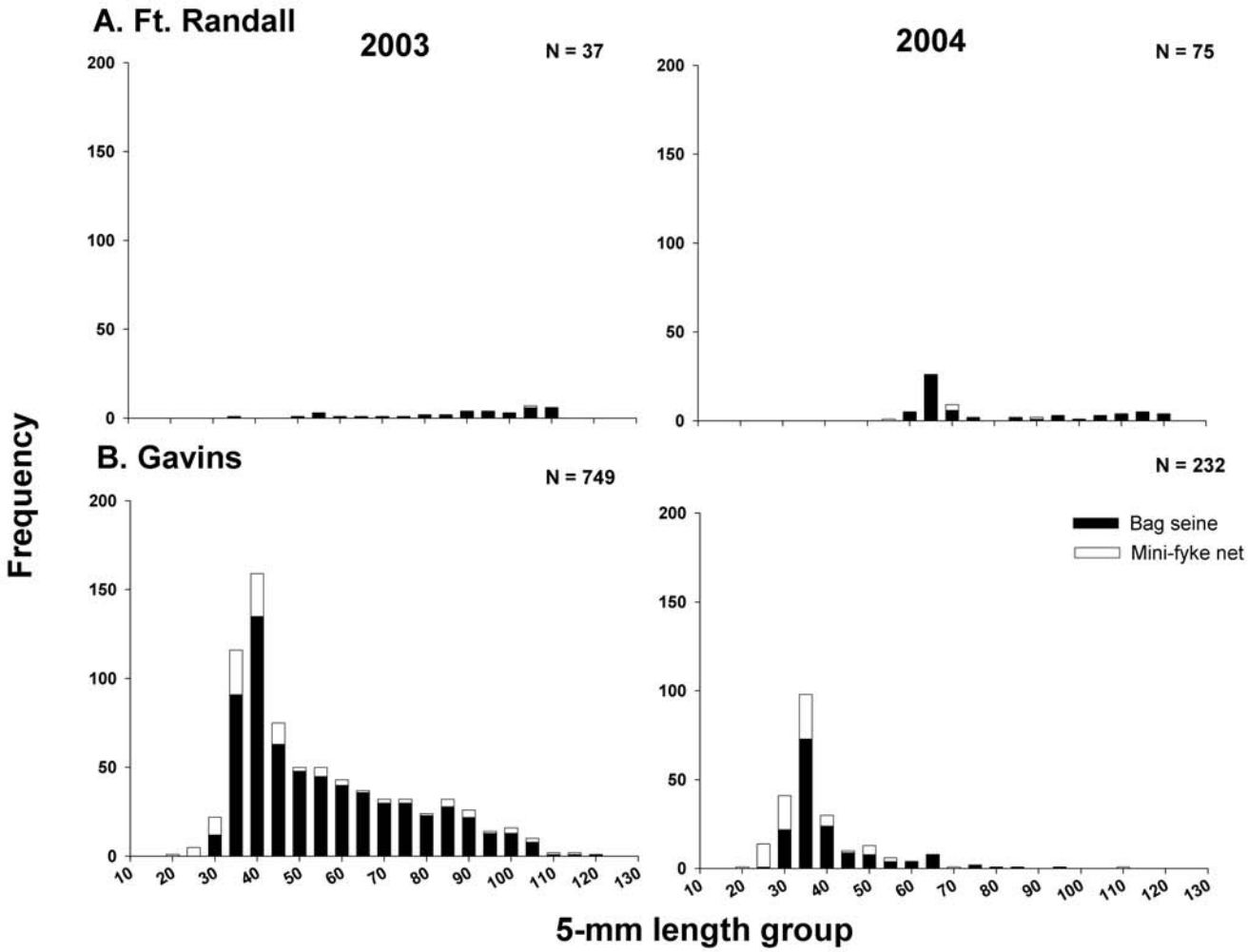

Figure 44. Frequency distribution of total lengths of gizzard shad captured with bag seines and mini-fyke nets in the Missouri River downstream of: A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

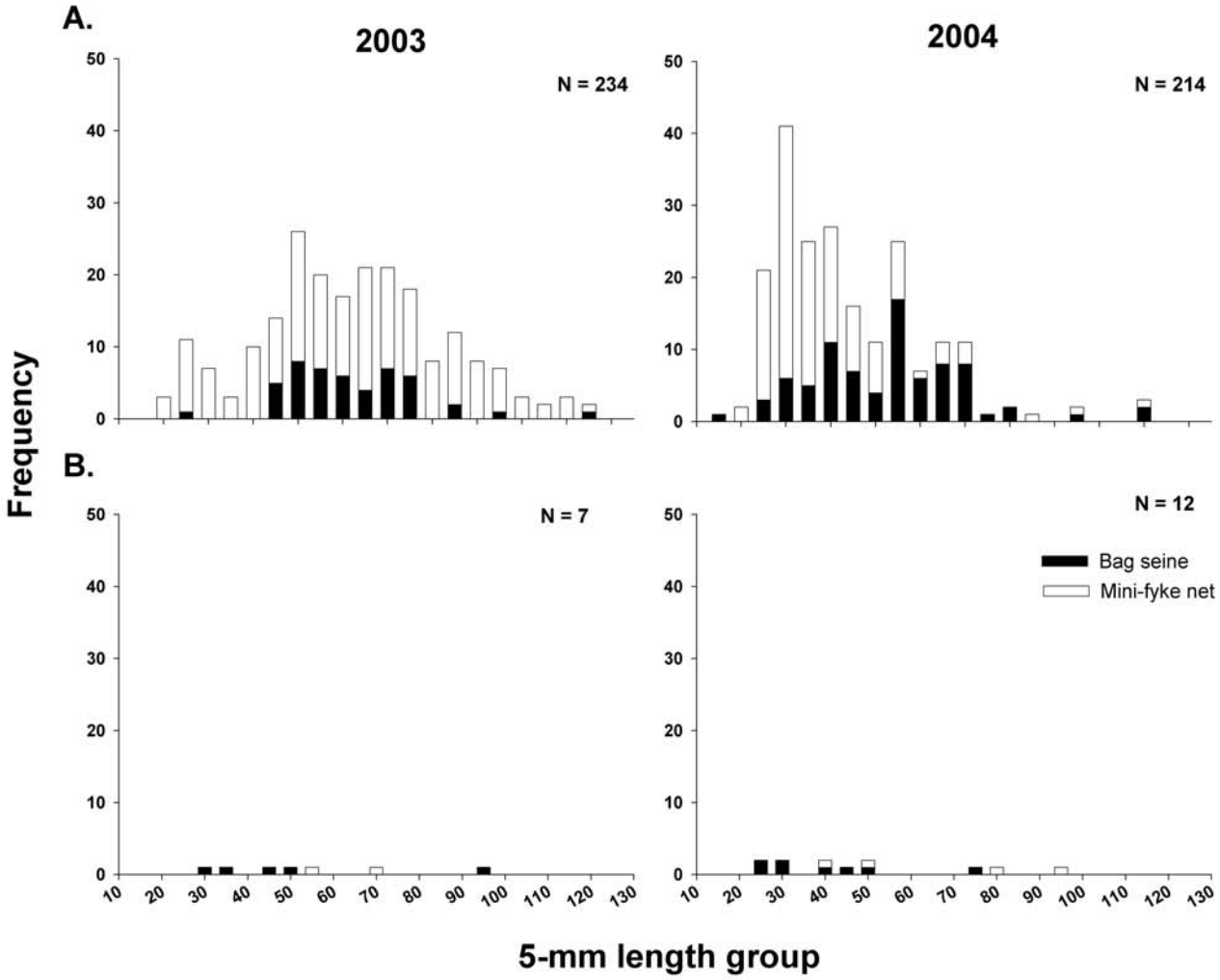

Figure 45. Frequency distribution of total lengths of smallmouth bass captured with bag seines and mini-fyke nets in the Missouri River downstream of: A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

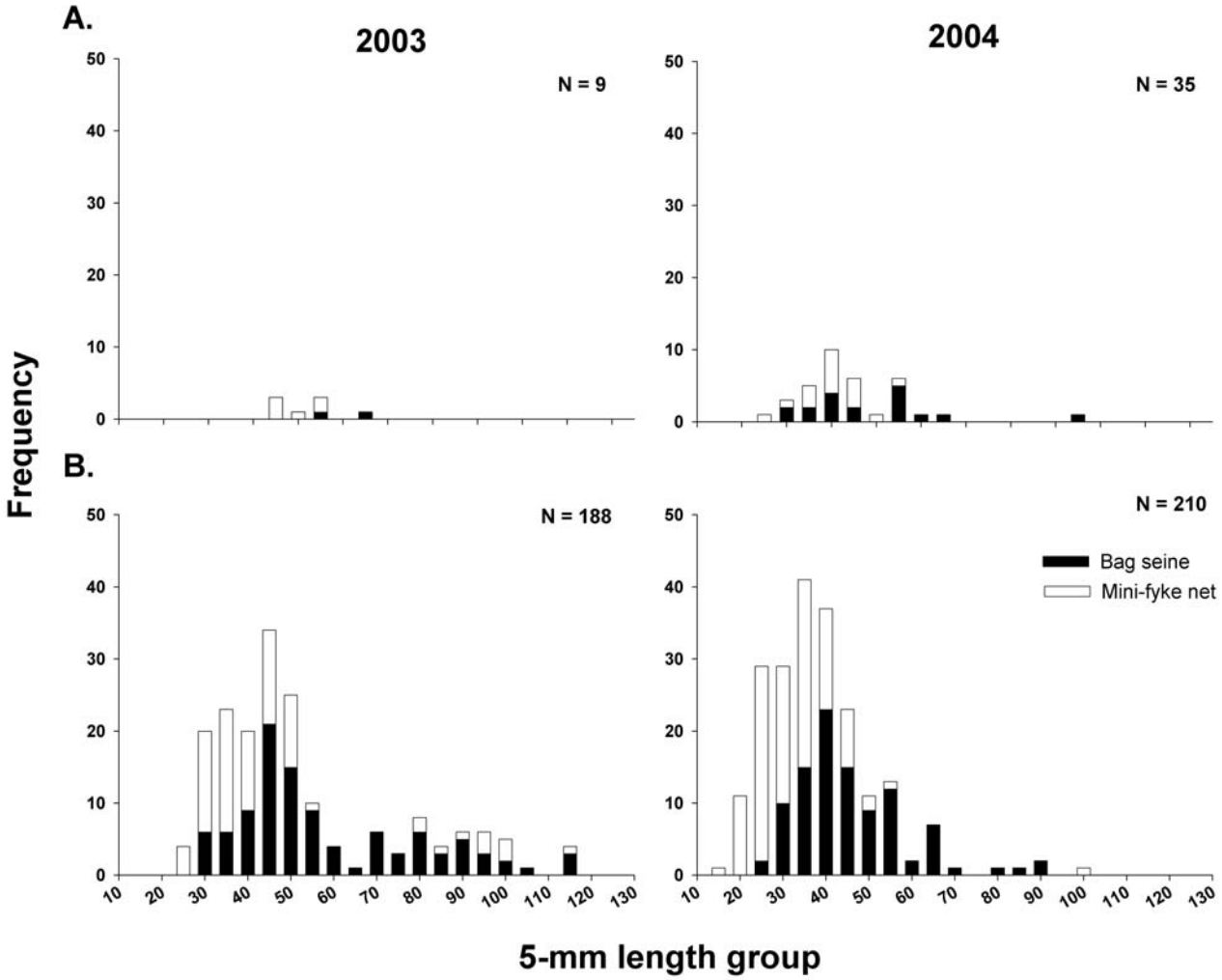

Figure 46. Frequency distribution of total lengths of white bass captured with bag seines and mini-fyke nets in the Missouri River downstream of A) Fort Randall Dam and B) Gavins Point Dam during 2003 and 2004.

DISCUSSION

As of 2004, bighead, silver, and grass carps have not been caught in the Missouri River above Gavins Point Dam and appear to not be reproducing downstream of the dam in South Dakota and Nebraska based on the lack of YOY captures. Since this study began, a standardized monitoring program for Missouri River fishes was instituted in the Fort Randall Reach in 2003 and the Gavins Point Reach in South Dakota in 2005 (Drobish 2006) that focused on main channel fishes but also assessed the shallow water community in the summer with the same mini-fyke net and bag seine as used in this study. No adult or YOY bighead, silver, and grass carps were captured in the Fort Randall Reach during 2004 - 2006 (Kaemingk et al. In press; Shuman et al. 2005, 2006, 2007). Adult bighead, silver, and grass carps have been collected with the same gears downstream of Gavins Point Dam in drifted trammel nets or static overnight gillnets (Stukel et al. 2006, 2007; Utrup et al. 2006a, 2006b). However, Utrup et al. (2006a, 2006b) concluded that gillnets and trammel nets were likely insufficient to assess relative abundance of adult Asian carps and served only to document their presence in the lower Missouri River. No YOY Asian carps have been collected or observed downstream of Gavins Point Dam in South Dakota and Nebraska waters since monitoring began in 2005 (personal communication September 2007, Sam Stukel, South Dakota Game and Parks, Yankton). Bighead and grass carp but no silver carp were captured as part of a benthic trawling study in the Mississippi River between the Missouri and Ohio river confluences (Herzog et al. 2005). During the Benthic Fishes Study of the Missouri River in 1996 - 1998, only grass carp were captured downstream of Gavins Point Dam in South Dakota and Nebraska (Berry et al. 2004). Only triploid grass carp are allowed in South Dakota; however, Nebraska allows use of diploid grass

carp (Conover et al. 2007) which could escape into the Missouri River and establish feral populations.

The establishment of bighead and silver carps in the Missouri River is recent with the majority of range expansion directed northward from the lower Mississippi River (Kolar et al. 2005). Bighead carp were first documented to spawn in the lower Missouri River in 1989 (Pflieger 1997) with known silver carp spawning documented more recently (Papoulias et al. 2006). This study provided one of the first observations of silver carp in South Dakota and Nebraska waters of the Missouri River when an adult fish jumped into our boat on July 18, 2003 while sampling in the mouth of the James River and indicated northward expansion of this species has continued upstream to Gavins Point Dam. During the Benthic Fishes Study that sampled throughout the Missouri River from 1996 – 1998, bighead carp captures (N = 22 fish) were reported only in the states of Kansas and Missouri; no silver carp were captured (Berry et al 2004). Of the 22 bighead carp captured by Berry et al. (2004), 86% were captured in 1998 which was likely at the onset of that species population growth in the lower Missouri River.

Sampling gears used to target YOY Asian carps in this study may have been ineffective to capture this life stage. Adult bighead and silver carp are sensitive to sound from outboard or electric trolling motors which can make capture difficult (FWS Great Plains FWMAO no date; Kolar et al. 2005; Utrup et al. 2006a, 2006b). We did not wait to begin sampling after beaching our boat and additional splashing caused by setting and retrieving minnow traps and mini-fyke nets may have scared fish away from the immediate area before we sampled with the beach seine. A fish kill in 1999 in the backwaters at the Upper Mississippi River National Wildlife refuge near St Louis, Missouri consisted of 97% Asian carps, indicating high abundance near the confluence of the Missouri and Mississippi rivers (Conover et al. 2007). Mini-fyke nets in the

lower 370 km of the Missouri River caught 198 bighead carps and 226 silver carps during summer of 2004 (Doyle et al. 2004). Although life stage was not differentiated, these fish were likely YOY. During this study, abundance of bighead carp and silver carp may have been too low in the South Dakota and Nebraska waters of the Missouri River during 2003 and 2004 for detection with mini-fyke nets and the bag seine. Silver carp YOY exhibit the same jumping behavior as adults when approached (personal communication, Duane Chapman, U.S. Geological Survey, Columbia, Missouri) and none were observed in this study. For adult and juvenile silver carp, visual counts of jumping fish along transects may provide a useful index of relative abundance. Hoop nets or electrofishing near wing dykes was recommended by Utrup et al. (2006a, 2006b) as means to assess relative abundance of adult Asian carps. If bighead and silver carps are truly not yet reproducing in the Missouri River waters of South Dakota and Nebraska downstream of Gavins Point Dam, this study provides valuable background information on the fish community and relative abundance to assess ecological change in the event these species indeed become established.

Shallow water main channel and side channel habitats of the Missouri River sampled in this study may not have been used by YOY Asian carps despite gears being set in areas of known past presence for adult bighead carp (FWS Great Plains FWMAO no date). However, Mississippi River Long Term Resource Monitoring Program data summarized by Kolar et al. (2005) found nearly equal proportions (28 – 40%) of small YOY bighead and silver carps (TL < 100 mm) in main channel borders, side channel borders, and continuous backwaters. A survey of Mississippi River Basin biologists by Kolar et al. (2005) stated that YOY bighead and silver carps in the lower Missouri River were commonly found in “low velocity off channel habitats associated with inside-bend sand bars and areas of flooded vegetation” (A. Starostka, FWS

Columbia Fisheries Resource Office, Columbia, MO). In this study, generally equal effort (20 – 30%) was expended on shallow sandbars within inside and outside bends in the main channel with greater effort expended in secondary channels (Figures 26, 27, 33, and 37). Mean column velocities within the large secondary connected channels downstream of Gavins Point Dam were 0.7 m/s in 2003 and 2004 which may have been too swift for YOY Asian carps, although velocity was measured in the center of the side channel. The Missouri River downstream of Gavins Point Dam in South Dakota and Nebraska is highly braided with many secondary channels (both large and small) but non-connected channels or slack backwater habitats are less common (Stukel et al. 2006). Flooded vegetation along the Missouri River is not common due to controlled flows out of Gavins Point Dam but do occur in the large tributaries such as the James, Vermillion, and Big Sioux rivers. Abundance of larval fishes in tributaries can be greater than in the Missouri River (Brown and Coon 1994) so future studies of juvenile Asian carp life history should focus on the importance of tributaries.

Water temperatures have been reduced, water clarity increased, and annual peaks in the pre-impoundment hydrograph essentially eliminated in the Missouri River downstream of the Fort Randall and Gavins Point dams (Hesse and Sheets 1993; NRC 2002; Pegg et al. 2003). Differences in temperature and turbidity within the Fort Randall and Gavins Point reaches likely resulted from the influence of primary tributaries and flow management at the respective dams. Water temperatures in the main channel of the Missouri River were 1 – 1.5 °C warmer in 2004 compared to 2003 in the Gavins Point Reach (Table 1) with peak temperatures > 25 °C from mid-July through early September (Figures 10 - 13). However, in the Fort Randall Reach in 2004 water temperatures were 0.8 – 1 °C cooler in inside bends and only 0.2 °C warmer in outside bends compared to 2003. Although peak water temperatures were higher in 2003

compared to 2004 (Figures 6 - 9), large daily pulses of cold hypolimnetic waters released from Lake Francis Case for peak power generation likely repressed main channel water temperatures in the Fort Randall Reach more when air temperatures were warmer. Like the main channel in the Gavins Point Reach, water temperatures in shallow side channels with lower flow were 1.5 °C warmer in 2003 in the Fort Randall Reach compared to 2004. Main channel water temperatures were greater in the Gavins Point Reach due to warm water inputs from the James River at the upstream sampling site. Modified thermal regimes from dams can influence spawning success of native fish and influence invertebrate production, hatch timing and drift propensity (Caissie 2006) which may explain the lack of small cyprinids in the Fort Randall reach. Turbidity was about 50% lower at all sites in the Fort Randall Reach compared to the Gavins Point Reach due to the greater influence of the James River which drains a larger watershed than the Niobrara River. No dissolved oxygen concentrations (< 5 mg/L) that could be stressful to fish (Coble 1982) were observed in this study downstream of either dam.

Shallow water fish assemblages in the Missouri River downstream of Fort Randall and Gavins Point dams in this study were similar to those observed in the Benthic Fishes Study in 1996 - 1998 (Berry et al. 2004). The most common species collected downstream of each dam in 1996 – 1998 and in 2003 – 2004 were emerald shiners and spotfin shiners. As in this study, greater numbers of gizzard shad, carpsuckers, and white bass were captured downstream of Gavins Point Dam in 1996 – 1998 compared to the Fort Randall Reach. The Fort Randall Reach fish assemblage in 1996 – 1998 still contained greater numbers of centrarchids compared to the Gavins Point Reach. However, unlike this study, the main centrarchids in the Fort Randall Reach were bluegills and white crappies while similar numbers of smallmouth bass were captured downstream of each dam in 1996 – 1998. The greater numbers of smallmouth bass

observed in the Gavins Point Reach in 1996 – 1998 compared to this study was likely due to use of electrofishing in the Benthic Fishes Study (Berry and Young 2001). In 2005, over 50% of the fish community within the Niobrara delta in the Fort Randall Reach was comprised of emerald shiners, spotfin shiners, gizzard shad and carpsuckers (Kaemingk et al. In press). Additionally, non-native fishes, primarily smallmouth bass and white bass (Bailey and Allum 1954) were more commonly collected at sites in each reach nearest to Lewis and Clark Lake.

The general pattern in fish abundance observed in this study in 2003 and 2004 was similar to the Benthic Fishes Study in 1996 – 1998 (Berry et al. 2004) in that greater fish abundance existed downstream of Gavins Point Dam compared to Fort Randall Dam. In addition to modified thermal regimes, clarity, and hydrograph downstream of Fort Randall and Gavins Point dams, peaking hydropower generation discharges out of Fort Randall are a likely cause for differing fish abundance in each reach. Daily mean flow out of Fort Randall Dam varied 10 fold during May through September which encompassed the spawning and most of the growing season of nearly all native Missouri River fishes (Pflieger 1997). For all months and all gears, mean overall shallow water fish abundance ranged from 18 - 100% lower in the Fort Randall Reach compared to the Gavins Point Reach except for 2003 mini-fyke net CPUE in July. In the Tallapoosa River in Alabama, relative abundance of fluvial specialist fishes doubled after minimum flows were increased (Travnichek et al. 1995) and the persistence of shallow water habitats was positively correlated with abundance of percids, catastomids, and cyprinids (Bowen et al. 1998). Despite differing temperature regimes observed in this study during 2003 and 2004, relative abundance did not greatly differ between years for either reach of the Missouri River. In general, consistently higher trends in fish abundance were observed in both years for the Gavins Point Reach, the reach with less variable daily flows.

Minnow traps were an effective method to sample the cyprinid community within the Missouri River. The 1/8-inch mesh conical trap is recommended because it caught significantly more fish and a wider size distribution of cyprinids than the 1/4-inch mesh trap. Minnow traps have been used as a low cost, effective method to target round gobies *Neogobius melanostomus* in rocky littoral habitats of the Great Lakes (Diana et al. 2006) areas not conducive to seining. Compared to bag seines and mini-fyke nets, minnow traps caught few species and are not recommended for doing faunal surveys in the Missouri River. Lapointe et al. (2006) also recommended against using minnow traps for faunal surveys in the Detroit River. Minnow trap and fyke net types and mesh size can be highly variable in the species captured, abundances, and size structure (Clavero et al. 2006); therefore, other designs or mesh sizes may be useful for sampling shallow water fishes or targeting desired species.

Bag seines and mini-fyke nets did not represent the same species composition, relative abundance, and size structure of the shallow water fish community in the Missouri River. Mini-fyke nets captured more species and shorter fishes than the bag seine but the seine captured more YOY catastomids and gizzard shad. Though species composition differed between seines and fyke nets, Clarke et al. (2007) recommended using fyke nets to sample littoral fishes in floodplain lakes due to higher species richness and diversity along with the ability to sample in more areas around snags and vegetation. The higher prevalence of zero catches with the bag seine in the Fort Randall Reach compared to the Gavins Point Reach indicated that seines were less effective in that reach, especially in the cattail marsh of the Niobrara River delta. Typical seining beaches within the delta were not common so the seine had to be quickly pulled in by dragging the lead line by hand along the bottom in knee-deep water at the edge of the cattails. Therefore, true relative abundance of fishes within the delta of the Fort Randall Reach is likely

underestimated by the bag seine. Daily water fluctuations within the Fort Randall Reach also likely reduced effectiveness of mini-fyke nets due to desiccation which necessitated setting the gear deep and when water levels rose in the afternoon, the lead would become inundated and not direct fish into the net. Differences in relative abundance between the Fort Randall and Gavins Point reaches could, in part, be due to differing efficiency of seines and mini-fyke nets in the two reaches.

Length distributions of cyprinids caught in minnow traps, bag seine and mini-fyke nets had significantly fewer small fish in the Fort Randall Reach compared to the Gavins Point Reach which indicates predation may be influencing the size structure of the shallow water fish communtiy. Based on bag seine and mini-fyke net catches, smallmouth bass were more abundant downstream of Fort Randall Dam compared to Gavins Point Dam in 2003 and 2004. Continued monitoring with bag seines and mini-fyke nets in 2005 found smallmouth bass were 70 - 80% more abundant in the Fort Randall Reach compared to the Gavins Point Reach (Shuman et al. 2006; Stukel et al. 2006). Additional predators that were more abundant in 2005 in the Fort Randall Reach compared to the Gavins Point Reach included: white crappies, walleyes and saugers (Shuman et al. 2006; Stukel et al. 2006). In contrast to this study, white bass were in greater abundance in the Fort Randall Reach during 2005 compared to the Gavins Point Reach. Abiotic factors such as water temperature and flow are likely causing differences in fish abundance between reaches; however, increased predation as evidenced by truncated size structure of cyprinids, may further highlight these differences.

MANAGEMENT IMPLICATIONS

1. As of 2004, no Asian carps were documented in the Missouri River above Gavins Point Dam in South Dakota and Nebraska. This study in 2003 was one of the first to document adult silver carp in South Dakota waters within the James River near its confluence with the Missouri River.

2. As of 2004, no evidence was found of Asian carp reproduction (i.e., young-of-year captures) in the unchannelized Missouri River downstream of Gavins Point Dam in South Dakota and Nebraska.

3. Future studies of Asian carp early life history should focus on use of the three major South Dakota tributaries downstream of Gavins Point Dam (James, Vermillion, and Big Sioux rivers) for spawning and nursery habitats.

4. Data collected during this study created a baseline of shallow water fish community structure and relative abundance vital to future assessments of ecological changes in the Missouri River. Over 40 fish species were captured in 2003 and 2004 downstream of Fort Randall and Gavins Point dams.

5. Dissolved oxygen concentrations < 5 mg/L were never observed while turbidity rarely exceeded 35 NTU in the Missouri River downstream of each dam during 2003 and 2004.

6. Conical minnow traps were effective to assess the predominate cyprinids in the shallow water fish community of the Missouri River. The 1/8-inch mesh is recommended due to capture of significantly more fish and a wider size distribution than the 1/4-inch mesh trap. Spotfin shiners comprised the greatest proportion of fish captured in minnow trap downstream of both dams in 2003 and 2004.

7. Minnow traps are recommended to be set in August when the prevalence of captures was greatest; generally over 50% of traps set in August captured fish.

8. Shallow water fish communities downstream of Fort Randall and Gavins Point Dams differed in that a greater percentage of centrarchids, principally smallmouth bass, was found in the Fort Randall Reach during 2003 and 2004.

9. Bag seines and mini-fyke nets differed in the assemblage of fishes captured. More species per deployment were captured with the mini-fyke nets while greater numbers of catastomids and gizzard shad were captured with the bag seine. Mini-fyke nets generally captured shorter fishes that the bag seine.

10. Abundance of fishes captured with multiple gears in this study, two types of minnow traps, bag seines, and mini-fyke nets was generally greater in the Gavins Point Reach compared to the Fort Randall Reach of the Missouri River during 2003 and 2004. Discharge out of Fort Randall Dam to meet peak hydropower demand fluctuated on average over one order of magnitude each day from May through September of 2003 and 2004 compared to nearly uniform discharge out of Gavins Point Dam over the same time frame.

11. Spatial variance in relative abundance of shallow water fishes was less within reaches and among macrohabitats than compared to differences between reaches.

12. Length distributions of cyprinids common in both reaches of the Missouri River were significantly truncated in the Fort Randall Reach indicating poor reproduction and recruitment or higher predation rates compared to the Gavins Point Reach.

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REFERENCES

Bailey, R. M. and M O. Allum. Fishes of South Dakota. Miscellaneous Publications of the Museum of Zoology, University of Michigan No. 119. Ann Arbor.

Berry, C. R., Jr., M.L. Wildhaber, and D.L. Galat. 2004. Fish distribution and abundance. Volume 3. Population structure and habitat use of benthic fishes along the Missouri and lower Yellowstone rivers. U.S. Geological Survey, Cooperative Research Units, South Dakota State University, Box 2140B, Brookings.

Berry, C. R., Jr., and B. A. Young. 2001. Introduction to the Benthic Fishes Study. Volume 1. Population structure and habitat use of benthic fishes along the Missouri and lower Yellowstone rivers. U.S. Geological Survey, Cooperative Research Units, South Dakota State University, Box 2140B, Brookings.

Bouchard, M. A., K. F. Higgins, D. M. Gardner, C. R. Berry, Jr., and S. R. Chipps. 2006. An annotated bibliography, Published articles (1861 – 2004) about the fish resources of South Dakota. Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings.

Bowen, Z. H., M. C. Freeman, and K. D. Bovee. 1998. Evaluation of generalized habitat criteria for assessing impacts of altered flow regimes on warmwater fishes. Transactions of the American Fisheries Society 127:455-468.

Breen, M. J. and C. R. Ruez, III. 2006. Gear bias in fyke netting: evaluating soak time, fish density and predators. North American Journal of Fisheries Management 26:32-41.

Brown, D. J., and T. G. Coon. 1994. Abundance and assemblage structure of fish larvae in the lower Missouri River and its tributaries. Transactions of the American Fisheries Society 123:718-732.

Cassie, D. 2006. The thermal regime of rivers: a review. Freshwater Biology 51:1389-1406.

Clark, S. J., J. R. Jackson, and S. E. Lochmann. 2007. A comparison of shoreline seines with fyke nets for sampling littoral fish communities in floodplain lakes. North American Journal of Fisheries Management 27:676-680.

Clavero, M., F. Blanco-Garrido, and F. Prenda. 2006. Monitoring small fish populations in streams: a comparison of four passive methods. Fisheries Research 78:243-251.

Coble, D. W. 1982. Fish populations in relation to dissolved oxygen in the Wisconsin River. Transactions of the American Fisheries Society 111:612-623.

Conover, G., R. Simmonds, and M. Whalen (editors). 2007. Management and control plan for Asian carps in the United States. Asian Carp Working Group, Aquatic Nuisance Species Task Force, Washington, D.C.

Diana, C. M., J. L. Jonas, R. M. Claramunt, J. D. Fitzsimons, and J. E. Marsden. 2006. A comparison of methods for sampling round goby in rocky littoral areas. North American Journal of Fisheries Management 26:514-522.

Doyle, W., N. Frohnauer, C. Lee, A. Plauck, N. Utrup, and T. Hill. 2005. 2004 Annual Report Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segments 13 and 14. U.S. Fish and Wildlife Service, Columbia Fisheries Resource Office, Columbia, MO. Prepared for the U.S. Army Corps of Engineers, Northwest Division. August 2005.

Drobish, M. R. (editor), 2006. Missouri River standard operating procedures for sampling and data collection. Volume 1.1. U.S. Army Corps of Engineers, Omaha Distric, Yankton, South Dakota.

Fowler, A. J., D. M. Lodge, and J. F. Hsia. 2007. Failure of the Lacey Act to protect US ecosystems against animal invasions. Frontiers in Ecology and the Environment 5:353-359.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. Special Publication 27. American Fisheries Society, Bethesda, Maryland.

Guillory, V., and R. D. Gasaway. 1978. Zoogeography of the grass carp in the United States. Transactions of the American Fisheries Society 107:105-112.

Henderson, S. 1980. Production potential of catfish grow-out ponds supplementally stocked with silver and bighead carp. Proceedings of the Annual Conference Southeast Association of fish and Wildlife Agencies 33(1979):584-590.

Herzog, D. P., V. A. Barko, J. S. Scheibe, R. A. Hrabik, and D. E. Ostendorf. 2005. Efficacy of a benthic trawl for sampling small-bodied fishes in large river systems. North American Journal of Fisheries Management 25:594-603.

Hesse, L. W. 1987. Taming the wild Missouri River: What has it cost? Fisheries 12(2):2-9.

Hesse, L. W., and W. Sheets. 1993. The Missouri River Hydrosystem. Fisheries 18(5):5-14.

Hintze, J. L. 2005. User's Guide – 1 Introduction, data, graphics. NCSS statistical system. NCSS, Kaysville, Utah.

Idrisi, N., E. L. Mills, L. G. Rudstam, and D. J. Stewart. 2001. Impact of zebra mussels (*Dreissena polymorpha*) on the pelagic lower trophic levels of Oneida Lake, New York. Canadian Journal of Fisheries and Aquatic Sciences 58:1430-1441

Jennings, D. P. 1988. Bighead carp (*Hypophthalmichthys nobilis*): Biological synopsis. Biological Report 88(29). U.S. Fish and Wildlife Service, Washington, DC.

Johal, M. S., H. R. Esmaeili, and K. K. Tandon. 2001. A comparison of back-calculated lengths of silver carp from bony structures. Journal of Fish Biology 59:1483-1493.

Kolar, C. S., D. C. Chapman, W. R. Courtenay, Jr., C. M. Housel, J. D. Williams, and D. P. Jennings. 2005. Asian carps of the genus *Hypophthalmichthys* (Pisces, Cyprinidae)-A biological synopsis and environmental risk assessment. Report to U.S. Fish and Wildlife Service per Interagency agreement 94400-3-0128.

Kaemingk, M. A., B. D. S. Graeb, C. W. Hoagstrom, and D. W. Willis. In press. Patterns of fish diversity in a mainstem Missouri River reservoir and associated delta in South Dakota and Nebraska, USA. River Research and Applications.

Lapointe, N. W. R., L. D. Corkum, and N. E. Mandrak. 2006. A comparison of methods for sampling fish diversity in shallow offshore waters of large rivers. North American Journal of Fisheries Management 26:503-513.

Mayer, C. M., A. J. VanDeValk, J. L. Forney, L. G. Rudstam and E. L. Mills. 2000. Response of yellow perch (*Perca flavescens*) in Oneida Lake, New York, to the establishment of zebra mussels (*Dreissena polymorpha*). Canadian Journal of Fisheries and Aquatic Sciences 57:742-754.

Mayer, C. M., L. G. Rudstam, E. L. Mills, S. G. Cardiff and C. A. Bloom. 2001. Zebra mussels (*Dreissena polymorpha*), habitat alteration, and yellow perch (*Perca flavescens*) foraging: system-wide effects and behavioural mechanisms. Canadian Journal of Fisheries and Aquatic Sciences 58:2459-2467.

Mitchell, A. J., and A. M. Kelly. 2006. The public sector role in the establishment of grass carp in the United States. Fisheries 31(3):113-121.

Natural Research Council (NRC). 2002. The Missouri River ecosystem, exploring the prospects for recovery. National Academy Press, Washington, DC.

Papoulias, D. M., D. Chapman, and D. E. Tillitt. 2006. Reproductive condition and occurrence of intersex in bighead and silver carp in the Missouri River. Hydrobiologia 571:355-360.

Pegg, M.A., C.L. Pierce, and A. Roy. 2003. Hydrological alteration along the Missouri River basin: a time series approach. Aquatic Sciences 65:63-72.

Pfleiger, W. L. 1997. The fishes of Missouri, revised edition. Missouri Department of Conservation, Jefferson City.

Reeves, K. S., and D. L. Galat. 2004. Use of sandbars as nursery habitat by larval fishes in the lower Missouri River. Progress report 2002-2003 Cooperative agreement 229 to Missouri Department of Conservation, Columbia. U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri, Columbia.

Shrank, S. J., and C. S. Guy. 2002. Age, growth and gonadal characteristics of adult bighead carp, *Hypophthalmichthys nobilis*, in the lower Missouri River. Environmental Biology of Fishes 64:443-450.

Shrank, S. J., P. J. Braaten, and C. S. Guy. 2001. Spatiotemporal variation in density of larval bighead carp in the lower Missouri River. Transactions of the American Fisheries Society 130:809-814.

Shrank, S. J., C. S. Guy, and J. F. Fairchild. 2003. Competitive interactions between age-0 bighead carp and paddlefish. Transactions of the American Fisheries Society 132:1222-1228.

Shuman, D. A., R. A. Klumb, and S. T. McAlpin. 2005. 2004 Annual Report Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River: Segments 5 and 6. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office, Pierre, South Dakota. Prepared for the U.S. Army Corps of Engineers, Kansas City and Omaha Districts. July 2005.

Shuman, D. A., G. A. Wanner, R. A. Klumb, and W. J. Stancill. 2006. 2005 Annual Report Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River: Segments 5 and 6. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office, Pierre, South Dakota. Prepared for the U.S. Army Corps of Engineers, Kansas City and Omaha Districts. July 2006.

Shuman, D. A., G. A. Wanner, R. A. Klumb, and W. J. Stancill. 2007. 2006 Annual Report Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River: Segments 5 and 6. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office, Pierre, South Dakota. Prepared for the U.S. Army Corps of Engineers, Missouri River Recovery Program. March 2007.

Stukel, S., J. Kral, and S. LaBay. 2006. 2005 Annual Report Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River: Segment 7. South Dakota Game Fish and Parks, Yankton, South Dakota. Prepared for the U.S. Army Corps of Engineers, Kansas City and Omaha Districts. June 2006.

Stukel, S., J. Kral, and S. LaBay.2007. 2006 Annual Report Pallid Sturgeon Population Assessment and Associated Fish Community Monitoring for the Missouri River: Segment 7. South Dakota Game Fish and Parks, Yankton, South Dakota. Prepared for the U.S. Army Corps of Engineers, Missouri River Recovery Program. March 2007.

Travnichek, V. H., M. B. Bain, and M. J. Maceina. 1995. Recovery of a warmwater fish assemblage after the initiation of a minimum-flow release downstream from a hydroelectric dam. Transactions of the American Fisheries Society 124:836-844.

U.S. Army Corps of Engineers (USACOE). 1994. Missouri River Master Water Control Manual Review and Update Study, Alternative evaluation Report, Volume 1. USACE Missouri River Division, Omaha, NE.

U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office. No date. An evaluation of sampling techniques and life history information on bighead carp in the Missouri River, below Gavins Point Dam, South Dakota and Nebraska. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office, Pierre, South Dakota.

Utrup, N., W. Doyle, C. Lee, A. Plauck, and T. Hill. 2006a. 2005 Annual Report Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 13. U.S. Fish and Wildlife Service, Columbia Fisheries Resource Office, Columbia, MO. Prepared for the U.S. Army Corps of Engineers, Northwest Division. June 2006.

Utrup, N., W. Doyle, C. Lee, A. Plauck, and T. Hill. 2006b. 2005 Annual Report Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River: Segment 14. U.S. Fish and Wildlife Service, Columbia Fisheries Resource Office, Columbia, MO. Prepared for the U.S. Army Corps of Engineers, Northwest Division. June 2006.

Zar. J. H. 1999. Biostatistical Analysis fourth edition. Prentice Hall, Upper Saddle River, New Jersey.

Appendix A. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) as fish/trap night and mean (±2 SE) monthly CPUE for 1/8-inch mesh conical minnow traps set in the Missouri River downstream of Fort Randall Dam during 2003 and 2004.

Species	2003							2004						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Blacknose dace	1	0.01 (0.02)	0 (0)	0.03 (0.07)	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Black crappie	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Bigmouth shiner	1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.009 (0.017)	0 (0)	0.029 (0.059)	0 (0)	0 (0)	0 (0)
Carpiodes spp.	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.009 (0.017)	0 (0)	0 (0)	0 (0)	0.067 (0.133)	0 (0)
Emerald shiner	35	0.35 (0.38)	0 (0)	0.03 (0.07)	0.06 (0.13)	0.61 (1.10)	0.88 (1.03)	3	0.03 (0.04)	0 (0)	0.03 (0.06)	0 (0)	0.13 (0.27)	0 (0)
Green sunfish	3	0.03 (0.03)	0 (0)	0.07 (0.10)	0.06 (0.13)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Iowa darter	1	0.01 (0.02)	0 (0)	0 (0)	0.06 (0.13)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Johnny darter	2	0.02 (0.04)	0 (0)	0 (0)	0 (0)	0.07 (0.13)	0 (0)	6	0.05 (0.05)	0 (0)	0.03 (0.06)	0.02 (0.03)	0.13 (0.18)	0.11 (0.22)
Northern pike	1	0.01 (0.02)	0 (0)	0.03 (0.07)	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Orange spotted sunfish	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.11)
Red shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	8	0.07 (0.07)	0.13 (0.25)	0.06 (0.12)	0 (0)	0.27 (0.41)	0 (0)
Rock bass	3	0.03 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0.19 (0.38)	4	0.03 (0.05)	0 (0)	0.06 (0.12)	0 (0)	0 (0)	0.11 (0.22)

Appendix A. (continued).

Species	2003							2004						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Sand shiner	10	0.10 (0.15)	0 (0)	0 (0)	0 (0)	0.07 (0.13)	0.50 (0.88)	65	0.56 (0.63)	0 (0)	0 (0)	0 (0)	2.73 (3.76)	1.33 (2.44)
Smallmouth bass	3	0.03 (0.03)	0 (0)	0 (0)	0.13 (0.17)	0.03 (0.07)	0 (0)	2	0.01 (0.02)	0 (0)	0 (0)	0.05 (0.07)	0 (0)	0 (0)
Spotfin shiner	563	5.57 (2.94)	0 (0)	0.07 (0.14)	2.44 (2.52)	14.68 (8.21)	4.19 (5.52)	325	2.80 (1.41)	0.25 (0.50)	2.47 (3.08)	3.08 (2.11)	7.40 (6.31)	1.33 (1.84)
Spottail shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.07 (0.13)	0 (0)
All fish	623	6.17 (3.09)	0 (0)	0.24 (0.21)	2.75 (2.45)	15.48 (8.38)	5.75 (7.28)	416	3.58 (1.66)	0.38 (0.75)	2.68 (3.24)	3.14 (2.11)	10.80 (7.22)	2.94 (4.06)

Appendix B. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) as fish/trap night and mean (±2 SE) monthly CPUE for 1/8-inch mesh conical minnow traps set in the Missouri River downstream of Gavins Point Dam during 2003 and 2004.

Species	2003							2004						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Bigmouth shiner	1025	9.67 (17.89)	0 (0)	0.48 (0.96)	0 (0)	0.97 (1.53)	70.21 (135.1)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Bluegill	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0 (0)
Bluntnose minnow	2	0.02 (0.03)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0.07 (0.14)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Channel catfish	3	0.03 (0.04)	0 (0)	0 (0)	0 (0)	0.06 (0.13)	0.07 (0.14)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Common carp	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3	0.03 (0.06)	0 (0)	0 (0)	0.10 (0.20)	0 (0)	0 (0)
Creek Chub	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Emerald shiner	230	2.170 (2.46)	0.14 (0.21)	0.52 (0.96)	0.06 (0.13)	1.75 (1.83)	11.29 (17.86)	98	0.91 (1.45)	0.06 (0.11)	0.13 (0.20)	0.07 (0.13)	0.14 (0.19)	5.93 (10.34)
Fathead minnow	10	0.09 (0.14)	0 (0)	0 (0)	0 (0)	0 (0)	0.71 (0.99)	3	0.03 (0.06)	0 (0)	0.10 (0.19)	0 (0)	0 (0)	0 (0)
Freshwater drum	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Johnny darter	3	0.03 (0.03)	0.05 (0.10)	0.08 (0.12)	0 (0)	0 (0)	0 (0)	3	0.03 (0.03)	0 (0)	0 (0)	0.07 (0.09)	0.07 (0.14)	0 (0)
Lepomis spp.	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0 (0)
Moxostoma spp.	2	0.02 (0.03)	0 (0)	0 (0)	0 (0)	0.06 (0.09)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix B. (continued).

Species	2003							2004						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Notropis spp.	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (0.14)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Orange spotted sunfish	4	0.04 (0.05)	0 (0)	0 (0)	0 (0)	0.09 (0.14)	0.07 (0.14)	2	0.02 (0.04)	0 (0)	0.07 (0.13)	0 (0)	0 (0)	0 (0)
Red Shiner	82	0.77 (0.47)	0 (0)	0.13 (0.19)	1.56 (2.03)	0.97 (0.97)	1.64 (1.40)	103	0.95 (0.81)	0 (0)	2.36 (2.74)	0.43 (0.38)	1.14 (0.72)	0.07 (0.13)
River Shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.07 (0.14)	0 (0)
Sand Shiner	440	4.15 (3.25)	0 (0)	2.35 (3.67)	1.81 (1.71)	2.81 (3.19)	19.07 (21.7)	101	0.94 (0.59)	0 (0)	2.23 (1.90)	0.57 (0.41)	0.93 (0.99)	0.13 (0.27)
Shorthead redhorse	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.31 (0.06)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Smallmouth Bass	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.07 (0.14)	0 (0)
Spotfin Shiner	1947	18.37 (7.17)	0.10 (0.13)	11.00 (11.28)	22.62 (24.8)	30.41 (14.4)	25.50 (23.4)	1919	17.77 (6.15)	0.500 (0.40)	14.35 (11.2)	15.40 (10.66)	43.79 (23.15)	26.00 (16.59)
Spottail Shiner	9	0.09 (0.09)	0 (0)	0 (0)	0 (0)	0.09 (0.14)	0.43 (0.58)	4	0.04 (0.05)	0 (0)	0.03 (0.06)	0 (0)	0.14 (0.29)	0.07 (0.13)
Unidentifed Cyprinid	6	0.06 (0.10)	0 (0)	0 (0)	0 (0)	0.19 (0.32)	0 (0)	2	0.02 (0.03)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0.07 (0.13)
Walleye	2	0.02 (0.03)	0 (0)	0 (0)	0 (0)	0.06 (0.09)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
White Bass	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
All fish	3775[a]	35.61 (24.17)	0.48 (0.56)	14.57 (15.69)	26.06 (27.59)	37.66 (18.71)	129.14 (169.2)	2242	20.76 (7.10)	0.56 (0.40)	19.26 (14.57)	16.73 (11.28)	46.36 (2436)	32.27 (21.00)

[a]Includes four unidentifiable fish.

Appendix C. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) as fish per trap night and mean (±2 SE) monthly CPUE for 1/4-inch mesh conical minnow traps set in the Missouri River downstream of Fort Randall Dam during 2003 and 2004.

Species	2003							2004						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Carpiodes spp.	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.032 (0.07)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Emerald shiner	24	0.24 (0.22)	0 (0)	0.10 (0.11)	0 (0)	0.52 (0.63)	0.31 (0.51)	6	0.05 (0.05)	0.08 (0.17)	0.03 (0.06)	0.03 0.06)	0 (0)	0.11 (0.22)
Green Sunfish	3	0.03 (0.03)	0 (0)	0.07 (0.09)	0 (0)	0 (0)	0.06 (0.13)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Northern Pike	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Red Shiner	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	4	0.03 (0.05)	0 (0)	0 (0)	0 (0)	0.06 (0.13)	0.17 (0.33)
Rock bass	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	4	0.03 (0.04)	0 (0)	0 (0)	0 (0)	0.06 (0.13)	0.17 (0.24)
Sand Shiner	2	0.02 (0.03)	0.13 (0.25)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	12	0.10 (0.14)	0 (0)	0 (0)	0 (0)	0.19 (0.38)	0.50 (0.89)
Smallmouth bass	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0.03 (0.06)	0 (0)	0 (0)
Spotfin Shiner	329	3.29 (1.81)	0 (0)	0.10 (1.12)	3.333 (4.406)	7.13 (4.94)	1.81 (2.56)	268	2.21 (1.52)	0.06 (0.11)	0.80 (1.34)	5.72 (4.97)	1.13 (1.01)	1.44 (1.90)
All fish	362	3.62 (1.88)	0.13 (0.25)	1.13 (1.11)	3.333 (4.406)	7.81 (5.14)	2.19 (2.58)	294	2.43 (1.56)	0.14 (0.20)	0.83 (1.34)	5.78 (4.97)	1.44 (1.13)	2.39 (3.14)

Appendix D. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) as fish/trap night and mean (±2 SE) monthly CPUE for 1/4-inch mesh conical minnow traps set in the Missouri River downstream of Gavins Point Dam during 2003 and 2004.

Species	2003							2004						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Bigmouth shiner	3	0.03 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0.19 (0.38)	3	0.03 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.40)
Bluegill	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.13)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Carpiodes spp.	2	0.02 (0.04)	0 (0)	0 (0)	0 (0)	0.07 (0.13)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Channel catfish	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Common carp	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	5	0.05 (0.10)	0 (0)	0 (0)	0.16 (0.32)	0 (0)	0 (0)
Emerald shiner	194	1.81 (2.53)	0.02 (0.04)	0.05 (0.09)	0 (0)	0.70 (0.60)	10.69 (16.61)	10	0.10 (0.10)	0 (0)	0.06 (0.09)	0 (0)	0.14 (0.29)	0.40 (0.55)
Flathead catfish	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.13)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Freshwater drum	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green sunfish	2	0.01 (0.02)	0.02 (0.04)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Johnny darter	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (0.13)
Moxostoma spp.	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Orange spotted sunfish	7	0.07 (0.06)	0 (0)	0 (0)	0 (0)	0.13 (0.16)	0.19 (0.27)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix D. (continued).

Species	2003							2004						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Red Shiner	11	0.10 (0.08)	0 (0)	0.09 (0.13)	0.25 (0.39)	0.10 (0.11)	0.13 (0.25)	29	0.28 (0.23)	0 (0)	0.23 (0.39)	0.58 (0.65)	0.14 (0.19)	0.13 (0.18)
Sand Shiner	56	0.52 (0.43)	0 (0)	0.32 (0.40)	1.56 (0.33)	0.33 (0.42)	0.88 (1.24)	5	0.05 (0.05)	0 (0)	0.03 (0.06)	0.03 (0.06)	0.07 (0.14)	0.13 (0.27)
Shorthead redhorse	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)	1	0.01 (0.02)	0.08 (0.15)	0 (0)	0 (0)	0 (0)	0 (0)
Spotfin Shiner	1201	11.22 (5.58)	0.17 (0.19)	3.41 (3.99)	9.81 (10.93)	25.33 (17.14)	12.81 (9.21)	978	9.40 (4.05)	0.92 (1.69)	6.52 (5.42)	8.55 (6.64)	11.07 (8.52)	22.93 (19.21)
Stonecat	1	0.004 (0.01)	0.02 (0.04)	0 (0)	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
All fish	1483	13.86 (6.52)	0.24 (0.23)	3.86 (4.52)	11.63 (13.39)	26.87 (17.48)	25.00 (21.38)	1032	9.92 (4.23)	1.00 (1.68)	6.84 (5.59)	9.32 (6.90)	11.42 (8.96)	23.87 (20.24)

Appendix E. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) as fish/trap night and mean (±2 SE) monthly CPUE for 1/8-inch nylon box minnow traps set in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003.

Species	Fort Randall Reach							Gavins Point Reach						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Bluegill	3	0.03 (0.06)	0 (0)	0 (0)	0 (0)	0.11 (0.22)	0 (0)	4	0.04 (0.04)	0 (0)	0 (0)	0.06 (0.13)	0.06 (0.09)	0.06 (0.13)
Bigmouth shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.13)
Channel catfish	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2	0.01 (0.02)	0.02 (0.05)	0 (0)	0 (0)	0 (0)	0.06 (0.13)
Emerald shiner	3	0.03 (0.04)	0 (0)	0 (0)	0 (0)	0.04 (0.07)	0.13 (0.17)	22	0.20 (0.35)	0 (0)	0 (0)	0 (0)	0.68 (1.22)	0.06 (0.13)
Green sunfish	1	0.01 (0.02)	0 (0)	0 (0)	0.06 (0.13)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.13)
Johnny darter	1	0.01 (0.02)	0.13 (0.25)	0 (0)	0 (0)	0 (0)	0 (0)	8	0.07 (0.06)	0 (0)	0.04 (0.08)	0.13 (0.17)	0.13 (0.15)	0.06 (0.13)
Orange spotted sunfish	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6	0.05 (0.07)	0 (0)	0.02 (0.04)	0 (0)	0.06 (0.13)	0.19 (0.38)
Red shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6	0.06 (0.09)	0 (0)	0.25 (0.42)	0 (0)	0 (0)	0 (0)
Rock bass	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.13)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sand shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9	0.08 (0.10)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0.50 (0.60)
Shorthead redhorse	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.13)
Shortnose gar	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0.04 (0.08)	0 (0)	0 (0)	0 (0)
Smallmouth bass	3	0.03 (0.04)	0 (0)	0 (0)	0.13 (0.17)	0.04 (0.07)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Spotfin shiner	32	0.33 (0.27)	0 (0)	0 (0)	0.44 (0.75)	0.67 (0.70)	0.44 (0.88)	95	0.88 (0.53)	0.02 (0.05)	0.88 (1.05)	0.50 (0.63)	1.65 (1.52)	0.88 (0.93)

Appendix E. (continued).

Species	Fort Randall Reach							Gavins Point Reach						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Spottail shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2	0.02 (0.03)	0 (0)	0.04 (0.08)	0 (0)	0.03 (0.06)	0 (0)
Unidentified cyprinid	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2	0.02 (0.04)	0 (0)	0 (0)	0 (0)	0.06 (0.13)	0 (0)
Walleye	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0.06 (0.13)	0 (0)	0 (0)
White bass	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0 (0)
All fish	44	0.45 (0.30)	0.13 (0.25)	0 (0)	0.63 (0.87)	0.85 (0.71)	0.63 (1.00)	161	1.49 (0.72)	0.05 (0.07)	1.27 (1.43)	0.75 (0.67)	2.74 (1.99)	2.00 (1.70)

Appendix F. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) as fish/trap night and mean (±2 SE) monthly CPUE for 4-way box minnow traps set in the Missouri River downstream of Fort Randall and Gavins Point dams during 2003.

Species	Fort Randall Reach							Gavins Point Reach						
	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep	Total Catch	Summer CPUE	May	Jun	Jul	Aug	Sep
Bluegill	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	13	0.12 (0.10)	0 (0)	0.04 (0.08)	0.25 (0.34)	0.27 (0.30)	0 (0)
Black bullhead	1	0.01 (0.02)	0 (0)	0.03 (0.07)	0 (0)	0 (0)	0 (0)	3	0.03 (0.03)	0.05 (0.09)	0.08 (0.12)	0 (0)	0 (0)	0 (0)
Channel catfish	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.07)	0 (0)
Freshwater drum	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0.06 (0.13)	0 (0)	0 (0)
Green sunfish	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0 (0)	4	0.04 (0.08)	0 (0)	0.17 (0.33)	0 (0)	0 (0)	0 (0)
Northern pike	1	0.01 (0.02)	0 (0)	0.06 (0.13)	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pumpkin seed	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Orange spotted sunfish	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3	0.03 (0.04)	0 (0)	0.04 (0.08)	0 (0)	0.07 (0.13)	0 (0)
Rock bass	1	0.01 (0.02)	0 (0)	0 (0)	0 (0)	0.03 (0.06)	0 (0)	1	0.01 (0.02)	0 (0)	0.04 (0.08)	0 (0)	0 (0)	0 (0)
Shorthead redhorse	1	0.01 (0.02)	0.13 (0.25)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0 (0)	0.06 (0.13)	0 (0)	0 (0)
Smallmouth bass	3	0.03 (0.06)	0 (0)	0 (0)	0 (0)	0.09 (0.19)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Spotfin shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0.04 (0.08)	0 (0)	0 (0)	0 (0)
Unidentified lepomis	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1	0.01 (0.02)	0 (0)	0.04 (0.08)	0 (0)	0 (0)	0 (0)
All fish	9	0.09 (0.07)	0.13 (0.25)	0.03 (0.07)	0.06 (0.13)	0.19 (0.21)	0 (0)	29	0.27 (0.16)	0.05 (0.10)	0.48 (0.52)	0.38 (0.36)	0.37 (0.32)	0 (0)

Appendix G. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) defined as fish/m^2 and mean (±2 SE) monthly CPUE of fishes collected with bag seines in the Missouri River downstream of Fort Randall Dam during 2003 and 2004.

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Bigmouth shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	2	0.0001 (0.0002)	0 (0)	0.0003 (0.0005)	0.0003 (0.0006)
Black crappie	1	0.0001 (0.0002)	0 (0)	0.0002 (0.004)	0 (0)	1	0.0001 (0.0001)	0.0001 (0.0003)	0 (0)	0 (0)
Bluegill	2	0.0002 (0.0004)	0 (0)	0.0004 (0.0006)	0 (0)	5	0.0004 (0.0005)	0 (0)	0.0011 (0.0017)	0.0003 (0.0006)
Bluntnose minnow	2	0.0002 (0.0004)	0 (0)	0.0004 (0.0006)	0 (0)	2	0.0001 (0.003)	0 (0)	0 (0)	0.0006 (0.0013)
Carpiodes spp.	98	0.0095 (0.0092)	0 (0)	0.0189 (0.0180)	0 (0)	42	0.0029 (0.0031)	0.0012 (0.0022)	0.0065 (0.0104)	0.0029 (0.0043)
Channel catfish	4	0.0004 (0.0006)	0 (0)	0.0008 (0.0011)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Common carp	0	0 (0)	0 (0)	0 (0)	0 (0)	2	0.0001 (0.0002)	0.0003 (0.0004)	0 (0)	0 (0)
Emerald shiner	790	0.0581 (0.0396)	0.1534 (0.1820)	0.0574 (0.0465)	0.0085 (0.0092)	996	0.0655 (0.0227)	0.0590 (0.0328)	0.0796 (0.0427)	0.0689 (0.0468)
Freshwater drum	3	0.0001 (0.0002)	0 (0)	0.0003 (0.0004)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Gizzard shad	36	0.0036 (0.0052)	0 (0)	0.00004 (0.0001)	0.0110 (0.0160)	57	0.0040 (0.0034)	0.0005 (0.0009)	0.0054 (0.0077)	0.0106 (0.0124)
Green sunfish	5	0.0005 (0.0008)	0.0006 (0.0012)	0.0008 (0.0016)	0 (0)	17	0.0012 (0.0020)	0.0001 (0.0003)	0.0003 (0.0005)	0.0048 (0.0090)
Hybognathus spp.	1	0.00003 (0.00005)	0 (0)	0.00005 (0.0001)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Johnny darter	4	0.0003 (0.0004)	0.0001 (0.0002)	0.0006 (0.0007)	0 (0)	13	0.0009 (0.0014)	0.0003 (0.0004)	0.0030 (0.0054)	0 (0)
Largemouth bass	2	0.0002 (0.0003)	0.0006 (0.0012)	0 (0)	0.0003 (0.0006)	31	0.0022 (0.0013)	0.0019 (0.0012)	0.0046 (0.0045)	0 (0)
Lepomis spp.	1	0.0001 (0.0002)	0 (0)	0.0002 (0.0004)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)

Appendix G. (continued).

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Moxostoma spp.	9	0.0009 (0.0018)	0 (0)	0.0018 (0.0036)	0 (0)	55	0.0039 (0.0035)	0.0042 (0.0055)	0.0065 (0.0077)	0 (0)
Northern pike	1	0.0001 (0.0002)	0 (0)	0.0002 (0.0004)	0 (0)	2	0.0001 (0.0002)	0 (0)	0.0003 (0.0005)	0.0003 (0.0006)
Orange spotted sunfish	1	0.0001 (0.0002)	0 (0)	0 (0)	0.0003 (0.0006)	0	0 (0)	0 (0)	0 (0)	0 (0)
Rainbow smelt	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.0001 (0.0001)	0 (0)	0 (0)	0.0003 (0.0006)
Red shiner	7	0.0005 (0.0004)	0.0014 (0.0017)	0.0004 (0.0007)	0 (0)	10	0.0007 (0.0007)	0.0008 (0.0011)	0.0011 (0.0017)	0 (0)
River carpsucker	2	0.0002 (0.0003)	0 (0)	0 (0)	0.0006 (0.0009)	8	0.0006 (0.0007)	0.0007 (0.0011)	0.0008 (0.0012)	0 (0)
River shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	2	0.0001 (0.0003)	0 (0)	0.0005 (0.0011)	0 (0)
Rock bass	0	0 (0)	0 (0)	0 (0)	0 (0)	4	0.0003 (0.0003)	0.0001 (0.0003)	0.0005 (0.0011)	0.0003 (0.0006)
Sand shiner	3	0.0002 (0.0003)	0 (0)	0.0003 (0.0004)	0.0003 (0.0006)	42	0.0029 (0.0017)	0.0027 (0.0027)	0.0040 (0.0034)	0.0022 (0.0020)
Sauger	1	0.0001 (0.0002)	0.0006 (0.0012)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Shorthead redhorse	21	0.0009 (0.0014)	0 (0)	0.0019 (0.0027)	0 (0)	13	0.0009 (0.0008)	0.0003 (0.0005)	0.0008 (0.0016)	0.0026 (0.0028)
Shortnose gar	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.0001 (0.0001)	0 (0)	0.0003 (0.0005)	0 (0)
Shovelnose sturgeon	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.0001 (0.0001)	0.0001 (0.0003)	0 (0)	0 (0)
Smallmouth bass	50	0.0047 (0.0021)	0.0006 (0.0012)	0.0059 (0.0036)	0.0051 (0.0029)	109	0.0076 (0.0032)	0.0059 (0.0044)	0.0105 (0.0071)	0.0083 (0.0056)
Spotfin shiner	149	0.0112 (0.0054)	0.0085 (0.0091)	0.0181 0.0010)	0.0020 (0.0020)	581	0.0407 (0.0389)	0.0240 (0.0126)	0.1057 (0.1470)	0.0029 (0.0030)
Spottail shiner	5	0.0003 (0.0004)	0.0006 (0.0012)	0.0004 (0.0007)	0 (0)	22	0.0015 (0.0014)	0.0010 (0.0014)	0.0038 (0.0044)	0 (0)

Appendix G. (continued).

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Unidentified cyprinid	3	0.0003 (0.0005)	0.0006 (0.0012)	0.0004 (0.0008)	0 (0)	2	0.0001 (0.0003)	0.0003 (0.0005)	0 (0)	0 (0)
Walleye	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.0001 (0.0001)	0 (0)	0.0003 (0.0005)	0 (0)
White bass	2	0.0001 (0.0002)	0 (0)	0.00005 (0.0001)	0.0003 (0.0006)	21	0.0014 (0.0010)	0.0018 (0.0015)	0.0013 (0.0022)	0.0003 (0.0006)
White crappie	2	0.0001 (0.0001)	0 (0)	0.0001 (0.0002)	0 (0)	1	0.0001 (0.0001)	0 (0)	0 (0)	0.0003 (0.0006)
Yellow perch	1	0.0001 (0.0002)	0 (0)	0.0002 (0.0004)	0 (0)	65	0.0046 (0.0033)	0.0043 (0.0044)	0.0073 (0.0087)	0.0019 (0.0028)
All fish[a]	1208	0.0935 (0.0424)	0.1670 (0.1810)	0.1103 (0.0548)	0.0285 (0.0189)	2109	0.1440 (0.0530)	0.1093 (0.0423)	0.2444 (0.1782)	0.1079 (0.0575)

[a]Total includes two unidentified fish.

Appendix H. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) defined as fish/m^2 and mean (±2 SE) monthly CPUE of fishes captured with a bag seine in the Missouri River downstream of Gavins Point Dam during 2003 and 2004.

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Bigmouth buffalo	5	0.0003 (0.0003)	0.0007 (0.0011)	0.0003 (0.0004)	0 (0)	2	0.0001 (0.0002)	0.0002 (0.0003)	0 (0)	0 (0)
Bigmouth shiner	392	0.0239 (0.0113)	0.0112 (0.0191)	0.0272 (0.0170)	0.0247 (0.0187)	307	0.0206 0.0089	0.0109 (0.0104)	0.0115 (0.0098)	0.0522 (0.0264)
Bluegill	27	0.0009 (0.0006)	0.0003 (0.0006)	0.0011 (0.0010)	0.0008 (0.0013)	8	0.0005 (0.0006)	0.0001 (0.0002)	0 (0)	0.0020 (0.0020)
Bluntnose minnow	1	0.0001 (0.0002)	0 (0)	0.0002 (0.0003)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Carpiodes spp.	2376	0.0970 (0.0617)	0.0555 (0.0317)	0.1475 (0.1093)	0.0197 (0.0099)	1202	0.0806 (0.0415)	0.0470 (0.0321)	0.1932 (0.1671)	0.0598 (0.0512)
Channel catfish	17	0.0007 (0.0006)	0.0009 (0.0019)	0.0010 (0.0010)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Common carp	12	0.0009 (0.0012)	0.0007 (0.0011)	0.0013 (0.0022)	0.0003 (0.0006)	61	0.0041 (0.0031)	0.0059 (0.0053)	0.0038 (0.0047)	0 (0)
Emerald shiner	953	0.0590 (0.0287)	0.0432 (0.0338)	0.0146 (0.0076)	0.1583 (0.0959)	564	0.0377 (0.0335)	0.0190 (0.0106)	0.0750 (0.0989)	0.0490 (0.0270)
Fathead minnow	6	0.0004 (0.0004)	0 (0)	0.0006 (0.0007)	0 (0)	1	0.0001 (0.0001)	0.0001 (0.0002)	0 (0)	0 (0)
Freshwater drum	13	0.0008 (0.0006)	0.0006 (0.0010)	0.0012 (0.0010)	0.0001 (0.0002)	10	0.0007 (0.0006)	0.0007 (0.0008)	0.0003 (0.0006)	0.0009 (0.0017)
Gizzard shad	1149	0.0580 (0.0300)	0.0677 (0.0549)	0.0572 (0.0412)	0.0536 (0.0621)	199	0.0134 (0.0132)	0.0132 (0.0113)	0.0269 (0.0272)	0.0015 (0.0024)
Hybognathus spp.	2	0.0001 (0.0001)	0 (0)	0 (0)	0.0002 (0.0003)	0	0 (0)	0 (0)	0 (0)	0 (0)
Johnny darter	12	0.0005 (0.0005)	0.0003 (0.0004)	0.0008 (0.0008)	0.0001 (0.0001)	5	0.0003 (0.0003)	0.0002 (0.0006)	0.0003 (0.0006)	0.0006 (0.0008)
Largemouth bass	0	0 (0)	0 (0)	0 (0)	0 (0)	4	0.0003 (0.0004)	0.0001 (0.0002)	0.0010 (0.0019)	0 (0)

Appendix H. (continued).

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Lepomis spp.	0	0 (0)	0 (0)	0 (0)	0 (0)	3	0.0002 (0.0004)	0 (0)	0 (0)	0.0009 (0.0017)
Longnose gar	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.0001 (0.0001)	0.0001 (0.0002)	0 (0)	0 (0)
Moxostoma spp.	12	0.0001 (0.0003)	0.0008 (0.0016)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Orange spotted sunfish	19	0.0006 (0.0006)	0.0001 (0.0001)	0.0010 (0.0010)	0 (0)	4	0.0003 (0.0003)	0.0001 (0.0002)	0.0006 (0.0013)	0.0003 (0.0006)
Quillback	2	0.0003 (0.0006)	0.0019 (0.0038)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Red shiner	13	0.0012 (0.0012)	0.0028 (0.0057)	0.0008 (0.0010)	0.0010 (0.0014)	15	0.0010 (0.0005)	0.0011 (0.0007)	0 (0)	0.0017 (0.0016)
River carpsucker	2	0.0002 (0.0003)	0 (0)	0.0002 (0.0004)	0.0003 (0.0006)	10	0.0007 (0.0007)	0.0011 (0.0011)	0 (0)	0.0003 (0.0006)
River shiner	6	0.0004 (0.0007)	0 (0)	0.0007 (0.0012)	0.0002 (0.0003)	10	0.0007 (0.0005)	0.0008 (0.0008)	0.0006 (0.0009)	0.0003 (0.0006)
Sand shiner	422	0.0211 (0.0087)	0.0196 (0.0323)	0.0208 (0.0093)	0.0225 (0.0164)	195	0.0129 (0.0041)	0.0071 (0.0034)	0.0131 (0.0090)	0.0267 (0.0125)
Sauger	5	0.0004 (0.0005)	0.0026 (0.0030)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Shorthead redhorse	90	0.0058 (0.0044)	0.0033 (0.0066)	0.0078 (0.0074)	0.0035 (0.0041)	133	0.0089 (0.0047)	0.0066 (0.0065)	0.0237 (0.0130)	0.0012 (0.0014)
Shortnose gar	2	0.0001 (0.0002)	0 (0)	0.0002 (0.0003)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Silver chub	1	0.0001 (0.0002)	0 (0)	0.0002 (0.0003)	0 (0)	1	0.0001 (0.0001)	0.0001 (0.0002)	0 (0)	0 (0)
Smallmouth bass	5	0.0004 (0.0003)	0.0006 (0.0010)	0.0005 (0.0005)	0 (0)	8	0.0005 (0.0005)	0.0007 (0.0008)	0.0006 (0.0009)	0 (0)
Smallmouth buffalo	2	0.0001 (0.0002)	0 (0)	0.0002 (0.0003)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Spotfin shiner	428	0.0276 (0.0147)	0.0383 (0.0640)	0.0186 (0.0123)	0.0392 (0.0272)	391	0.0263 (0.0082)	0.0193 (0.0088)	0.0128 (0.0143)	0.0551 (0.0241)

Appendix H. (continued).

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Spottail shiner	17	0.0007 (0.0006)	0 (0)	0.0006 (0.0008)	0.0013 (0.0014)	9	0.0006 (0.0005)	0.0006 (0.0008)	0.0003 (0.0006)	0.0009 (0.0013)
Unidentified cyprinid	63	0.0041 (0.0031)	0.0110 (0.0103)	0.0035 (0.0044)	0.0010 (0.0018)	95	0.0064 (0.0055)	0.0002 (0.0003)	0.0080 (0.0091)	0.0197 (0.0009)
Walleye	6	0.0007 (0.0010)	0.0039 (0.0060)	0 (0)	0 (0)	6	0.0004 (0.0005)	0.0005 (0.0008)	0.0006 (0.0009)	0 (0)
White bass	106	0.0061 (0.0035)	0.0091 (0.0115)	0.0064 (0.0040)	0.0037 (0.0068)	146	0.0098 (0.0091)	0.0062 (0.0038)	0.0282 (0.0423)	0.0017 (0.0016)
White crappie	1	0.00003 (0.0001)	0 (0)	0.00005 (0.0001)	0 (0)	1	0.0001 (0.0001)	0 (0)	0.0003 (0.0006)	0 (0)
Yellow perch	1	0.00003 (0.0001)	0.0002 (0.0003)	0 (0)	0 (0)	1	0.0001 (0.0001)	0.0001 (0.0002)	0 (0)	0 (0)
All fish	6174[a]	0.3125 (0.0854)	0.2762 (0.1385)	0.3144 (0.1339)	0.3305 (0.1271)	3392	0.2273 (0.0580)	0.1425 (0.0403)	0.4010 (0.2256)	0.2747 (0.0942)

[a]Total includes six unidentified fish.

Appendix I. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) defined as fish/net night and mean (±2 SE) monthly CPUE for mini-fyke nets set in the Missouri River downstream of Fort Randall Dam during 2003 and 2004.

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Bigmouth buffalo	0	0 (0)	0 (0)	0 (0)	0 (0)	2	0.013 (0.025)	0.027 (0.054)	0 (0)	0 (0)
Bigmouth shiner	2	0.031 (0.063)	0.125 (0.250)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Black bullhead	1	0.016 (0.031)	0.063 (0.125)	0 (0)	0 (0)	2	0.019 (0.028)	0.014 (0.027)	0.042 (0.083)	0 (0)
Black crappie	38	0.594 (0.469)	0.125 (0.171)	0.969 (0.896)	0.313 (0.437)	11	0.139 (0.190)	0 (0)	0.458 (0.614)	0 (0)
Blacknose shiner	1	0.016 (0.0313)	0 (0)	0.0312 (0.063)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Bluegill	25	0.391 (0.320)	0.063 (0.125)	0.344 (0.306)	0.813 (1.114)	20	0.222 (0.147)	0.122 (0.131)	0.167 (0.197)	0.500 (0.518)
Bluntnose minnow	141	2.203 (3.475)	8.625 (13.718)	0.094 (0.105)	0 (0)	37	0.437 (0.685)	0.068 (0.088)	0.042 (0.083)	1.722 (2.985)
Carpiodes spp.	10	0.156 (0.179)	0 (0)	0.156 (0.313)	0.313 (0.352)	19	0.222 (0.231)	0.392 (0.464)	0.125 (0.250)	0 (0)
Channel catfish	1	0.016 (0.031)	0 (0)	0.031 (0.063)	0 (0)	6	0.076 (0.107)	0.108 (0.216)	0.083 (0.115)	0 (0)
Common carp	1	0.016 (0.031)	0.063 (0.125)	0 (0)	0 (0)	4	0.032 (0.038)	0.068 (0.079)	0 (0)	0 (0)
Emerald shiner	3250	50.781 (59.192)	186.500 (228.361)	3.781 (2.348)	9.063 (11.712)	609	7.367 (3.105)	6.676 (4.958)	4.458 (3.012)	12.667 (7.827)
Fathead minnow	88	1.375 (2.499)	5.500 (9.941)	0 (0)	0 (0)	3	0.038 (0.076)	0 (0)	0 (0)	0.167 (0.333)
Freshwater drum	2	0.031 (0.044)	0.063 (0.125)	0 (0)	0.063 (0.125)	0	0 (0)	0 (0)	0 (0)	0 (0)
Gizzard shad	1	0.016 (0.031)	0 (0)	0.031 (0.063)	0 (0)	5	0.063 (0.091)	0 (0)	0.125 (0.250)	0.111 (0.222)
Green sunfish	43	0.672 (0.924)	0.563 (0.657)	1.063 (1.820)	0 (0)	7	0.082 (0.071)	0.041 (0.060)	0.167 (0.197)	0.056 (0.111)

Appendix I. (continued).

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Hybognathus spp.	5	0.078 (0.128)	0.313 (0.507)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Johnny darter	47	0.734 (0.693)	1.938 (2.686)	0.469 (0.269)	0.063 (0.125)	62	0.729 (0.332)	0.905 (0.487)	0.917 (0.761)	0.111 (0.152)
Largemouth bass	14	0.219 (0.211)	0.250 (0.289)	0.313 (0.396)	0 (0)	76	0.835 (1.050)	0.595 (0.401)	1.750 (3.414)	0.111 (0.222)
Lepomis spp.	3	0.047 (0.069)	0 (0)	0.094 (0.138)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Longnose gar	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.013 (0.025)	0 (0)	0 (0)	0.056 (0.111)
Moxostoma spp.	0	0 (0)	0 (0)	0 (0)	0 (0)	45	0.570 (0.586)	0.919 (1.207)	0.375 (0.479)	0.111 (0.222)
Northern pike	3	0.047 (0.053)	0 (0)	0.094 (0.105)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Notropis spp.	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.013 (0.025)	0 (0)	0.042 (0.083)	0 (0)
Orange spotted sunfish	15	0.234 (0.295)	0.125 (0.171)	0.250 (0.500)	0.313 (0.625)	0	0 (0)	0 (0)	0 (0)	0 (0)
Rainbow smelt	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.013 (0.025)	0 (0)	0 (0)	0.056 (0.111)
Red shiner	81	1.266 (1.512)	4.875 (5.805)	0.094 (0.138)	0 (0)	13	0.158 (0.166)	0.041 (0.060)	0.250 (0.421)	0.278 (0.452)
River carpsucker	0	0 (0)	0 (0)	0 (0)	0 (0)	2	0.013 (0.025)	0.027 (0.054)	0 (0)	0 (0)
Rock bass	7	0.109 (0.063)	0.063 (0.125)	0 (0)	0.375 (0.403)	5	0.063 (0.055)	0 (0)	0.125 (0.138)	0.111 (0.152)
Sand shiner	23	0.359 (0.297)	1.063 (1.008)	0.156 (0.256)	0.063 (0.125)	137	1.671 (0.893)	1.216 (1.047)	2.917 (2.340)	0.944 (0.832)
Sauger	2	0.031 (0.044)	0.063 (0.125)	0.031 (0.0623)	0 (0)	1	0.013 (0.025)	0.027 (0.054)	0 (0)	0 (0)
Shorthead redhorse	8	0.125 (0.122)	0 (0)	0.156 (0.158)	0.188 (0.375)	7	0.089 (0.115)	0 (0)	0.167 (0.333)	0.167 (0.243)

Appendix I. (continued).

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Shortnose gar	17	0.266 (0.168)	0.438 (0.315)	0.281 (0.287)	0.063 (0.125)	10	0.127 (0.091)	0.108 (0.129)	0 (0)	0.333 (0.280)
Silver chub	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.013 (0.025)	0 (0)	0.042 (0.083)	0 (0)
Smallmouth bass	177	2.766 (0.776)	1.188 (0.987)	2.906 (1.083)	4.063 (1.784)	706	5.297 (6.741)	9.257 (14.332)	2.542 (1.777)	0.833 (0.763)
Smallmouth buffalo	1	0.016 (0.031)	0.063 (0.125)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Spotfin shiner	1200	18.750 (15.477)	55.313 (58.646)	8.781 (4.902)	2.125 (1.504)	438	4.835 (1.352)	6.081 (2.122)	5.458 (2.200)	1.444 (2.218)
Spottail shiner	6	0.094 (0.097)	0.188 (0.272)	0.094 (0.138)	0 (0)	32	0.405 (0.305)	0.676 (0.615)	0.208 (0.269)	0.111 (0.152)
Stonecat	0	0 (0)	0 (0)	0 (0)	0 (0)	3	0.025 (0.031)	0.027 (0.038)	0.042 (0.083)	0 (0)
Unidentified cyprinid	3	0.047 (0.053)	0 (0)	0.094 (0.105)	0 (0)	42	0.494 (0.712)	0.892 (1.510)	0.042 (0.083)	0.278 (0.354)
Walleye	2	0.031 (0.044)	0.063 (0.125)	0 (0)	0.063 (0.125)	0	0 (0)	0 (0)	0 (0)	0 (0)
White bass	0	0 (0)	0 (0)	0 (0)	0 (0)	22	0.234 (0.171)	0.391 (0.317)	0.042 (0.083)	0.167 (0.333)
White crappie	16	0.250 (0.199)	0.688 (0.700)	0.125 (0.149)	0.063 (0.125)	21	0.203 (0.141)	0.243 (0.262)	0.125 (0.138)	0.222 (0.258)
Yellow perch	6	0.094 (0.086)	0.313 (0.301)	0.031 (0.063)	0 (0)	28	0.310 (0.272)	0.635 (0.564)	0.042 (0.083)	0 (0)
All fish	5242[a]	81.906 (65.762)	268.625 (244.815)	20.531 (6.723)	17.938 (11.690)	2380[b]	24.842 (7.764)	29.554 (15.012)	20.792 (8.247)	20.556 (9.486)

[a]Total includes two unidentified fish.
[b]Total includes one unidentified fish.

Appendix J. Total catch, mean (±2 SE) summer catch-per-unit-effort (CPUE) defined as fish/net night and mean (±2 SE) monthly CPUE for mini-fyke nets set in the Missouri River downstream of Gavins Point Dam during 2003 and 2004.

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Bigmouth shiner	46	0.742 (0.409)	0.875 (0.892)	0.710 (0.617)	0.667 (0.637)	62	1.016 (0.747)	0.414 (0.759)	1.063 (1.523)	2.063 (1.945)
Black bullhead	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.016 (0.033)	0 (0)	0 (0)	0.0623 (0.125)
Black crappie	1	0.016 (0.032)	0.063 (0.125)	0 (0)	0 (0)	3	0.049 (0.073)	0.069 (0.138)	0 (0)	0.063 (0.125)
Bluegill	73	1.177 (0.703)	1.125 (1.515)	1.355 (1.100)	0.867 (0.9330	27	0.443 (0.271)	0.241 (0.292)	0.313 (0.301)	0.938 (0.806)
Bluntnose minnow	7	0.113 (0.104)	0.250 (0.289)	0.097 (0.142)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Carpiodes spp.	15	0.242 (0.170)	0.375 (0.512)	0.194 (0.172)	0.200 (0.289)	15	0.246 (0.166)	0.103 (0.152)	0.313 (0.397)	0.438 (0.407)
Channel catfish	19	0.306 (0.246)	0.125 (0.171)	0.452 (0.462)	0.200 (0.289)	3	0.049 (0.073)	0 (0)	0 (0)	0.188 (0.272)
Common carp	6	0.097 (0.100)	0.375 (0.359)	0 (0)	0 (0)	9	0.148 (0.139)	0.310 (0.283)	0 (0)	0 (0)
Emerald shiner	3216	51.871 (36.993)	0.875 (0.403)	29.226 (19.022)	153.067 (137.921)	844	13.836 (13.148)	1.241 (0.804)	3.688 (3.567)	46.813 (47.195)
Fathead minnow	3	0.048 (0.055)	0.063 (0.125)	0.032 (0.065)	0.067 (0.133)	7	0.115 (0.125)	0.069 (0.096)	0.125 (0.250)	0.188 (0.375)
Freshwater drum	43	0.694 (0.389)	1.313 (1.234)	0.548 (0.369)	0.333 (0.465)	38	0.623 (0.778)	0.345 (0.436)	1.688 (2.856)	0.063 (0.125)
Gizzard shad	405	6.532 (8.271)	16.313 (30.389)	3.871 (5.471)	1.600 (1.910)	133	2.180 (2.375)	3.517 (4.919)	1.500 (1.449)	0.438 (0.515)
Green sunfish	2	0.032 (0.045)	0 (0)	0 (0)	0.133 (0.182)	2	0.033 (0.046)	0 (0)	0.125 (0.171)	0 (0)
Johnny darter	13	0.210 (0.123)	0.313 (0.301)	0.258 (0.185)	0 (0)	6	0.098 (0.112)	0.172 (0.223)	0 (0)	0.063 (0.125)
Largemouth bass	1	0.016 (0.032)	0.063 (0.125)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)

Appendix J. (continued).

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Lepomis spp.	4	0.065 (0.063)	0 (0)	0.129 (0.122)	0 (0)	1	0.016 (0.033)	0 (0)	0 (0)	0.063 (0.125)
Longnose gar	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.016 (0.033)	0.034 (0.069)	0 (0)	0 (0)
Moxostoma spp.	1	0.016 (0.032)	0.063 (0.125)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Orange spotted sunfish	12	0.194 (0.220)	0 (0)	0.097 (0.108)	0.600 (0.868)	6	0.098 (0.090)	0.103 (0.115)	0.063 (0.125)	0.125 (0.250)
Pumpkinseed	1	0.016 (0.032)	0 (0)	0 (0)	0.067 (0.133)	0	0 (0)	0 (0)	0 (0)	0 (0)
Rainbow smelt	0	0 (0)	0 (0)	0 (0)	0 (0)	2	0.033 (0.046)	0 (0)	0.063 (0.125)	0.063 (0.125)
Red shiner	46	0.742 (0.371)	1.750 (1.133)	0.355 (0.237)	0.467 (0.581)	57	0.934 (0.512)	1.552 (0.970)	0.250 (0.289)	0.500 (0.606)
River shiner	0	0 (0)	0 (0)	0 (0)	0 (0)	4	0.066 (0.079)	0.138 (0.164)	0 (0)	0 (0)
Sander spp.	15	0.242 (0.484)	0.938 (1.875)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
Sand shiner	135	2.177 (1.182)	2.188 (0.917)	2.032 (1.971)	2.467 (2.639)	268	4.393 (4.172)	1.621 (1.874)	8.063 (14.571)	5.750 (5.786)
Sauger	2	0.032 (0.045)	0 (0)	0.032 (0.065)	0.067 (0.133)	0	0 (0)	0 (0)	0 (0)	0 (0)
Shorthead redhorse	12	0.194 (0.151)	0.125 (0.250)	0.323 (0.269)	0 (0)	11	0.180 (0.119)	0.241 (0.190)	0.250 (0.289)	0 (0)
Shortnose gar	13	0.210 (0.131)	0.125 (0.171)	0.226 (0.201)	0.267 (0.307)	14	0.230 (0.230)	0.069 (0.138)	0 (0)	0.750 (0.806)
Smallmouth bass	3	0.048 (0.055)	0 (0)	0.032 (0.065)	0.133 (0.182)	4	0.066 (0.064)	0.034 (0.069)	0.063 (0.125)	0.125 (0.171)
Spotfin shiner	1339	21.597 (15.334)	10.875 (8.555)	15.710 (8.958)	45.200 (59.842)	1159	19.000 (12.613)	20.655 (22.724)	8.563 (3.988)	26.438 (24.860)
Spottail shiner	20	0.323 (0.400)	0.125 (0.171)	0.161 (0.209)	0.867 (1.596)	9	0.148 (0.203)	0.310 (0.422)	0 (0)	0 (0)

Appendix J. (continued).

Species	2003					2004				
	Total Catch	Summer CPUE	July	August	September	Total Catch	Summer CPUE	July	August	September
Unidentified catastomid	0	0 (0)	0 (0)	0 (0)	0 (0)	1	0.016 (0.033)	0.034 (0.069)	0 (0)	0 (0)
Unidentified cyprinid	47	0.758 (0.896)	0.125 (0.171)	0.484 (0.635)	2.000 (3.470)	4	0.066 (0.131)	0 (0)	0.250 (0.500)	0 (0)
Walleye	14	0.226 (0.141)	0.500 (0.447)	0.161 (0.134)	0.067 (0.133)	8	0.131 (0.109)	0.241 (0.214)	0.063 (0.125)	0 (0)
White bass	113	1.823 (1.723)	5.063 (6.435)	0.839 (0.656)	0.400 (0.545)	126	2.066 (1.385)	3.724 (2.747)	1.063 (1.024)	0.063 (0.125)
White crappie	18	0.290 (0.262)	0.500 (0.876)	0.226 (0.201)	0.200 (0.400)	7	0.115 (0.115)	0.172 (0.223)	0.125 (0.171)	0 (0)
Yellow perch	1	0.016 (0.032)	0.063 (0.125)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0 (0)
All fish	5647[a]	91.081 (44.119)	44.625 (40.493)	57.548 (24.860)	209.933 (158.386)	2832	46.426 (21.629)	35.414 (25.321)	27.625 (16.858)	85.188 (64.243)

[a]Total includes one unidentified fish.