RESEARCH AND MONITORING

2004 PALLID STURGEON RECOVERY EFFORTS IN THE UPPER MISSOURI RIVER, MONTANA (RPMA #1)

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LOCATION:	Missouri River, (above Fort Peck Dam), Montana Recovery Priority Management Area 1
PERIOD COVERED:	January 1, 2004 through December 31, 2004 (2004 field season)
PROJECT PERSONNEL:	Bill Gardner Fishery Biologist Lewistown 406-538-4658

OBJECTIVES

1. To determine habitat preference, movements, abundance, feeding and growth of wild pallid sturgeon in Recovery Priority Management Area 1.

2. Conduct annual adult pallid sturgeon standardized netting to develop a baseline for future comparisons.

3. To assist with with collection of adult spawners for use in hatchery propagation efforts.

4. To assist with the release of hatchery-reared pallids and evaluate survival, growth and recruitment over the years.

5. To coordinate and implement recovery efforts in conjunction with North Dakota, South Dakota, and the U.S. Fish and Wildlife Service.

SUMMARY

This report details the pallid sturgeon recovery efforts for 2004 in Recovery Priority Management Area 1 (RPMA 1). Since 1998 there has been a total of 6,003 hatchery-reared juvenile pallid sturgeon released into RPMA 1. A total of 68 pallid sturgeon were captured this year consisting of 6 adults (comprised of 4 recaptures and 2 new fish), 57 hatchery 1997-year class pallid sturgeon (PS-97), 2 hatchery 2001-year class pallid sturgeon (PS-01) and 3 hatchery 2003-year class pallid sturgeon (PS-03). The fall pallid sturgeon standardized baseline survey resulted in a catch rate of 0.18 pallids/drift and this was 3.6 times greater than the survey's average long term rate. The PS-97 group density in the Robinson Bridge area was estimated to

be 228 pallids, therefore, the minimum survival rate for these 7-year-old fish was 31%. The growth rate for the PS-97 group was 40 mm/year (fork length) and appears to be much less than expected. Three of PS-97 group were captured in upriver areas indicating that this group is still well dispersed in the area. Twenty-nine radio tagged, hatchery-reared, age-1pallid sturgeon were released into the Marias River and nealy all (90%) of the radioed pallids moved out of the Marias River and into the Missouri River in less than 50 days. By the end of the study (day 63) 72% of the radioed pallids had moved downstream of the lowest monitoring station (Judith Landing) approximately half way through RPMA 1. It was estimated that at least 53% (15) of the radioed pallids remained upstream of RM 1910 (the lowest downstream distance surveyed and 35 miles above the reservoir) at the end of the study. One female pallid was successfully spawned with two males resulting in fertilized eggs.

INTRODUCTION

The Pallid Sturgeon Recovery Plan (Dryer and Sandvol 1993) lists the 230-mile unaltered reach of upper Missouri River above Fort Peck Reservoir as one of the six recovery-priority management areas (RPMA 1). There has been a long history of pallid sturgeon presence in this reach, however, losses of habitat and the migration barrier caused by the completion of Fort Peck Dam in the late 1930's probably initiated adverse impacts to the resident pallid sturgeon population. Significant flow and sediment regime alterations in the late 1950's as a result of operations at the newly constructed Canyon Ferry and Tiber Dams most likely further impacted the pallid population to the point of near extinction. A study that evaluated the status of pallid sturgeon during 1990-96 concluded that the population was endangered of going extinct within 10-20 years unless immediate actions are taken. A preliminary adult population estimate indicated that only 45 pallids remain in this reach. Additionally, the population was found to be senescent and that there have been no significant recruitment in the last 10 years (Gardner 1997).

Pallid sturgeon recovery in RPMA 1 consists of the following tasks as outlined in the Plan:

- 1.1. Restore Habitats and functions of the Missouri and Mississippi River ecosystems, while minimizing impacts on other uses of the rivers.
- 1.3. Increase public awareness of the laws and needs for protecting pallid sturgeon.
- 1.4. Establish refugia of pallid sturgeon broodstock.
- 2.1. Obtain information on life history and habitat requirements of all life stages of pallid sturgeon.
- 2.2. Research additional solutions to the impacts of man's activities on pallid sturgeon and their habitat.
- 2.4. Obtain information on population status and trends.
- 3.3. Reintroduce pallid sturgeon and/or augment existing populations.
- 4.1. Communicate with sturgeon researchers and managers.

The Montana Fish Wildlife and Parks (FWP) in cooperation with the U.S. Fish and Wildlife Service (FWS) initiated pallid sturgeon recovery in RPMA 1 with the release of 732 hatchery-reared, yearling pallid sturgeon during 1998.

RESULTS

Reintroduction

Since 1998 there have been only 3 years that juvenile pallid sturgeon were released:

- 1998 a total of 732 yearling pallids were released (PS-97).
- 2002 a total of 2,063 yearling pallids were released (PS-01).
- 2004 a total of 3,050 yearling pallids (PS-03) and 158, 3-yr old pallids (PS-01).

The pallids stocked in 1998 (PS-97) were Yellowstone River stock raised at Gavins Point National Fish Hatchery. These fish arrived in very good condition and were released at three sites: Loma, Judith Landing and Robinson Bridge during late August. The pallids stocked in 2002 (PS-01) were Upper Missouri River stock raised at Bozeman Fish Technology Center. These fish arrived in good condition but exhibited fin curl of both the pectoral and pelvic fins. It was estimated by Matt Toner Bozeman Fish Technology Center (BFTC) that only 14.4% had minor or no noticeable fin curl; the remaining 86% of the pallids exhibited moderate to severe fin curl. Approximately 400 each were released during late July at Loma, Coal Banks and Judith Landing while 876 were released at Robinson Bridge. The pallids stocked in 2004 (PS-03) were Yellowstone River stock raised at Bozeman Fish Technology Center. These fish arrived in good condition but exhibited fin curl of both the pectoral and pelvic fins. The fin curl condition was estimated to be minor or not noticeable for about 25% of the PS-03's and didn't appear to be as severe as that reported for the PS-01 pallids. Approximately 600 each were released during late August at Marias River (Circle Bridge), Loma, Coal Banks, Judith Landing and Robinson Bridge.

We planned to stock pallids every year after 1998, however, concerns about an irido virus in the hatcheries and propagation failures precluded stocking during 1999, 2000, 2001, and 2003. The present pallid sturgeon stocking plan calls for stocking 5,600 yearling fish into RPMA 1 annually (FWP 2004).

It is important to evaluate the success of the pallid sturgeon augmentation program so that problems can be resolved early on in the program. Once again a considerable amount of effort was directed at evaluating the survival and growth of these released fish because over several million dollars have been invested raising them in the hatcheries for recovering and repopulating the Missouri River. Stocking densities, age of stocked fish, acclimation and growth of stocked fish, and location of release sites are all important aspects for evaluating survival and ultimately recruitment of the released hatchery juvenile pallid sturgeon. The study area is a 184-mile reach (RM 1867-2051) of the Missouri River immediately upstream of Musselshell River Confluence (Fort Peck Reservoir) (Figure 1). A considerable effort is directed each year at evaluating the success of these releases. A variety of sampling methods are used including trammel drift netting, setline sampling, angling, and trawling.

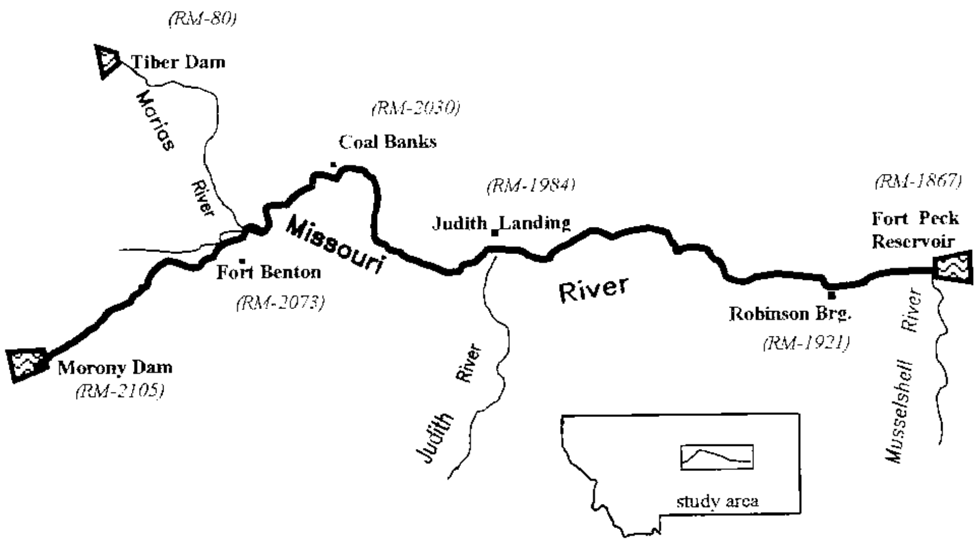

Figure 1. Map of the Middle Missouri River, MT, study area.

A total of 68 pallid sturgeon were captured this year consisting of 6 adults (comprised of 4 recaptures and 2 new fish), 57 hatchery 1997-year class pallid sturgeon (PS-97), 2 hatchery 2001-year class pallid sturgeon (PS-01) and 3 hatchery 2003-year class pallid sturgeon (PS-03) (Table 1). All but two of the pallid sturgeon were captured in the Robinson Bridge Section (RM 1887.1 – 1925.5), although sampling occurred throughout the entire study area. Individual capture information is given in Appendix A.

Table 1. Effort by sampling method and number of pallid sturgeon captured in the Middle Missouri River, MT, during 2004.

	Effort	Adults	Juv-97	Juv-01	Juv-03	Total
Trammel net	128 drifts	1	19	2 [1/]	2	24
Spawning nets	195 drifts	4	0	0	--	4
Trawl	154 tows	--	1	0	0	1
Setlines	183 sets	0	33	0	0	33
Angling	28 hrs	1	4	0	0	5
Other	--	0	0	0	1	1
		6	57	2	3	68

[1/] Both of the PS-01 were released in 2004 as 3 yr olds.

Juvenile Pallid Sturgeon Netting Survey

Attempts were made to capture the juvenile pallid sturgeon by drifting small mesh trammel nets. A total of 1 adult, 19 PS-97 2 PS-01 and 2 PS-03 pallids were captured by drift netting. The largest proportion (50%) of the 24 pallids was captured at inside bend macro-habitat areas. Eighty percent of the pallids were netted at depths of less than 2 meters. Additionally, a total of

702 fish representing 18 species were sampled while netting throughout the study area (Table 2). Shovelnose sturgeon, flathead chub and river carpsucker dominated the catch, comprising 55, 9 and 7 percent of the fish sampled, respectively.

Table 2. Average catch rates (no./drift) of fish sampled while drifting trammel nets in the Middle Missouri River, MT, May-October, 2004.

	Coal Bnk	Judith L.	Robinson	Total #
Blue sucker	0.1	0.1	T	7
Burbot			T	2
Carp	0.1		0.3	29
Channel catfish		0.1	0.1	11
Flathead chub	0.4	0.4	0.5	61
Freshwater drum			T	3
Goldeye	0.4	0.4	0.2	33
Longnose sucker	1.5	0.3		33
Pallid sturgeon		0.1	0.2	23
Rainbow trout			T	1
River carpsucker	0.3	0.3	0.4	47
Sauger	0.2	0.5		14
Shorthead redhorse	0.3	0.3	0.1	20
Shovelnose sturgeon	4.6	2.5	2.8	386
Smallmouth buffalo		0.1	0.2	20
Smallmouth bass	0.1			1
Walleye			0.1	9
White sucker	0.1			2
Total # fish	147	96	457	702
Total # drifts	18	19	91	128
Average depth (m)	1.3	1.8	1.8	
Average distance (m)	203	292	280	
Avg. duration (min.)	7.0	6.3	7.2	

Setline Sampling

Setline sampling enables us to effectively sample difficult places to net that could be important habitat areas for juvenile pallid sturgeon. Preliminary sampling with setlines during 2003 showed this method was fairly productive for catching juvenile pallids. A total of 183 sets were made during April-June, 2004 and results are given in Table 3. Thirty-three pallids, all PS-97, were sampled using setlines. The majority (55%) of pallids were caught on setlines fished in the channel cross-over macro-habitat type. Additionally, a total of 564 fish, representing 13 species, were sampled. Goldeye, stonecat and flathead chub dominated the catch, comprising 28, 17 and 14 percent of the fish sampled, respectively.

Angling with a rod and reel was also used to capture pallid sturgeon. A total of 1 adult and 4 PS-97 pallids were caught using this method. Additionally, 1 other pallid (PS-03) was sampled inadvertently while conducting routine electrofishing surveys in the upper reach.

Benthic Trawling

The main purpose for trawling was to evaluate pallid and shovelnose sturgeon spawning success. A total of 1,330 fish, representing 18 species, were sampled while trawling during August in the Coal Banks and Robinson Bridge sections of the Missouri River and in the confluence area of the Marias River (Table 4). Most of the trawling occurred in the lower 36 miles of the study area between RM-1921 and RM-1885 where it is thought most of the age-0 shovelnose sturgeon (SNS) usually reside. Similar to years past, longnose dace, age 0 channel catfish, sturgeon chub, and stonecat dominated the catch comprising 26, 23, 19, and 18 percent of the fish sampled, respectively. The trawling results, once again indicates there is a fairly healthy sturgeon chub population at Coal Banks. Prior to 2003 sturgeon chub were not known to occur here.

Only 1 age-0 SNS was sampled this year compared to 2 in 2003 (Gardner 2004). During the first year of intensive trawling (1995) a total of 28 age-0 SNS were sampled in about 100 tows (Gardner 1996) indicating this method was effective at sampling age-0 SNS when they are more numerous. Based on the low catches of age-0 SNS this year and previous years, it appears there has been poor SNS spawning success at least during the past 6 years.

Fall Pallid Sturgeon Standardized Baseline Survey

A total of 9 pallid sturgeon were sampled while conducting the standardized fall survey in the 16-mile Robinson Bridge trend area (Table 5). This was the most pallids ever netted here while conducting the survey and is mainly the result of the abundance of the PS-97 pallids and the improved efficiency of netting these larger fish. The nine juvenile hatchery pallids were comprised of 6 PS-97, 2 PS-01 and 1PS-03. This baseline survey has been completed 8 times since 1996; Table 5 summarizes these survey results.

Table 3. Average catch rates (average number/set) of fish sampled by setlines in the Middle Missouri River, MT, 2004.

	Coal Banks	**C P U E Judith L.**	**Robinson**	**Total # Fish**
Burbot			T	2
Carp	0.2	0.1	0.2	28
Channel catfish	0.2	0.5	0.3	59
Flathead chub	0.2	0.6	0.4	81
Freshwater drum	0.4	T	0.1	25
Goldeye	1.0	1.2	0.8	159
Longnose sucker	T			2
Pallid sturgeon		0.1	0.2	33
River carpsucker			T	3
Sauger	0.1	0.1	0.1	24
Shorthead redhorse	0.4	0.1	0.1	21
Shovelnose			0.2	29
Stonecat	0.1	0.5	0.6	98
Total # Fish # Sets	60	73	431	564
	23	22	138	

Survival Growth and Dispersal

A total of 6,003 hatchery-reared pallid sturgeon have now been released into RPMA 1 since 1998 consisting of three age-classes. Attempts were made to sample as many juvenile pallids as possible for evaluation of growth, movement patterns, habitat selection and abundance estimates. All release site areas were sampled, although a much greater amount of effort was directed in the Robinson Bridge area. A density estimate of the PS-97 pallid group was completed in the Robinson Bridge area using a simple mark-recapture, “with replacement” estimator model. I used PIT tag numbers for the marks to identify if the fish was a new or previously sampled fish. A total of 26 fish were classified as marked during 2003 and in our recovery run during 2004 a total of 34 were classified as captured (C) fish for estimate purposes; 3 of these fish were recaptures from the previous year (R). The density of PS-97 in the Robinson Bridge area (RM 1887 – 1925) was 228 (95%C.I. 93-569) in this 38-mile reach. A total of 732 PS-97 pallids were released into RPMA 1 on August, 1998, therefore the survival rate for the 1997-year class is 31%. This is a minimum estimate because it does not include the other PS-97 pallids in upriver areas. The survival model used in the 2004 stocking plan (FWP 2004) predicts that 83 PS-97 will survive through age 7 (2004). It appears that the observed 31% survival rate (228) is considerably greater than predicted (83).

Table 4. Average catch rates (average number/tow) of fish sampled by trawling in the Middle Missouri River, MT, 2004.

	Marias R.	**Coal Banks**	**Robinson**	**Total #**
Burbot y			T	1
Carp y		0.1	T	3
Channel catfish y		0.6	2.1	305
Emerald shiner	0.2	0.1	T	5
Flathead chub	6.0	0.1	0.2	56
Hybognathus spp	0.5		T	4
Longnose dace	1.5	9.5	T	340
Longnose sucker		0.2		7
Pallid sturgeon (jv)			T	1
Mottled sculpin	0.5	0.1		5
Sand shiner	0.5			2
Sauger y			T	2
Shorthead redhorse y		0.1	T	4
Shovelnose sturgeon y			T	1
Sicklefin chub			0.8	111
Stonecat	7.2	5.5	0.1	233
Sturgeon chub	0.2	0.9	1.6	249
White sucker y	0.2			1
# Fish	68	601	661	1330
# Tows	4	35	135	135
Avg. Depth (m)	0.6	1.4	1.8	
Macro-habitat type (%)				
CHXO	25	40	62	
ISB		21	19	
OSB	75	13	18	
SCC		9		
TRM		17		

Table 5. Sampling statistics recorded for the pallid sturgeon standardized sampling program in the Middle Missouri River, MT, 1996-2004.

	Average (1996 – 2002)	2003	2004
Pallid Sturgeon			
Number sampled	2.7	6	9
Number adults	0.8	1	0
Number juveniles	1.8	5	9
Avg number/drift	0.05	0.12	0.18
Shovelnose Sturgeon			
Number sampled	217	239	196
Avg Wt. (gm)	1524	1407	1566
Number/drift	4.4	4.8	3.9
Avg. drift duration (min)	6.8	7.0	7.1
Avg. drift distance (m)	256	284	273
Avg. depth @ drift site (m)	2.0	1.6	1.6

Only 2 PS-01 pallids were sampled this year, both released in 2004 as 3-year old fish, however, none of the PS-01's that were released as yearlings (during 2002) were captured this year. Three PS-03 were also sampled. It is probably too early to make any meaningful predictions regarding the survival of these two groups this early in the evaluation.

Evaluations regarding growth of the juvenile hatchery pallids were basically confined to the PS-97 group because adequate numbers of observations were gathered only on this group. Average lengths and weights for the three pallid groups sampled this year were:

- PS-03 (N=2) average FL = 358 mm
- PS-01 (N=2) average FL = 578 mm; average WT = 570 g (* released as 3-yr old)
- PS-97 (N=57) average FL = 531 mm (458 – 711) (SD = 144) average WT= 488 g (317 – 1225) (SD = 153)

The PS-97 group appeared to be growing at a slower rate than expected. It was interesting that the PS-01 pallids released as 3-year olds during this year were larger than the average age-7 PS-97 pallid. There also was a wide variability in sizes within the PS-97 group as demonstrated by the high standard deviation values.

A total of 115 PS-97's have been captured and measured over the past seven years. Table 6 shows the average fork length for these pallids. Over the last five years the PS-97 group has been growing at the average rate of 40 mm (FL) per year. This is considerably less than what has been reported for hatchery released white sturgeon in the Kootenai River, Idaho. Ireland et al. (2002) reports an average growth rate of 64 mm (TL) per year.

Table 6. Average sizes of the 1997- year class pallid sturgeon captured over the years since being released in 1998. Middle Missouri River, MT, 1998-2004.

	Average Fork-length (mm) at Age-class						
	1 yr	2yr	3yr	4yr	5yr	6yr	7yr
Pallid juvenile-97	292	389	462	439	478	525	531
Number measured	3	3	5	7	9	31	57

Twenty-nine of the 38 PS-97 captured in the Robinson Bridge area during 2004 had PIT tags, therefore, their stocking histories could be traced for additional information. Nearly 50% (14) of the PS-97 sampled in the Robinson area had been released in the general area indicating good survival of these fish compared to the PS-97 released at the two upriver sites (RM 1984 and RM 2051). Since we were emphasizing our sampling effort in the Robinson area this does not come as a great surprise. It is believed that a portion the upriver released PS-97 pallids still remain upstream of our Robinson Bridge sampling area. The survival rate of the upriver released PS-97 pallids remains unknown and because of the extensive river length above the Robinson area (~130 miles) it will be difficult to evaluate this with the current amount of effort. Most likely the PS-97 pallids released at Loma and Judith Landing have a similar survival rate to that observed at Robinson area and they are more dispersed throughout this upper reach. It is desirable to have the stocked pallids dispersed throughout RPMA 1 for better utilization of the available habitat, therefore, stocking in the upriver areas should continue.

This year the Marias River, 60 miles upstream of the confluence, was added to the existing four pallid sturgeon release sites in RPMA 1. The Marias River has a solid record of pallid sturgeon use prior to and a few years after damming of this river. The increase in miles of river may help give more time for the hatchery fish to acclimate to natural conditions. I wanted to evaluate if and how fast the pallids would drift out the Marias and where they eventually took residence in the Missouri River. The result of using this new site was evaluated with radio telemetry. Twenty-nine of the PS-03 pallids were surgically implanted with a nano radio transmitters and released in the Marias at Circle Bridge (RM 60) on August 24, 2004. Automatic radio receiving stations were positioned on the Missouri River at Loma (Missouri/Marias River confluence) (RM 2051), Coal Banks (RM 2031) and Judith Landing (RM 1984). The pallids were monitored through October 26 when the battery life of the transmitters were projected to expire (63d). Table 7 summarizes the results of the juvenile pallid dispersal study. It was fairly obvious that nealy all (90%) of the radioed PS-03 pallids moved out of the Marias River and into the Missouri River in less than 50 days. By the end of the study (day 63) 72% of the radioed pallids had moved downstream of the lowest monitoring station (Judith Landing) approximately half way through RPMA 1. Finally, it was estimated that at least 53% (15) of the radioed pallids remained upstream of RM 1910 (the lowest downstream distance surveyed and 35 miles above the reservoir) at the end of the study. This was determined by accounting for the eight radios above Judith Landing (based on the loggers) and locating seven more by airplane between Judith Landing and RM 1910.

Table 7. Percentage of radio PS-03 that passed the radio receiving stations within the indicated time period. The PS-03 radio pallids were initially released in the Marias River, 60 miles upriver from the Loma Station (located at the confluence). Fish were monitored from August 24 to October 26, 2004 (63d).

Days at Large	**Loma (RM 2051)**	**Coal Banks (RM 2031)**	**Judith Landing (RM 1984)**
4-9d	52	45	10
10-29d	28	28	38
30-49d	10	7	17
≥50d	3	3	7
Percent of radios undetected[1/]	7	17	78

[1/] Most likely radio pallids remained upriver.

Propagation Assistance

Preserving a representation of the Upper Missouri River pallid sturgeon gene pool is an important goal for recovery. To that end, a pilot effort was initiated in 2000 to test the feasibility of collecting sperm from wild male pallids in this area and ship the fresh milt to Garrison National Fish Hatchery (GNFH) for use in their pallid sturgeon propagation program and cryopreserve representative sperm samples. Results from the initial effort proved worthwhile and collection of pallid sperm from the wild population was incorporated into my work plan.

River flow conditions during June were less than normal, with discharges ranging from about 7,200 to 11,000 cfs during June. These lower June flows made netting for adult pallid sturgeon fairly effective. Two females and three males were captured and examined for spawning readiness. A list of the pallid sturgeon captured and their sizes and tag numbers are presented in Appendix B. One of the females contained mature eggs, while the other female had small immature eggs. All three male pallids and the one mature female were held in a 16 ft diameter tank for staging. A 17-gram radio transmitter was surgically implanted into the immature female before she was released back into the river so that she could be located next year. The one female was spawned on the site and crossed with two of the males in the tank and with another two Yellowstone River males (shipped sperm). The spawning was successful and the fertilized eggs were hatched-out and resulting fry reared at the BFYC. Sperm samples from two of the (new) male pallids sturgeon were shipped to GNFH and cryopreserved for use in the future propagation efforts and brood stock development.

Habitat Restoration

The long-term recovery objective is to down list and de-list the pallid sturgeon through protection and habitat restoration activities by 2040 (Dryer and Sandvol 1993). No habitat restoration has been accomplished in RPMA 1 because habitat requirements for pallid sturgeon are largely unknown. Two hypotheses suggested as possible reasons for causing pallid sturgeon near-extinction in RPMA 1 are that Canyon Ferry and Tiber Dams have altered stream flows to the point that pallid sturgeon habitats are not being maintained. Also, the operations of these dams may have altered the timing and magnitude of the spring pulse, thereby affecting behavior queues important for initiating the spawning migration. The second hypothesis is that Fort Peck Reservoir is a barrier to pallid sturgeon larvae drift and any of the larvae drifting into the reservoir will die because the lentic conditions of the reservoir are unsuitable habitat for age-0 pallid. Additionally, Fort Peck Dam is a barrier to both up and down river migrations for pallid sturgeon, thus isolating RPMA 1 pallid sturgeon.

There has been two spring pulse flows from Tiber Dam (Marias River) since 1997 as a direct results of discussions with the US Bureau of Reclamation. An 8-day pulse-flow peaking at 4,510 cfs occurred in 1997 and a 32-day pulse-flow peaking at 5,280 cfs occurred during 2002. The effects of these pulse-flows on pallid sturgeon were not evaluated so it is unknown if any of the desired objectives were accomplished. An aerial survey of the river during the pulse-flow was completed and it was noted that basic channel forming functions were occurring, such as flooding of the immediate floodplain, flushing of large amounts of organic matter into the channel and an increased sediment load. Very little damage of bank side infrastructure was noticed.

Fort Peck Reservoir at the bottom end of RPMA 1 has decreased in volume to an all time low. During 1997 the reservoir was at one of its highest levels (2248.6 msl), but since then the recent severe drought has draughted the reservoir 45 feet to an elevation of 2203.8 msl at the end of June. This presently has exposed approximately 20 miles of river. Pallid sturgeon have been found in this “new” section of river. Three PS-97 (6% of total) were sampled in this area this year, however the sampling effort was limited compared to upriver areas.

RECOMMENDATIONS

1. Continue with multi-sampling methods for hatchery-reared juvenile pallid sturgeon. The survival rate for the PS-97 group was finally determined but this was only after the group was 7 years old. It would be better to get a survival estimate sooner after the fish are released.

2. The fall pallid sturgeon abundance survey should be continued on an annual basis as funding allows. The hatchery pallid sturgeon should be approaching a size where they are more effectively sampled and this effort will more accurately describe their abundance in the area and be a better measure for comparisons in the future.

3. The Upper Missouri River pallid sturgeon gene pool needs to be preserved. Efforts to collect sperm from ripe males and eggs from females should continue as conditions allow. The fresh sperm should be either used during the current propagation year or stored in cryopreservation.

4. Continue sampling for age-0 pallid and shovelnose sturgeon with the trawl. Trawling has provided a considerable amount of information on shovelnose spawning success and the distribution and abundance of several unique fish species such as the sicklefin and sturgeon chubs.

5. A greaterer effort should be directed at evaluating habitat changes as a result of spring pulse flows provided from Canyon Ferry and Tiber Dams. Also, the value of additional river resulting from the low Fort Peck Reservoir pool should be evaluated to determine if more pallid sturgeon habitat is created. Additional funding will be required to address these important habitat issues.

6. Annual releases of hatchery pallid sturgeon are essential for developing a pallid population with a genetically diverse and sound age structure. This has not happened in RMA-1 because of the difficulty with propagation and a severely restrictive ban on releasing hatchery pallids in the area due to pallid sturgeon irido virus (PSIV) concerns. These potential fish that were not stocked due to the ban were invaluable because of the impending threat of extinction in the area. The MTFWP needs to consider allowing healthy hatchery pallid sturgeon to be stocked into RMA-1 from all the pallid sturgeon hatcheries providing they test negative for PSIV. This will insure that releases of pallid sturgeon will occur on a regular basis in RMA-1.

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Prepared by: William M. Gardner May 30, 2005

Appendix A.
A list of pallid sturgeon captured in the Upper Missouri River, MT, 2004.

Id #	PIT Num	Type	Cap.date	FL	WT	Elasto	RECAP	Meth	RM	HAB	FLOW	PITTAG1	RADIO
1	?	JV-97	20040623	553	573	?	?	TNT1	1897.3	ISB	7190	?	
2	132126586A	JV-97	20040501	475	330	blue	NO	LL	1918.1	CHXO-bar	5088	LOST	
3	132129383A	JV-97	20040805	489	378	orange	?	TNT1	1911.4	ISB	3880	LOST	40.621PG
4	132133555A	JV-97	20040521	476	367	green	NO	TNT1	1913.8	CHXO-isl.	5590	LOST	
5	132156240A	JV-97	20040901	525	455	orange	?	TNT1	1911.3	OSB	4980	132156240A	
6	132161665A	JV-97	20040727	556	588	yellow	?	TRAWL	1893.8	OSB	4000	LOST	40.791PG
7	132179611A	JV-97	20040505	472	317	yellow	NO	LL	1918.5	CHXO-bar	5452	LOST	40.031PG
8	132211792A	A	20040604	1289	17500		YES	GN-6X10	1920.3	ISB-pool	10000	132211792A	
9	132222105A	JV-97	20041015	458	367	green	?	TNT1	1899.5	ISB	4200	132222105A	
10	132252257A	JV-97	20040526	546	480	green	NO	LL	1987.1	CHXO-pool	9150	LOST	
11	132255346A	JV-97	20040921	657	928	orange	?	TNT2	1925.0	OSB	4730	132255346A	
12	132262326A	JV-97	20040414	526	430	blue	NO	LL	1901.0	ISB	4670	LOST	40.600PG
13	132276383A	JV-97	20040421	518	429	orange	NO	LL	1907.0	ISB	4270	LOST	10.101PG
14	132311450A	JV-97	20040505	492	415	green	NO	LL	1918.5	CHXO-bar	5452	LOST	40.091PG
15	132313570A	JV-97	20040501	470	323	green	NO	LL	1918.1	CHXO-bar	5088	LOST	
16	132335326A	JV-97	20040415	566	598	orange	NO	LL	1894.1	ISB	4600	LOST	
17	132335370A	JV-97	20040415	510	404	yellow	NO	LL	1920.5	TRM	4670	LOST	40.641PG
18	132335370A	JV-97	20040505	503	399	yellow	YES	LL	1918.1	CHXO-bar	5452	132335370A	40.641PG
19	132335691A	JV-97	20040820	569	608	orange	?	TNT1	1916.1	ISB	4000	LOST	
20	132335691A	JV-97	20040921	568	624	orange	YES	TNT2	1916.7	ISB	4730	LOST	
21	17610815796	JV-97	20040630	497	403	green	?	TNT1	1987.1	CHXO	6380	17610815796	
22	17611258756	JV-97	20040609	520	470	orange	?	LL	1919.6	CHXO-bar	10250	17611258756	
23	17611374869	JV-97	20040610	546	518	yellow	?	LL	1918.3	CHXO	11625	17611374869	
24	1F4A4B5973	A	20040602	1257	12700		YES	GN-6X10	1916.0	CHXO-isl.	11000		149.800/017
25	410870674F	JV-97	20041015	563	557	green	NO	TNT1	1899.5	ISB	4200	410870674F	
26	41093A4D0B	JV-97	20040414	520	452	yellow	NO	LL	1887.6	ISB	4670	41093A4D0B	
27	410945166F	JV-97	20040414	589	624	yellow	NO	LL	1887.6	ISB	4670	410945166F	

Appendix A (continued)

Id#	PIT Num	Type	Cap.date	FL	WT	Elasto	RECAP	Meth	RM	HAB	FLOW	PITTAG1	RADIO
28	41094F4F3D	JV-97	20040413	563	540	yellow	NO	LL	1897.5	ISB	4670	41094F4F3D	40.611PG
29	410956305D	JV-97	20040616	522	473	blue	NO	TNT1	1893.0	ISB	10400	410956305D	
30	4109586D19	JV-97	20040606	502	425	yellow	NO	LL	1918.2	CHXO-bar	9000	4109586D19	
31	414746273A	A	20040409	1429	18100		YES	ROD	1905.5	OSB-pool		414746273A	
32	414D431A5D	JV-97	20040504	483	353	green	NO	LL	1918.1	CHXO-bar	5320	414D431A5D	40.041PG
33	414D44475A	JV-97	20040508	488	338	orange	YES	LL	1917.9	CHXO-bar	5650	414D44475A	40.721
34	414D447D55	JV-97	20040501	498	364	orange	YES	LL	1918.1	CHXO-bar	5088	414D447D55	
35	414D460667	JV-97	20040401	520	404	green	NO	ROD	1901.1	ISB	4860	414D460667	40.131PG
36	414D471439	JV-97	20040415	503	408	blue	NO	LL	1901.0	ISB	4670	414D471439	40.681PG
37	414D496D64	JV-97	20040331	526	445	orange	NO	ROD	1901.4	ISB	4860	414D496D64	40.011PG
38	414D4D2D11	JV-97	20040331	495	361	red	NO	LL	1908.7	ISB	4860	414D4D2D11	40.751PG
39	414D507C16	JV-97	20040504	587	607	red	NO	LL	1918.1	CHXO-bar	5320	414D507C16	40.761PG
40	414D547923	JV-97	20040503	495	320	red	YES	LL	1918.1	CHXO-bar	5320	414D547923	40.061PG
41	414D547A34	JV-97	20040623	560	558	blue	NO	TNT1	1896.4	ISB	7190	414D547A34	
42	414D547B17	JV-97	20040920	561	567	green	NO	TNT2	1920.5	TRM	4720	414D547B17	
43	414D556218	JV-97	20040428	584	572	orange	YES	LL	1916.4	CHXO	4156	414D556218	
44	414D574F03	JV-97	20040423	615	755	yellow	NO	TNT1	1925.2	CHXO-isl.	4000	414D574F03	40.651PG
45	414D5C252F	JV-97	20040501	508	508	green	NO	LL	1918.1	CHXO-bar	5088	414D5C252F	
46	414D5E4E63	JV-97	20040624	541	536	green	NO	LL	1909.4	ISB-bar	7190	414D5E4E63	
47	414D5F2146	JV-97	20040413	515	430	orange	NO	LL	1894.1	ISB	4670	414D5F2146	
48	414D5F2146	JV-97	20040901	522	458	orange	YES	TNT1	1907.0	ISB	4980	414D5F2146	
49	414D60616C	JV-97	20040526	518	435	blue	NO	LL	1987.1	CHXO-pool	9150	414D60616C	
50	414D606661	JV-97	20040920	561	562	orange	NO	TNT2	1922.3	ISB	4720	414D606661	
51	414D610D5E	JV-97	20040414	533	463	red/red	YES	LL	1887.6	ISB	4670	414D610D5E	40.781
52	414D614B09	JV-97	20040421	502	365	blue	NO	LL	1907.0	ISB	4270	414D614B09	40.071PG
53	414D622051	JV-97	20040414	523	465	yellow	NO	TNT1	1910.2	OSB	4670	414D622051	40.141PG

Appendix A (continued)

Id #	PIT Num	Type	Cap.date	FL	WT	Elasto	RECAP	Meth	RM	HAB	FLOW	PITTAG1	RADIO
54	414D63303B	JV-97	20040414	492	357	blue	NO	ROD	1905.3	OSB-pool	4670	414D63303B	40.671PG
55	414D661A52	JV-97	20040604	492	351	red	NO	LL	1918.2	CHXO	10000	414D661A52	
56	435D6A1054	JV-01	20040921	552	481	pink/blu	NO	TNT2	1916.4	ISB	4730	435D6A1054	
57	435D755069	JV-01	20040921	604	658	?	NO	TNT2	1917.7	CHXO-pool	4730	435D755069	
58	44427B2A72	JV-03	20040909	322	90	red/grn	NO	elec	2034.0	OSB	4434	44427B2A72	
59	4443046601	JV-03	20040921	393		red/yell	NO	TNT2	1915.9	ISB-isl.	4730	4443046601	
60	444362342F	JV-03	20041014			red/yell	NO	TNT1	1913.5	OSB	4200	444362342F	
61	4527066B0F	JV-97	20040331	539	531	orange	NO	ROD	1901.4	ISB	4860	LOST	40.111PG
62	45272B3964	JV-97	20040323	505	408	green	NO	LL	1905.3	ISB	5140	LOST	
63	45294F7023	JV-97	20040922	558	527	yellow	?	TNT2	1913.4	CHXO-isl.	4740	lost	
64	452A3D6110	JV-97	20040428	585	646	green	YES	LL	1915.7	CHXO-isl.	4156		
65	452A4E1F15	A	20040428	1270	13200		YES	TNT-1	1914.3	CHXO-pool	4156	452A4E1F15	149.800/016
66	452A646C21	JV-97	20040921	711	1225	yellow	?	TNT2	1925.1	OSB	4730	lost	
67	7F7D487531	A	20040506	1407	13600		YES	GN-6X10	1915.6	CHXO-isl.	5518	7F7D487531	149.800/012
68	7F7E42795C	A	20040608	1363	16100		YES	GN-6X10	1920.7	CHXO	8875	7F7E42795C	149.800/010

Appendix B. A list of pallid sturgeon spawners captured during spring 2003, Upper Missouri River, MT.

PIT#	Date	FL (mm)	WT (kg)	RM	Sex	Recap	# Days in Tank
132211792A	June 4	1289	17.5	1920.3	F	No	8
414746273A	June 2	1435	16.1	1920.5	F	Yes	1
7F7E42795C	June 6	1363	16.1	1920.7	M	Yes	6
757D487531	June 1	1407	13.6	1916.1	M	Yes	13
1F4A4B5973	June 2	1257	13.0	1916.0	M	Yes	12

HABITAT USE, DIET, AND GROWTH OF HATCHERY-REARED JUVENILE PALLID STURGEON AND INDIGENOUS SHOVELNOSE STURGEON IN THE MISSOURI RIVER ABOVE FORT PECK RESERVOIR, MONTANA

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In 1998, 732 age-1 hatchery-reared juvenile pallid sturgeon (HRJPS) were stocked into the Missouri River above Fort Peck Reservoir (Recovery Priority Area 1 of the Pallid Sturgeon Recovery Plan) to augment the wild pallid sturgeon population. These hatchery-reared fish provided a unique opportunity to study the ecology of juvenile pallid sturgeon because limited recruitment of pallid sturgeon throughout their range limits abundance of these fish.

Additionally, evaluation of these HRJPS is necessary to determine their performance in a natural lotic environment, because stocking hatchery-reared fish that cannot adapt to their natural lotic environment would be an inefficient way to recover the species. Therefore, we evaluated the habitat use, diet, and growth of 1997 year class HRJPS and indigenous shovelnose sturgeon in Recovery Priority Area 1. Although similar in many aspects, pallid sturgeon and shovelnose sturgeon are two distinct species, and differences in ecology should exist. Therefore, a large amount of resource overlap between the two species may indicate limiting habitat for HRJPS. Alternatively, observed differences in habitat use and diet may help define the needs of HRJPS relative to indigenous shovelnose sturgeon.

Shovelnose sturgeon and HRJPS were collected for radio-tagging and diet analysis using rod and reel, set lines, benthic trawl, and trammel nets in 2003 and 2004. Thirty HRJPS and 23 shovelnose sturgeon were captured and implanted with radio-transmitters. Mean river kilometer (calculated for each radio-tagged fish using river kilometers recorded at each fish location) was used as a measure of the most frequented areas of the study site by radio-tagged fish. Home range was defined as the number of river kilometers used by a radio-tagged fish, and was calculated by subtracting the river kilometer at the furthest downstream location from the river kilometer at the furthest upstream location (e.g., if the furthest downstream location was river kilometer 3,090, and the furthest upstream location was river kilometer 3,100, then the home range of that fish was 10 km). Two-tailed *t*-tests were used to test the hypotheses that: 1) mean river kilometer was not different between shovelnose sturgeon and HRJPS; and 2) mean home range was not different between shovelnose sturgeon and HRJPS.

A total of 666 locations were obtained from 29 HRJPS and 21 shovelnose sturgeon. Mean home range was similar between HRJPS (15.0 km; 90% confidence interval ± 5.0 km) and shovelnose sturgeon (16.5 ± 4.7 km) ($P = 0.73$). However, mean river kilometer differed significantly between the two species (3,072.9 + 4.6 for HRJPS; 3,089.7 + 6.3 for shovelnose sturgeon; $P < 0.001$). Lotic habitat created by receding reservoir water levels was frequented by HRJPS, indicating that Fort Peck Reservoir influences the amount of available habitat for juvenile pallid sturgeon.

Diet information was obtained from 50 HRJPS and 155 shovelnose sturgeon using a gastric lavage. No stomach contents were obtained from 30% of the HRJPS and 26% of the shovelnose sturgeon that were lavaged. Fish (percent occurrence = 54%; percent composition by weight = 90%) composed the majority of the HRJPS diet, whereas Chironomidae larvae (percent occurrence = 70%; percent composition by weight = 67%) were the primary prey of shovelnose sturgeon (Figures 1 and 2). Sturgeon chub and sicklefin chub composed 79% of the of the identifiable fish remains (N = 19) in HRJPS stomach contents, while channel catfish, flathead chub, sand shiner, and shorthead redhorse composed the other 21%. Interestingly, 94% of the HRJPS lavaged during the spring were empty, whereas only 23% were empty during the summer and autumn. Additionally, 36% of the shovelnose sturgeon stomachs were empty during spring, and 24% were empty during summer and autumn. These results suggest that shovelnose sturgeon are actively feeding more than HRJPS in the spring, or that food is limiting to HRJPS during this period.

Radio-tagged fish were also recaptured to estimate growth by drifting trammel nets over known fish locations from July through August in 2003 and April through October in 2004. Growth rate of HRJPS and shovelnose sturgeon (calculated for both fork length and weight) was determined from the time a transmitter was implanted until a fish was recaptured using relative growth rate (Busacker et al. 1990). One-tailed t-tests were used to test the hypotheses that shovelnose sturgeon displayed a faster relative growth rate in fork length and weight than HRJPS from April through October. No differences existed in mean relative growth rate of fork length (P = 0.25) or weight (P = 0.19) between shovelnose sturgeon (0.02 ± 0.02 %/d for fork length; 0.06 ± 0.04 %/d for weight) and HRJPS (0.01 ± 0.01 %/d for fork length; 0.03 ± 0.04 %/d for weight).

More information on this project will be available in the completion report. The completion report will be finalized by July 29, 2005. Contact Chris Guy at cguy@montana.edu or Bill Gardner at fwplew@tein.net for the report.

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Busacker, G.P., I.R. Adelman, and E.M. Goolish. 1990. Growth. Pages 363-387 *in* C.B. Schreck and P.B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland.

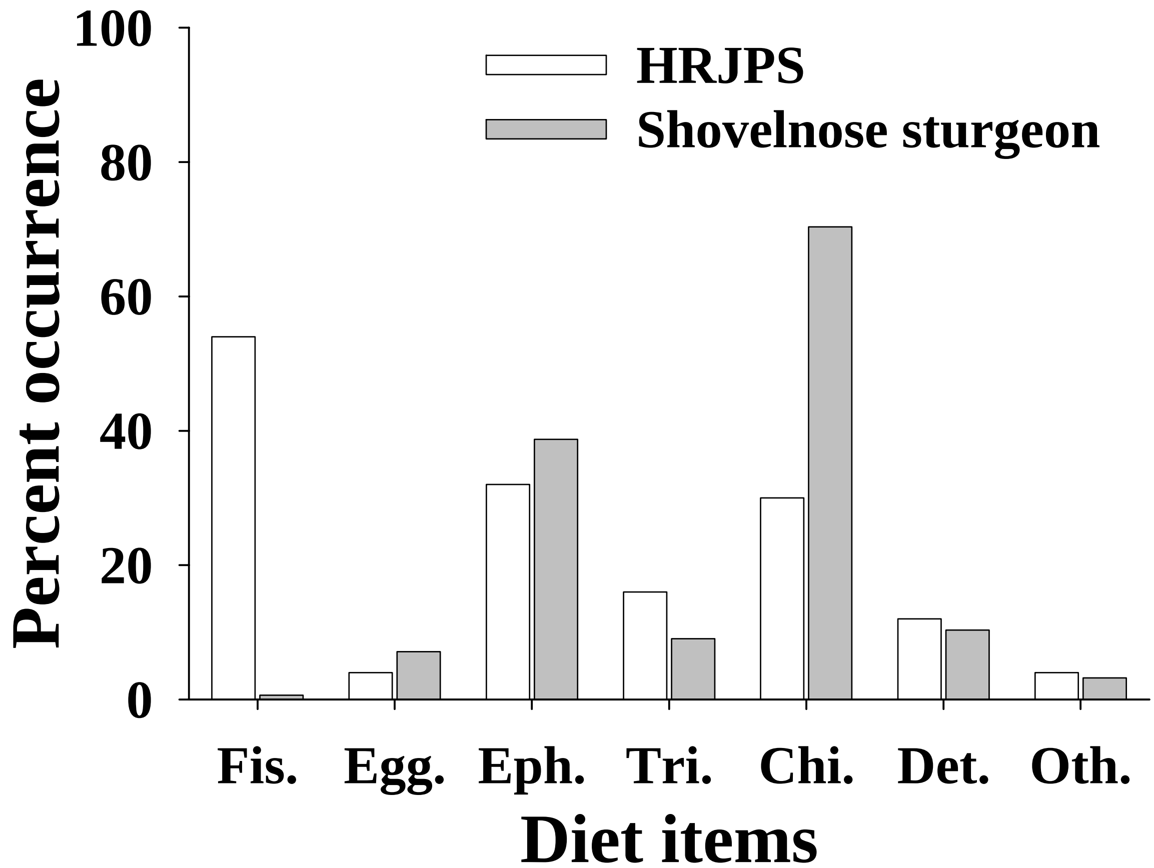

Figure 1. Mean percent occurrence of fish (Fis.), fish eggs (Egg.), Ephemeroptera (Eph.), Trichoptera (Tri.), Chironomidae (Chi.), detritus (Det.), and other prey (Oth.) in the diets of HRJPS (N = 50; 30% empty) and shovelnose sturgeon (N = 155; 26% empty) sampled in the Missouri River above Fort Peck Reservoir, Montana (river kilometers 3,004 to 3,138), in 2003 and 2004.

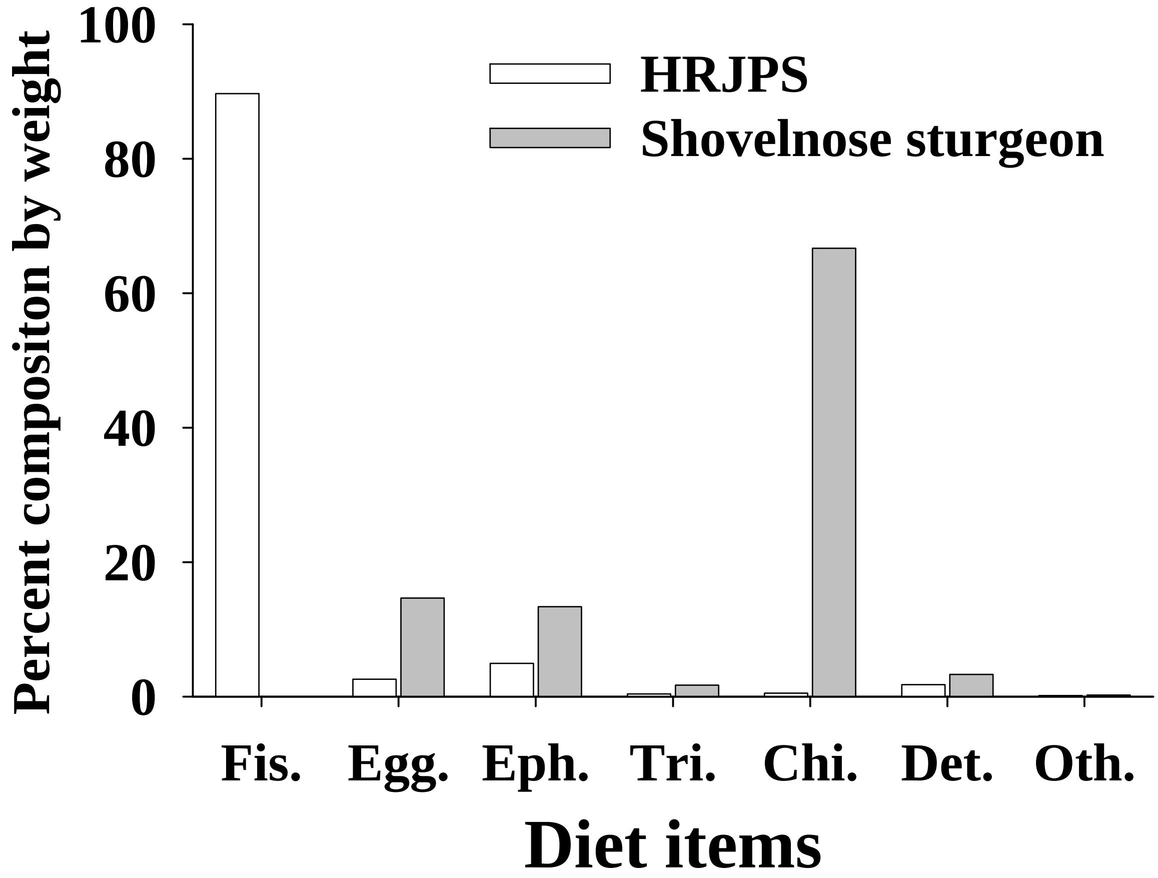

Figure 2. Mean percent composition by weight of fish (Fis.), fish eggs (Egg.), Ephemeroptera (Eph.), Trichoptera (Tri.), Chironomidae (Chi.), detritus (Det.), and other prey (Oth.) in the diets of HRJPS (*N* = 50) and shovelnose sturgeon (*N* = 155) sampled in the Missouri River above Fort Peck Reservoir, Montana (river kilometers 3,004 to 3,138), in 2003 and 2004.

LOWER MISSOURI AND YELLOWSTONE RIVERS
PALLID STURGEON STUDY
2004 REPORT

by

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ABSTRACT

Status of the endangered pallid sturgeon *Scaphirhynchus albus* population in the Missouri and Yellowstone river of RPMA #2 was studied by (1) capture wild adult pallid sturgeon for broodstock, (2) estimate adult pallid sturgeon abundance (3) project adult pallid sturgeon extirpation date (4) quantify hatchery reared pallid sturgeon (HRPS) survival (5) quantify HRPS growth (6) quantify retention rates of passive integrated transponder (PIT) tags of HRPS captured in RPMA #2, (7) examine the relation between HRPS presence and turbidity, (8) quantify the weight-length relation for captured HRPS, (9) quantify mean distance moved by captured HRPS, and (10) determine HRPS net movements either upstream, downstream, or equally distributed. Forty-seven individual adult pallid sturgeon were captured during broodstock efforts in 2004, with nine new fish. A current abundance estimate for RPMA#2 is 158 individuals with a projected extirpation date of 2024. Ninety-three HRPS were captured during 2004 and survival rates were estimated for ages 1-2, 43.9% and 5-6, 67.7%. Eighty-nine captured HRPS grew an average of 55.3 mm in fork length (FL), with an average daily growth of 0.36 mm/d. Sixty-six of 86 scanned HRPS retained their PIT tags, resulting in a 76.7% retention rate. Mean turbidity at sampling sites where HRPS were not sampled were statistically different from sites where HRPS were sampled ($P < 0.0001$, df = 630). The weight-length relation for 67 captured HRPS was quantified as, $W = 10\text{^}[-4.56 + 2.63 * \log_{10}(FL)]$. Total distance moved by HRPS averaged 33.4 river kilometers (rkm), and time at liberty averaged 404d, yielding an average movement rate of 0.25 rkm /d. Hatchery-reared pallid sturgeon net movements were downstream in direction.

BACKGROUND

The pallid sturgeon *Scaphirhynchus albus* is a long-lived (> 50 years; S. Krentz, U.S. Fish and Wildlife Service, unpublished data), late maturing (females may spawn for the first time at ages 15-20; Keenlyne and Jenkins 1993) species indigenous to the Missouri and lower Mississippi rivers, and large tributaries entering these river systems (Bailey and Cross 1954). Habitats have been extensively altered throughout the historical range of pallid sturgeon, causing declines in growth, reproduction, and survival, and ultimately resulting in the designation of pallid sturgeon as an endangered species in 1990 (Dryer and Sandvol 1993).

One of the few remaining concentrations of pallid sturgeon is in the lower Yellowstone River below the Tongue River and in the Missouri River between Fort Peck Dam and Lake Sakakawea (recovery-priority management area #2, RPMA #2; Dryer and Sandvol 1993). Similar to populations in other regions, long-term viability of pallid sturgeon in RPMA #2 is in jeopardy. It is hypothesized that habitat fragmentation coupled with regulated flows from Fort Peck Dam and suppressed water temperatures during the spring and early summer spawning period have failed to provide adequate spawning cues for pallid sturgeon. In addition, cold water releases from Fort Peck Dam have limited the amount of riverine habitat suitable for spawning and rearing. As a consequence, there has been no documented recruitment for decades as evidenced by a population composed of large (e.g., > 1200 mm; > 8 kg; Liebelt 1996, 1998) and presumably old individuals (≥ 35 years; S. Krentz, U.S. Fish and Wildlife Service, personal communication). Larval pallid sturgeon have been sampled in RPMA #2 during 2002, 2003, and 2004 (Braaten and Fuller 2004), but wild age-1 to sub-adult pallid sturgeon have yet to be sampled.

Lack of natural recruitment in the RPMA #2 pallid sturgeon population has warranted remedial actions to prevent extirpation. First, the U.S. Army Corps of Engineers proposes to modify operations of Fort Peck Dam following specifications outlined in the Missouri River Biological Opinion (U.S. Fish and Wildlife Service 2000). Modified dam operations are proposed to increase discharge and enhance water temperatures during late May and June to provide spawning cues and enhance environmental conditions for pallid sturgeon and other native fishes. Modified dam operations scheduled to begin during 2001, have yet to be enacted.

The second remedial action involves a stocking and population supplementation program. The goal of this program is to “reconstruct an optimal population size within the habitat’s carrying capacity while preserving and maintaining the gene pool to the greatest extent possible” (Upper Basin Pallid Sturgeon Workgroup Stocking Team 1997). The stocking and augmentation plan was implemented in 1998 when 295 age-1 hatchery-reared pallid sturgeon (HRPS; 1997 progeny) were stocked in the lower Missouri River below Fort Peck Dam, and 485 age-1 HRPS were stocked in the lower Yellowstone River. Additional HRPS were stocked in RPMA #2 during 2000 (679), 2002 (3,061), 2003 (4,124), and 2004 (1,845). Although initially successful in enhancing numbers of pallid sturgeon in the population, the recovery directive of the stocking and augmentation plan continues to be hindered by a lack of information on post-stocking critical rates (survival, growth, etc.) of HRPS (Upper Basin Pallid Sturgeon Workgroup Stocking Team 1997). As a consequence, it is not known if current stocking strategies will ensure adequate survival of HRPS to sexual maturity (e.g., 15 years) and perpetuate a self-sustaining, genetically viable population. The stocking and augmentation plan assumes a minimum annual survival rate of 60% for stocked HRPS (Upper Basin Pallid Sturgeon Workgroup Stocking Team 1997).

The stocking and augmentation plan specified that a monitoring program would be implemented to thoroughly evaluate stocking success and survival. An appropriate monitoring program has been enacted. Initial sampling efforts for stocked HRPS suggest survival rates may be less than 60% as assumed in the stocking and augmentation plan. Inconsistency in captures and stockings of year classes has made survival estimation difficult.

Specific study objectives were to: 1) capture wild adult pallid sturgeon for broodstock; 2) estimate adult pallid sturgeon abundance; 3) project adult pallid sturgeon extirpation date; 4) quantify HRPS survival; 5) quantify HRPS growth; 6) quantify retention rates of passive integrated transponder (PIT) tags of HRPS captured in RPMA #2; 7) examine the relation between HRPS presence and turbidity; 8) quantify the weight-length relation for captured HRPS; 9) quantify mean distance moved by captured HRPS; and 10) determine HRPS net movements either upstream, downstream, or equally distributed. Results from these study objectives will be used to provide comments on or propose changes to current propagation, stocking, and monitoring efforts. The project was designed for a minimum of two field seasons, and this report summarizes the findings of the second field season (2004), which was funded by the Western Area Power Administration. A final report summarizing all five years of agreement number 94-BAO-70 is due out in December 2005.

METHODS

Study Area

The Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea confluence and the Yellowstone River between Sidney bridge and the confluence with the Missouri River was partitioned into nine 37-66 rkm study reaches: 1) Fort Peck Dam to Oswego; 2) Oswego to Wolf Point; 3) Wolf Point to Poplar; 4) Poplar to Brockton; 5) Brockton to Culbertson; 6) Culbertson to Bainville; 7) Bainville to Confluence; 8) Confluence to Lake Sakakawea; and 9) Sidney to Confluence (Table 1 and Figure 1). Within each study reach, five inside bend-outside bend-channel crossover habitat complexes (Sappington et al. 1998) were randomly selected for sampling with trammel nets and benthic beam trawls (45 total complexes). Gardner and Stewart (1987), Tews (1994), Liebelt (1996), and Bramblett and White (2001) have previously described these river reaches.

Adult Pallid Sturgeon Sampling

Drift trammel nets were used to capture adult pallid sturgeon near the confluence of the Missouri and Yellowstone rivers, ND, and upstream to the Fairview Bridge area in the Yellowstone River during April 20-29 and 9 November (Figure 2). Nets used for sampling were 30.5 or 45 m in length with two panels (15.2 cm and 25.4 cm mesh), a floating core nylon top line, and a lead core bottom line (22.7 kg). Drift trammel nets were attached to a float on one end and secured to a boat on the opposite end with 4.6-12.2 m of nylon rope. Nets were set perpendicular to the current and were drifted with the aid of a boat for up to 15 minutes, depending on current velocities and snags encountered. Drifts were timed using a stopwatch. All species other than pallid sturgeon were enumerated. Catch-per-unit-effort (CPUE) rates were determined for pallid sturgeon by calculating the mean number sampled per drift h.

All adult pallid sturgeon were handled according to established protocol. Adult pallid sturgeon not used for propagation purposes were released immediately as possible in order to reduce the stresses associated with capture and handling. Biosonic 125 kHz passive integrated transponder (PIT) tags were implanted in base of the dorsal fin on unmarked adult pallid sturgeon.

Hatchery-reared Pallid Sturgeon Sampling

Drift trammel net and beam trawl tows were used to capture HRPS in the nine study reaches of the Missouri and Yellowstone rivers from May 2004 to October 2004 (Figure 3). Nets used for sampling were 45 m in length and contained three panels. Inner panels were 2.5 cm mesh (bar measure) with 15.2 cm mesh outer panels a floating core nylon top line, and a lead core bottom line (22.7 kg). Trammel nets were attached to a float on one end and secured to a boat on the opposite end with 5.6-12.2 m of rope, and were set perpendicular to the current. Trammel nets were drifted with the current for at least 75 m when possible. Benthic beam trawls used for sampling had a 0.5 m x 2 m opening with rock hoppers along the bottom lip, a bag length of 5.5 m with a inner mesh size of 32 mm and an outer mesh size of 200 mm. Benthic beam trawls were secured to the bow of the boat with 10 m of rope and towed in a down stream direction. Each trawl tow will be at least 75 m when possible. Sampling sequence of study reaches and sites was randomly assigned sampling sites within reaches were sampled according to accessibility.

Within each study reach, the channel crossover (CHXO) at the upstream and downstream end of each bend, the outside bend (OSB), the inside bend (ISB), and secondary channels (where possible; SCC) were each sampled with two trammel net drifts. Three benthic beam trawl tows were conducted at each bend, one from the upstream CHXO to the bend, one in the bend, and one from the bend to the downstream CHXO. Channel crossovers considered part of two adjacent complexes were sampled only once. When a HRPS was sampled, two additional trammel net drifts or benthic beam trawls were conducted at the same specific location.

Wildcat surveys were conducted sporadically from May 2004 to November 2004. Surveys were conducted in areas where HRPS have consistently bee been captured , areas where HRPS seemed to congregate from telemetry data, and areas that were not originally included in the sampling schedule (e.g. the Milk River). Gear types used include drift trammel nets and benthic bean trawls as described above with the addition of 22.5m drift trammel nets and hook and line sampling. The 22.5m drift trammel nets had the same mesh panels as the 45m nets with the only difference being length, to accommodate narrow channels where 45m nets were impractical. Hook and line sampling consisted of circle hooks (size 2 or 4) baited with nightcrawlers on standard fishing gear were used when hook and line sampling. Angling hook hours were timed with a stopwatch and recorded.

All fish sampled were counted, many were weighed, measured, sexed, and tagged, and all HRPS were screened for PIT tag identification, weighed to the nearest gram, measured to the nearest millimeter in fork length (FL), and released. Information recorded at each capture location included RKM, GPS coordinates at the beginning and end of each trammel net drift, macrohabitat type (CHXO, ISB, OSB, or SCC), water temperature, and turbidity (nephelometric turbidity units; NTUs). Trammel net and benthic trawl efforts were recorded as time (total minutes), and drift or tow distance (m) was calculated from GPS coordinates. Catch-per-unit-effort of HRPS was calculated as the mean number sampled per sampling h.

DATA ANALYSIS

Population estimation were calculated with an Jolly-Seber estimator in program MARK (White and Burnham 1999). The simplest model of program MARK was used to get an abundance estimate by year. This analysis assumes that: 1) all animals in the population at the time of capture are captured with equal probability, 2) all animals survive between capture occasion with equal probability, 3) survival and capture of an animal is independent of the survival and capture of all other animals, 4) captured animals and previously uncaptured animals survive equally well, and 5) all tagged animals retain their tags and are correctly identified (Pollock et al. 1990).

Survival of HRPS in the study area was to be estimated from catch per unit effort (CPUE) data of specific year classes as described by Ricker (1975), but consistent data from successive years has been inadequate, so I used a Cormack-Jolly-Seber (CJS) open population survival model in program MARK. The CJS model estimates apparent survival, as it is virtually impossible to distinguish between losses due to emigration from mortality. This analysis assumes that: 1) every marked animal in the population at time *t*, has the same probability of capture. 2) every marked animal in the population immediately after time *t*, has the same probability of surviving to time *t*+1, 3) marks are not missed or lost, and 4) all samples are instantaneous, relative to the interval between time *t* and *t*+1, and each release is made immediately after the sample.

Growth was estimated as an average daily growth rate for HRPS of known time at liberty and known FL at the time of stocking and capture:

$$\frac{L_r - L_s}{T},$$

where L_r is FL at the time of capture, L_s is the FL at the time of stocking, and T it time at liberty (days).

PIT tag retention was estimated:

$$PIT\ tag\ retention = \frac{Number\ of\ PIT\ tags\ present}{Number\ tagged} * 100,$$

where the $Number\ of\ PIT\ tags\ present$ represents the number of functioning PIT tags detected in fish, and *Number tagged* represents the number of HRPS sampled that were known to have been PIT tagged before being stocked.

A power function describing the weight-length relation for captured HRPS was quantified:

$$W = aL^b,$$

where W is weight (g), L is FL (mm), and a and b are parameters. The parameters a and b were estimated from linear regression of logarithmically transformed weight-length data and the formula:

$$\log_{10}(W) = a` + b * \log_{10}(L),$$

where W is weight, L is FL, $a`$ is $\log_{10} a$ and is the y-axis intercept, and b is the slope of the equation.

Mean distance moved (rkm) by HRPS was estimated in from GPS coordinates, and 95% confidence intervals were constructed:

$$LCL = \overline{X} - t_{\alpha/2} S / \sqrt{N}$$
$$UCL = \overline{X} + t_{\alpha/2} S / \sqrt{N},$$

where LCL is the lower 95% confidence limit, UCL is the upper 95% confidence limit, $\overline{X}$ is the sample mean distance moved, S is the sample standard deviation, $t_{\alpha/2}$ is the critical value from a T distribution with N-1 degrees of freedom, and N is the sample size (Milton and Arnold 1995).

To test whether HRPS movements were upstream, downstream, or equally distributed while at liberty, the observed proportion of HRPS that made net upstream movements was compared to the expected proportion of 0.50 (Milton and Arnold 1995):

$$Z = \frac{P_U - 0.50}{\sqrt{\frac{P_U(1-P_U)}{N}}},$$

where Z is the test statistic, P_U is the observed proportion of HRPS that made net upstream movements from their stocking site, and N is the number of HRPS sampled. Hatchery-reared pallid sturgeon net movements would be downstream in direction when the test statistic Z is less than -1.96, upstream in direction when the test statistic Z is greater than 1.96, and equally distributed when the test statistic Z is between –1.96 and 1.96.

RESULTS AND DISCUSSION

Adult Pallid Sturgeon Sampling

Broodstock collection efforts of our Pallid Sturgeon Study crew, the Fort Peck Flow Modification crew, and the USFWS resulted in the capture of 58 adult pallid sturgeon, consisting of 49 individuals, in 2004. Forty-one individual pallid sturgeon were captured in broodstock collection efforts in the spring (20 April to 29 April), with eight new fish. Six individual pallid sturgeon were captured in broodstock collection efforts in the fall (9 November), with one new fish. Three individuals were captured incidentally during HRPS sampling efforts, with one new fish. Of the 49 adults captured for broodstock, seven were transported to the Miles City State Fish Hatchery, 16 were transported to Garrison Dam National Fish Hatchery, and three were transported to Gavins Point National Fish Hatchery for possible use in the propagation program. All other pallid sturgeon were released in the vicinity of their capture site, some after measurement data were collected. Unfortunately, one of the post-spawn females pallid sturgeon transported to Garrison Dam National Fish Hatchery died. This female pallid sturgeon likely died due to accumulated stresses associated with capture, transportation, and induced spawning.

We, (the Pallid Sturgeon Study Crew) captured 18 HRPS during broodstock efforts, 177 in drift trammel nets at 1,417 mins for a CPUE of 0.76. Fifteen individual pallid sturgeon were captured in broodstock collection efforts in the spring (20 April to 29 April), with three new fish in . Three individual pallid sturgeon were captured in broodstock collection efforts in the fall (9 November), with zero new fish.

Relatively low and stable flows in both the Missouri and Yellowstone rivers resulted in optimal netting conditions during the broodstock collection effort. All adult pallid sturgeon were scanned for PIT tags when captured. Ten of the 49 adult pallid sturgeon captured during 2004 were unmarked fish and 39 were recaptures from previous years. This recapture rate (79.6%) was much lower than the 89.5% recapture rate observed during 2003 (Kapuscinski and Baxter 2004) and relatively high compared to recapture rates observed in previous years (53% during 2000 and 2001; Yerk and Baxter 2001; Yerk and Baxter 2002).

Most adult pallid surgeon captured during 2004 were released immediately and not measured in order to reduce the stresses associated with capture and handling.

Previous work indicated pallid sturgeon were concentrated at the confluence area of the Missouri and Yellowstone rivers in the spring and fall (Tews 1994). Liebelt (2000) suggested that the confluence area of the Missouri and Yellowstone rivers is a staging area for spawning adult pallid sturgeon prior to their migrating upstream into the Yellowstone River in response to a rising hydrograph. Bramblett and White (2001) reported that aggregations in late spring and early summer suggested that pallid sturgeon might spawn in the lower nine river miles of the Yellowstone River. All adult pallid sturgeon captured during spring 2004 broodstock efforts were captured near the Confluence (Figure 2). Relatively cool surface water temperatures ranged from 8.5 to 13.9 °C during the broodstock collection effort suggesting that these fish were staging for their spawning run.

A current population estimate was calculated at 158 individuals (SE = 16.2, 95% confidence interval [CI] = 129-193). Linear regression of abundances and time (years) resulted in the following:

$$P = -8.3284 * \mathrm{Y} + 16856$$

Where *P* is the estimated abundance, -8.3284 is the slope, *Y* is the year, and 16856 is the intercept (Figure 4). By substituting 0 for abundance *P* and solving the equation for year *Y*, we can see that if wild pallid sturgeon in RPMA #2 continue to decline in abundance at the rate described by the above function, they will be extirpated from RPMA #2 during 2024. The population of wild pallid sturgeon in RPMA #2 may be extirpated before 2024, however, if pallid sturgeon reach an old-age threshold before 2024, if fishing mortality is acting on the population, or if pallid sturgeon collected in future propagation efforts die. Also, we have certainly violated the following assumptions; that all animals in the population at the time of capture are captured with equal probability, since the data is a by product of our broodstock collection efforts that are generally limited to an area right around the confluence neglecting fish that may hold in other areas of the Missouri and Yellowstone rivers and that all tagged animals retain their tags. Tag retention in adult fish is currently unknown and it is very likely that tag loss is occurring, or that tags and readers have malfunctioned, violating the assumption that all tagged animals retain their tags, leading to an overestimate of the current population. To get a more accurate estimate of the current adult pallid sturgeon population a more comprehensive sampling effort coupled with a double tagging scheme (e.g. PIT tag and a coded wire tag) needs to take place.

The window of opportunity for recovering wild pallid sturgeon in RPMA #2 is closing rapidly. Aggressive measures should be taken to maximize recovery efforts during the next 10 years. Habitats must be rehabilitated immediately if wild pallid sturgeon in RPMA #2 are expected to contribute to future generations. Rapid population recovery is improbable, even in protected sturgeon populations, given that strong year-classes are widely separated periodic phenomena in natural populations (Sulak and Randall 2002).

<u>HRPS</u>

A total of 93 HRPS individuals were captured in RPMA #2 during 2004 sampling efforts. Fifty-one HRPS were captured during monitoring efforts, 45 in drift trammel nets at 15,300 mins for a CPUE of 0.18 and six in benthic beam trawl tows at 4,573 mins for a CPUE of 0.078 (Table 2). Forty-five HRPS were captured during wildcat surveys, 34 in 45 m drift trammel nets at 4,444 mins for a CPUE of 0.46, nine in 22.5 m drift trammel nets at 936 mins for a CPUE of 0.58, zero in benthic beam trawl tows at 70 mins, and two in 3,744 mins of angling for a CPUE of 0.032 (Table 2).

Hatchery reared pallid sturgeon were captured at 24 of 90 different bend complexes from May-November 2004. Forty-seven were captured in the Missouri River between study reaches two and eight and 46 were captured in the Yellowstone River, three of these between the Confluence (rkm 0) and Fairview (rkm 9) and 43 below Sidney at rkm 41.8 (Figures 5 and 6). Captured HRPS included individuals from all available year classes (1997,1998, 1999, 2001, 2002, and 2003).

Survival estimates are difficult due to the inconsistency stocking events and lack of consistent year class captures. Consequently it was only possible for MARK to estimate annual survival estimates between ages 1-2, 43.9% (SE = 0.266, 95% confidence interval [CI] = 8.6-86.7) and ages 5-6, 67.7% (SE = 0.170, 95% CI = 31.3-90.6). Because of the wide CI's neither estimate may be very useful; however, the age 1-2 estimate indicate lower survival than stated in the stocking plan (60%) while the age 5-6 estimate is supportive of the survival than stated in the stocking plan (60%). Stocking rates will need to be adjusted as more information on HRPS survival in the wild becomes available. If an appropriate monitoring effort continues to be conducted annually, survival rates for multiple age intervals can accurately be estimated with a CJS model in program MARK.

Eighty nine HRPS captured averaged 343.6 mm (range, 172-652 mm) in FL and 151.6g (range, 24-1075g) in weight. Sixty three HRPS grew an average of 55.3 mm while at liberty 30-2208 d, and had an average daily growth rate of 0.36 mm/d .

Eighty eight of the 93 captured HRPS were PIT tagged before being stocked. Sixty six out of 86 HRPS (2 fish not scanned) held functioning PIT tags, resulting in a 76.7% retention rate. When a captured HRPS is lacking a PIT tag, it is not possible to quantify vital information on growth rates, movements, or potential stocking site related mortality. Gardner (2003) observed a 65.5% PIT tag retention rate for 55 HRPS captured in RPMA #1 during 1998-2003. These observed PIT tag retention rates require that alternative tagging locations (e.g. behind the head, etc.) should be explored. Estimated retention rates for PIT tags injected into the musculature beneath the armor of the head near the dorsal midline in juvenile white sturgeon *Acipenser transmontanus*, range 92-99% (K. Kappenman, USFWS and S. McKenzie, Golder Associates; personal communication). Laboratory studies examining alternative approaches for tagging HRPS and improving retention rates are currently being conducted at the BFTC.

Turbidity ranged from 2.1 to 801 NTUs at all sites sampled, but ranged from 13.4 to 427 NTUs at HRPS capture sites. Mean turbidity at sampling sites where HRPS were not sampled (97.3 NTUs) were statistically different from sites where HRPS were sampled (116.9 NTUs; t-test assuming equal variances, $P < 0.0001$, df = 630). Pallid sturgeon historically occupied turbid river systems (Kallemeyn 1983; Dryer and Sandvol 1993), but the relation between site turbidity and HRPS presence is unknown in RPMA #2.

The weight-length relation for 67 captured HRPS was quantified as:

$$W = 10\text{^}[-4.56 + 2.63 * \log_{10}(FL)]$$

Where *W* is weight (g), *L* is FL (mm), and -4.56 and 2.63 are parameters estimated by linear regression of logarithmically transformed weight-length data (Figure 8). It is unclear at this time if the observed weight-length relation for HRPS captured in RPMA #2 is related to growth, survival, or recruitment. Compared to shovelnose sturgeon *Scaphirhynchus platorynchus* have a higher predicted weight-length than captured HRPS in the same length range ($P < 0.0001$, df = 64). More research into how weight-length data is related to other population characteristics is necessary and could benefit recovery efforts where HRPS are stocked.

Sixty five captured HRPS were at liberty for an average of 404 d. Movements of 12 captured HRPS ranged from 3.2 to 169.8 rkm in total distance. These 12 HRPS moved an average of 33.5 rkm while at liberty or 0.25 rkm /d. During 1999-2002 twenty three HRPS captured moved an average of 0.08 rkm /d while at liberty (K. Kapuscinski, Montana Fish, Wildlife & Parks, unpublished data). The upper and lower 95% confidence limits about the average distance moved by HRPS were 27.1 and 14.5 rkm. Captured HRPS net movements were downstream in direction ($Z = -4.05$); eighteen HRPS made net upstream movements of 437.9 rkm, and the remaining 47 of 65 HRPS made net downstream movements of 1535.0 rkm. Six captured HRPS moved between the rivers, four of these were stocked at Fairview and one at Intake on the Yellowstone River and migrated 10.5-55.5 rkm up the Missouri River over the course of at least one year. One happy wanderer HRPS appears to have traveled from rkm 2609 on the Missouri River to rkm 42 on the Yellowstone River, a distance of 105.4 rkm in six weeks. This seems highly unlikely as the fish also had a growth rate (0.66mm/d) nearly double the average, and is more likely due to an error in the database or a mix up at the hatchery. Overall it appears that HRPS seem to be located in the lower reaches of the study area due to their propensity to move downstream in search of suitable habitat. From 1999-2003, 26 of 34 HRPS captured in RPMA #2 made net downstream movements (M. Klungle, Montana Fish, Wildlife & Parks, unpublished data). The propensity of pallid sturgeon to move downstream after being stocked is an important factor when determining stocking sites. Upstream stocking sites are currently given preference over downstream sites in order to ensure that HRPS have the opportunity to settle in all habitats located between Fort Peck Dam and Lake Sakakawea and Intake Diversion Dam and the Confluence.

On 26 August, 70 HRPS were released at Sidney bridge (rkm 48) of the Yellowstone River with Lotek NTC 3-1 nanotag 37 day transceivers. These transceivers were implanted into HRPS to determine fidelity of fish stocked in the Yellowstone River. Nineteen tracking runs were made on the Yellowstone River between rkm 113 and rkm 0 and the Missouri River between rkm 2564 and rkm 2482. Tracking runs ranged from 10 to 113 rkm's and were made bi-weekly from 27 August to 7 October (42d) relocating sixty nine of the 70 fish at least once (Figure 9). Telemetered fish were relocated from 39.4 rkm above to 38.6 rkm below the Sidney bridge stocking site (Figure 9). The 69 relocated HRPS were at liberty an average of 5d (range, 1 – 35d) between relocations. These telemetered HRPS moved an average of 2.4 rkm (range, 0-20.6 rkm) between relocations or 0.52 rkm/d. The upper and lower 95% confidence limits about the average distance moved were 2.2 and 2.8 rkm. Relocated HRPS net movements were downstream in direction (Z=-3.41); 21 telemetered HRPS made a net upstream movement of 303.8 rkm, and the remaining 49 made net downstream movements of 450.7 rkm. Half of these telemetered HRPS were relocated at rkm 41.8 and eight were recaptured with drift trammel nets at this location.

One thousand eight hundred and fifty six HRPS were stocked in RPMA #2 this year at site on the Milk River, two sites on the Missouri River and two sites on the Yellowstone River. 410 stocking plan equivalents were stocked up the Milk River, 391 Wolf Point, and 339 Culbertson on the Missouri River and 809 stocking plan equivalents were stocked at 360 Intake and 356 Sidney on the Yellowstone River.

ACKNOWLEDGMENTS

I sincerely thank my project technician and crew leader, Matt Baxter, and our seasonal technicians Cody Dix, Landon Johnson, Lisa Dobbs, Amanda Bryson, and Ben Bailey for their hard work and dedication to this project. Thank you to Ryan Lott, Landon Holte, Bill Viste, Nate McClenning and William Waller of the Fort Peck Flow Modification crew for lending a hand whenever they could. Patrick Braaten, Matt Baxter, and Dave Fuller, Montana Fish, Wildlife & Parks, shared their knowledge and expertise. Lastly, I would like to thank Ted Anderson and Dirk Shulund of Western Area Power Administration for their continued support of pallid sturgeon research.

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Table 1. Nine study reaches of the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea confluence and the Yellowstone River between Sidney bridge and the confluence with the Missouri River.

Reach	Top	Bottom	rkm[a]	rkm[a]
1	Fort Peck Dam	Oswego	2848.5	2782.5
2	Oswego	Wolf Point bridge	2782.5	2741
3	Wolf Point bridge	Poplar River	2741	2704
4	Poplar River	Brockton	2704	2655
5	Brockton	Culbertson bridge	2655	2610
6	Culbertson bridge	Bainville	2610	2575
7	Bainville	Confluence	2575	2546
8	Confluence	Lake Sakakawea	2546	2490
9	Intake	Sidney bridge	113	48

[a] river kilometers

Table 2. Number of HRPS captures, total minutes sampled and CPUE for gear types drift trammel nets (45 and 22.5 m), benthic beam trawl tows, and hook and line sampling effort on 2004.

Effort[a]	Gear type	# HRPS	# mins	CPUE[b]
MON	DTN[c]	45	15,300	0.18
MON	BT[d]	6	4,573	0.078
WC	DTN[c]	34	4,444	0.46
WC	DTN[e]	9	936	0.58
WC	BT	0	70	-
WC	H&L[f]	2	3,744	0.032

[a]Effort as either MON-monitoring or WC-wildcat surveys.
[b]Catch-per-unit-effort in HRPS per h.
[c]Drift trammel net, 45 m in length.
[d]Benthic beam trawl.
[e]Drift trammel net, 22.5 m in length.
[f]Hook and line sampling with size 2 or 4 circle hooks baited with nightcrawlers.

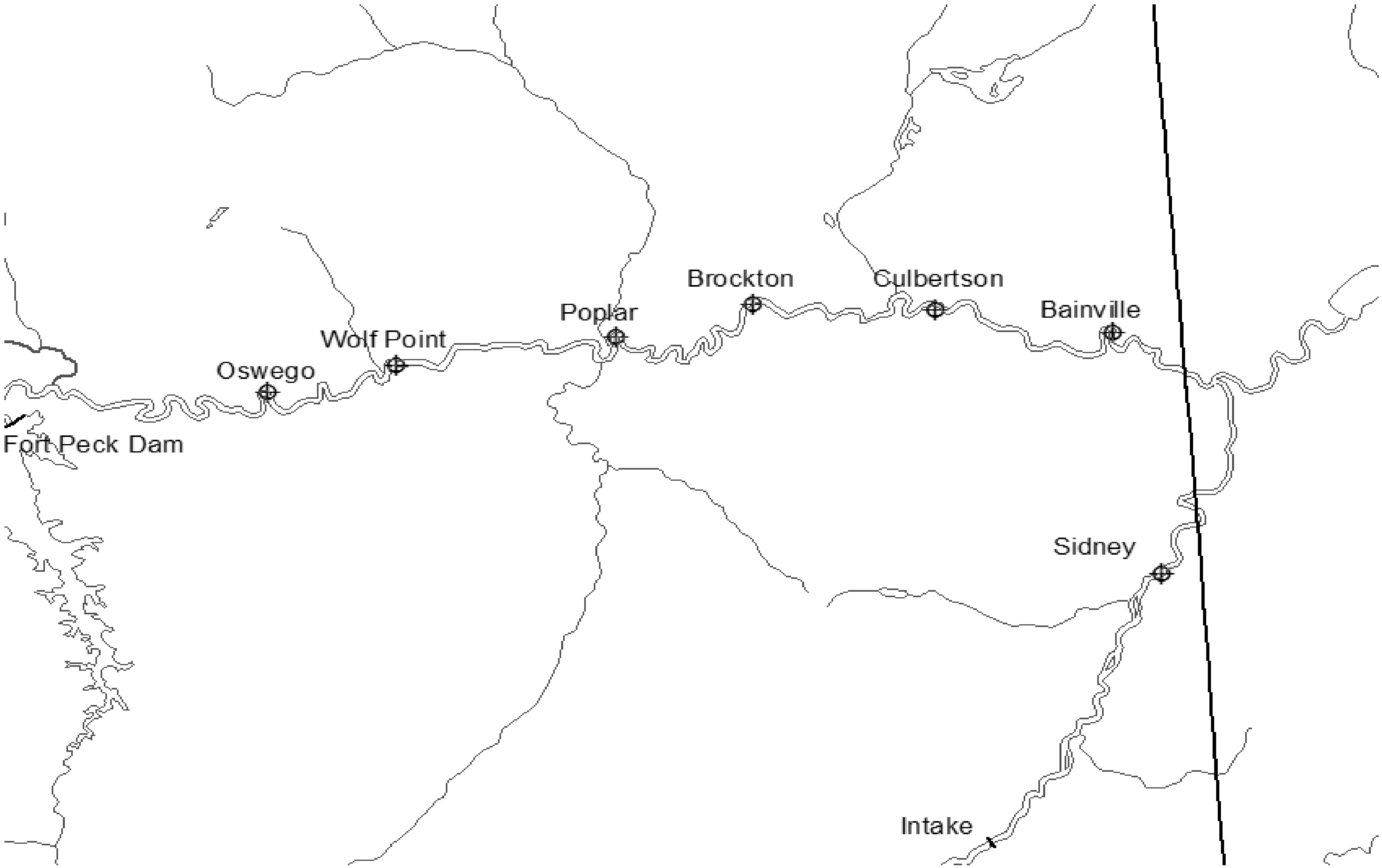

Figure 1. Study reaches of the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea confluence and the Yellowstone River between Sidney bridge and the confluence with the Missouri River.

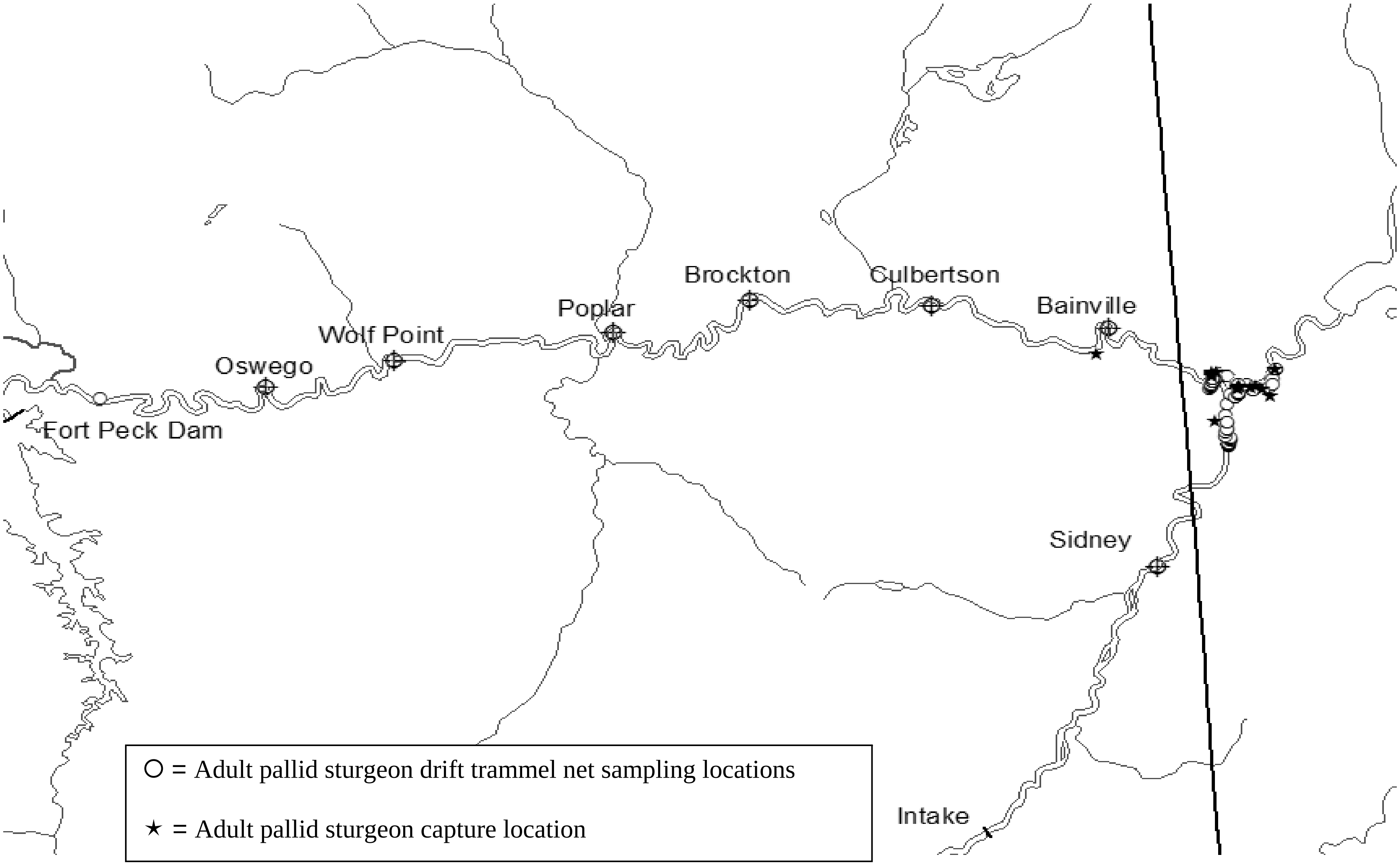

Figure 2. Drift trammel net sampling and capture locations for adult pallid sturgeon along the Missouri and Yellowstone rivers with capture locations, 2004.

Figure 3. Drift trammel net and benthic beam trawl tow sampling locations for HRPS along the Missouri and Yellowstone rivers, 2004.

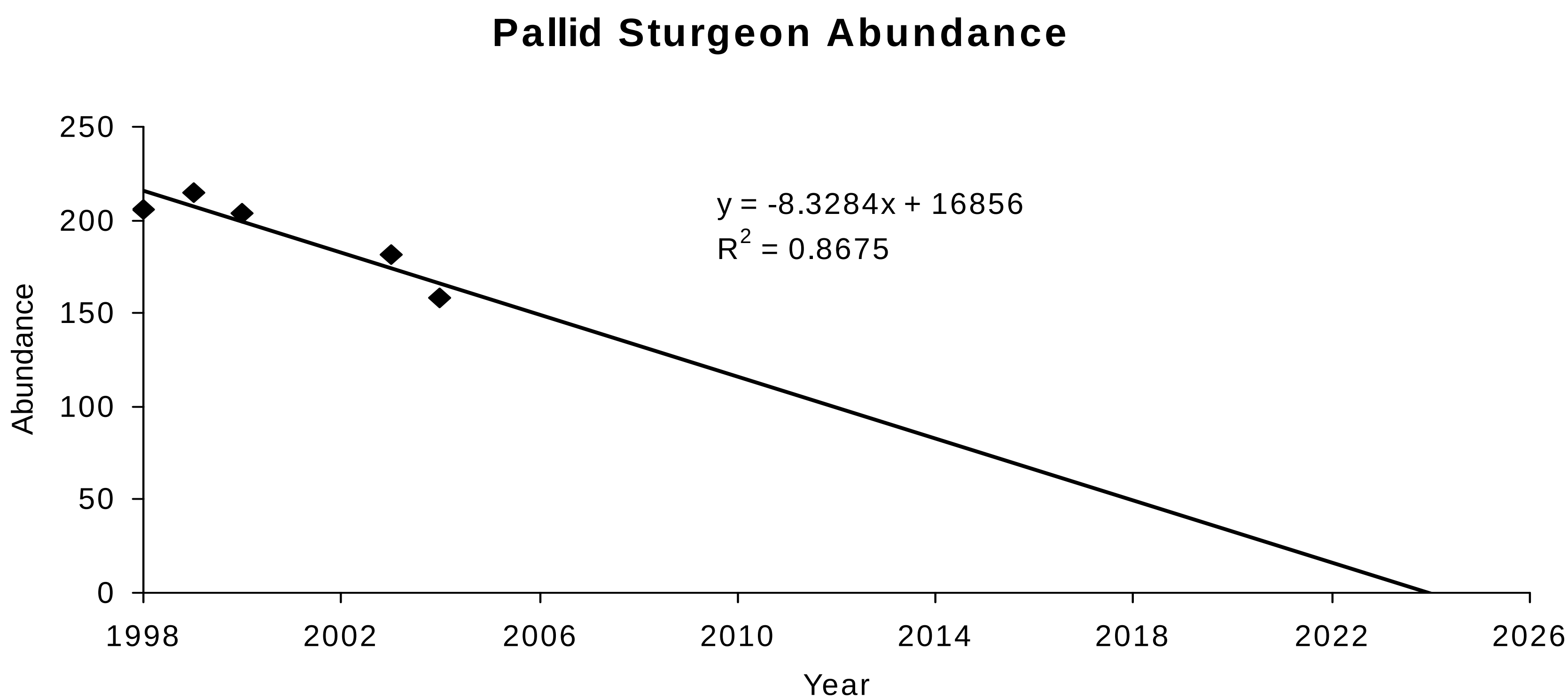

Figure 4. Pallid sturgeon abundance estimates for years 1998, 1999, 2000, 2003, and 2004 with trend line predicting an extirpation date of 2024.

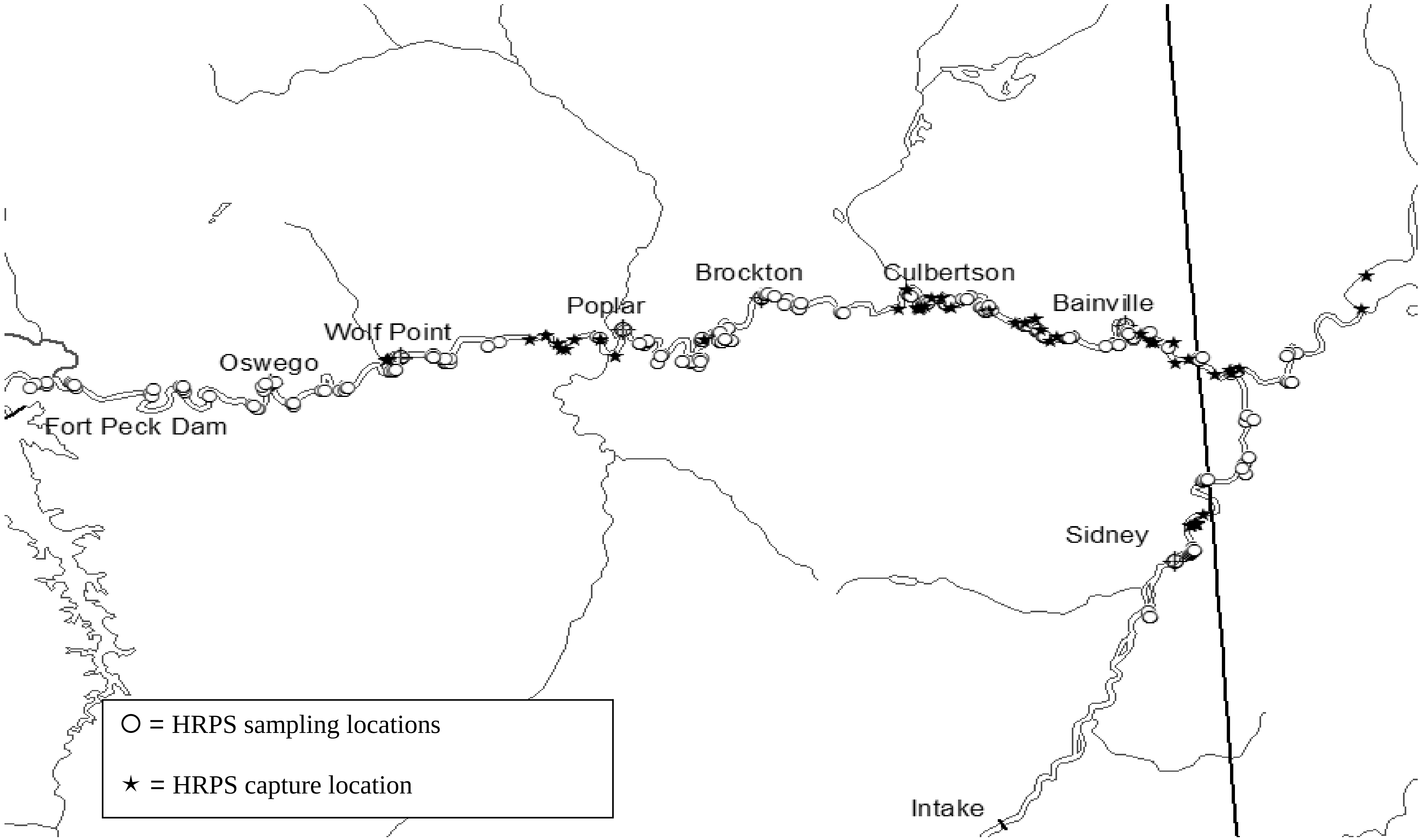

Figure 5. Drift trammel net sampling and HRPS capture locations along the Missouri and Yellowstone rivers, 2004.

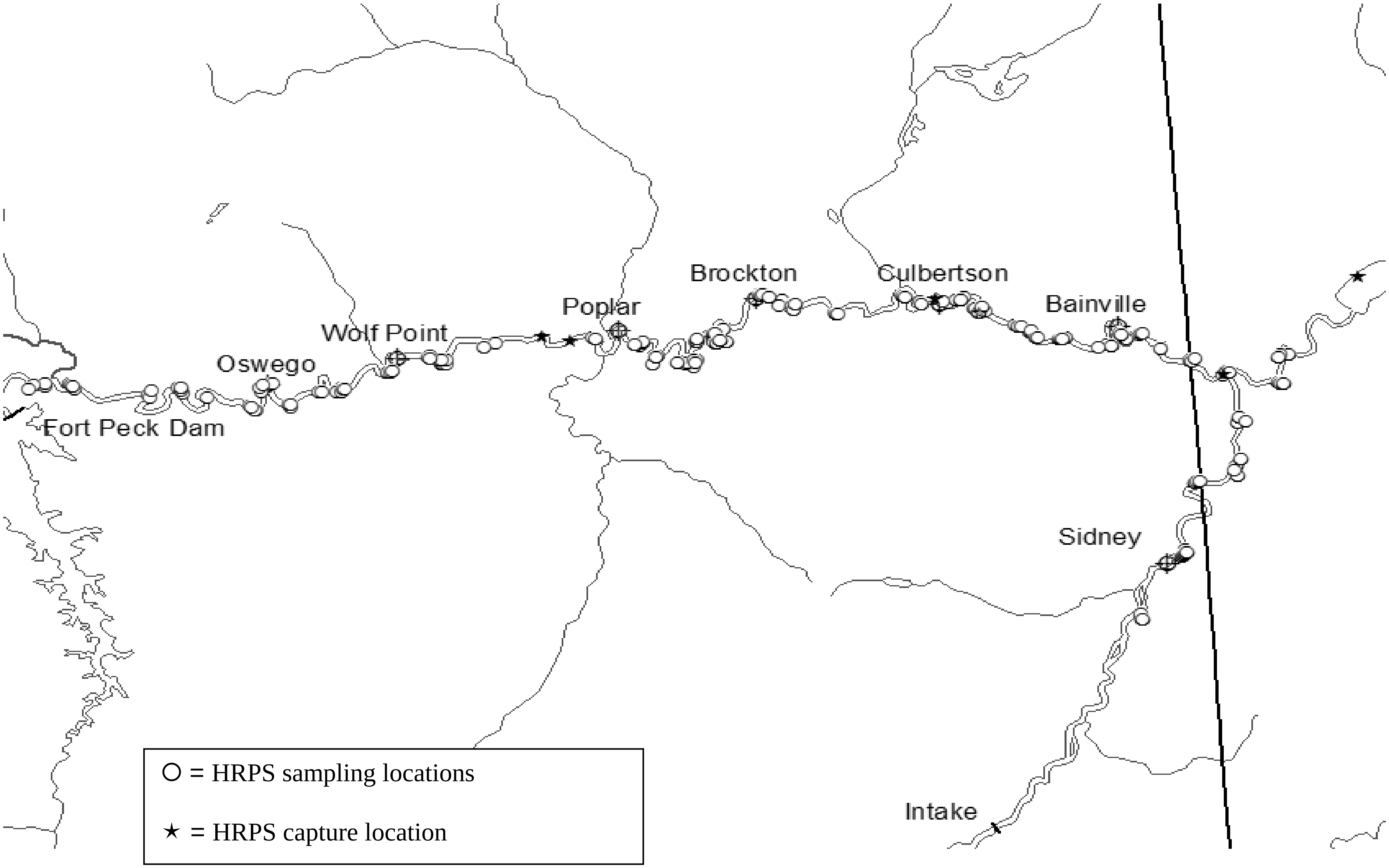

Figure 6. Benthic trawl tows and HRPS capture locations along the Missouri and Yellowstone rivers, 2004.

Figure 7. Hook and line sampling and capture locations for HRPS along the Missouri and Yellowstone rivers, 2004.

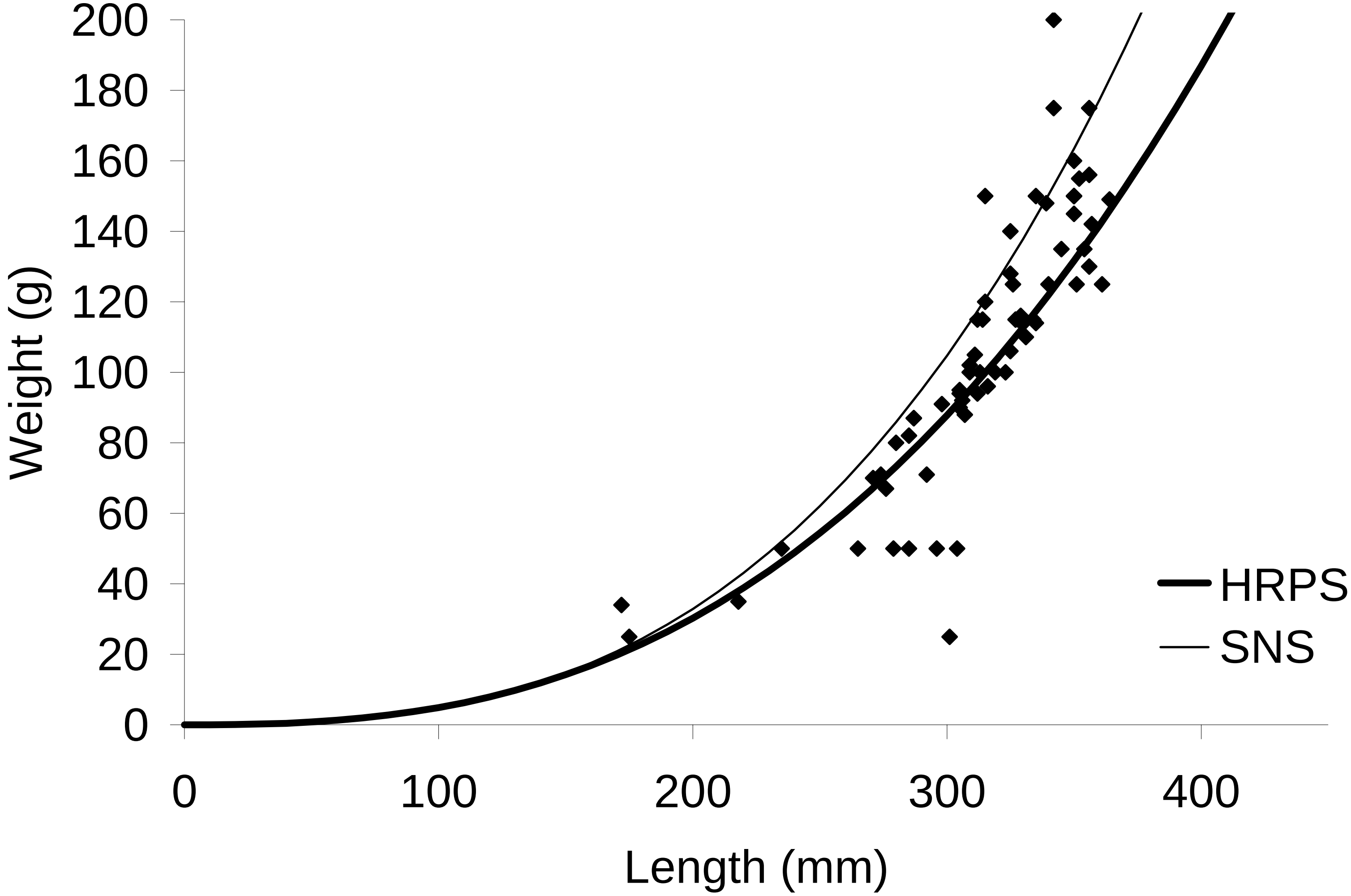

Figure 8. Weight-length relations plotted as a function of length for 68 hatchery-reared pallid sturgeon and 111 shovelnose sturgeon (<365 mm) captured in the study area during 2004.

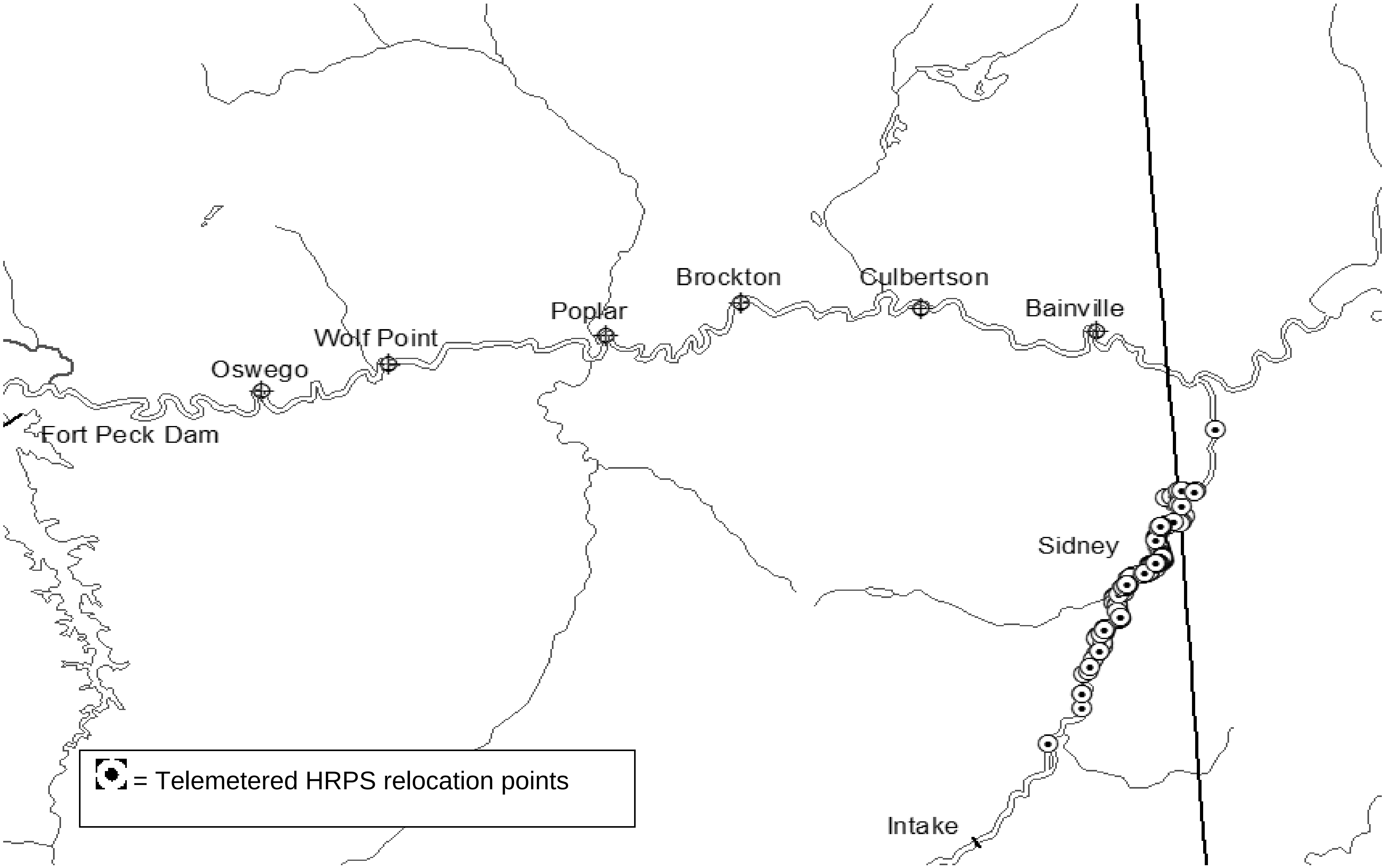

Figure 9. Relocation points of 69 of the 70 telemetered HRPS released at Sidney Bridge, MT, on 26 August.

ASSESSMENT OF THE SUITABILITY OF THE YELLOWSTONE RIVER FOR PALLID STURGEON RESTORATION EFFORTS

Annual Report for 2004

By

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U. S. Bureau of Reclamation

May 2005

Pallid sturgeon, a species native to the Yellowstone River, was listed as endangered in 1990. Declines in pallid sturgeon distribution and abundances are attributed to alteration of a natural flow regime and habitat degradation caused by impoundments and channelization throughout the upper Missouri River (Kallemeyn 1983). No recruitment has occurred in at least 30 years and this species will likely be extirpated from Recovery Priority Management Area (RPMA) 2 by 2018 (Kapuscinski 2004). Accordingly, recovery efforts have focused on preserving the pallid sturgeon genetic pool through a captive breeding program until habitat restoration permits the re-establishment of self-sustaining populations (Kapuscinski and Baxter 2004). Because limited time remains before extant populations senesce, identification of areas that provide the best opportunity for survival to maturity and eventual reproductive success of hatchery-reared pallid sturgeon is critical. However, inadequate information regarding the survival, growth, food habits, movements, and habitat use at many current stocking locations exists because of few encounters with stocked fish following release (Kapuscinski and Baxter 2004); it is unknown whether release areas are unsuitable, resulting in emigration or poor survival, or are simply ineffectively sampled. Nonetheless, identification of sites most likely to provide the best opportunity for survival to maturity of hatchery-reared pallid sturgeon is essential for continued existence of this species.

Heretofore, recovery and research efforts in RPMA 2 have been restricted to the Missouri River between Fort Peck and Sakakawea reservoirs and the 114 kilometers of the Yellowstone River downstream of Intake Diversion. However, unnatural, dam-influenced discharge, sediment, and temperature regimes may limit the success of pallid sturgeon recovery efforts in the Missouri River. Because of its relatively pristine character, including an intact near-natural hydrograph and associated temperature and sediment regimes, the Yellowstone River may provide a better opportunity for pallid sturgeon recovery until natural conditions can be restored to the Missouri River. The importance of natural riverine function is emphasized by the movements and behavior of extant pallid sturgeon; the Yellowstone River may be the only location in RPMA 2 that is used for and supports successful spawning (Bramblett and White 2001; Kapuscinski and Baxter 2004). Furthermore, recent sampling indicates that the Yellowstone River below Intake Diversion supports relatively high survival of hatchery-reared pallid sturgeon (M. Klungle, Montana Department of Fish, Wildlife and Parks, personal communication).

Although the Yellowstone River comprises the majority of RPMA 2 and provides the most pristine habitat range-wide, stocking has not occurred in the 265 kilometers of potentially usable habitat between Cartersville and Intake diversions because of hypotheses that most pallid sturgeon stocked in this reach would disperse long distances downstream and become entrained in Intake Canal. Downstream dispersal was expected because of the scarcity of apparently preferred sand substrate habitats upstream of the sand-to-rock transition area that occurs near Sidney, Montana (river kilometer 50). However, the observed psammophilic tendency of pallid sturgeon is ambiguous and may be influenced by study area and life history stage (e.g. Erickson 1992, Bramblett and White 2001). Adult pallid sturgeon are regularly documented immediately downstream of Intake Diversion (river kilometer 114) over predominately gravel and cobble substrates (Backes et al. 1994; Bramblett and White 2001) and anecdotal evidence suggests that they were historically common upstream of Intake Diversion. Pallid sturgeon were most recently documented above Intake Diversion in 1991 (Watson and Stewart 1991). Potential entrainment rates of pallid sturgeon stocked upstream of Intake Diversion were unknown. Therefore, the goal of this study was to determine dispersal patterns and entrainment probabilities of pallid sturgeon stocked in the Yellowstone River between Cartersville and Intake diversions to assess the suitability of this reach for future population restoration efforts.

STUDY AREA

The study area consists of the 379 km of the Yellowstone River below Cartersville Diversion. Mean annual discharge at the USGS gauging station in Miles City, Montana, is 323 m^3/s and mean annual peak discharge is 1480 m^3/s. River geomorphology varies throughout the study area in direct response to valley geology; straight, sinuous, braided, and irregular-meander channel patterns occur (Silverman and Tomlinsen 1984). The channel is often braided or split and long side channels are common. Islands and bars range from large vegetated islands to unvegetated point and mid-channel bars (White and Bramblett 1993). Substrate is primarily gravel and cobble upstream of river kilometer 50 and is primarily fines and sand below (Bramblett and White 2001). The fish assemblage is comprised of 49 species from 15 families, including eight state-listed Species of Special Concern and one federally listed endangered species (White and Bramblett 1993; Carlson 2003). The primary deleterious anthropogenic effect on the fish assemblage is water withdrawal for agriculture (White and Bramblett 1993). About 90% of all water use on the Yellowstone River is for irrigation, which corresponds to annual use of 1.5 million acre-feet (White and Bramblett 1993). Six mainstem low-head irrigation diversions dams occur on the lower Yellowstone River. The largest and downstream-most of these, Intake Diversion, diverts about 38 m^3/s during the mid-May to mid-September irrigation season (Hiebert et al. 2000).

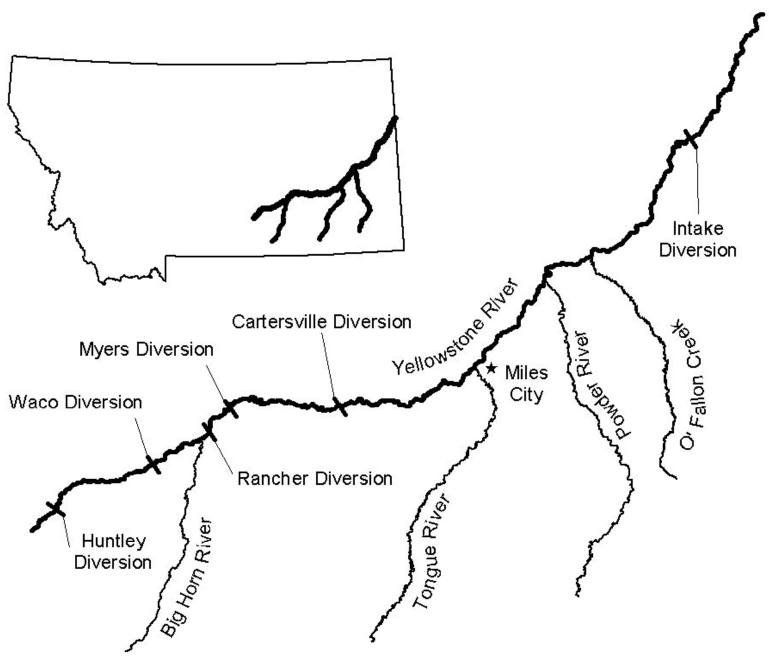

Figure 1. The lower Yellowstone River, its major tributaries, and diversion dams.

METHODS

Twenty-one hatchery-reared 2001 year-class pallid sturgeon weighing 856 to 1796 g were telemetered at the Bozeman Fish Technology Center (BFTC) May 24, 2004. Transmitters were 68 mm long and 16 mm in diameter, weighed 31.5 g, had a minimum battery life of 967 days, and were labeled with a return address and phone number to facilitate return if fish were found dead. Each transmitter emitted a unique code detectable with radio antennae at 164.994 MHz and acoustic hydrophone at 65.5 KHz. Transmitters were implanted using procedures modified from Hart and Summerfelt (1975). Incisions were closed using either monofilament or synthetic braided absorbable suture material. The 450-mm long whip antennae trailed externally (Ross and Kleiner 1982). Following surgery, fish remained at the BFTC for six weeks to monitor recovery from surgery.

Telemetered pallid sturgeon were released into three geomorphically distinct reaches of the Yellowstone River July 7, 2004; five fish were released about 15 kilometers downstream of Cartersville Diversion, nine fish were released near the Tongue River, and seven fish were released near O' Fallon Creek. Telemetered pallid sturgeon were relocated by boat once per week during July and August and twice per month during September and October. Following detection, coordinates of each pallid sturgeon location were determined using a hand-held global positioning unit. Location was converted to river kilometer using geographic information system software. Fixed receiving stations were placed near the head of Intake canal and at the confluence with the Missouri River to assess entrainment in Intake Canal and emigration out of the Yellowstone River.

Dispersal pattern was described by plotting relocation histories of telemetered pallid sturgeon. Net movement rates (km/d) during each month were calculated for each telemetered pallid sturgeon. Net movement rate was calculated by dividing the change in river kilometer between successive relocations by the number of days that had elapsed between relocations such that a positive rate indicated upstream movement and a negative rate indicated downstream movement (Bramblett 1996). Because additional movement may have occurred between relocations, calculated movement rates represent the minimum movement for the time period between relocations. Median monthly movement rates were compared using a Kruskal-Wallis test (Zar 1999). Probability of entrainment was calculated by dividing the number of telemetered pallid sturgeon entrained by the number released.

RESULTS

Most pallid sturgeon remained upstream of Intake Diversion and each geomorphic reach was occupied throughout the study period (Figure 2). Downstream dispersal was observed for about 30 days post-stocking; however, upstream movements were also common 30 to 90 days post-stocking (Figure 2). Net movement rates of pallid sturgeon varied among months ($P < 0.001$; Figure 3) and indicated predominately downstream movements in July, downstream and upstream movements in August, and few movements in September and October. Three fish were entrained in Intake Canal, which corresponds to a 0.143 (0.00, 0.293; 95% confidence interval) probability of entrainment. Two fish emigrated out of the Yellowstone River during August.

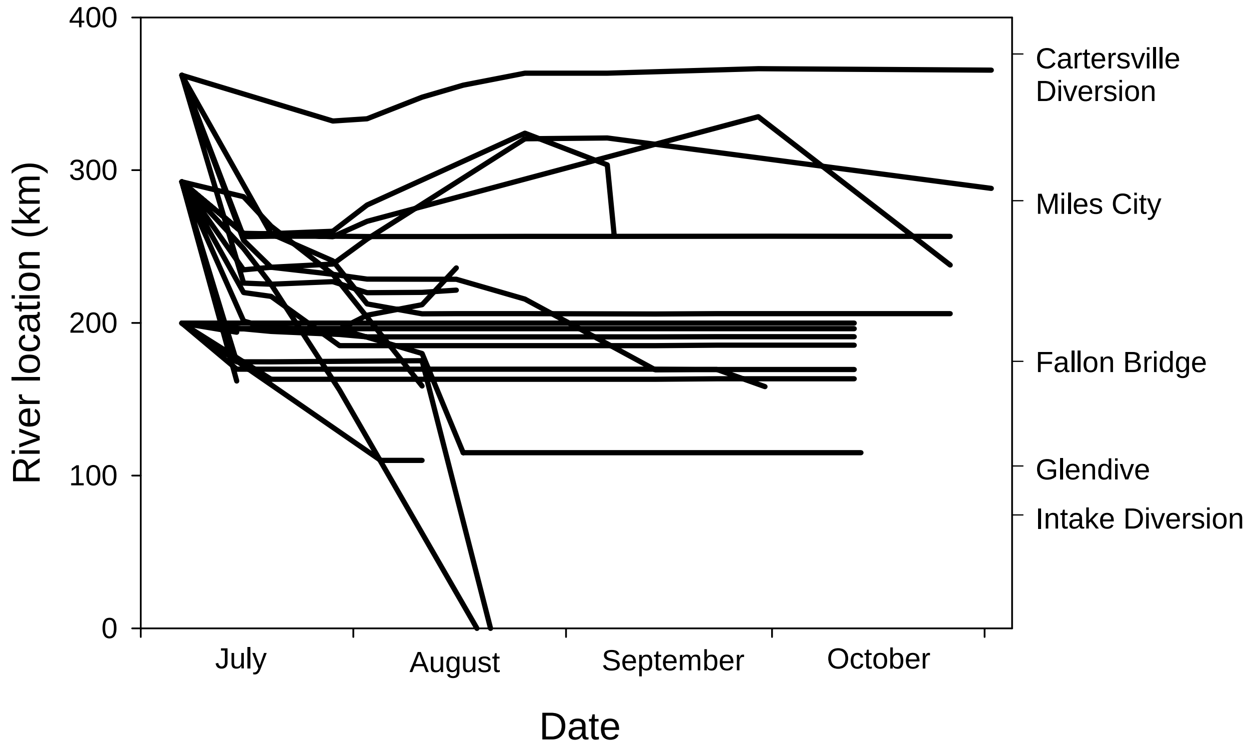

Figure 2. Dispersal pattern of telemetered pallid sturgeon in the Yellowstone River, 2004. Lines represent movements of individual telemetered pallid sturgeon. River location describes the distance from the confluence with the Missouri River.

High rates of transmitter expulsion likely occurred during this study. A total of 38 fish were telemetered at the BFTC but 17 expelled their transmitters prior to release, which corresponds to a 44.7% expulsion rate. Following transmitter expulsion, all fish not euthanized died within a week. Two shed transmitters were recovered following release of fish into the Yellowstone River and several fish remained sedentary for most of the study, suggestive of transmitter expulsion. Two-inch inner-mesh trammel nets were drifted through locations where sedentary fish occurred but none were recaptured. A final tracking run in May 2005 revealed that no movement had occurred over the winter or during lowland runoff.

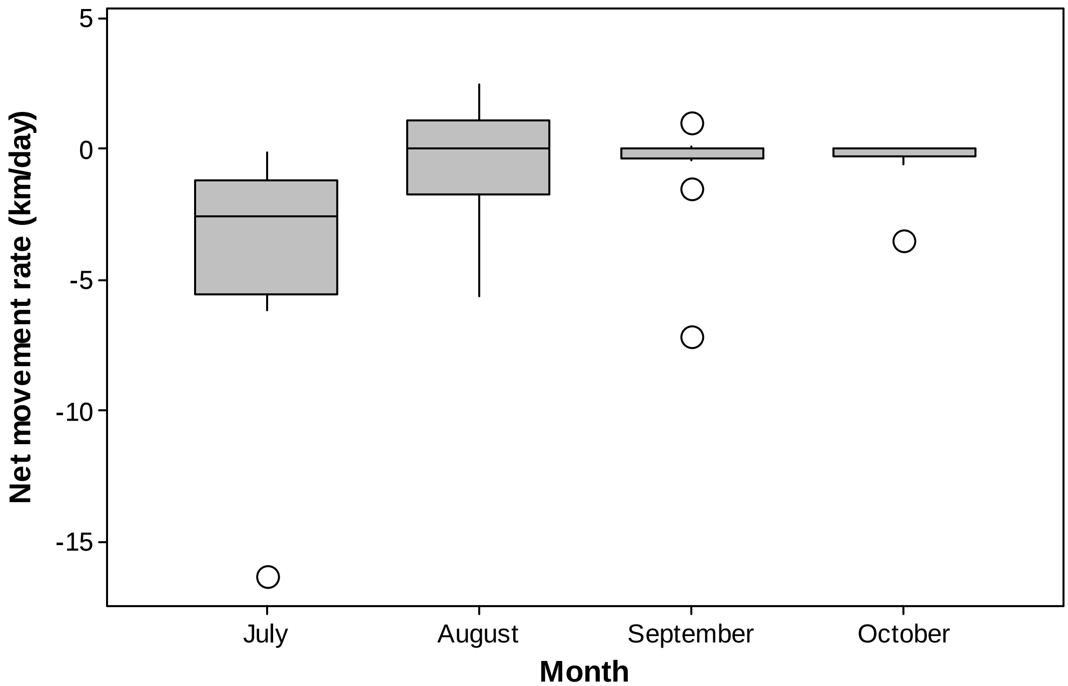

Figure 3. Net movement rates by month of telemetered pallid sturgeon in the Yellowstone River, 2004. Lines within boxes represent medians, boxes represent 25th and 75th percentiles, whiskers represent 10th and 90th percentiles, and circles represent outliers beyond the 10th and 90th percentiles. Negative values indicate predominately downstream movements, positive values indicate predominately upstream movements, and values near zero indicate no directionality of movement. Net movement rates among months are significantly different ($P \geq 0.001$).

DISCUSSION

Inferences of this study are limited by potentially high transmitter expulsion rates. Transmitter weight-to-fish weight ratios were less than 2% and did not significantly affect expulsion probability. Ratios of transmitter weight, length, or volume to fish weight, length, or condition factor also did not significantly affect expulsion probability. However, mean transmitter weight-to-fish weight ratio in this study (1.6%) was significantly larger than in a study (1.1%) where no transmitter expulsion occurred ($P < 0.001$; P. Gerrity, Montana Cooperative Fishery Research Unit, personal communication). Accordingly, future pallid sturgeon telemetry efforts should attempt to achieve transmitter weight-to-fish weight ratios closer to 1% than the widely accepted 2%. Use of suture material instead of surgical staples may also have contributed to higher probabilities of expulsion. Inferences of this study were also limited by advanced age at stocking (age 3), extensive hatchery institutionalization, and severe fin degeneration.

Preliminary research indicates that the Yellowstone River between Cartersville and Intake diversions is suitable for pallid sturgeon restoration efforts, but further research is needed. Limited downstream dispersal and continual occupancy of all geomorphic reaches suggests that pallid sturgeon will remain in the study area following stocking and observed entrainment probabilities in Intake Canal imply that entrainment-related mortality is lower than anticipated.

Continuation of this research using age 1 fish with healthy fins, more conservative transmitter weight-to-fish weight ratios, and additional criteria to judge suitability, including estimates of survival, habitat use, food habits, and growth, would provide needed insight into the suitability of this substantial and potentially important reach of RPMA 2 for pallid sturgeon restoration efforts. Research efforts to address these factors while avoiding the aforementioned limitations will commence August 2005.

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FORT PECK FLOW MODIFICATION BIOLOGICAL DATA COLLECTION PLAN
SUMMARY OF 2004 ACTIVITIES

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EXTENDED ABSTRACT

The Missouri River Biological Opinion developed by the U. S. Fish and Wildlife Service formally identified that seasonally atypical discharge and water temperature regimes resulting from operations of Fort Peck Dam have precluded successful spawning and recruitment of pallid sturgeon *Scaphirhynchus albus* in the Missouri River below Fort Peck Dam. In response, the U. S. Army Corps of Engineers (USACE) proposes to modify operations of Fort Peck Dam to enhance environmental conditions for spawning and recruitment of pallid sturgeon. Modified dam operations include releasing warm surface water over the Fort Peck Dam spillway. The Fort Peck Flow Modification Biological Data Collection Plan (hereafter Fort Peck Data Collection Plan) was implemented in 2001 to evaluate the influence of proposed flow and temperature modifications on physical habitat and biological response of pallid sturgeon and other native fishes. Research and monitoring activities conducted during 2004 as part of the multi-year Fort Peck Data Collection were similar to those activities conducted during 2001, 2002, and 2003; however, slight modifications were implemented in 2004. For 2004, primary research and monitoring activities included: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining use and movements of adult pallid sturgeon in the Missouri River downstream from Fort Peck Dam, 3) examining flow- and temperature-related movements of paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus*, 4) quantifying larval fish distribution and abundance, 5) quantifying the reproductive success of shovelnose sturgeon and pallid sturgeon based on captures of young-of-year sturgeon, and 6) assisting in the collection of adult pallid sturgeon for the propagation program. The Fort Peck Data Collection Plan is supported by the USACE, and jointly implemented by the Montana Department of Fish, Wildlife, and Parks and the U. S. Geological Survey - Columbia Environmental Research Center.

Similar to 2001 through 2003, proposed flow modifications were not implemented in 2004 due to inadequate precipitation and insufficient reservoir levels. For research component 1, continuous-recording water temperature loggers (39 total) positioned at 17 locations in the Missouri River, selected tributaries, and selected off-channel areas provided baseline water temperature profiles to which changes in water temperatures resulting from modified dam operations could be compared. Water temperature between mid-April and mid-October in the Missouri River upstream from Fort Peck reservoir averaged 17.6^{o}C. During this same time period, the mean water temperature was 12.3^{o}C 7.7 km downstream from Fort Peck Dam, and 15.8^{o}C 288 km downstream from Fort Peck Dam. Thus, despite an extended length of free-flowing river, impacts of Fort Peck Dam on water temperature were still evident in downstream reaches.

For research component 2, two adult pallid sturgeon were sampled in the lower 113 km of the Missouri River upstream from the Yellowstone River confluence. Both individuals were sampled in the same 2.5-km reach of the river (rkm 2584.0 – 2586.5), but were sampled about 1-month apart (May 20, June 23). The first pallid sturgeon was unmarked and implanted with a radio transmitter. The second pallid sturgeon carried a radio transmitter that had been implanted by the USFWS.

Under research component 3, extensive radiotracking was conducted between April and October in the lower Yellowstone River and in the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea. A total of 25 individual tracking events were conducted throughout the river systems resulting in a cumulative distance of 10,800 km tracked. We obtained 799 relocations of blue suckers, 253 relocations of paddlefish, and 1,065 relocations of shovelnose sturgeon via boat. Seven continuous-recording telemetry logging stations logged an additional 480 contacts of implanted fish. Species-specific information on relocation locations and movement patterns are presented. In addition, a total of 241 manual relocations of pallid sturgeon implanted by U. S. Fish and Wildlife Service personnel were obtained. In September 2004, radio transmitters were implanted in an additional 22 shovelnose sturgeon, 20 blue suckers, and 10 paddlefish. These individuals, added to the existing population of implanted fish, will be relocated during the next few years to ascertain discharge- and temperature-related movement patterns and aggregations prior to, during, and after proposed flow changes are implemented.

Under research component 4, larval fishes were sampled two times per week between late-May and early-August at three sites in the mainstem Missouri River (below Fort Peck Dam, Wolf Point, Nohly), two tributaries (Milk River, Yellowstone River), and the spillway channel. A total 11,526 larvae representing eight families were sampled across sites during 2004. Representatives of Catostomidae (i.e., suckers) were the numerically dominant taxon and composed 91.2% of the larvae sampled. Other relatively abundant taxa sampled included Cyprinidae (i.e., minnows and carps, 3.2%), Percidae (perches, 2.9%), and Hiodontidae (i.e., goldeye, 1.2%). Larval paddlefish (Polyodontidae) and larval sturgeon (Scaphirhynchus spp., Acipenseridae) composed 0.8% and 0.2% of the larval fishes sampled, respectively. Larval sturgeon were sampled in the Missouri River at Wolf Point (N = 9) and Nohly (N = 7), and in the Yellowstone River (N = 12).

For research component 5, weekly sampling for young-of-year sturgeon (*Scaphirhynchus* sp.) was conducted late-July through early-September in the Yellowstone River, and Missouri River upstream and downstream from the Yellowstone River confluence. No young-of-year sturgeon were sampled in the Yellowstone River or Missouri River upstream from the Yellowstone River confluence. Conversely, 81 young-of-year sturgeon were sampled from the Missouri River downstream from the Yellowstone River confluence.

For component 6, crews working under the Fort Peck Data Collection Plan were successful in capturing adult pallid sturgeon for the propagation program. A total of 23 adult pallid sturgeon were sampled during efforts in April, June, and November; however, not all individuals were used in the propagation program.

INTRODUCTION

The U.S. Army Corps of Engineers (USACE) proposes to modify operations of Fort Peck Dam following specifications outlined in the Missouri River Biological Opinion (USFWS 2000). Modified dam operations are proposed to increase discharge and enhance water temperature during late May and June to provide spawning cues and enhance environmental conditions for pallid sturgeon *Scaphirhynchus albus* and other native fishes. In contrast to cold hypolimnetic (i.e., from the bottom of the reservoir) releases through Fort Peck Dam, water from Fort Peck Reservoir will be released over the spillway during flow modifications to enhance water temperature conditions. The USACE proposes to conduct a mini-test of the flow modification plan to evaluate structural integrity of the spillway and other engineering concerns (USACE 2004). A full-test of the flow modifications will occur when a maximum of 537.7 m^3/s (19,000 ft^3/s) will be routed through the spillway. Spillway releases will be accompanied by an additional 113.2 m^3/s (4,000 ft^3/s) released through the dam. Pending results from the full-test, modified flow releases from Fort Peck Dam in subsequent years will be implemented in an adaptive management framework. All proposed flows are dependent on adequate inflows to Fort Peck Reservoir and adequate water levels in the reservoir.

The original schedule of events for conducting the flow modifications called for conducting the mini-test during 2001 and conducting the full-test in 2002. However, insufficient water levels in Fort Peck Reservoir during 2001, 2002, 2003, and 2004 precluded conducting these tests. As a consequence, physical and biological data collected between 2001 and 2004 represent baseline conditions under existing dam operations.

The Fort Peck Flow Modification Biological Data Collection Plan (hereafter referred to as the Fort Peck Data Collection Plan) is a multi-component research and monitoring program designed to examine the influence of proposed flow modifications from Fort Peck Dam on physical habitat and biological response of pallid sturgeon and other native fishes. Primary research activities of the multi-year Fort Peck Data Collection Plan during 2004 included: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining use and movements of adult pallid sturgeon in the Missouri River downstream from Fort Peck Dam, 3) examining flow- and temperature-related movements of paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus*, 4) quantifying larval fish distribution and abundance, 5) quantifying the reproductive success of shovelnose sturgeon and pallid sturgeon based on captures of young-of-year sturgeon, and 6) assisting in the collection of adult pallid sturgeon for the propagation program. The Fort Peck Data Collection Plan is funded by the USACE, and jointly implemented by the Montana Department of Fish, Wildlife, and Parks (MTFWP) and the U. S. Geological Survey Columbia Environmental Research Center – Fort Peck Project Office.

STUDY AREA

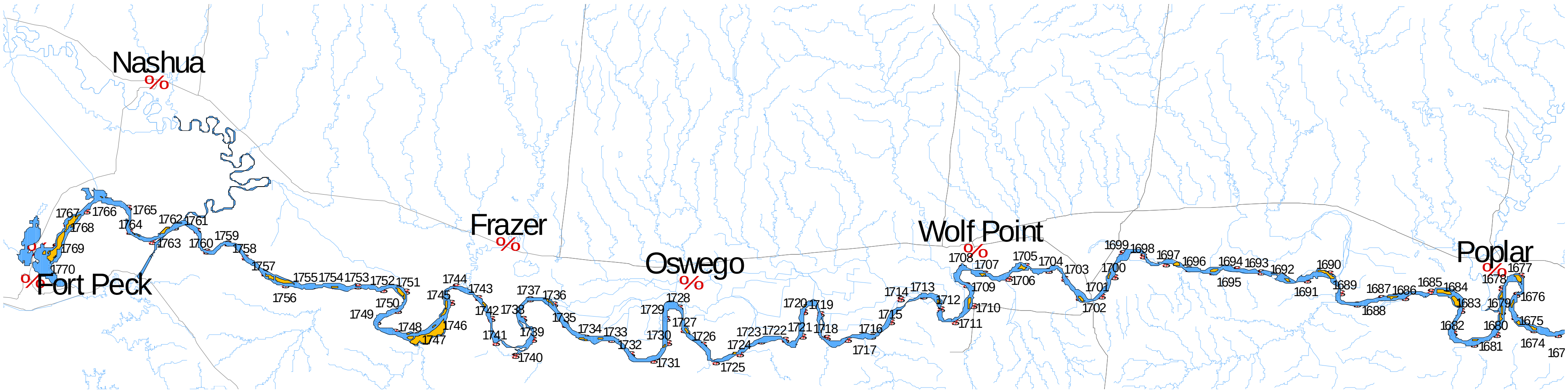
The Missouri River study area extends from Fort Peck Dam located at river kilometer (rkm) 2,850 (river mile, RM 1,770) to the headwaters of Lake Sakakawea near rkm 2,471 (RM 1,544.5; Figure 1). The study area also includes the lower 113 rkm (70 RM) of the Yellowstone River (Figure 1). See Gardner and Stewart (1987), White and Bramblett (1993), Tews (1994), Bramblett and White (2001), and Bowen et al. (2003) for a complete description of physical and hydrological characteristics of the study area.

METHODS

Monitoring Component 1 - Water temperature and turbidity.
Water temperature logger deployment. Water temperature loggers (Optic StowAway, -5^{o}C – +37^{o}C, 4 min response time, accuracy $\pm$ 0.2^{o}C from 0 - 21^{o}C) were deployed at 17 locations (total of 39 loggers) from early April to late October at sites in the Missouri River, Yellowstone River, selected tributaries, and off-channel areas (Table 1). Duplicate loggers were secured adjacent to the north and south bank lines at sites in the Missouri River to assess lateral variations in water temperature. Water temperature loggers were positioned at the bottom of the river channel. An additional logger was stratified in the water column at selected sites to assess vertical variations in water temperature. Water temperature loggers were programmed to record water temperature at 1-hr intervals, and periodically downloaded during the deployment period. The water temperature logger deployed in the Missouri River upstream from Fort Peck Lake (i.e., at Robinson Bridge) was maintained by Bill Gardner (MTFWP, Lewiston).

Statistical analysis of water temperature. Analysis of variance or t-tests were used to compare mean daily water temperature among water temperature loggers positioned on the north and south bank locations, and stratified in the water column. Analysis of variance was used to compare mean daily water temperature among all logger locations.

Assessment of water temperature logger precision. Precision of water temperature loggers was assessed prior to and following retrieval from the field. In April 2004, all water temperature loggers (except the logger deployed at Robinson Bridge) were subjected to a series of common water bath treatments to evaluate precision and accuracy among loggers. The water bath treatments were comprised of three temperature ranges (cold, < 10^{o}C, tailwater of Fort Peck Dam; cool, 10-20^{o}C, laboratory water bath; warm, > 20^{o}C, laboratory water bath). Following retrieval from the field, water temperature loggers were subjected to a series of common water bath treatments in November (cold, < 10^{o}C, tailwaters of Fort Peck Dam; cool, 10-20^{o}C, laboratory water bath; warm, > 20^{o}C, laboratory water bath). Pre- and post-deployment precision of loggers for each water bath treatment was evaluated with univariate statistics (mean, standard deviation, minimum, maximum, and range) computed over all loggers. The mean, minimum, maximum, and range were screened for precision. If precision was low (e.g., broad range of temperature for an individual water bath trial), logger data were scrutinized to determine which logger(s) was contributing to the extreme values. After identifying and deleting the "suspect" logger(s), univariate statistics were computed again to assess precision.



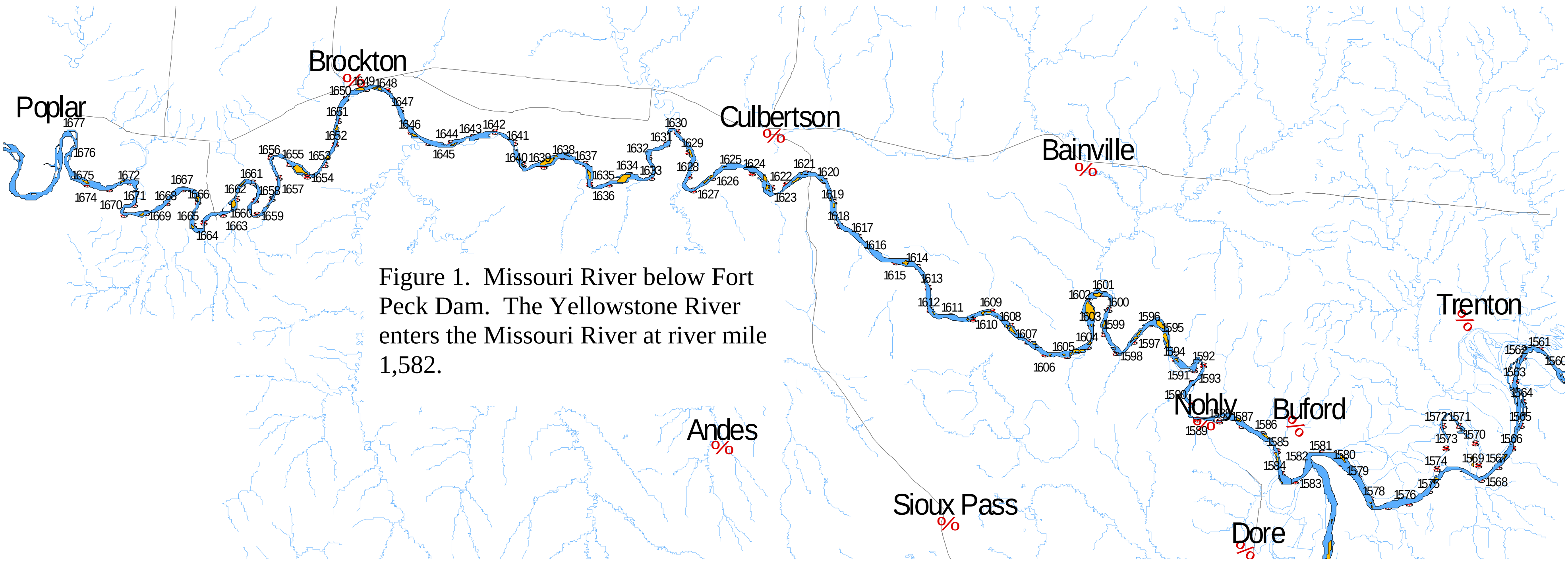


Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

Table 1. Sites, approximate river mile (RM; distance upstream from the Missouri River-Mississippi River confluence or distance upstream in a specified tributary), bank locations (north, south, strat = stratified in the water column), serial numbers, and dates of deployment for water temperature loggers deployed in the Missouri River and adjacent areas during 2004. NR = not recovered at the end of the season.

Site	RM	Bank location	Latitude	Longitude	Logger serial no.	Deploy date	Retrieval Date
Above Fort Peck Lake	1,920.5	South				4/3/04	10/24/04
Fort Peck Lake					429712	5/7/04	10/18/04
Downstream from	1,765.2	North	48.05562	106.36471	681738	4/12/04	10/21/04
Fort Peck Dam		South	48.06158	106.37810	389571		
		Strat	48.06227	106.37866	389497		
Spillway			48.03992	106.34095	429720	4/12/04	10/21/04
Milk River	4.0		48.06698	106.30306	389563	4/12/04	10/21/04
Nickels Ferry	1,759.9	North	48.04531	106.28736	681731	4/12/04	10/13/04
		South	48.04512	106.28533	389574		
		Strat	48.04531	106.28736	389575		
Nickels Rapids	1,757.5	North	48.03517	106.25085	681751	4/12/04	10/21/04
		South	48.03548	106.25468	429696		
		Strat	48.03548	106.25468	389561		
Frazer Pump	1,751.5	North	48.03093	106.12471	429717	4/12/04	10/21/04
		South	48.03030	106.12668	389501		
		Strat	48.03093	106.12471	667824		
Frazer Rapids	1,746.0	North	48.00736	106.12995	389490	4/12/04	10/21/04
		South	48.00644	106.12871	407323		
		Strat	48.00759	106.13408	681727		
Grandchamps	1,741.5	North	48.03632	106.08177	429709	4/12/04	10/21/04
		South	48.03442	106.08173	667855		
		Strat	48.03442	106.08173	429715		
Wolf Point	1,701.5	North	48.07058	105.52975	389572	4/13/04	10/19/04
		South	48.08272	105.51755	429697		
		Strat	48.08272	105.51755	667869		
Poplar	1,680	North	48.06685	105.20470	429726	4/13/04	NR
		South	48.06262	105.21539	429719		10/19/04
		Strat	48.06262	105.21539	681743		
Poplar River	0.4		48.08384	105.19500	389560	4/13/04	4/5/05
Culbertson	1,620.9	North	48.09068	104.42635	429711	4/13/04	10/19/04
		South	48.09068	104.42635	429713		
		Strat	48.08901	104.42650	681745		
Nohly	1,591.2	North	48.02080	104.09800	389504	4/13/04	10/19/04
		South	48.01315	104.10785	681723		
		Strat	48.01315	104.10785	429723		
Yellowstone River	3.5		47.85807	103.96649	681730	4/15/04	10/20/04
Below	1,576.5	North	47.95966	103.90449	429704	4/14/04	NR
Yellowstone River		South	47.95845	103.89724	681724		NR
		Strat	47.95845	103.89724	389489		NR

Field measurements of turbidity. Turbidity (nephelometric turbidity units; NTU) was measured from late May through August with continuous-recording (1-hr interval) turbidity data loggers (Hydrolab Datasonde 4a, serial numbers 39046, 39047, 39048, 39049, measurement range 0 – 1000 NTU, accuracy ± 2%). Turbidity loggers were deployed in the Missouri River near Frazer Rapids (rkm 2,811; RM 1,746), near Poplar (rkm 2,708; RM 1,682) and near Nohly (rkm 2,558; RM 1589), and in the Yellowstone River 0.81 km (0.5 miles) upstream from the confluence.

A*ssessments of turbidity logger precision and accuracy*. Prior to deployment in 2004, all four turbidity loggers were serviced at the factory including complete cleaning and calibration through 1000 NTU. Therefore, the turbidity loggers were not subjected to pre-deployment assessments of accuracy and precision. After deployment, turbidity loggers were subjected to a series of standard formazin NTU treatments (20 NTU, 200 NTU, 800 NTU) to assess accuracy and precision. Each logger was programmed to record 10 NTU measurements (10 second recording interval) in each NTU treatment. Analysis of variance was used to compare NTU among turbidity loggers for the three treatments.

Monitoring Component 2 – Seasonal use, telemetry, and movements of adult pallid sturgeon in the Missouri River downstream from Fort Peck Dam.

This study component was expanded for 2004 from previous years. The majority of sampling effort expended for adult pallid sturgeon to date has occurred in the Yellowstone River and Missouri River downstream from the Yellowstone River confluence. Conversely, minimal sampling effort for adult pallid sturgeon has occurred in the Missouri River upstream from the Yellowstone River confluence. Incidental collections of adult pallid sturgeon (Braaten and Fuller 2003) and occasional movements of adult pallid sturgeon in the Missouri River upstream from the Yellowstone River confluence (D. Fuller, MTFWP, personal observation) suggest this reach of the Missouri River may be used by adult pallid sturgeon more than previously anticipated. Thus, a sampling program directed specifically towards adult pallid sturgeon in this river reach was required to more thoroughly address this question.

The study area for this research component spanned 120 km from rkm 2553 (MT/ND state line) to rkm 2673 (near Brockton, MT). This reach of the Missouri River supports water temperatures that are fairly suitable for pallid sturgeon, unlike river reaches farther upstream that are cooler resulting from hypolimnetic releases from Fort Peck Dam. In addition, this reach is characterized by a diversity of habitat types including islands, secondary channels, and deep bluff pools – similar to habitat conditions in the Missouri River downstream from the Yellowstone River where pallid sturgeon are found.

The sampling design targeted five habitat types for sampling. Based on Sappington et al. (1998), the habitats included inside bends (ISB), outside bends (OSB), channel crossovers (where the thalweg crosses from one side of the river to the other side of the river, CHXO), connected secondary channels (SCC), and the downstream tips of islands (convergence zone of the current that usually for a scour hole, ITIP). Between April and August, river bends were randomly selected from the pool of available bends in the reach. Within each bend, all of the habitat types were identified. Some bends did not contain ITIP and SCC; therefore, it was necessary in some instances to move either downstream or upstream to find these habitats. All habitats were sampled using drifting trammel nets. Large-mesh trammel nets (6" inner panel x 10" outer panel) were used during April, May and June to target specifically large adult pallid sturgeon. During July and August, small-mesh trammel nets (1" inner panel x 6" outer panels) were used not only to target adult pallid sturgeon, but also to effectively sample juvenile pallid sturgeon. Although the large-mesh trammel net is the "standard gear" for sampling large pallid sturgeon in the upper portions of the Missouri River, large pallid sturgeon can also be sampled with the smaller-mesh trammel nets. Two drifted trammel net samples were conducted in each ISB, OSB, ITIP, and SCC habitat within the bend complex as allowed based on the length of the habitat. Two drifted trammel net samples were conducted in the CHXO upstream and downstream of the bend complex (total of 4 CHXO samples per bend complex). Adult pallid sturgeon sampled in this reach of the Missouri River were targeted for transmitter implantation and radio tracking in conjunction with other telemetry studies (see below).

Monitoring Component 3 – Flow- and temperature-related movements of paddlefish, blue suckers, and shovelnose sturgeon.

Manual tracking of implanted fish.- Manual tracking by boat of fish implanted with CART tags in 2001, 2002, and 2003 was initiated in April 2004. The Missouri River between Fort Peck Dam and the Highway 85 bridge near Williston, N.D. (342 km), and the Yellowstone River from the confluence to Intake Diversion (116 km) were tracked at weekly intervals from April through July, and biweekly from August through October. Two radio frequencies (149.760 MHz, 149.620 MHz) were simultaneously monitored during the boat-tracking run using two 4-element Yagi antennae. A hydrophone was used to scan acoustic frequencies (65.6 kHz, 76.8 kHz) in deep areas of the two rivers. The entire study area could be tracked in a 3-day time interval. Several variables (radio/acoustic frequency, fish code, latitude, longitude, river mile, conductivity, water depth, habitat type, water temperature, turbidity, time-of-day) were recorded at fish locations. Aerial tracking was conducted on October 8 with a Lotek SRX-400 receiver in conjunction with a single 4-element Yagi antennae.

Stationary telemetry logging stations.- Stationary telemetry logging stations were deployed in April 2004 at seven sites (Milk River, rkm 4.0, RM 2.5; Nickels, rkm 2,828, RM 1,756.5; near Wolf Point, rkm 2,755, RM 1,711; near Poplar, rkm 2,706, RM 1,681; near Brockton, rkm 2,658, RM 1,651; near Culbertson, rkm 2,603, RM 1,616.5; near Williston, rkm 2,471, RM 1,544.5). The logging stations at Nickels, Wolf Point, Poplar and Brockton were positioned on a 2.4-m x 2.4-m floating platform away from the bankline, and secured to the bankline using cables and an iron arm. Two unidirectional hydrophones (one pointing upstream, one pointing downstream) were attached to these platforms. The logging stations at the Milk River, Culbertson, and Williston were placed on shore with two directional antennas. Each logging station was equipped with a battery powered receiver (Lotek SRX- 400), solar panels, and an environmental enclosure kit containing dual 12-volt batteries, and an antennae switchbox. Data recorded by the logging stations were downloaded to a laptop computer two times per month between April and October.

Transmitter implantation.-Sampling for paddlefish, blue suckers, and shovelnose sturgeon for transmitter implantation was conducted in September 2004. Species were sampled using drifted trammel nets and surface-drifted gill nets (primarily targeting paddlefish). A minimum of 20 suitable-sized individuals of each species was targeted for transmitter implantation. Our goal was to extend flow- and temperature-related movement inferences to all areas of the Missouri River below Fort Peck Dam and Lake Sakakawea. Therefore, species were collected in several areas between rkm 2,850 (RM 1,770) and rkm 2,545 (RM 1,581; Figure 1).

The three species were implanted with two varieties of combined acoustic/radio tags (CART tags, Lotek Wireless Incorporated, New Market, Ontario). The CART tag emits alternating radio and acoustic coded signals at established time intervals. The coded signal emitted by each CART tag is unique to facilitate identification of individual fish. Blue suckers and shovelnose sturgeon were implanted with the CART 16-2S (16 mm x 68 mm, air weight = 31.5 g, 865-day longevity, 4-second pulse interval, 149.620 Mhz, 76.8 kHz). Paddlefish were implanted with the CART 32-1S (32 mm x 101 mm, air weight = 114 g, 1,095-day longevity.

Surgical implantation of transmitters was conducted after 1-6 individuals were captured at a sampling location. After being sampled, fish were placed in streamside live cars. Individuals were placed in a partially submerged V-shaped trough during surgical implantation of transmitters, and water was continually flushed over the gills using a bilge pump apparatus. After making an abdominal incision about midway between the pectoral fin and pelvic fin, a shielded needle technique (Ross and Kleiner 1982) was used to extrude the transmitter antennae through the body cavity. The transmitter was then inserted into the body cavity, and the incision was closed with silk sutures. Fish were placed in live cars for a brief period prior to release to assess post-surgery health.

Analyses of telemetry data.-A complete analysis of telemetry data will be conducted after completion of the study; however, summary analyses were conducted to report and illustrate trends. As additional fish are implanted with CART tags each year of the study, comparisons of telemetry data among years need to be adjusted for the increased number of tagged fish. Thus, spatial and temporal use of the Missouri River, Yellowstone River, and Milk River were quantified using the percent of implanted individuals each year relocated in different areas. Relocations and movements of each species were quantified across three riverine reaches that corresponded distinct spatial and temporal use patterns. For blue suckers, the reaches included the Milk River (184 km), Missouri River (342 km) and Yellowstone River (116 km). The reaches for shovelnose sturgeon consisted of the Missouri River from Fort Peck Dam to Wolf Point (112 km), the Missouri River from Wolf Point to the headwaters of Lake Sakakawea (230 km), and the Yellowstone River (116 km). For paddlefish and pallid sturgeon, the reaches consisted of the Missouri River above the confluence of the Yellowstone River (ATC; 302 km), the Missouri River below the confluence of the Yellowstone River (BTC; 40 km), and the Yellowstone River (116 km).

Monitoring Component 4 – Larval Fish

Sampling protocols. Larval fish were sampled two times per week from late May through early August at six sites (Table 2). Similar to 2001, 2002 and 2003, sites on the mainstem Missouri River were located just downstream from Fort Peck Dam, near Wolf Point, and near Nohly. Sites located off the mainstem Missouri River included the spillway channel, the Milk River, and the Yellowstone River. Larval fish at all sites were sampled with 0.5-m-diameter nets (750 µm mesh) fitted with a General Oceanics Model 2030R velocity meter.

Specific larval fish sampling protocols varied among sites and were dependent on site characteristics (Table 2). Two to five replicates were collected at the sites, where one replicate was comprised of four subsamples (two subsamples simultaneously collected on the right and left side of the boat at sampling locations near the left and right shorelines). At all sites except the spillway site, the left and right sampling locations corresponded to inside bend and outside bend locations at the mid-point of a river bend. The spillway channel had minimal sinuosity; therefore, samples did not reflect inside and outside bend locations. Only two replicates were available in the spillway channel (one replicate in both of the spillway channel pools), and three replicates were available at the site downstream from Fort Peck Dam. The full complement of five replicates was available at the other sites. At all sites exclusive of the spillway and Milk River, paired subsamples near the left and right bank locations were comprised of one net fished on the bottom and one net fished in the middle of the water column. Thus, each replicate was comprised of two bottom subsamples and two mid-water column subsamples. Nets were maintained at the target sampling location by affixing lead weights to the net. Larval nets were fished for a maximum of 10 minutes (depending on detrital loads). The boat was anchored during net deployment (e.g., “passive” sampling) except when high velocities warranted use of the outboard motor to maintain a fixed position. Irregular bottom contours, shallow depths, and silt substrates were not conducive to bottom sampling in the Milk River and spillway channel. In addition, minimal current velocity in these two locations required an “active” larval fish sampling approach. Therefore, larval fish in the Milk River and spillway channel were sampled in the upper 1-m of the water column as the boat was powered upstream for a maximum of 10 minutes. Larval fish samples were placed in a 5-10% formalin solution containing phloxine-B dye and stored.

Table 2. Larval fish sampling locations , number of replicates, samples, and net locations for 2004 sampling events. Abbreviations for net location are as follows: B = bottom, M = mid-water column, S = surface (0.5 - 1.0 m below the surface).

Site	**Approximate river mile**	**Replicates**	**Samples per replicate**	**Net location**
Missouri River below Fort Peck Dam	1,763.5-1,765.3	3	4	B/M
Spillway channel	1,762.8	2	4	S
Milk River	0.5-4.0	5	2-4	S
Missouri River near Wolf Point	1,701.0-1,708.0	5	4	B/M
Missouri River near Nohly	1,584-1,592	5	4	B/M
Yellowstone River	0.1-2.0	5	4	B/M

Larval fish were sampled at the same replicate and subsample locations throughout the sampling period except when changes in discharge necessitated minor adjustments in the sampling location. For example, an attempt was made to sample larval fish at total water column depths between 1.5 m and 3.0 m. This protocol was used to minimize variations in larval fish density associated with vertical stratification of larvae in the water column. When river discharge changed, water depth in a previously sampled specific location also changed. Consequently, the specific sampling location also changed slightly among sampling events.

Laboratory methods. Larval fish were extracted from samples and placed in vials containing 70% alcohol. Larvae were identified to family and enumerated. Damaged individuals that could not be identified were classified as unknown. Eggs were identified as paddlefish/sturgeon or other, and enumerated.

<u>Monitoring Component 5 – Young-of-year sturgeon</u>

Sampling for young-of-year sturgeon was conducted with a benthic (beam) trawl between late July and early September 2004 in the Missouri River above the Yellowstone River confluence (i.e., ATC), Missouri River below the Yellowstone River confluence (i.e., BTC), and in the Yellowstone River. Four replicate sampling locations were established at each site (Table 3) where each replicate was comprised of an inside bend, outside bend, and channel crossover habitat complex (IOCX) associated with a river bend. A dual sampling protocol was followed to quantify young-of-year sturgeon. Standard sampling consisted of conducting a single trawl in each habitat type within the IOCX. If a young-of-year sturgeon was collected in the standard trawl, two additional “targeted trawls” were conducted in the exact same location. If young-of-year sturgeon were sampled in either of the two targeted trawls, two additional targeted trawls were conducted. This process was repeated up to a maximum of eight targeted trawls. Targeted sampling was conducted to obtain information on aggregations. An exception to the IOCX sampling protocol was followed at replicate 1 in the Missouri River BTC where nine standard trawl subsamples were used to characterize this location. This location produced several young-of-year sturgeon in previous years (Braaten and Fuller 2002, 2003, 2004), thus intensive sampling was conducted at this location. The targeted sampling protocol was followed at this site.

Young-of-year sturgeon were processed in the field and laboratory. Total length (mm, excluding the caudal filament) was measured in the field. One of the pectoral fins or fin buds was clipped and placed in alcohol. After fin clipping, the fish was placed in a 5-10% formalin solution. In the laboratory, diagnostic morphological criteria (Snyder 2002) were used to tentatively distinguish young-of-year sturgeon as pallid sturgeon or shovelnose sturgeon. Pectoral fin tissue from individuals tentatively identified as pallid sturgeon will be sent to Dr. Ed Heist (Southern Illinois University) for genetic testing.

Table 3. Young-of-year sturgeon sampling sites used in 2004. ATC = above the Yellowstone River confluence, BTC = below the Yellowstone River confluence. River km denotes distance upstream from the mouth.

Site	Replicate	River km
Missouri River ATC	1	2551.0
	2	2555.5
	3	2558.0
	4	1563.0
Missouri River BTC	1	2499.5
	2	2540.0
	3	2542.0
	4	2546.0
Yellowstone River	1	0.4
	2	1.2
	3	3.2
	4	6.4

Component 6 - Assisting in the collection of adult pallid sturgeon for the propagation program.

Crews working under the Fort Peck Data Collection collaborated with USFWS personnel and other personnel from the MTFWP to capture adult pallid sturgeon for the propagation program. Sampling for adult pallid sturgeon was conducted in late April, June, and November 2004. Sampling was primarily concentrated in the lower Yellowstone River and Missouri River downstream from the Yellowstone River confluence.

RESULTS AND DISCUSSION

Hydrologic conditions

Modified discharge releases through the Fort Peck Dam spillway were not implemented in 2004. As a consequence, discharge conditions in the Missouri River were characteristic of regulated dam operations augmented by tributary inputs. The Milk River exhibited two periods of elevated discharge conditions during 2004 as discharge peaked in late May and mid-June (Figure 2). For the time frame spanning April through September, mean daily discharge in the Milk River during 2004 (17.2 m^3/s) was greater than the three previous years of the study (5.7 – 11.6 m^3/s). In the mainstem Missouri River, mean daily discharge increased during late April as discharge releases from Fort Peck Dam were increased; however, discharge at Wolf Point and Culbertson peaked during late May as inputs from the Milk River augmented regulated releases from Fort Peck Dam (Figure 2). Discharge in the Missouri River was relatively stable from July through late September. Mean daily discharge at Wolf Point and Culbertson during 2004 (232 m^3/s) was fairly similar to 2002 and 2003, but greater than 2001. Hydrologic conditions in the Yellowstone River during 2004 were characterized by relatively low discharge between April and September (mean daily discharge = 194 m^3/s), and the Yellowstone River exhibited maximum discharge during mid-June (Figure 2). In comparison to previous years, mean daily discharge during 2004 was slightly less than 2001 (205 m^3/s), but significantly lower than 2002 (281 m^3/s) and 2003 (284 m^3/s).

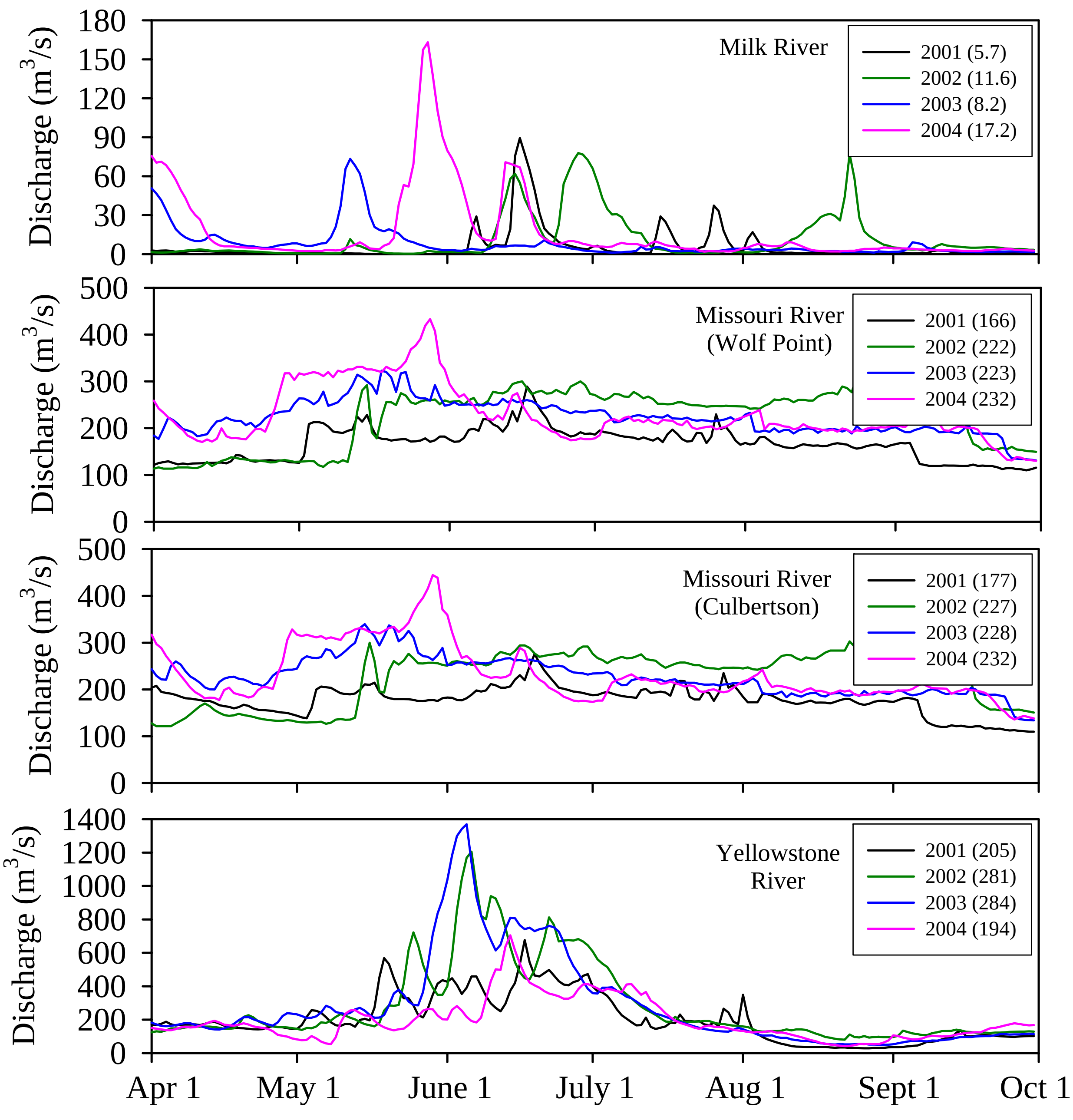


Figure 2. Mean daily discharge in the Milk River, Missouri River at Wolf Point and Culbertson, and in the Yellowstone River during 2001, 2002, 2003, and 2004. Values listed in parentheses represent mean daily discharge (m^3/s) for the specified year between April 1 and September 30. Note the change in ordinate values among graphs.

Monitoring Component 1 - Water temperature and turbidity

General comments on water temperature loggers. Of the 39 water temperature loggers deployed during 2004, 35 (90%) loggers were retrieved. The water temperature logger located on the north bank of the river at Poplar could not be retrieved. However, the south bank and stratified loggers at Poplar were retrieved to provide assessments of water temperature at this site. All three loggers located in the Missouri River downstream from the Yellowstone River confluence could not be retrieved due to excessive sediment deposition. Thus, no data were available for this site.

Pre- and post-deployment assessments of water temperature logger precision. Pre- and post-deployment assessments indicated a high level of precision among water temperature loggers through a broad range of water temperatures (Table 4, 5). For pre-deployment assessments, the range of water temperatures recorded by the loggers for a common treatment varied from 0.32^{o}C to 0.54^{o}C, and these results indicated that all loggers were exhibiting a high level of precision. Similarly, precision was high for the post-deployment tests as indicated by a narrow temperature range (0.39 – 0.67^{o}C) across common water temperature treatments. The only exception to the high level of precision occurred during the first warm treatment when the water temperature range was high (12.16^{o}C). Six loggers reported unusually low water temperatures (13.4 – 21.3^{o}C) in this first trial, and these minimum temperatures contributed to the high water temperature range. However, the high range of water temperatures did not occur in the subsequent warm treatments as evidenced by the low range and high precision. It is likely that these six loggers did not adjust to the ambient water temperature bath conditions as quickly as the other loggers. However, after 15-minute acclimation period, the precision of these loggers was similar to the other loggers. Based on these results, the precision of water temperature loggers was exceptionally good during the 2004 deployment period. Thus, water temperatures recorded by the loggers characterize precise and accurate water temperature conditions in the Missouri River, off-channel areas, and tributaries.

Lateral and vertical comparisons of water temperature. There were 10 sites where water temperature loggers were positioned adjacent to both river banks and stratified in the water column (Table 6). For eight of the 10 locations, mean daily water temperature did not significantly differ ($P > 0.05$) among logger locations indicating homeothermal conditions laterally and vertically in the water column. However, water temperature differed significantly ($P < 0.05$) among logger locations at two sites during the 2004 deployment period as water temperature averaged 1.3^{o}C (Nickels Ferry) and 0.7^{o}C (Nickels Rapids) warmer on the north bank of the river than the south bank of the river.

Table 4. Pre-deployment summary statistics for water temperature comparisons among 39 water temperature loggers in common water bath treatments for 2004. Slight discrepancies in the range (maximum-minimum) occur in the table due to rounding.

Treatment	Sample	Logger mean	Logger minimum	Logger maximum	Logger range	Logger SD
Cold	1	3.5	3.4	3.7	0.38	0.09
	2	3.5	3.4	3.9	0.54	0.12
	3	3.5	3.4	3.9	0.54	0.13
	4	3.6	3.4	3.7	0.38	0.11
	5	3.6	3.4	3.9	0.49	0.11
Cool	1	19.2	19.0	19.4	0.41	0.10
	2	19.2	19.0	19.4	0.41	0.10
	3	19.2	19.0	19.4	0.41	0.09
	4	19.1	19.0	19.4	0.41	0.08
	5	19.1	18.9	19.2	0.33	0.09
Warm	1	26.1	25.9	26.3	0.41	0.12
	2	25.9	25.7	26.1	0.41	0.09
	3	25.5	25.4	25.8	0.41	0.11
	4	25.3	25.0	25.4	0.41	0.13
	5	25.0	24.5	25.1	0.32	0.09

Table 5. Post-deployment summary statistics for water temperature comparisons among 33 water temperature loggers in common water bath treatments for 2004. Slight discrepancies in the range (maximum-minimum) occur in the table due to rounding.

Treatment	Sample	Logger mean	Logger minimum	Logger maximum	Logger range	Logger SD
Cold	1	7.6	7.3	7.8	0.48	0.11
	2	7.5	7.3	7.7	0.39	0.11
	3	7.4	7.1	7.8	0.67	0.17
	4	7.6	7.3	7.8	0.48	0.12
	5	7.5	7.3	7.7	0.47	0.12
Cool	1	14.8	14.6	15.0	0.48	0.12
	2	15.1	14.8	15.4	0.53	0.15
	3	15.3	15.0	15.5	0.48	0.12
	4	15.5	15.2	15.8	0.63	0.14
	5	15.6	15.4	15.9	0.56	0.15
Warm	1	23.2	13.4	25.5	12.16	3.28
	2	24.5	24.2	24.7	0.48	0.14
	3	23.5	23.3	23.9	0.56	0.14
	4	22.6	22.3	22.8	0.51	0.12
	5	21.8	21.7	22.2	0.52	0.13

Table 6. Summary statistics and probability values (P, from ANOVA or t-tests) for comparisons of mean daily water temperature (°C) among water temperature loggers located on the north bank and south bank, and stratified in the water column during 2004. Means with the same superscript within sites are not significantly different (P > 0.05). The letter listed in parentheses designates whether the stratified logger was positioned on the north bank (N), south bank (S), or mid-channel (M).

Site	Logger location	Number of days	Mean	SD	Minimum	Maximum	P
Below Fort Peck	North	192	12.3	3.2	4.5	16.5	0.081
Dam	South		12.4	3.2	4.4	16.6	
	Stratified		11.7	3.3	4.0	16.1	
Nickels Ferry	North	185	13.5 [a]	3.2	5.2	17.4	0.0001
	South		12.2 [b]	3.2	4.1	16.3	
	Stratified(N)		13.5 [a]	3.2	5.3	17.4	
Nickels Rapids	North	192	12.9 [b]	3.2	4.7	17.2	0.03
	South		12.2 [a]	3.2	4.1	16.5	
	Stratified(S)		12.2 [a]	3.2	4.1	16.5	
Frazer Pump	North	192	13.1	3.3	4.8	17.4	0.18
	South		12.6	3.3	4.4	16.9	
	Stratified(N)		13.1	3.3	4.8	17.4	
Frazer Rapids	North	192	12.7	3.1	4.8	16.9	0.56
	South		13.0	3.4	4.8	17.3	
	Stratified		12.7	3.3	4.7	17.0	
Grandchamps	North	192	12.9	3.3	5.0	17.0	0.59
	South		13.2	3.4	5.1	17.6	
	Stratified(S)		13.2	3.4	5.0	19.0	
Wolf Point	North	189	14.3	3.7	5.2	20.9	0.94
	South		14.3	3.7	5.1	20.9	
	Stratified(S)		14.4	3.8	5.2	21.0	
Poplar	South	189	14.7	3.9	5.2	22.1	0.69
	Stratified(S)		14.8	3.9	5.3	22.3	
Culbertson	North	189	15.7	4.3	5.8	24.5	0.80
	South		15.5	4.4	5.0	24.6	
	Stratified		15.8	4.3	5.8	24.6	
Nohly	North	189	15.2	4.1	4.8	23.3	0.48
	South		15.6	4.3	4.8	23.6	
	Stratified(S)		15.7	4.5	4.5	24.9	

Longitudinal water temperatures. Mean daily water temperature differed significantly (P < 0.0001) among Missouri River mainstem, tributaries, and off-channel locations during 2004 (Table 7; Figure 3). For mainstem sites, mean daily water temperature was greatest in the Missouri River upstream from Fort Peck Dam (Robinson Bridge, 17.6°C) and significantly lower in the Missouri River below Fort Peck Dam (12.3°C). Thus, hypolimnetic releases from Fort Peck Dam suppressed water temperature by an average of 5.3°C during the common deployment period. However, maximum water temperature was suppressed 10.4°C between Robinson

Bridge (maximum = 26.7°C) and below Fort Peck Dam (maximum = 16.3°C). Mean daily water temperature warmed longitudinally from below Fort Peck Dam to the lowermost Nohly site (mean = 15.8°C), but mean daily water temperature at Nohly was significantly less than at the Robinson Bridge site. Thus, thermal impacts of cold hypolimnetic releases from Fort Peck Dam remained evident 174 rm (280 km) downstream from Fort Peck Dam. For off-channel locations, mean daily water temperature was greatest in the Yellowstone River (mean = 17.6°C) and Milk River (17.2°C), but significantly less in the spillway channel (15.8°C). The coefficient of variation (CV) of mean daily water temperatures exceeded 22% for all sites during 2004.

Table 7. Mean daily water temperature (°C) summary statistics (mean, minimum, maximum, standard deviation, SD; coefficient of variation, CV) for Missouri River mainstem locations and off-channel locations in 2004. Summary statistics for all sites (except Fort Peck Lake) were calculated for common deployment dates (4/15/04-10/13/04, N = 182 days) to standardize comparisons among all loggers. Fort Peck Lake was not included in the ANOVA comparisons because it had a shorter deployment period (5/7/04-10/18/04; 165 days). Means with the same superscript are not significantly different ($P > 0.05$). Mainstem Missouri River sites are listed from upstream to downstream. See Figure 3 for a graphical representation of mean daily water temperatures.

Location	**Site**	**Mean**	**Minimum**	**Maximum**	**SD**	**CV**
Missouri River mainstem	Robinson Bridge	17.6 [a]	9.1	26.7	4.2	23.8
	Fort Peck Lake	15.9	7.0	22.0	3.6	22.7
	Below Fort Peck Dam	12.3 [lm]	4.3	16.3	3.2	25.7
	Nickels Rapids	12.6 [jklm]	4.3	16.7	3.2	25.1
	Nickel Ferry	13.2 [ij]	4.9	17.1	3.1	23.4
	Frazer Pump	13.2 [ijk]	4.7	17.2	3.2	24.3
	Frazer Rapids	13.0 [ijkl]	4.8	17.1	3.2	24.5
	Grandchamps	13.4 [i]	5.0	17.5	3.3	24.4
	Wolf Point	14.5 [h]	5.2	20.9	3.6	25.0
	Poplar	15.0 [h]	5.2	22.2	3.8	25.3
	Culbertson	15.9 [e]	6.6	24.6	4.1	26.1
	Nohly	15.8 [ef]	6.8	23.9	4.0	25.7
Off-channel or tributary	Spillway	15.8 [ef]	6.7	21.4	3.6	22.6
	Milk River	17.2 [abc]	7.2	27.4	4.2	24.5
	Poplar River	16.7 [c]	7.1	25.3	4.1	24.8
	Yellowstone River	17.6 [ab]	8.4	26.3	4.0	22.7

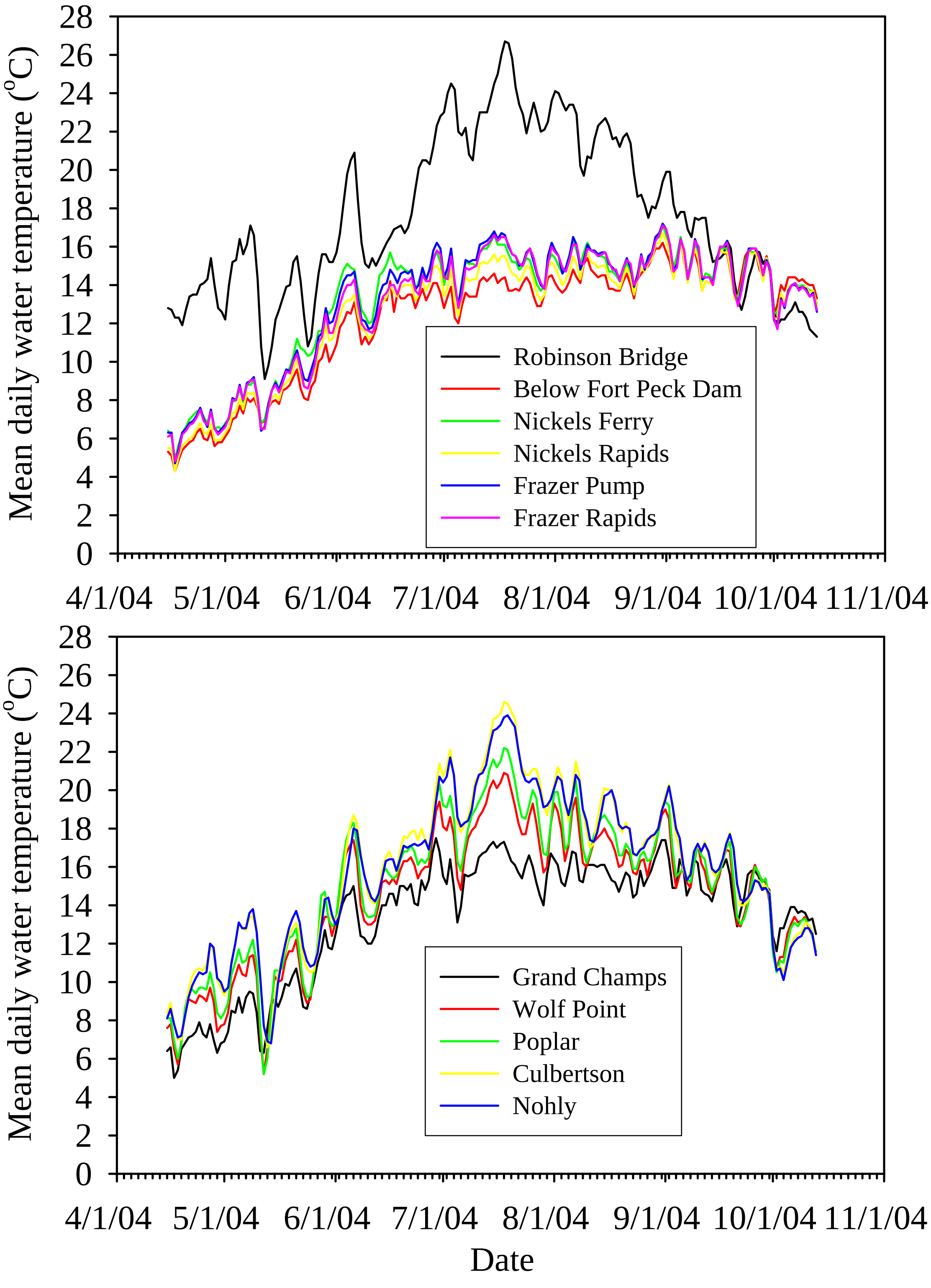


Figure 3. Mean daily water temperature (°C) at 12 sites on the mainstem Missouri River during 2004.

Inter-annual comparisons of mean daily water temperature within sites. Mean daily water temperature was compared among years for 18 sites (Table 8). Five sites (Fort Peck Lake, Redwater River, Poplar, Poplar River, Missouri River below Yellowstone River) included only two or three years of data. For the 13 sites which included data from 2001-2004, mean daily water temperature differed significantly among years except at the Culbertson site. Mean daily water temperature was significantly warmer during 2001 at four sites (Robinson Bridge, Spillway, Wolf Point, Nohly), significantly warmer during 2003 at two sites (Milk River, Yellowstone River), and significantly warmer at six sites during 2004 (Fort Peck Dam, Nickels Ferry, Nickels Rapids, Frazer Pump, Frazer Rapids, and Grandchamps).

Inter-annual comparisons of mean daily air temperatures. Mean daily air temperatures were obtained from the National Weather Service in Glasgow, MT to assess water temperature regimes during 2001, 2002, 2003, and 2004 in the context of air temperatures. For dates spanning May 17 through October 9 (common dates for water temperature loggers deployed in all years and for air temperature, N = 146 days), there was a significant difference in mean daily air temperature among years (ANOVA, $F = 6.70$, $P = 0.0002$). Mean daily air temperature was greatest during 2003 (mean = 19.1^{o}C) and 2001 (mean = 18.4^{o}C), and coolest during 2002 (mean = 17.6^{o}C) and 2004 (mean = 16.4^{o}C).

Water temperature patterns among years do not closely correspond to air temperature patterns among years. For example, although mean daily air temperature was coolest during 2004, six mainstem Missouri River sites located downstream from Fort Peck Dam (Fort Peck Dam, Nickels Ferry, Nickels Rapids, Frazer Pump, Frazer Rapids, and Grandchamps) exhibited significantly greater water temperatures during 2004 than other years (Table 8). Thus, these sites exhibited warmest water temperatures during the coolest year of air temperatures. Water temperature patterns corresponded to air temperature patterns at two sites (Milk River, Yellowstone River) where air and water temperature were greatest during 2003 and least during 2004 (Table 8). These results suggest that water temperature at sites directly influenced by hypolimnetic releases from Fort Peck Dam are not strongly influenced by air temperatures; whereas, thermal regimes in small tributaries (i.e., Milk River) and free-flowing rivers (i.e., Yellowstone River) are more strongly influenced by ambient air temperature regimes.

Table 8. Summary statistics (mean, °C; minimum, maximum, standard deviation, SD; coefficient of variation, CV; ANOVA probability value, P) for comparisons of mean daily water temperature among 2001, 2002, 2003 and 2004 at mainstem Missouri River sites and off-channel sites. Common dates for all years are 5/17-10/9 (N = 146 days) with the exception of Fort Peck Lake where dates are 5/17 – 8/29 (N = 105 days). Means with the same letter within a site are not significantly different (P > 0.05).

Site	Year	Mean	Minimum	Maximum	SD	CV	P
Missouri River above Fort Peck Lake (Robinson Bridge)	2001	20.1[a]	10.3	25.8	3.7	18.4	0.0039
	2002	18.7[bc]	9.2	26.7	4.2	22.5	
	2003	19.3[ab]	11.4	25.2	4.0	20.5	
	2004	18.7[bc]	10.8	26.7	3.9	20.9	
Fort Peck Lake	2003	19.0[a]	8.4	23.6	3.8	20.2	<0.0001
	2004	16.4[b]	7.9	22.0	3.6	22.3	
Below Fort Peck Dam	2001	13.0[b]	8.2	15.2	1.5	11.6	<0.0001
	2002	12.2[c]	6.3	15.4	2.0	16.6	
	2003	12.4[c]	7.5	15.5	1.7	13.7	
	2004	13.5 [a]	8.0	16.3	1.8	13.5	
Spillway	2001	18.4[a]	10.7	23.8	3.0	16.6	<0.0001
	2002	15.7[c]	8.6	20.0	2.7	16.9	
	2003	16.9[b]	11.5	22.5	3.0	17.9	
	2004	17.0[b]	9.7	21.4	2.8	16.3	
Milk River	2001	19.1[b]	9.9	26.2	3.8	19.6	0.0012
	2002	18.9[b]	8.4	26.9	4.5	23.8	
	2003	20.3[a]	10.9	27.4	4.7	23.2	
	2004	18.4[b]	10.7	27.4	3.7	20.2	
Nickels Ferry	2001	13.4[b]	8.3	18.4	1.8	13.6	<0.0001
	2002	13.2[b]	6.5	19.1	2.5	18.7	
	2003	12.5[c]	8.5	15.3	1.5	11.7	
	2004	14.5[a]	9.1	17.1	1.6	10.8	
Nickels Rapids	2001	13.5[a]	8.5	16.6	1.7	12.5	<0.0001
	2002	12.9[b]	6.7	16.1	2.2	16.9	
	2003	12.8[b]	8.1	15.9	1.6	12.3	
	2004	13.8[a]	8.6	16.7	1.7	12.6	
Frazer Pump	2001	13.9[b]	8.5	17.0	1.8	13.1	<0.0001
	2002	13.3[c]	7.1	17.9	2.3	17.6	
	2003	13.3[c]	8.5	16.9	1.7	12.6	
	2004	14.4[a]	9.0	17.2	1.8	12.5	
Frazer Rapids	2001	13.8[b]	8.3	17.3	1.8	13.3	<0.0001
	2002	13.1[c]	7.1	17.1	2.3	17.2	
	2003	12.9[c]	8.1	15.7	1.5	11.8	
	2004	14.3[a]	8.6	17.1	1.9	13.0	
Grandchamps	2001	14.4[a]	8.5	18.1	2.0	14.1	<0.0001
	2002	13.5[b]	7.5	17.3	2.3	16.9	
	2003	13.6[b]	8.3	17.4	1.8	13.4	
	2004	14.6[a]	8.6	17.5	2.0	13.3	
Wolf Point	2001	16.5[a]	9.4	22.7	3.1	18.7	0.0003
	2002	15.0[c]	9.3	19.4	2.8	18.8	
	2003	15.6[bc]	9.0	21.2	2.9	18.4	
	2004	15.8[ab]	8.9	20.9	2.6	16.2	
Redwater River	2001	19.0[a]	8.5	26.8	4.2	22.3	0.0001
	2003	15.3[b]	9.3	20.0	2.9	18.7	

Table 8. Continued.

Site	Year	Mean	Minimum	Maximum	SD	CV	P
Poplar	2001	16.8	9.9	21.2	2.8	16.8	0.251
	2003	16.3	9.4	22.3	3.2	19.9	
	2004	16.3	9.2	22.2	2.8	17.2	
Poplar River	2001	19.4a	10.2	25.9	3.9	19.9	0.0009
	2004	17.9b	9.8	25.3	3.5	19.4	
Culbertson	2001	17.9	9.7	24.0	3.5	19.3	0.084
	2002	17.0	8.3	23.9	3.9	23.0	
	2003	17.9	10.4	24.7	4.0	22.5	
	2004	17.2	10.5	24.6	3.3	19.4	
Nohly	2001	18.9[a]	11.4	25.3	3.8	20.0	0.0007
	2002	17.5[bc]	7.7	25.4	4.3	24.6	
	2003	18.2[ab]	10.2	25.0	4.2	23.0	
	2004	17.1[c]	10.1	23.9	3.2	18.7	
Yellowstone River	2001	19.3[abc]	10.7	26.6	4.2	21.7	0.051
	2002	19.3[ab]	8.4	27.9	4.8	24.7	
	2003	20.1[a]	11.1	27.2	4.7	23.1	
	2004	18.7[bc]	11.1	26.3	3.4	18.3	
Below Yellowstone River	2001	19.4[a]	9.8	26.0	4.1	20.9	0.44
	2002	18.8[a]	8.2	27.3	4.5	24.2	
	2003	18.9[a]	10.6	27.8	4.4	23.2	

Water temperature in Fort Peck Lake.-Water temperature in Fort Peck Lake was measured in the spillway bay area between 5/7/04 and 10/18/04 (Figure 4). Between these dates, mean daily water temperature was 15.9^{o}C (minimum = 7.0^{o}C, maximum = 22.0^{o}C, SD = 3.6, CV = 22.7). Mean daily water temperature in the spillway bay first exceeded 15^{o}C on June 5 (15.8^{o}C), but did not consistently remain above 15.0^{o}C until June 25. Water temperature first exceeded 16.0^{o}C and 17.0^{o}C on June 28 (17.4^{o}C), but water temperature did not remain consistently above 17.0^{o}C until July 7.

As proposed under the Fort Peck spillway release scenario, the target dates for achieving and maintaining 18^{o}C at Frazer Rapids span from about May 15 through July 1 (USFWS 2000; USACE 2004). The following results and discussion presents possible scenarios for meeting the water temperature requirements at Frazer Rapids based on 2004 lake and river temperature data. A modified version of river discharge - water temperature mixing models presented in USACE (2002, 2004) was used to predict water temperatures at Frazer Rapids as if the full-test spillway release scenario (537 m^3/s spillway releases, 113.2 m^3/s hypolimnetic dam releases) had been conducted in 2004. This model also includes date-specific discharge and water temperature inputs from the Milk River, and date-specific water temperatures from loggers positioned below the dam. Discharge rates through the dam and over the spillway were fixed in the model to represent maximum full-test conditions. We modified the mixing model slightly because warming of water released through the spillway may occur as it travels along the 1.6-km long (1 mile) spillway ramp. Thus, we estimated a 0.5^{o}C warming along the spillway ramp. Thus, lake water traveling down the spillway ramp was increased 0.5^{o}C prior to being mixed with discharge releases through the powerhouse and discharge from the Milk River.

Water temperature simulations based on discharge-temperature mixing models indicated that water temperature would not have reached 18.0^{o}C at Frazer Rapids if the spillway releases would have been implemented during 2004 (Figure 4). For the period between 15 May and June 30, the maximum predicted water temperature at Frazer Rapids would have occurred on 28 June (17.3°C) and 29 June (17.3°C). Despite the lack of achieving 18.0°C, spillway releases would have enhanced water temperatures at Frazer Rapids by an average of 0.7°C during the simulated time period.

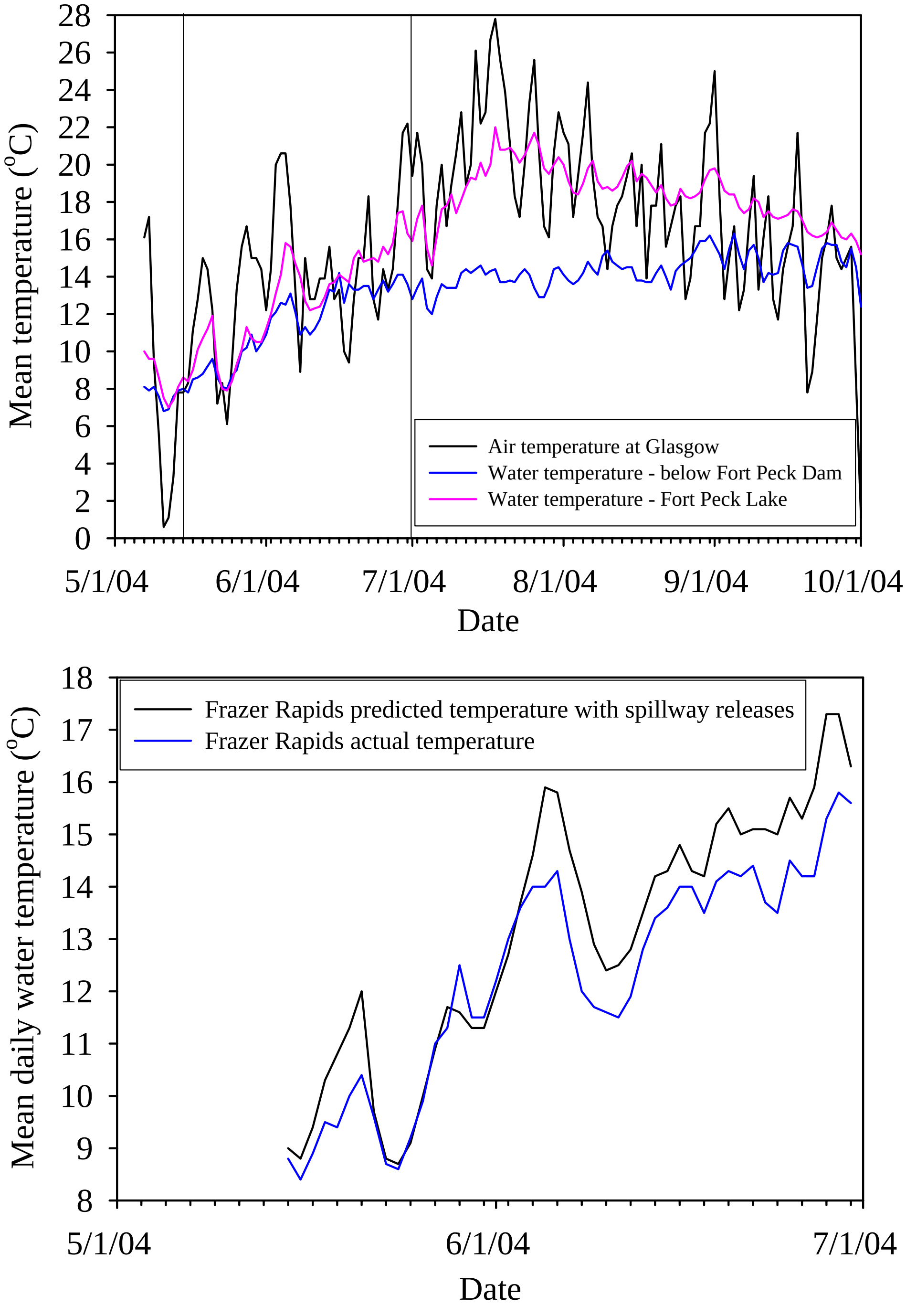


Figure 4. Mean daily temperature regimes during 2004. Top panel: Mean daily air temperature for Glasgow, MT, and mean daily water temperature for Fort Peck Lake and the Missouri River downstream from Fort Peck Dam. The vertical lines delimit dates when the proposed mini-test

and full-test are to be conducted when sufficient water levels are available in Fort Peck Lake. Lower Panel: Actual and predicted mean daily water temperature at Frazer Rapids.

General comments on turbidity loggers. Three of four turbidity loggers (Yellowstone River, Poplar, Frazer Rapids) deployed during 2004 functioned properly during the deployment period. The turbidity logger positioned at Nohly experienced slight structural damage during deployment as the 6-pin connector used to connect the logger and computer cable was broken. The unit was sent to the factory for repair. In addition, although the Nohly turbidity logger appeared to be functioning correctly despite the damaged connector, downloading of the unit (after it was returned from the factory) indicated that the logger had experienced several episodes of power loss while deployed, and the logger stopped recording all data on 15 July.

Post-deployment precision and accuracy of turbidity loggers. The Nohly turbidity logger was not included in post-deployment assessments because the unit could not be connected to a computer due to the broken connector. The unit was returned after post-deployment assessments had been conducted on the other turbidity loggers.

Post-deployment turbidity assessments indicated significant differences (ANOVA, $P < 0.0001$) in turbidity among treatment levels and loggers (Table 9). At the 20 NTU treatment, the turbidity measurements from all loggers exceeded the treatment NTU and measured turbidity was 4.1% higher (Frazer logger), 36% higher (Poplar logger), and 7.4% higher (Yellowstone River logger). For the 200 NTU treatment, the Yellowstone River logger (1.5% higher) and Frazer logger (0.9% lower) were accurate, but the Poplar turbidity logger exceeded the standard by 36%. At the 800 NTU treatment, measurements of turbidity from the three loggers exceeded the treatment NTU and measured turbidity was 4.6% higher (Frazer), 25% higher (Poplar), and 11.7% higher (Yellowstone River). Across treatment levels, the Frazer logger averaged 2.6% higher, the Poplar logger averaged 32.3% higher, and the Yellowstone River logger averaged 6.9% higher than the NTU standard treatment levels. These results suggested that turbidity loggers deployed during 2004 tended to record turbidities that were higher than turbidities in the river.

Table 9. 2004 post-deployment assessment summary statistics (mean NTU; minimum; maximum; standard deviation, STD; coefficient of variation, CV; ANOVA P-values) for comparisons of turbidity loggers in three turbidity treatments. Means within a treatment that have the same letter are not significantly different ($P > 0.05$). The sample size for each treatment is 30 (10 measurements per logger per treatment).

Formazin treatment (NTU)	Logger	Mean turbidity (NTU)	Minimum	Maximum	STD	CV	P
20	Frazer	20.8[a]	20.0	21.8	0.8	3.9	<0.0001
	Poplar	27.2[b]	26.3	28.3	0.8	2.8	
	Yellowstone	21.5[c]	20.8	22.4	0.6	2.8	
200	Frazer	198.2[a]	197.7	199.1	0.4	0.2	<0.0001
	Poplar	271.2[b]	270.6	272.1	0.5	0.2	
	Yellowstone	203.0[c]	201.5	204.7	1.0	0.5	
800	Frazer	837.0[a]	829.8	848.1	5.7	0.7	<0.0001
	Poplar	999.9[b]	999.9	999.9	0	0	
	Yellowstone	893.9[c]	887.2	898.7	3.7	0.4	

Field turbidity measurements. Hourly field measurements of turbidity recorded by the turbidity loggers varied greatly during late-May through August deployment period. At Poplar, hourly turbidity measurements exceeded 1000 NTU (maximum value of logger) at least once during a 24-hr period on 14 dates. In the Yellowstone River, 1000 NTU was exceeded at least once during a 24-hr period on 10 dates. The turbidity logger at Frazer recorded 1000 NTU at least once during a 24-hr period on six dates. In addition, the Frazer turbidity logger recorded numerous instances of 0 NTU on several dates between 25 June and 31 August (see below for additional results and discussion). The Nohly turbidity logger did not record 1000 NTU on any dates. Because the turbidity loggers did not record turbidity exceeding 1000 NTU, turbidity readings that exceeded 1000 NTU were truncated to 1000 NTU for estimations of daily turbidity. Truncation of turbidity data reduced the accuracy of mean daily estimates, resulted in conservative estimates of mean daily turbidity, and precluded quantitative statistical comparisons of spatial and temporal differences in mean daily turbidity. Therefore, only general trends in turbidity are reported.

Spatial and temporal trends in turbidity occurred among sites (Table 10). In the Missouri River, median daily turbidity generally increased from the most upstream Frazer site to the most downstream Nohly site. A similar pattern was evident when field measurements of turbidity were corrected to account for logger inaccuracies as discussed earlier. Median turbidity in the Yellowstone River was similar to Poplar turbidity and less than turbidity at Nohly; however, direct comparisons of the Nohly site to other sites is hindered given the shorter recording period for the Nohly turbidity logger.

Table 10. Turbidity summary statistics for turbidity loggers in the Missouri River at Frazer, Poplar, and Nohly, and in the Yellowstone River during 2004. Statistics for measured turbidity are based on actual turbidity values recorded by the loggers. Statistics for corrected turbidity are based on correction factors to account for measured error determined from post-deployment accuracy and precision tests.

Site	Metric	Maximum	75% quartile	Median	25% quartile	Minimum	Number of days
Frazer	Measured NTU	1000	48.0	4.5	1.2	0	98
	Corrected NTU	974	46.7	4.4	1.2	0	
Poplar	Measured NTU	1000	230.5	91.6	39.0	22.0	98
	Corrected NTU	677	156.0	62.0	26.4	14.9	
Nohly	Measured NTU	858	213.6	117.1	72.4	46.5	50
Yellowstone River	Measured NTU	1000	231.6	67.3	33.7	9.5	85
	Corrected NTU	931	215.6	62.3	31.4	8.8	

Temporally, river discharge exhibited an influence on river turbidity at all sites where increases in discharge or varying discharge were usually associated with an increase in turbidity (Figure 5). These trends were most evident during the late-May and mid-June discharge increases for the Frazer, Poplar, and Nohly sites, and during the mid-June and early-July discharge increases in the Yellowstone River. Small increases in turbidity also occurred at the Poplar and Nohly sites during early and mid-July when discharge increased. Increased turbidities at Poplar, Nohly, and the Yellowstone River are slightly off-set from increased discharge levels due to travel time required for water to reach the sites from the upstream gauging stations. Increased turbidities also occurred during periods of relatively stable or declining hydrographs. For example, turbidity in the Yellowstone River increased briefly during mid-August as discharge was declining. Similarly, turbidity increased at Poplar and Frazer during late-August as discharge was relatively stable during this time period. Turbidity at Frazer was low and relatively static from late-June through mid-August; whereas, turbidity at Poplar was dynamic during this time period under similar discharge conditions. These results suggested a possible problem with the Frazer turbidity logger during this time period. Additional turbidity data collected during radio telemetry tracking runs also indicated that turbidity was low (5.8 – 12.2 NTU) from late-June through mid-August near the Frazer site. This supporting information corroborates the turbidity logger data further indicating that turbidity was low at the Frazer site during this time period.

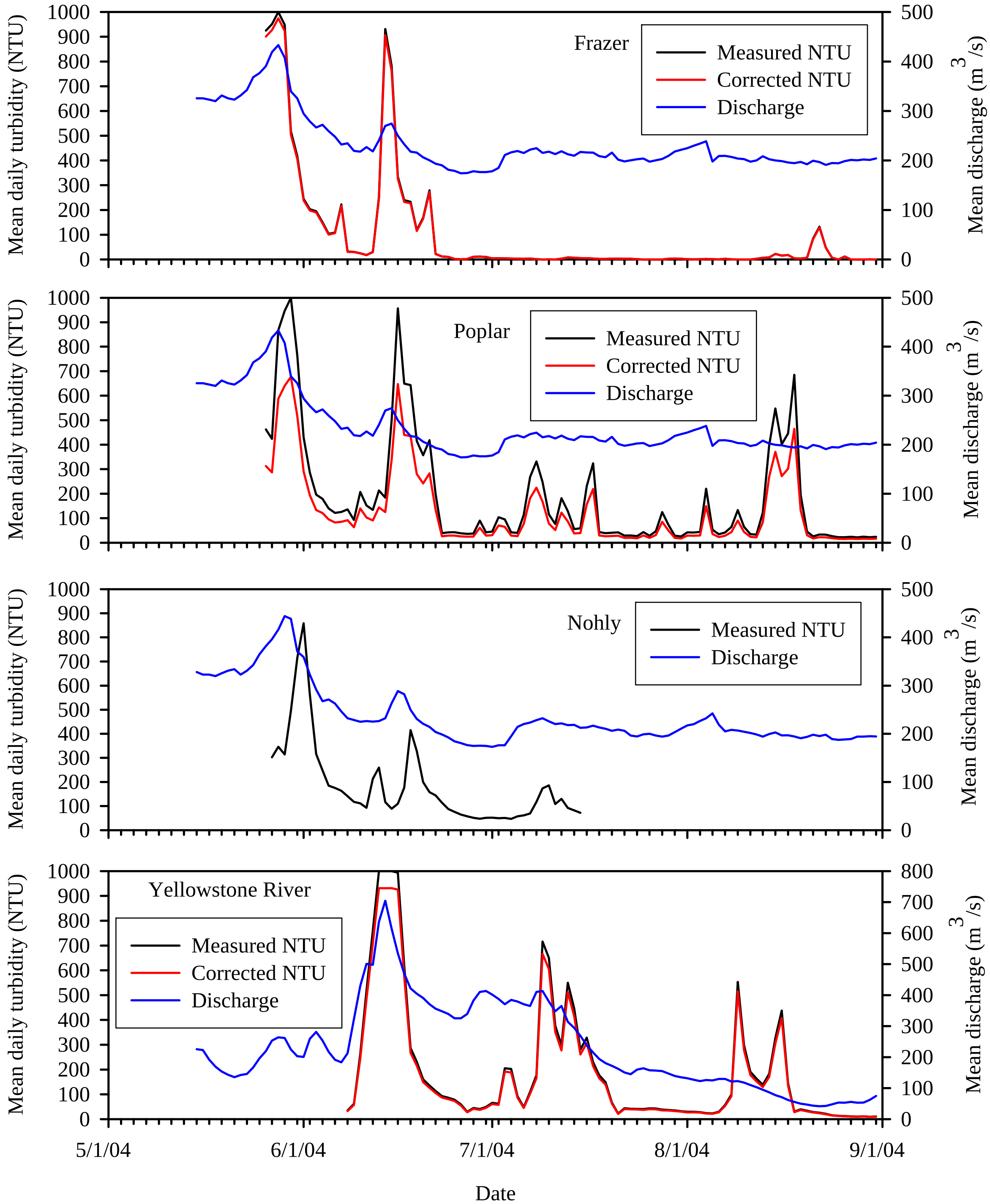


Figure 5. Mean daily turbidity (NTU; solid line) from turbidity loggers and discharge (m^3/s; dotted line) in the Missouri River near Frazer, Poplar, and Nohly, and in the Yellowstone River during 2004.

Monitoring Component 2 – Seasonal use, telemetry, and movements of adult pallid sturgeon in the Missouri River downstream from Fort Peck

Targeted sampling for pallid sturgeon in the lower 120 km of the Missouri River resulted in a total of 627 drifts and 4,442 total minutes of sampling effort (Table 11). The proportion of effort expended reflected the study design and availability of habitats as effort (based on percent of time) was greatest for CHXO (40.3%), ISB (20.7%), OSB (19.7%), ITIP (10.8%), and SCC (8.4%). Among habitats and months, 13 fish species and 290 individuals were sampled. The five most frequently sampled fish species based on numerical representation included shovelnose sturgeon (27.9%), goldeye (21.4%), sauger (11.7%), river carpsucker (8.3%), and channel catfish (7.2%). The remaining species comprised 23.5% of the catch.

Sampling during April, May, and June exclusively with large-mesh trammel nets focused to sample large adults inhabiting the study area, migrating through the study area, or using the study area for spawning as water temperature increased to suitable spawning temperatures. Two adult pallid sturgeon were sampled during this time frame. The first pallid sturgeon (14.5 kg, male) was sampled from a CHXO habitat on 20 May at rkm 2584 (rm 1605). Physical characteristics of the sampled habitat included: minimum depth = 2.0 m, maximum depth = 6.1 m, substrate = sand/silt, water temperature = 13.5^{o}C, turbidity = 138 NTU. This individual did not have any previous marks or tags, thus it was presumed that this encounter represented the first time this had been caught. The pallid sturgeon was implanted with a CART 32 (code 114, radio frequency 149.620 Mhz). The second pallid sturgeon was sampled from a CHXO habitat on 23 June at rkm 2586.5 (rm 1606.5). This pallid sturgeon represented a previously tagged individual (radio code 31) that was implanted by the USFWS. Physical characteristics of the sampled habitat included: minimum depth = 1.4 m, maximum depth = 3.6 m, substrate = sand, water temperature = 17.9^{o}C, turbidity = 130 NTU. Despite the 1-month lag time between captures of these individuals, both pallid sturgeon were sampled within the same 2.5-km river reach. Collections of these individuals in the same general area lend toward speculation that this river reach may possibly provide important habitat elements for pallid sturgeon during the spring and early summer. Additional sampling in subsequent years could be conducted to more thoroughly address this hypothesis.

Paddlefish were sampled only between April and June. This time frame encompasses the period when paddlefish are moving into the upper Missouri River for spawning or moving downstream through the study area after spawning as documented in other research components of this study.

In addition to the collection of adult pallid sturgeon, the switch to smaller-mesh trammel nets during July and August resulted in the capture of 14 hatchery-raised and released juvenile pallid sturgeon (Table 11). These individuals were sampled from all habitat types except ITIP. Information (e.g., PIT tag numbers, length, weight) on these juveniles was forwarded to Matt Klungle, MTFWP pallid sturgeon biologist, for inclusion into his study of juvenile pallid sturgeon survival estimates.

An additional 21 trammel net drifts were conducted beyond the scope of the existing study. Four of these drifts were focused in an SCC where a hatchery pallid sturgeon had previously been sampled. These drifts resulted in one additional hatchery pallid sturgeon. Eleven drifts were designated as “wild” sampling in a variety of habitats. Six additional drifts upstream from the study area were conducted in OSB and CHXO habitats. The extra sampling did not result in the capture of pallid sturgeon, but other species including sauger, goldeye, river carpsuckers, shovelnose sturgeon, longnose suckers, smallmouth buffalo, and channel catfish were sampled.

Results from this research component indicate that adult pallid sturgeon use the Missouri River upstream from the Yellowstone River confluence during spring and early summer. These results corroborate earlier findings where telemetered pallid sturgeon have been relocated in the Missouri River upstream from the Yellowstone River confluence (D. Fuller, personal observation, also see below). In addition, adult pallid sturgeon have also been sampled in this portion of the Missouri River during fall (Braaten and Fuller 2003). However, collective information from the research components suggest that the number of pallid sturgeon using this reach is low in comparison to numbers of pallid sturgeon using the Yellowstone River.

Table 11. Effort (drifts, time) and numbers of fish sampled by month and habitat during 2004. Sampling during April, May and June was conducted with 6” x 10” drifted trammel nets, and sampling in July and August was conducted with 1” x 6” drifted trammel nets. Species codes are as follows: WLYE = walleye, PDFH = paddlefish, SGER = sauger, PDSG = pallid sturgeon, RVCS = river carpsucker, GDEY = goldeye, CARP = common carp, CNCF = channel catfish, SMBF = smallmouth buffalo, SHRH = shorthead redhorse, FHCB = flathead chub, BUSK = blue sucker.

		Effort		**Species**												
Month	Habitat	Number of drifts	Total drift time (min)	WLYE	PDFH	SGER	SNSG	PDSG	RVCS	GDEY	CARP	CNCF	SMBF	SHRH	FHCB	BUSK
April	CHXO	27	209		1											
	ISB	12	87		1											
	ITIP	12	68	1												
	OSB	14	107													
	SCC	7	47													
May	CHXO	58	426		3		2	1								
	ISB	29	226													
	ITIP	21	156		2											
	OSB	28	199		3	1										
	SCC	11	82													
June	CHXO	88	678		2		1	1								
	ISB	39	311		2											
	ITIP	33	220		1											
	OSB	43	321		3											
	SCC	29	195													
July	CHXO	49	305			9	19	4	13	20	1	7	1		3	
	ISB	26	163			4	7	3	8	13	1	2				
	ITIP	4	37				1			1		2	1			
	OSB	24	147			7	12	1	1	7	4	3		1		
	SCC	6	51	1		4	5	3	1	6	3		1			1
August	CHXO	29	173			5	9	2		5	1	4		2	3	2
	ISB	22	134	1		4	22	1		10		2		2	2	
	OSB	16	100				3		1		1	1				1
Totals		627	4442	3	18	34	81	16	24	62	11	21	3	5	8	4

Monitoring Component 3 – Flow- and temperature-related movements of paddlefish, blue suckers, and shovelnose sturgeon

Manual relocations and ground station contacts.- At the onset of manual tracking in April 2004, there were 59 shovelnose sturgeon (12 males, 39 females, 8 unknown sex), 52 blue suckers (21 males, 18 female, 13 unknown), 53 paddlefish (33 males, 17 females, 3 unknown), and 12 pallid sturgeon (10 males, 1 female, 1 unknown) implanted with CART tags throughout the study area. We conducted 25 tracking events between April and November, and cumulatively searched 10,800 km of riverine habitat in the Missouri River and Yellowstone River (Table 12). Twenty-one tracking events covered the entire study area; whereas, four tracking events covered only selected reaches. We obtained 799 relocations of blue suckers, 253 relocations of paddlefish, and 1065 relocations of shovelnose sturgeon. We also obtained 202 relocations of pallid sturgeon implanted by the USFWS and MTFWP.

Table 12. Dates, river reaches, total river kilometers tracked, and numbers of relocations obtained for blue suckers, paddlefish, shovelnose sturgeon, and pallid sturgeon by boat during 2004.

Tracking Dates	Reaches tracked	Total km	Blue sucker	Paddlefish	Pallid sturgeon	Shovelnose sturgeon
3/29–4/4	Wolf Point-Dam	112	21	1	1	20
4/5–4/11	All	457.6	29	7	19	49
4/12–4/18	All	457.6	32	7	11	50
4/19–4/25	All	457.6	39	12	15	54
4/26–5/2	All	457.6	33	10	8	51
5/3–5/9	All	457.6	34	16	6	48
5/10–5/16	All	457.6	36	16	8	52
5/17– /23	All	457.6	31	19	10	52
5/24–5/30	All	457.6	18	19	9	47
5/31–6/6	All	457.6	18	13	7	47
6/7–6/13	All	457.6	29	18	8	47
6/14–6/20	All	457.6	33	13	8	49
6/21–6/27	All	457.6	38	9	9	45
6/28–7/4	All	457.6	34	8	10	50
7/5–7/11	All	457.6	30	6	7	42
7/12–7/18	All	457.6	37	6	7	41
7/19–7/25	All	457.6	37	2	3	45
7/26–8/1	All	457.6	27	2	3	47
8/9–8/15	All	457.6	37	6	7	44
8/23–8/29	Missouri River	342.4	19	12	6	22
9/6–9/12	All	457.6	40	4	8	45
9/20–9/26	Missouri River, Yellowstone River to Sidney	392	36	2	6	31
10/4–10/10	All	457.6	43	11	7	33
10/18–10/24	All	457.6	33	17	9	27
11/1–11/8	Missouri River	342.4	35	17	10	27
Totals	25	10798.4	799	253	202	1065

The seven continuous-recording logging stations deployed during 2004 contributed additional movement and relocation information that augmented the manual tracking data set (Table 13). The logging stations recorded 260 contacts for 1-23 individual blue suckers, 117 contacts of 2-24 individual paddlefish, and 103 contacts of 1-16 individual shovelnose sturgeon. The Culbertson logging station experienced technical difficulties throughout the season. The Nickels logging station recorded the highest numbers of contacts for blue suckers and shovelnose sturgeon. The number of paddlefish contacts was highest at the Williston logging station.

Table 13. Number of contacts and number of individual fish recorded by seven logging stations for blue suckers, paddlefish, and shovelnose sturgeon during 2004.

	Blue sucker		**Paddlefish**		**Shovelnose Sturgeon**	
Logging station	**Contacts**	**Individual fish**	**Contacts**	**Individual fish**	**Contacts**	**Individual fish**
Milk River	70	18	17	3	3	2
Nickels	77	22	10	3	53	16
Wolf Point	28	22	17	6	16	9
Poplar	29	18	11	8	8	7
Brockton	43	23	18	11	16	11
Culbertson	11	6	2	2	5	3
Williston	2	2	42	24	2	1

Blue sucker relocations and movements.-Of the 52 tagged blue suckers, 49 were relocated during 2004. Relocations of an individual ranged from 2 – 26 (median = 17; Figure 6).

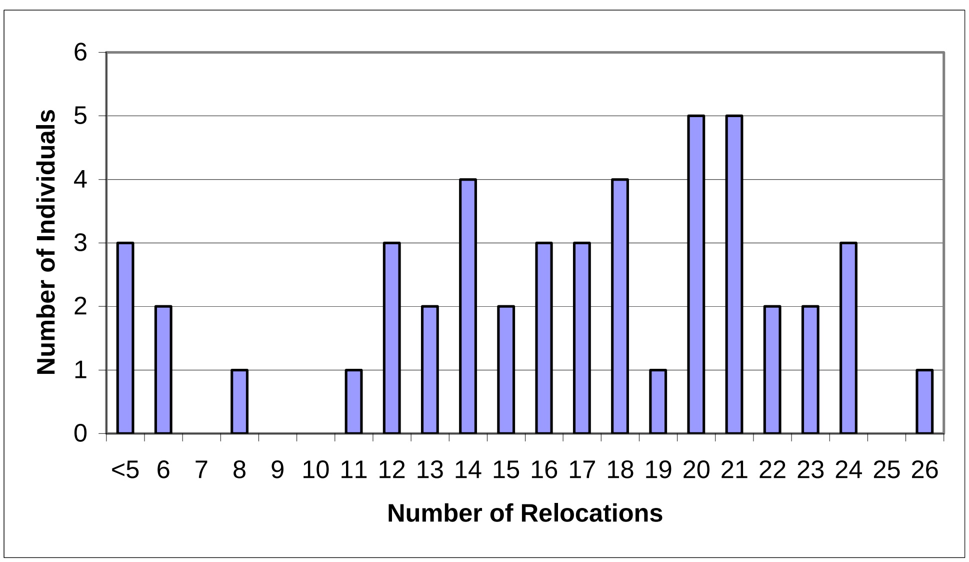


Figure 6. Number of relocations of individual blue suckers in 2004.

The distribution and relative abundance of blue suckers varied among rivers through time (Figure 7). During April and mid-May, blue suckers primarily used (50-75% of relocations) the Missouri River between Fort Peck Dam and Williston and most were relocated upstream from Wolf Point. The percentage of blue suckers relocated in this reach varied between 24% and 48% during June and late August, then increased during mid-September. The increased relative abundance of blue suckers in the reach during mid-September was primarily due to movements of blue suckers out of the Yellowstone River when discharge was low and water temperature was high.

The occurrence of blue suckers in the Milk River (Figure 7) was dependant on discharge. Fish entered the Milk River (N = 17) as indicated by our ground based telemetry station during a large pulse of water in mid-May (Figure 2). The residence time of blue suckers in the Milk River spanned a 3-week time period as evidenced by ground station information and was directly related to the decrease in flow. Ground stations indicated that 25 % of the implanted blue suckers were in the Milk River during the first week of June.

Use of the Yellowstone River by radio tagged blue suckers exhibited a distinct pattern among tracking periods (Figure 7). Relative abundance of blue suckers in the Yellowstone River was low from early April to late May (<5% of implanted individuals), consistently increased through June, remained high (30-35% of implanted individuals) through late August, then declined during mid-September and early October.

Passage of blue suckers over Intake Diversion Dam on the Yellowstone River occurred, but was not specific to dates or discharge. Individuals passed over the dam from April 7, 2004 through July 21, 2004 (N = 10) and passed downstream over the dam from August 11, 2004 through November 3, 2004 (N = 9). There was only one blue sucker that was relocated near the structure that did not pass over it. Most of this information was based on the telemetry logging station positioned at Intake Diversion Dam. The furthest upstream movement recorded in the Yellowstone River was rkm 198. The median movement for blue suckers was nearly 425 kilometers for the season and ranged from 2 – 1058 kilometers. See Appendix A for a map view of blue sucker relocations in the Missouri River and Yellowstone River by month.

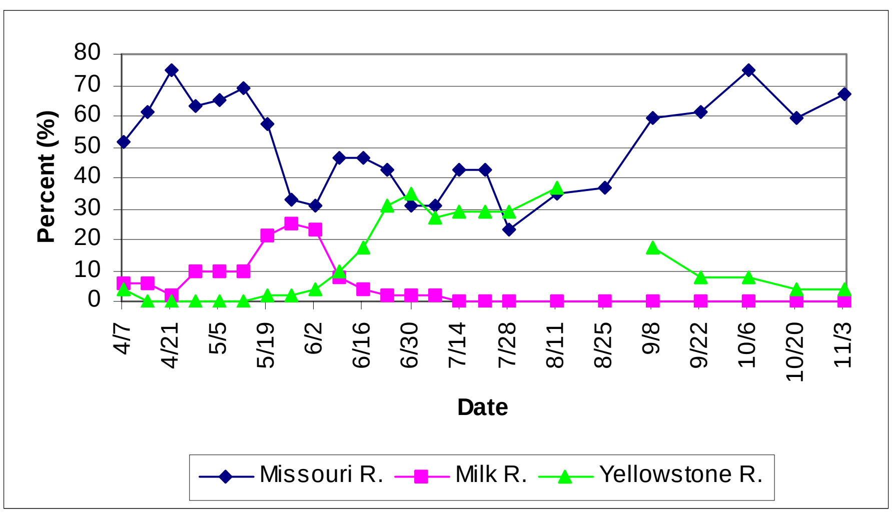


Figure 7. Percent of implanted blue suckers relocated in the Milk, Missouri, and Yellowstone Rivers in 2004 by date. Use of the Milk River was determined from contacts at the Milk River logging station since the Milk River was not manually tracked

Inter-annual trends in blue sucker relocations.-The Missouri River was a concentration area for blue suckers during 2003 and 2004, but use of this reach varied during the year (Figure 8). Relocations of blue suckers were initially high in April, decreased in May as fish entered the Milk River, then increased as individuals moved out of the Milk River and returned to the Missouri River. After Milk River immigration and emigration events were completed, use of the Missouri River steadily declined as blue suckers exited the Missouri River and entered the Yellowstone River. Fish migrated back into the Missouri in September. However, several individuals remained in the Missouri River for the entire year (minimum 30% in 2003, minimum 23% in 2004). Although similar immigration and emigration dynamics among rivers occurred in 2003 and 2004, the timing of movement dynamics varied slightly between years, and there was no significant correlation of relocation percentages between 2003 and 2004 ($r = 0.36$, $P = 0.115$, $N = 20$). The weak correlation is likely attributed to differences in the dates that the Milk River had suitable water conditions, and the subsequent influence of Milk River hydrologic conditions on immigration and emigration dynamics (see below).

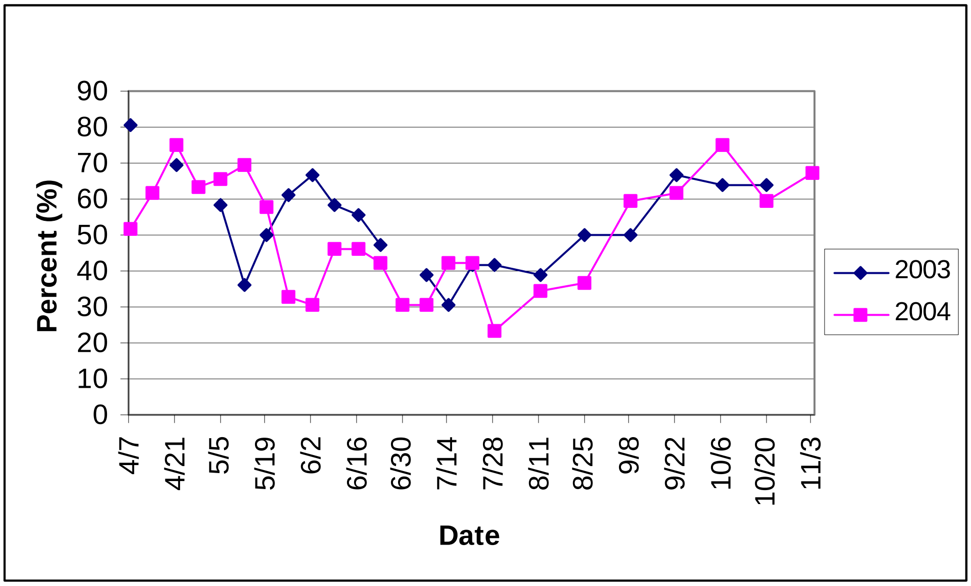


Figure 8. Percent of implanted blue suckers relocated in the Missouri River in 2003 and 2004.

Blue suckers exhibited seasonal use of the Milk River in 2003 and 2004 (Figure 9). Individuals migrated up the Milk River in early May 2003 and late May 2004 during an increase in the hydrograph (maximum 37% in 2003, maximum 25% in 2004; see Figure 2 for Milk River hydrographs). When discharge declined, blue suckers moved out of the Milk River and re-entered the Missouri River. There were no relocations of blue suckers in the Milk River later than mid-July in 2003 or 2004. Although the Milk River was used in 2003 and 2004, temporal use of the Milk River was not consistent between years as evidenced by a weak correlation of relocation percentages between 2003 and 2004 ($r = 0.29$, $P = 0.177$, $N = 23$). The lack of correlation is most likely attributed temporal differences in Milk River discharge between years, and the influence of discharge on blue sucker use of the Milk River.

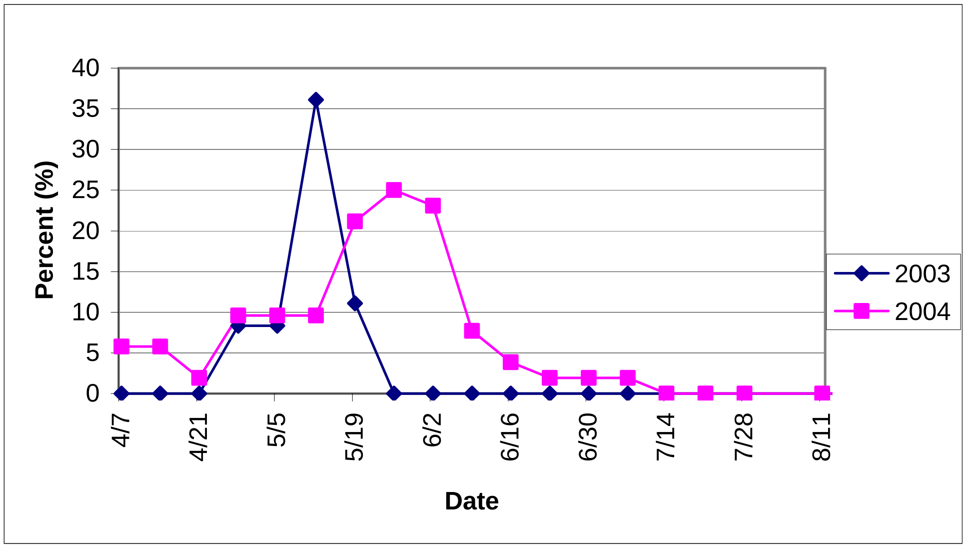


Figure 9. Percent of implanted blue suckers relocated in the Milk River in 2003 and 2004. Use of the Milk River was determined from contacts at the Milk river logging station since the Milk River was not manually tracked.

The Yellowstone River was rarely used during April and early May by implanted blue suckers in 2003 and 2004 (Figure 10). Use of the Yellowstone River rapidly increased in early June and remained high (maximum 45% in 2003, maximum 37% in 2004) through early September. Use of the Yellowstone River was low from late September through November (< 10%) in both years. Temporal use of this reach was very consistent between years based on a strong correlation of relocation percentages between 2003 and 2004 ($r = 0.93$, $P < 0.0001$, $N = 20$). Thus, these results suggest that use patterns of the Yellowstone River by blue suckers is fairly similar between years despite inter-annual differences in Yellowstone River hydrologic conditions. Conversely, temporal use of the Milk River and Missouri River by blue suckers varies between years, and is strongly influenced by temporal (e.g., weekly) variations in hydrologic conditions in the Milk River that subsequently influence immigration and emigration dynamics.

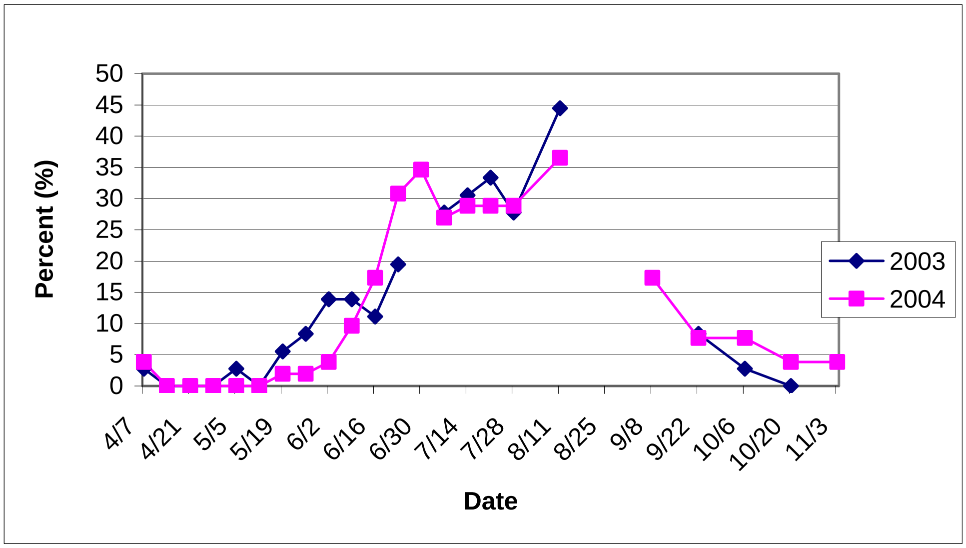


Figure 10. Percent of implanted blue suckers relocated in the Yellowstone River in 2003 and 2004

Paddlefish relocations and movements.-Forty-four of the 53 paddlefish implanted with CART tags were relocated during 2004. The nine paddlefish not relocated were assumed to have spent the seasons in Lake Sakakawea. Relocations of an individual ranged from 1 - 19 (median = 7; Figure 11).

Figure 11. Number of relocations of individual paddlefish in 2004.

Paddlefish exhibited distinct use patterns of Missouri River reaches and the Yellowstone River in 2004 (Figure 12). Relative abundance of paddlefish in the Missouri River above the confluence of the Yellowstone River (ATC) increased in early and mid-May, and 17% of the implanted individuals were using this reach by late May. In addition, three paddlefish entered the Milk River for three weeks based on ground station information. These three fish were included in the ATC relocations for this time frame. One individual was recorded by a logging station (operated by the U. S. Bureau of Reclamation) located at Tampico – 168 km (105 rm) upstream from the mouth of the Milk River. Paddlefish steadily exited the Missouri River. ATC through late July. Although paddlefish were not relocated ATC after July, one individual was assumed to have returned to the dredge cuts based on ground station data and relocating this individual during winter in the dredge cuts.

Relative abundance of paddlefish in the Missouri River below the Yellowstone River confluence (BTC) followed distinct seasonal patterns (Figure 12). The percentage of relocations in this reach increased through April, decreased through May, and remained low (<10%) through June and July as most paddlefish were ascending either the Missouri River ATC or the Yellowstone River. Use of this reach steadily increased from August through early November (maximum 32%).

Temporal use of the Yellowstone River by paddlefish occurred during a 2.5 month period (Figure 12). Relative abundance was low in April, increased in May and early June, then declined through July. No fish were relocated in the Yellowstone River after July. The maximum upstream location of paddlefish occurred at rkm 112 (RM 70). About 23% of the implanted paddlefish moved up the Yellowstone River. Of the total number of migrating paddlefish, 43% ascended the Missouri River while 57% ascended the Yellowstone River in 2004. See Appendix B for a map view of paddlefish relocations in the Missouri River and Yellowstone River by month.

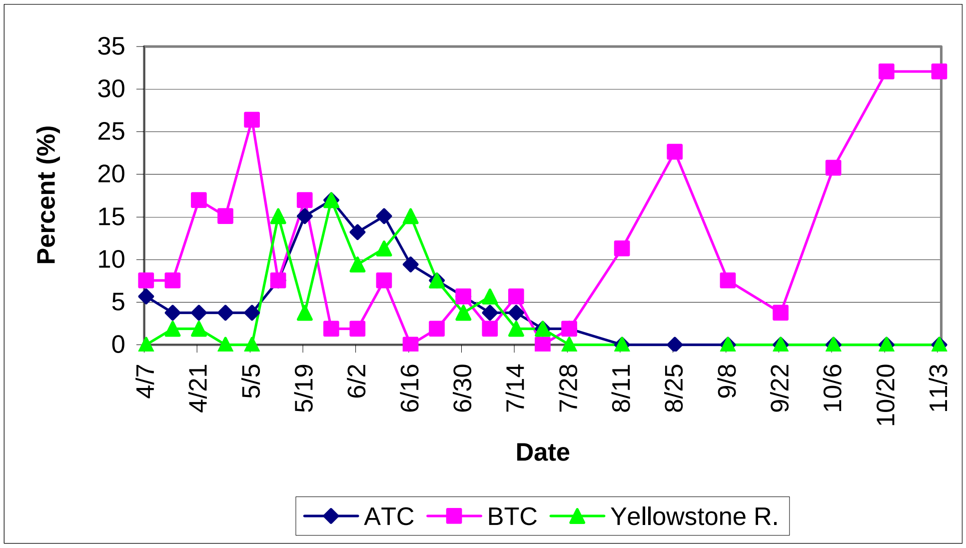


Figure 12. Percentage of implanted paddlefish relocated in reaches of the Missouri River and Yellowstone River during 2004.

Inter-annual trends in paddlefish relocations.-Paddlefish migrated up the Missouri River ATC in early May of 2003 and 2004 (Figure 13). Use of this reach remained relatively high (12 - 18% of implanted individuals) for seven weeks (2003) and four weeks (2004). Relocations gradually declined through July and August. Temporal use of this reach was very consistent between years based on a strong correlation of relocation percentages between 2003 and 2004 ($r = 0.82$, $P < 0.0001$, $N = 20$).

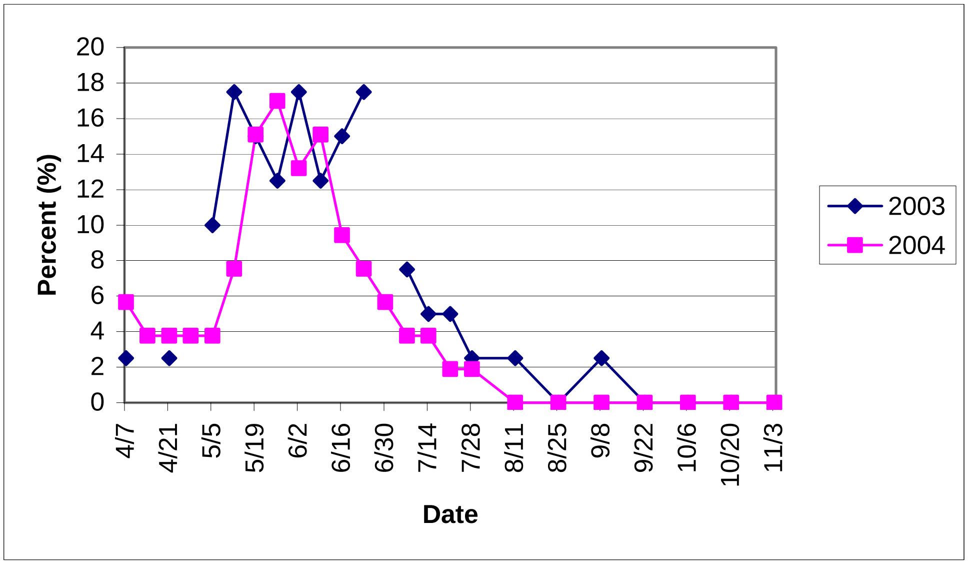


Figure 13. Percent of implanted paddlefish relocated in the Missouri River above the Yellowstone River confluence in 2003 and 2004.

Paddlefish exhibited seasonal movements for the Missouri River reach BTC (Fig 14). In 2003 and 2004, use of this reach declined through mid-May as most paddlefish ascended either the Missouri River or Yellowstone River. Relocations remained low in this reach (<10%) through late July, then increased through August. Temporal use of this reach was consistent between years based on a significant correlation of relocation percentages between 2003 and 2004 ($r = 0.51$, $P = 0.020$, $N = 20$).

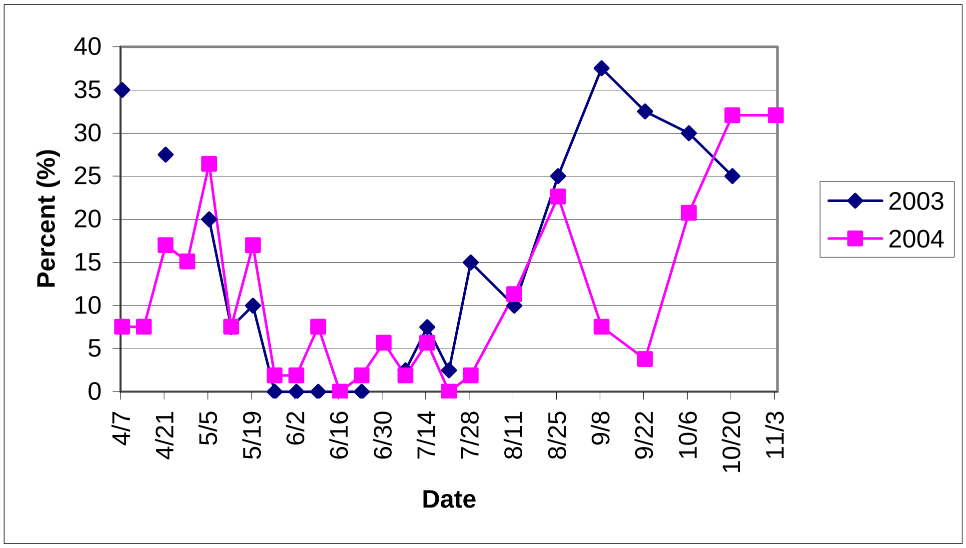


Figure 14. Percent of implanted paddlefish relocated in the Missouri River below the Yellowstone River confluence in 2003 and 2004.

The Yellowstone River was used seasonally by implanted paddlefish (Figure 15). Paddlefish ascended the Yellowstone River in mid-April 2003 and early May 2004. In 2003, there was a maximum of 28% of the implanted paddlefish relocated in the Yellowstone River on the weeks of 5-19 and 6-2; whereas, a maximum of 17% of implanted individuals were relocated in during the week of 5-24 during 2004. Relocations declined through out most of June and July. No paddlefish were found in the Yellowstone River after the week of 7-14-2003 or the week of 7-28-2004. Temporal use of the Yellowstone River was consistent between years based on a strong correlation of relocation percentages between 2003 and 2004 ($r = 0.61$, $P = 0.006$, $N = 19$).

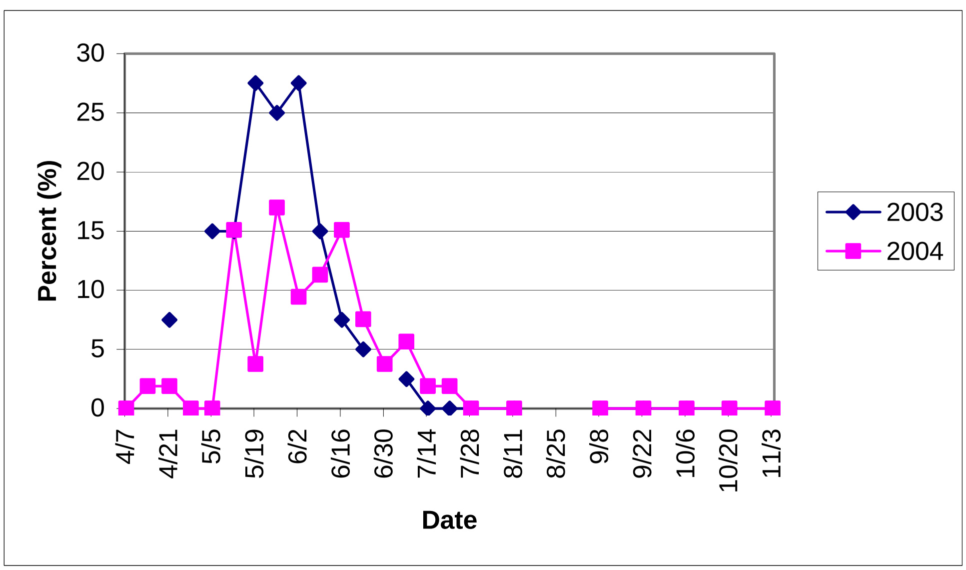


Figure 15. Percent of implanted paddlefish relocated in the Yellowstone River in 2003 and 2004.

Shovelnose sturgeon relocations and movements.-Fifty-five of 59 radio-tagged shovelnose sturgeon in the study area during 2004 were relocated. Relocations of an individual ranged from 1 – 26 (median = 20; Figure 16).

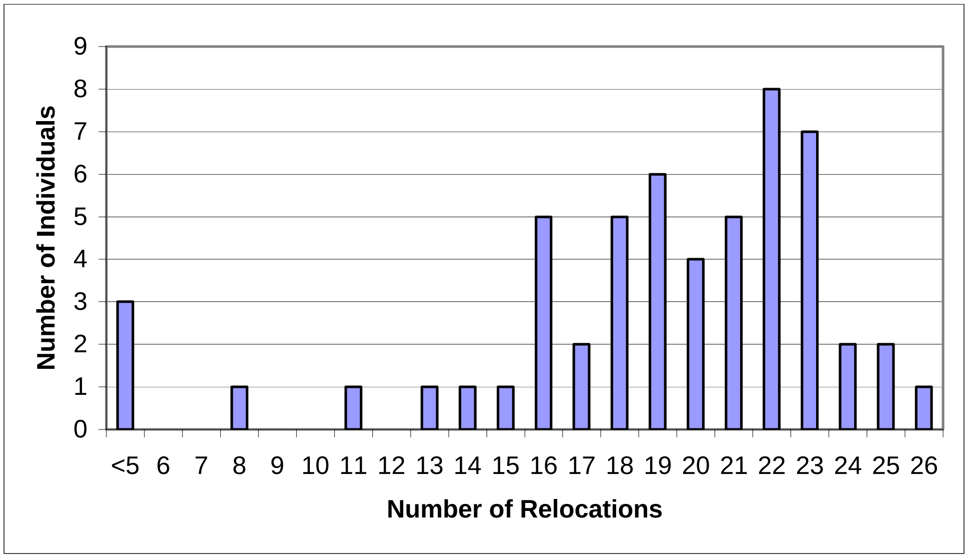


Figure 16. Number of relocations of individual shovelnose sturgeon in 2004.

Use of the Missouri River between Fort Peck Dam and Wolf Point by shovelnose sturgeon was relatively stable from early April through mid-May (Figure 17). Use of this reach declined slightly in mid-May, and varied throughout the remainder of the tracking season. However, a minimum of 25% of the implanted shovelnose sturgeon remained in the study reach for the duration of the season.
The lower Missouri River reach from Wolf Point to the headwaters of Lake Sakakawea is twice as long as the other two reaches. However, this reach exhibited the lowest relative abundance of shovelnose sturgeon (<15% of implanted individuals) during all tracking periods with the exception of one week in early September when 17% of the fish were found in this reach (Figure 17). Less than 10% of implanted individuals were relocated in this reach from June through August.

The percentage of shovelnose sturgeon relocations in the Yellowstone River increased from early May through late June (Figure 17). Thirty-five percent to 45% of the shovelnose sturgeon were relocated in the Yellowstone River from mid-May to mid-August. Use of this reach declined from late July until the end of the tracking season. The furthest upstream relocation was 365 km up the Yellowstone River. Shovelnose sturgeon were capable of long-range movements. The median range of activity was 225 km (minimum 8 km, maximum 640 km). See Appendix C for a map view of shovelnose sturgeon relocations in the Missouri River and Yellowstone River by month.

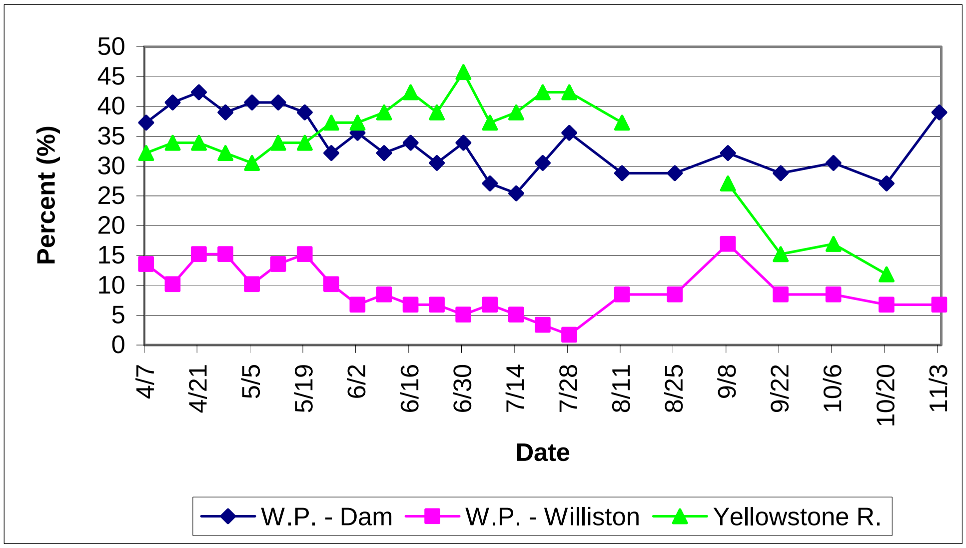


Figure 17. Percent of implanted shovelnose sturgeon relocated in the Missouri River reaches and the Yellowstone River in 2004.

Inter-annual trends in shovelnose sturgeon relocations.- The Missouri River from Wolf Point to Fort Peck Dam was a concentration area during 2003 and 2004 (Figure 18). Although use gradually decreased from mid-April through August (2003) or mid-July (2004), a large number of individuals remained in this reach throughout the tracking season (minimum 25% in 2003 and 2004). Temporal use of this reach was generally consistent between years based on a strong correlation of relocations percentages between 2003 and 2004 ($r = 0.77$, $P < 0.0001$, $N = 20$).

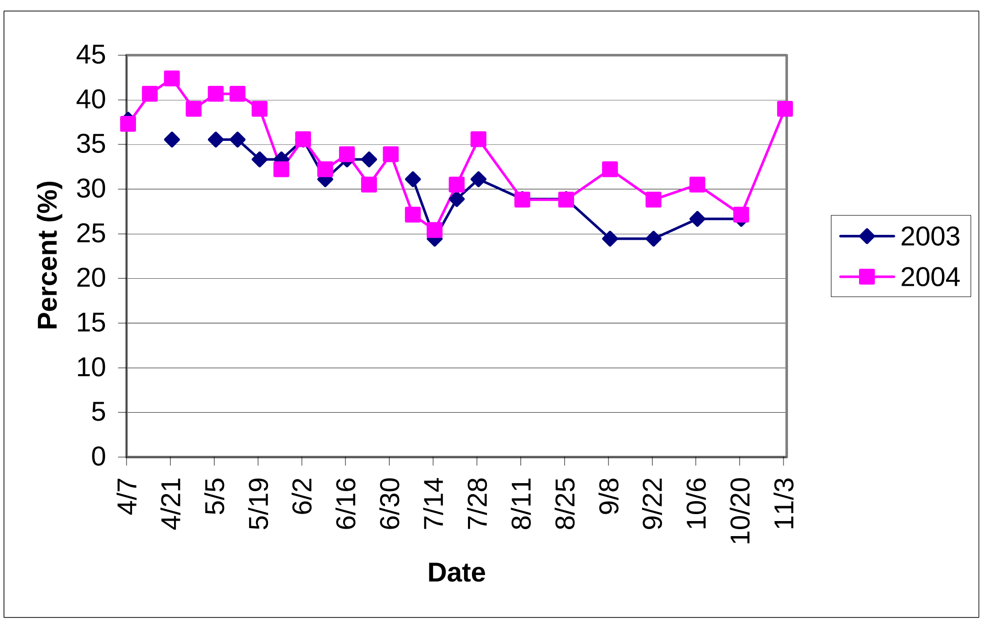


Figure 18. Percent of implanted shovelnose sturgeon relocated in the Missouri River from Wolf Point to Fort Peck Dam in 2003 and 2004.

The Missouri River reach between Wolf Point and Williston was a movement corridor and dead zone during the tracking season (Figure 19). Although shovelnose sturgeon were present in this reach during April and May, densities declined through late July (< 10%) as individuals emigrated from this reach and migrated primarily into the Yellowstone River. Densities of shovelnose sturgeon in this reach increased during September as individuals emigrated from the Yellowstone River back into the reach. Temporal use of this reach was consistent between years based on a significant correlation of relocation percentages between 2003 and 2004 ($r = 0.46$, $P = 0.041$, $n = 20$).

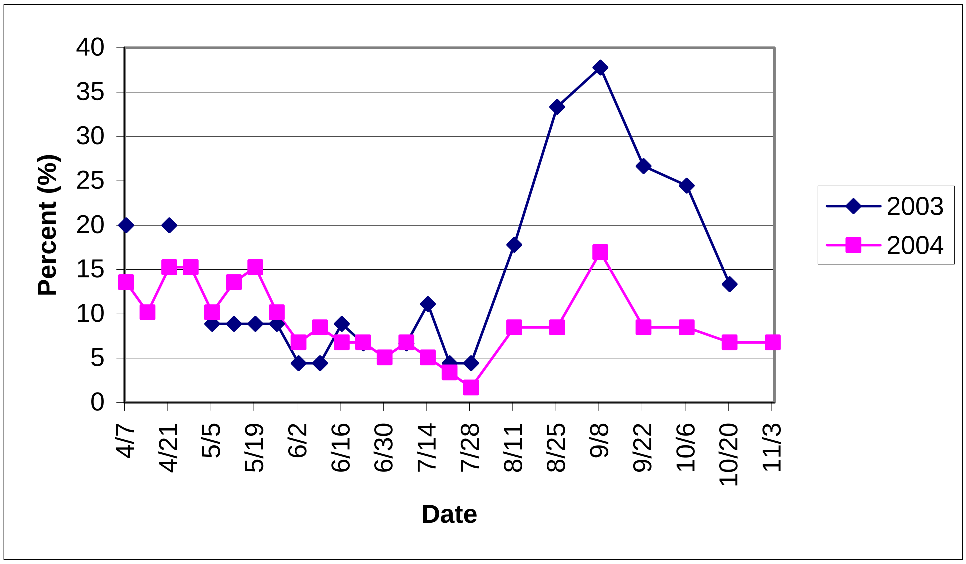


Figure 19. Percent of implanted shovelnose sturgeon relocated in the Missouri River from Wolf Point to Williston in 2003 and 2004.

The Yellowstone River was a concentration area for shovelnose sturgeon, but use of this reach varied during the year (Figure 20). Use of this reach increased from April through late June (2003; maximum 45%) and July (2004; maximum 46%) then declined through late September and October as individuals moved into the Missouri River. Several shovelnose sturgeon remained in the Yellowstone River throughout the tracking season. A significant correlation of relocation percentages between years ($r = 0.74$, $P = 0.0009$, $N = 17$) suggests temporal use of the Yellowstone River was consistent between 2003 and 2004.

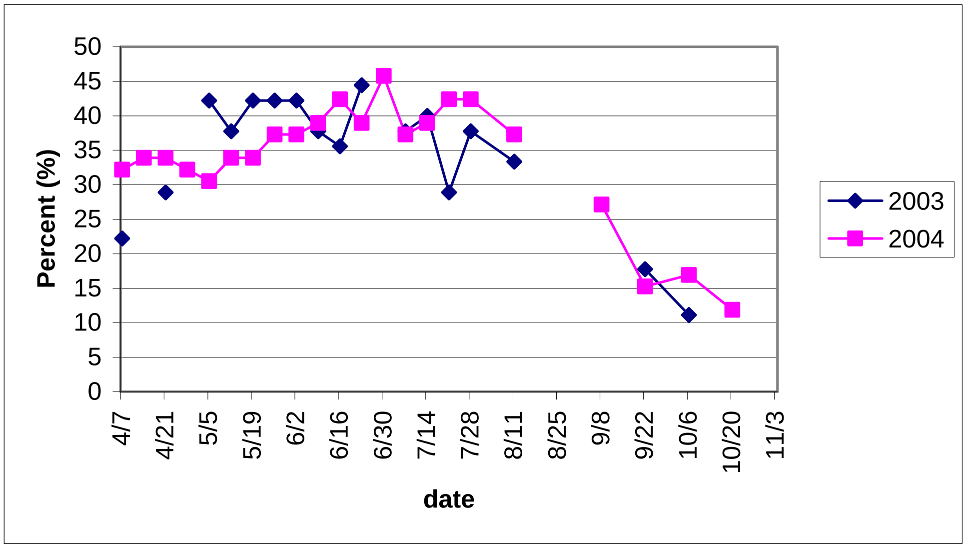


Figure 20. Percent of implanted shovelnose sturgeon relocated in the Yellowstone River in 2003 and 2004.

Pallid Sturgeon.- All twelve pallid sturgeon were relocated this year; however, one individual was relocated only one time during an aerial survey in the headwaters of Lake Sakakawea. The twelve fish that were externally tagged in 2003 shed their tags by early spring 2004. All pallid sturgeon analyses are being conducted by the USFWS in Bismarck, ND. We provided the USFWS with 241 manual relocations and several ground station contacts that were obtained during our routine tracking operations. Whereas the USFWS telemetry efforts are focused on the lower Yellowstone River and the Missouri River below the confluence, tracking efforts as conducted under the Fort Peck Data Collection Plan provide comprehensive coverage of the Missouri River and Yellowstone River and provide more detailed information on movements and river use of pallid sturgeon.

Use of the Missouri River ATC by pallid sturgeon occurred during 2004 (Figure 21). Use of this reach was low (< 10% of implanted individuals) during April, but increased to greater than 30% by the end of May. Use of the ATC from May through the end of the tracking season varied from 0 to 25%. One individual that was implanted in the tailrace immediately downstream from Fort Peck Dam remained in the tailrace area until mid-June then began a gradual downstream movement. This individual entered the Yellowstone River in early July for two weeks, and ascended the Missouri River to above Wolf Point where it over-wintered.

In general, there was inverse use pattern for pallid sturgeon between the Yellowstone River and Missouri River BTC (Figure 21). Pallid sturgeon use of the Missouri River BTC was high during April and early May, then declined as individuals migrated from this reach into the Yellowstone River. Pallid sturgeon primarily used the Yellowstone River through mid-July, then emigrated from the Yellowstone River back to the Missouri River from late-July through the end of the tracking season.

Telemetered adult pallid sturgeon exhibited the capability to migrate long distances. However, migratory distances varied among rivers. For example, the farthest upstream relocation of pallid sturgeon in the Yellowstone River was at rkm 71.8 (RM 44.6). Conversely, pallid sturgeon normally residing in the Yellowstone River or in the Yellowstone River confluence area were relocated in the Missouri River as far upstream as the mouth of the Milk River (rkm 2831, RM 1758.5). In addition, a pallid sturgeon migrated at least 4.0 rkm (RM 2.5) up the Milk River. This first-documented account of pallid sturgeon in the Milk River by MTFWP personnel occurred on May 28 when an implanted male crossed the Milk River logging station. This individual exited the Milk River on the following day.

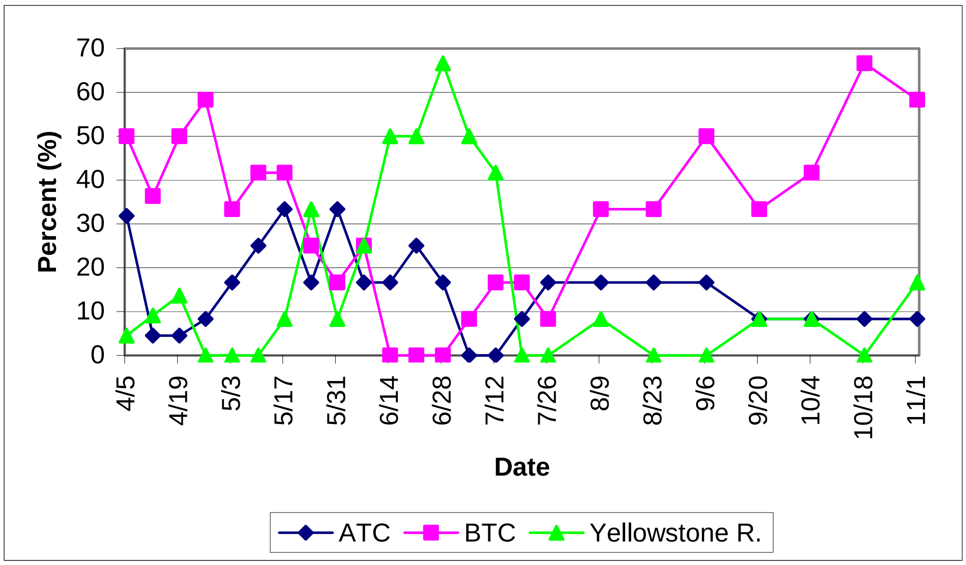


Figure 21. Percent of implanted pallid sturgeon relocated in the reaches of the Missouri River and Yellowstone River in 2004.

Transmitter implantation.- Sampling during September 2004 resulted in capturing 22 shovelnose sturgeon, 20 blue suckers, and 10 paddlefish suitable for implanting CART tags (Table 14). Shovelnose sturgeon and blue suckers were collected in the Missouri River from the Milk River confluence to the Yellowstone River confluence. Because the Fort Peck project is not granted permission to implant paddlefish in the North Dakota portions of the Missouri River where paddlefish are abundant and can be readily caught, sampling efforts for paddlefish were restricted to the upper reach of the Missouri River below Fort Peck Dam where paddlefish are not as abundant. One concentration of paddlefish was found in the Missouri River near Wolf Point and Sand Creek (rkm 2763, rm 1716), and ten individuals were implanted at this site.

Table 14. Number, sex ratio (male:female:undetermined), length (mm), and weight (g) for shovelnose sturgeon, blue suckers, and paddlefish implanted with transmitters during September 2004.

Species	Number tagged	Sex Ratio	Metric	Mean	Minimum	Maximum
			Length	780 mm	703 mm	865 mm
Shovelnose sturgeon	22	7:14:1	Weight	2213 gm	1600 gm	1300 gm
			Length	725 mm	647 mm	809 mm
Blue sucker	20	8:11:1	Weight	3266 gm	1750 gm	5000 gm
			Length	1014 mm	940 mm	1185 mm
Paddlefish	10	6:2:2	Weight	15.75 kg	11 kg	27 kg
			Length			
Pallid sturgeon *	2	1:1:0	Weight	14.5 kg		

* These two individuals were implanted in the spring 2004. In addition to these fish, the USFWS implanted 9 post-spawn pallid sturgeon in the fall 2004 (7 males and 2 females).

Monitoring Component 4 – Larval Fish

Larval fish during 2004 were sampled on 21 individual sampling events between May 25 and August 3. The larval fish sampling regime resulted in a total of 2,072 larval fish subsamples (252 samples at the site downstream from Fort Peck Dam, 166 samples in the spillway, 394 samples in the Milk River, 420 samples at Wolf Point, 420 samples at Nohly, 420 samples in the Yellowstone River). Mean volume of water sampled per subsample was 66.3 m^3 at the site downstream from Fort Peck Dam (total = 16,699 m^3), 23.2 m^3 in the spillway (total = 3,849 m^3), 75.1 m^3 in the Milk River (total = 29,577 m^3), 82.8 m^3 at Wolf Point (total = 34,757 m^3), 71.1 m^3 at Nohly (total = 29,867 m^3), and 55.6 m^3 in the Yellowstone River (total = 23,372 m^3). ..

Relative abundance of larval fishes and eggs. A total 11,526 larvae representing eight families were sampled across sites during 2004 (Table 15). Representatives of Catostomidae (e.g., suckers) were the numerically dominant taxon and composed 91.2% of the larvae sampled. Other relatively abundant taxa sampled included Cyprinidae (e.g., minnows and carps, 3.2%), Percidae (e.g., perches, 2.9%), and Hiodontidae (exclusively goldeye, *Hiodon alosoides*, 1.2%). Larval Polyodontidae (exclusively paddlefish, *Polyodon spathula*) and larval sturgeon (*Scaphirhynchus spp,* Acipenseridae) composed 0.8% and 0.2% of the larval fishes sampled, respectively.

Table 15. Number (N) and frequency (%) of larval fishes, and numbers of juveniles, adults, and eggs sampled at six sites during 2004. T = less than 0.1%.

	Below Fort Peck Dam		**Spillway**		**Milk River**		**Wolf Point**		**Nohly**		**Yellowstone River**	
Taxon	N	%	N	%	N	%	N	%	N	%	N	%
Acipenseridae							9	0.6	7	1.9	12	1.8
Catostomidae	123	98.4	1390	94.8	7102	96.5	1263	82.7	162	44.1	471	69.3
Cyprinidae	1	0.8	55	3.8	147	2.0	43	2.8	16	4.4	106	15.6
Hiodontidae			4	0.3	66	0.9	4	0.3	14	3.8	48	7.1
Ictaluridae											5	0.7
Percidae	1	0.8	12	0.8			177	11.6	131	35.7	9	1.3
Polyodontidae					42	0.6	14	0.9	16	4.4	20	2.9
Sciaenidae					1	T	1	T	2	0.5		
Unknown-sturgeon/paddlefish									1	0.3	2	0.3
Unknown-other			5	0.3	3	T	16	1.0	18	4.9	7	1.0
Total larvae	125		1466		7361		1527		367		680	
Juveniles			18		35		2		4		5	
Adults					4				1			
Sturgeon/paddlefish eggs									1		2	
Misc. eggs	810		136		9525		2856		1847		10903	

Composition of the larval fishes sampled in 2004 varied among taxa and sites (Table 15). Seven families of larval fishes were sampled in the Yellowstone River, and in the Missouri River at Wolf Point and Nohly. Five families were sampled in the Milk River; whereas, the least number of families was sampled in the spillway (4 families) and at the site downstream from Fort Peck Dam (3 families). Representatives of Catostomidae and Cyprinidae were sampled at all six sites. Hiodontidae (goldeye) were sampled at five sites, but were not present at the site downstream from Fort Peck Dam. Percidae (walleye and sauger) were sampled at all sites with the exception of the Milk River. Ictalurids (catfishes) were sampled exclusively in the Yellowstone River. Larval freshwater drum (Sciaenidae) were sampled only in the Milk River, and in the Missouri River at Nohly and Wolf Point. Paddlefish (Polyodontidae) were sampled at four sites including the Milk River, Yellowstone River, and the Missouri River at Wolf Point and Nohly. Larval sturgeon (Acipenseridae) were sampled in the Yellowstone River, and in the Missouri River at Wolf Point and Nohly.

Spatial and temporal periodicity and densities of larval Scaphirhynchus sp. and larval paddlefish. The periodicity and densities of larval sturgeon and paddlefish sampled during 2004 varied among sampling sites and dates. Although larval sturgeon were not sampled in the Milk River, reproduction by paddlefish occurred in the Milk River as evidenced by collection of 42 paddlefish larvae (Table 16). Larval paddlefish were sampled only during two dates, and mean densities varied from 0.78 larvae/100 m^3 on June 9 to 1.67 larvae/100 m^3 on June 7.

Table 16. Total number of paddlefish sampled (N), mean density (mean; number/100 m^3), median density, minimum density, and maximum density of larval paddlefish by date in the Milk River during 2004.

Date	N	Mean	Median	Minimum	Maximum
5/25					
5/28					
5/31					
6/03					
6/07	32	1.67	1.00	0.53	4.47
6/09	10	0.78	0.57	0	2.06
6/14					
6/16					
6/21					
6/23					
6/28					
6/30					
7/06					
7/09					
7/12					
7/14					
7/19					
7/21					
7/26					
7/29					
8/02					

In the Missouri River at Wolf Point, larval sturgeon and paddlefish were sampled over about a two month time period (Table 17). First, a total of nine larval sturgeon were sampled on six dates between July 8 and August 2. Mean density of larval sturgeon tended to be highest on July 15 (0.21 larvae/100 m^3) and August 2 (0.13 larvae/100 m^3), but less than 0.08 larvae/100 m^3 on the other four dates. Larval paddlefish (N = 14) were sampled on five dates between June 8 and July 1. Densities of larval paddlefish were relatively high (> 0.20 larvae/100 m^3) on June 10, June 14, and June 24, but less than 0.08 larvae/100 m^3 on June 8 and July 1.

Table 17. Total number sampled (N), mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of larval sturgeon (*Scaphirhynchus* sp.) and larval paddlefish by date in the Missouri River at Wolf Point during 2004.

	Scaphirhynchus sp.					**Paddlefish**				
Date	**N**	**Mean**	**Median**	**Min.**	**Max.**	**N**	**Mean**	**Median**	**Min.**	**Max.**
5/25										
5/27										
6/01										
6/04										
6/08						1	0.06	0	0	0.30
6/10						4	0.21	0.28	0	0.29
6/14						3	0.21	0.26	0	0.43
6/17										
6/21										
6/24						5	0.32	0.33	0	0.69
6/29										
7/01						1	0.07	0	0	0.35
7/06										
7/08	1	0.07	0	0	0.34					
7/12										
7/15	3	0.21	0.31	0	0.43					
7/20	1	0.05	0	0	0.26					
7/22	1	0.07	0	0	0.37					
7/26	1	0.05	0	0	0.24					
7/28										
8/02	2	0.13	0	0	0.35					

Larval sturgeon in the Missouri River at Nohly were sampled on only three dates (July 15, July 19, and July 29) during 2004 (Table 18). The highest density of larval sturgeon occurred on July 15 (mean = 0.29 larvae/100 m^3) when four larvae were sampled. Densities of larval sturgeon on July 19 and July 29 were less than 0.14 larvae/100 m^3. Larval paddlefish were sampled in the drift on six dates between June 8 and June 30. Highest concentrations of larval paddlefish occurred on June 15 (mean = 0.52 larvae/100 m^3) and June 17 (0.44 larvae/100 m^3).

Table 18. Total number sampled (N), mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of larval sturgeon and larval paddlefish by date in the Missouri River at Nohly during 2004.

	Scaphirhynchus spp.					**Paddlefish**				
Date	**N**	**Mean**	**Median**	**Min.**	**Max.**	**N**	**Mean**	**Median**	**Min.**	**Max.**
5/26										
5/28										
6/01										
6/03										
6/08						2	0.17	0	0	0.86
6/10						1	0.11	0	0	0.54
6/15						6	0.52	0.61	0	1.06
6/17						4	0.44	0	0	1.25
6/22										
6/24										
6/28						1	0.08	0	0	0.40
6/30						2	0.21	0	0	0.79
7/07										
7/09										
7/13										
7/15	4	0.29	0	0	0.82					
7/19	2	0.13	0	0	0.35					
7/21										
7/26										
7/29	1	0.08	0	0	0.41					
8/03										

Totals of 12 larval sturgeon and 20 larval paddlefish were sampled from the Yellowstone River during 2004 (Table 19). Larval sturgeon were sampled primarily on three dates (July 7, July 9, and July 13) when mean densities exceeded 0.20 larvae/100 m^3. One larval sturgeon was sampled on August 3 and mean density was low (0.13 larvae/100 m^3). Larval paddlefish in the Yellowstone River were sampled consistently between June 22 and June 30 at densities varying from 0.05 – 0.48 larvae/100 m^3. However, highest densities of paddlefish occurred on an earlier date (June 8), and mean density was 0.53 larvae/100 m^3.

Table 19. Total number sampled (N), mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of larval sturgeon (*Scaphirhynchus* sp.) and larval paddlefish by date in the Yellowstone River during 2004.

	Scaphirhynchus spp.					**Paddlefish**				
Date	**N**	**Mean**	**Median**	**Min.**	**Max.**	**N**	**Mean**	**Median**	**Min.**	**Max.**
5/26										
5/28										
6/01										
6/03										
6/08						3	0.53	0	0	1.47
6/10										
6/15										
6/17										
6/22						6	0.41	0	0	0.85
6/24						8	0.48	0	0	2.17
6/28						2	0.16	0	0	0.44
6/30						1	0.05	0	0	0.24
7/07	3	0.23	0.33	0	0.43					
7/09	4	0.28	0.27	0	0.57					
7/13	4	0.30	0.37	0	0.43					
7/15										
7/19										
7/21										
7/26										
7/29										
8/03	1	0.13	0	0	0.63					

Larval nets fished on the bottom sampled a greater proportion of larval sturgeon than larval nets fished in the mid-water column. For example, across sites, 86% of the larval sturgeon sampled during 2004 were collected in nets fish on the bottom (100% at Nohly, 89% at Wolf Point, and 75% in the Yellowstone River).

Spatial and temporal periodicity and densities of larval fishes exclusive of Acipenseridae and Polyodontidae. The larval fish community at the site downstream from Fort Peck Dam was comprised almost exclusively of Catostomidae (Figure 22). Mean densities of Catostomidae increased from early June to a maximum of 3.75 larvae/100 m^3 on June 28, then declined through late July. Percids were present only during late May; whereas, representatives of Cyprinidae were sampled only during mid-July.

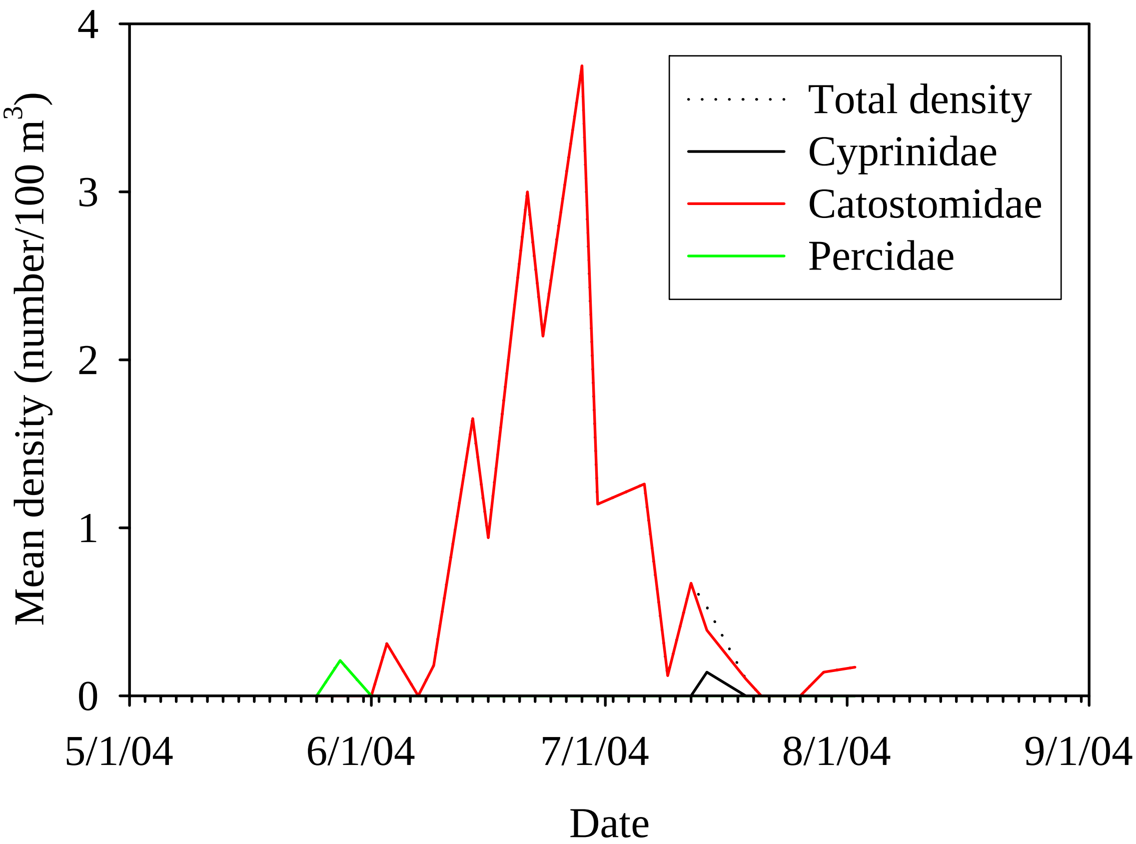


Figure 22. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, and Percidae sampled in the Missouri River at the site downstream from Fort Peck Dam during 2004.

Larval fishes in the spillway channel exhibited two periods of exceptionally high densities (Figure 23). The first period of elevated densities occurred on June 28 when Catostomids composed 100% of the larval fish assemblage and exhibited a mean density of 461 larvae/100 m^3. Mean densities declined through early July then increased to a secondary peak on July 12 when mean density was 346 larvae/100 m^3. Catostomids composed 93% of the total density on this date, and there was a slight larval contribution (7%) from representatives of Cyprinidae. Larval percids were sampled on three dates during late May (mean densities ≤ 2.1 larvae/100 m^3); whereas, goldeye (Hiodotidae) were collected on three dates during early June (mean densities ≤ 1.0 larvae/100 m^3).

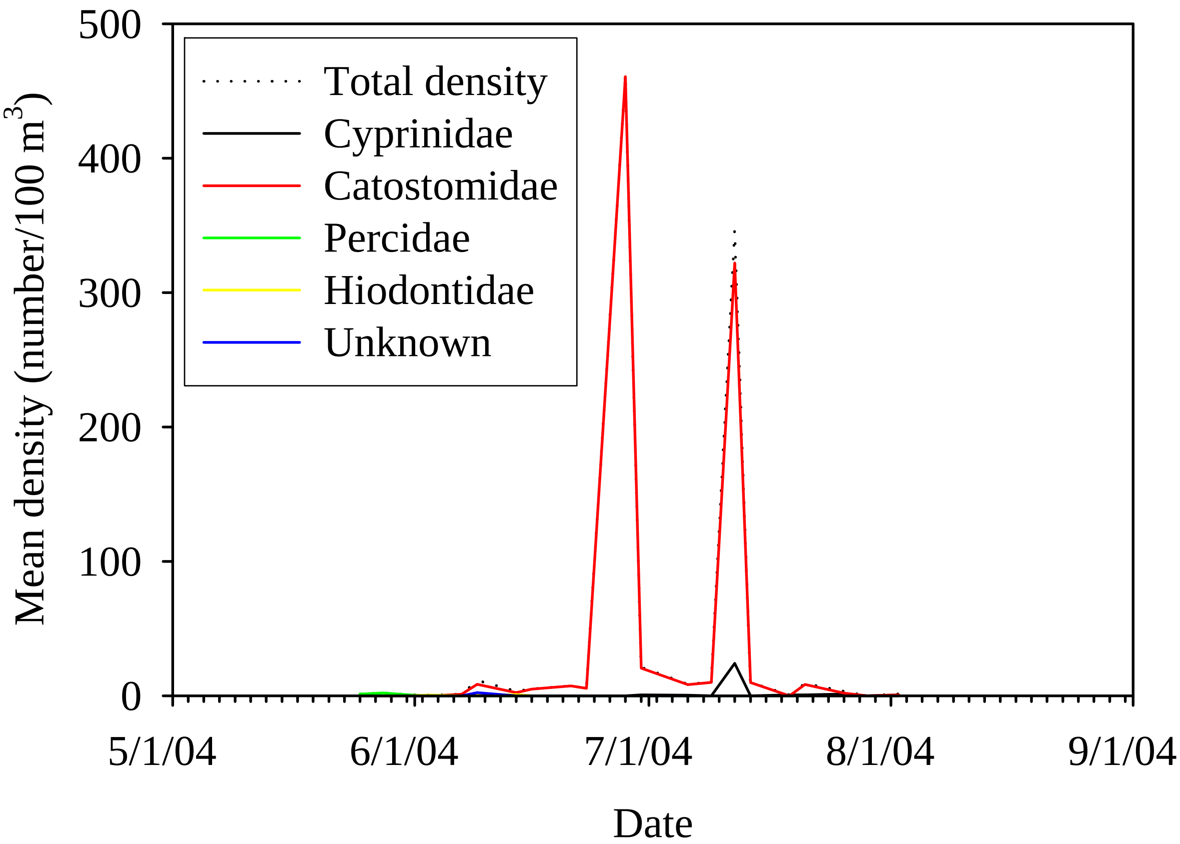


Figure 23. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Hiodontidae, and unknown sampled in the Fort Peck spillway channel during 2004.

Similar to the dam and spillway sites, the larval fish assemblage sampled in the Milk River was comprised almost exclusively of Catostomidae (Figure 24). Catostomids exhibited two dates of elevated densities when mean density was 171 larvae/100 m^3 (June 7) and 121 larvae/100 m^3 (June 23). Representatives of Cyprinidae were sampled on 17 of 21 sampling dates, but mean densities on these dates was low ($\leq$ 4.3 larvae/100 m^3). Goldeye were sampled on 10 of 21 sampling dates but at low densities (mean $\leq$ 0.89 larvae/100 m^3). Freshwater drum were sampled only on July 29 (mean density = 0.07 larvae/100 m^3).

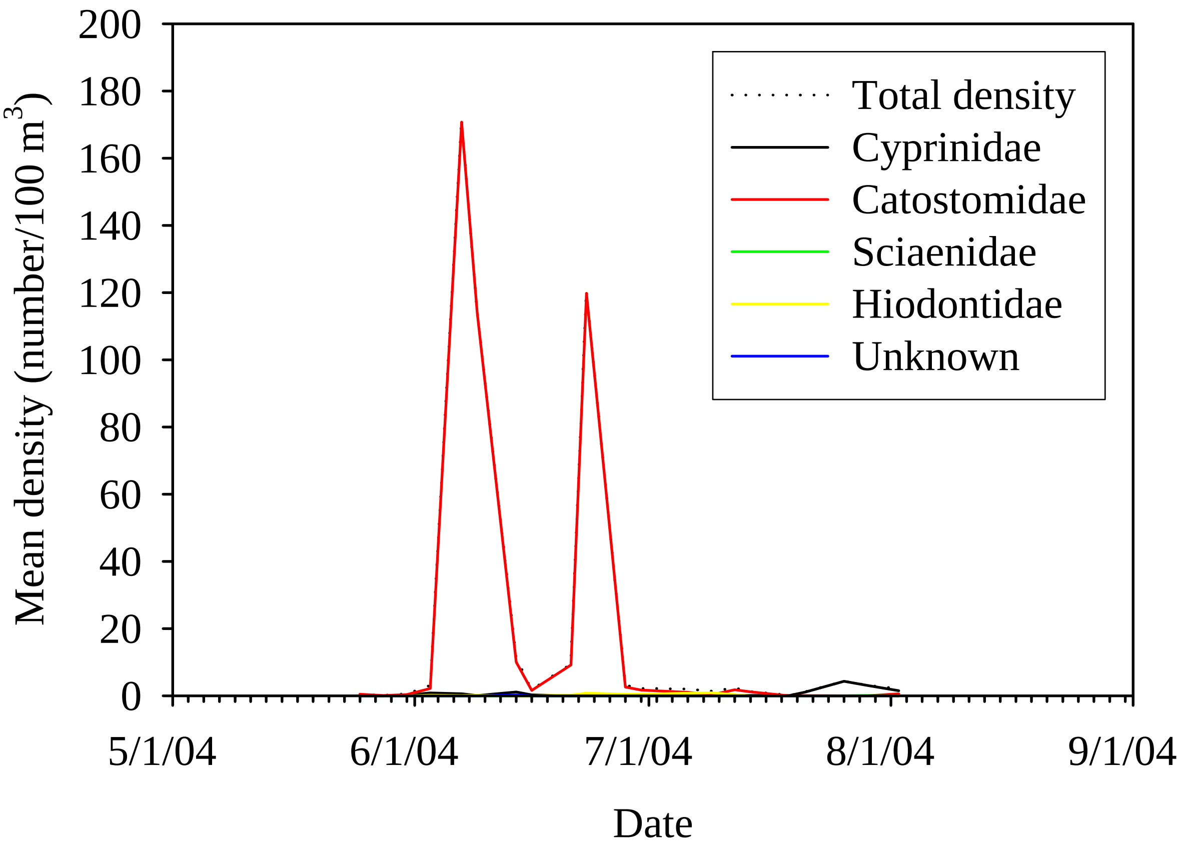


Figure 24. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Sciaenidae, and unknown sampled in the Milk River during 2004.

The larval fish community sampled at Wolf Point exhibited multiple periods of elevated densities primarily resulting from temporal periodicity in the densities of Percidae and Catostomidae (Figure 25). The first period of elevated densities occurred on June 1 (mean density = 2.86 larvae/100 m^3) as percids composed 94% of the larvae sampled. As densities of percids declined during early June, mean total density increased to 8.7 larvae/100 m^3 on June 14 as representatives of Catostomidae composed 87% of the larval fish assemblage. Three additional peaks in larval fish densities occurred at Wolf Point on June 29 (mean = 9.47 larvae/100 m^3), July 1 (mean = 9.47 larvae/100 m^3), and July 12 (mean = 8.5 larvae/100 m^3) when Catostomids composed greater than 96% of the larvae sampled. Three additional taxa including Cyprinidae, goldeyes, and freshwater drum were sampled on 15, 3, and 1 date, respectively, but densities were less than 0.53 larvae/100 m^3.

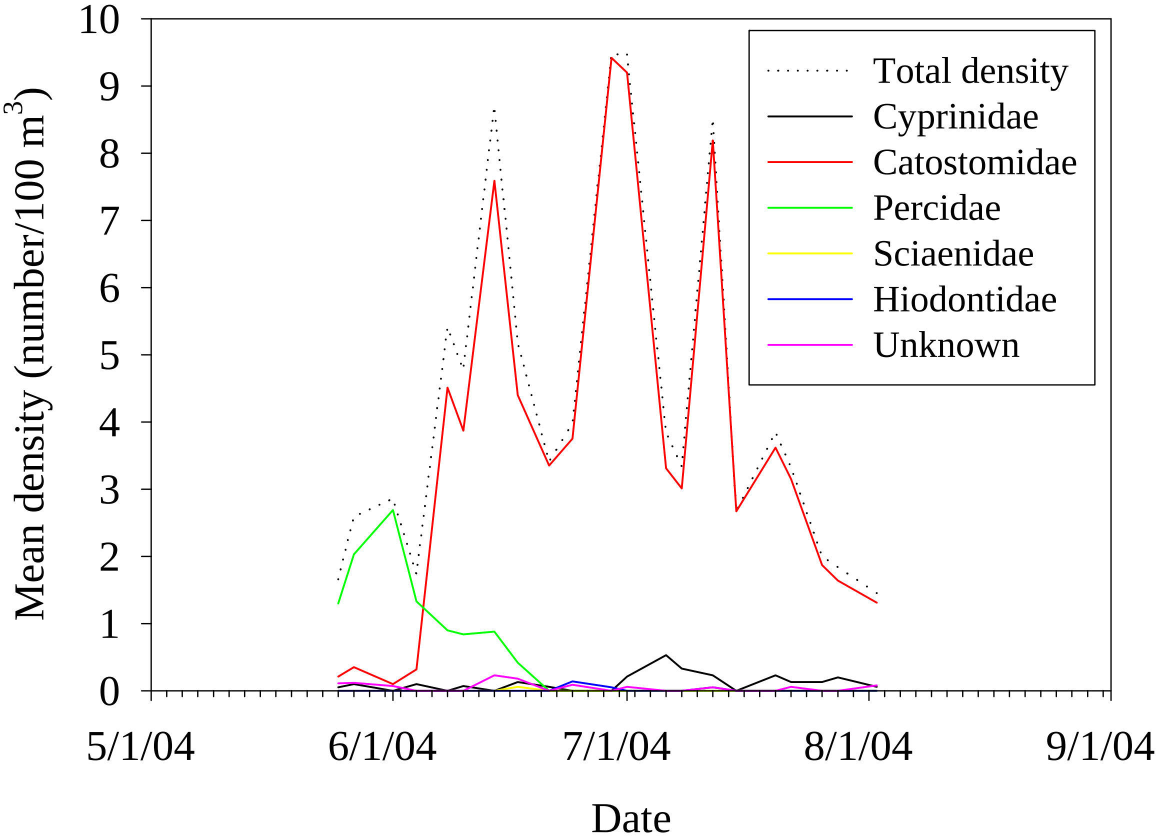


Figure 25. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Sciaenidae, and unknown sampled in the Missouri River at Wolf Point during 2004.

The larval fish community in the Missouri River at Nohly exhibited three major periods of elevated densities that were attributed primarily to the temporal periodicity of Percidae and Catostomidae, and secondarily to contributions from other taxa (Figure 26). The first peak in larval densities occurred on June (mean = 2.55 larvae/100 m^3) as representatives of Percidae composed 87% of the larval fish assemblage sampled. Densities declined slightly through early June then increased on June 17 (mean density = 4.99 larvae/100 m^3) as Catostomidae increased in abundance (69% of the total) in conjunction with an slight increased in the abundance of Percidae (28% of the total). Larval densities declined through late June, but density increased on June 30 (mean = 1.66 larvae/100 m^3) as Catostomidae composed 97% of the larval fish community. Representatives of Cyprinidae, freshwater drum, and goldeye were sampled on 8, 1, and 5 dates, respectively, but densities of these taxa were low on all dates (mean density ≤ 0.41 larvae/100 m^3).

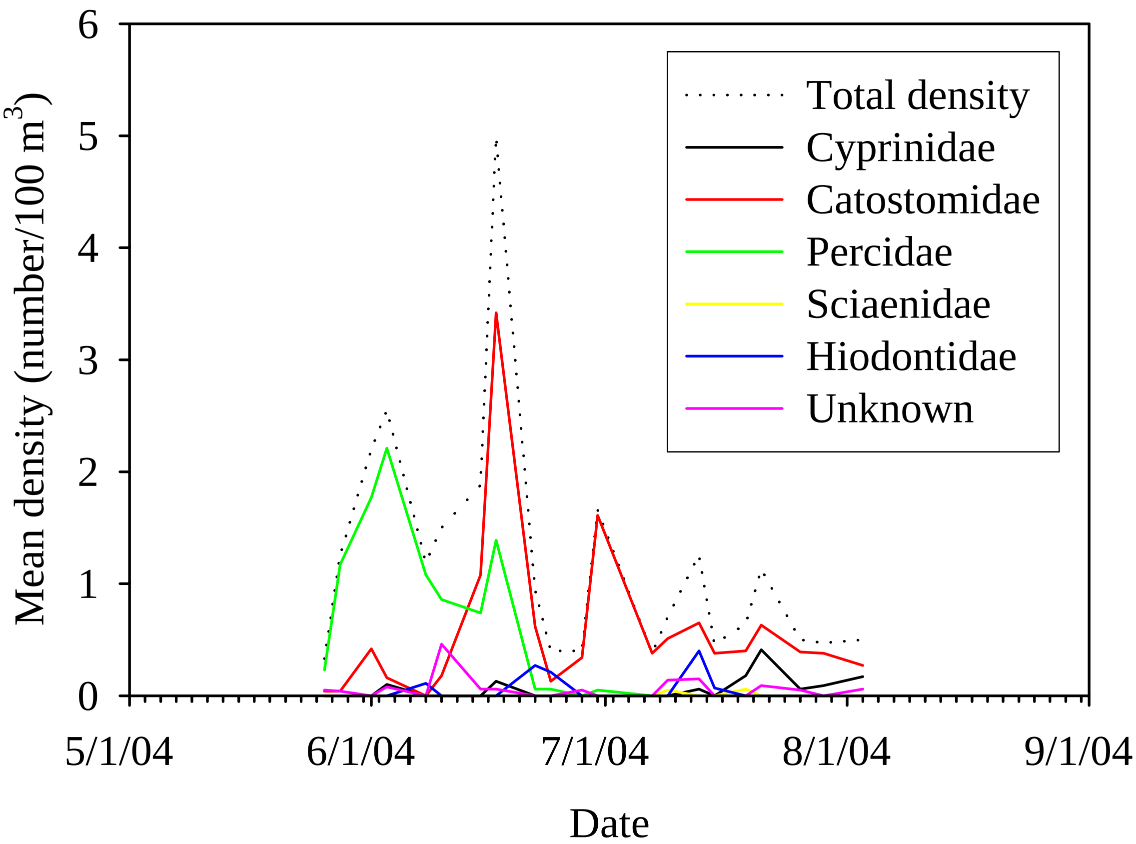


Figure 26. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Sciaenidae, Hiodontidae, and unknown larvae sampled in the Missouri River near Nohly during 2004.

The larval fish assemblage in the Yellowstone River exhibited temporal variations in density during the 2004 sampling period that corresponded primarily to the temporal periodicity of Catostomidae and Cyprinidae in the drift (Figure 27). Larval fish densities peaked on June 10 (mean = 10.43 larvae/100 m^3) as representatives of Catostomidae composed 89% of the larval fish densities. Following a decline in larval fish densities during mid-June, densities increased on June 30 (mean = 5.0 larvae/100 m^3) and July 9 (mean = 5.0 larvae/100 m^3) as Catostomids composed 77 – 91% of the larval fish densities. Densities of Catostomidae decreased through late July and early August, but larval fish densities increased on July 13 (mean = 5.36 larval/100 m^3) and July 29 (mean = 3.27 larvae/100 m^3) as Cyprinids increased in abundance and composed 49 – 94% of the larval fish densities. Percidae larvae were sampled early in the season on three dates (May 26, May 28, and June 3), but densities were low (mean ≤ 0.67 larvae/100 m^3). Larval goldeyes were sampled on 12 dates between June 3 and July 13 at low densities (mean ≤ 0.84 larvae/100 m^3) except for one date when goldeye density was 1.54 larvae/100 m^3 (June 15). Ictalurids were sampled on June 10 (mean density = 0.23 larvae/100 m^3) and July 13 (0.40 larvae/100 m^3).

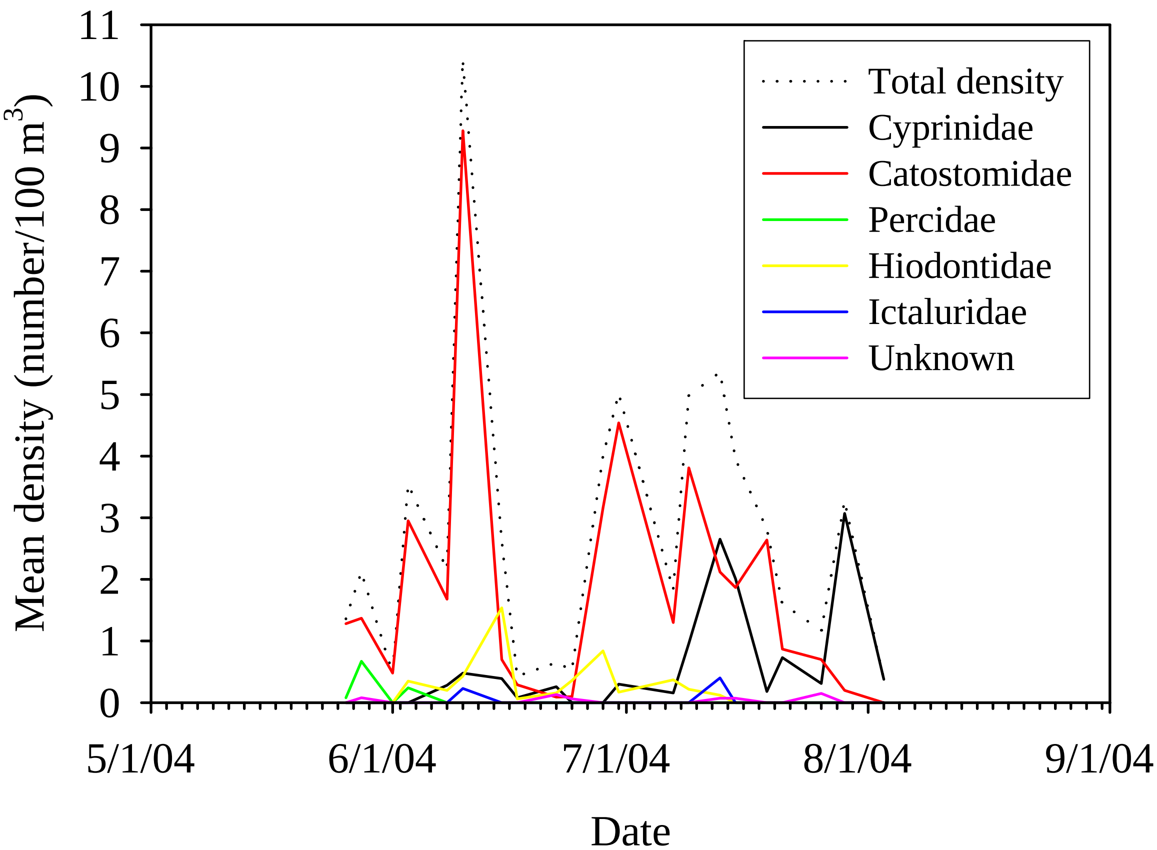


Figure 27. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Ictaluridae, and unknown larvae sampled in the Yellowstone River during 2004.

Inter-annual trends in larval fish densities.- The final analyses of larval fish densities across spatial (e.g., sites) and temporal (e.g., inter-annual, weekly) scales will be completed after the study is completed; however, summary statistics were calculated for 2001, 2002, 2003, and 2004 to present trends in larval fish densities to date (Figure 28). Larval fish densities at the site downstream from Fort Peck Dam have exhibited minimal inter-annual variation among years as median density has been less than 1.0 larvae/100 m^3 during all years. Densities of larval fishes at the other sites have exhibited increased inter-annual variation, and in general, median densities were lowest during 2003 in the spillway channel, Milk River, Wolf Point, and Nohly. In the Yellowstone River, median densities were generally lowest during 2003 and 2004.

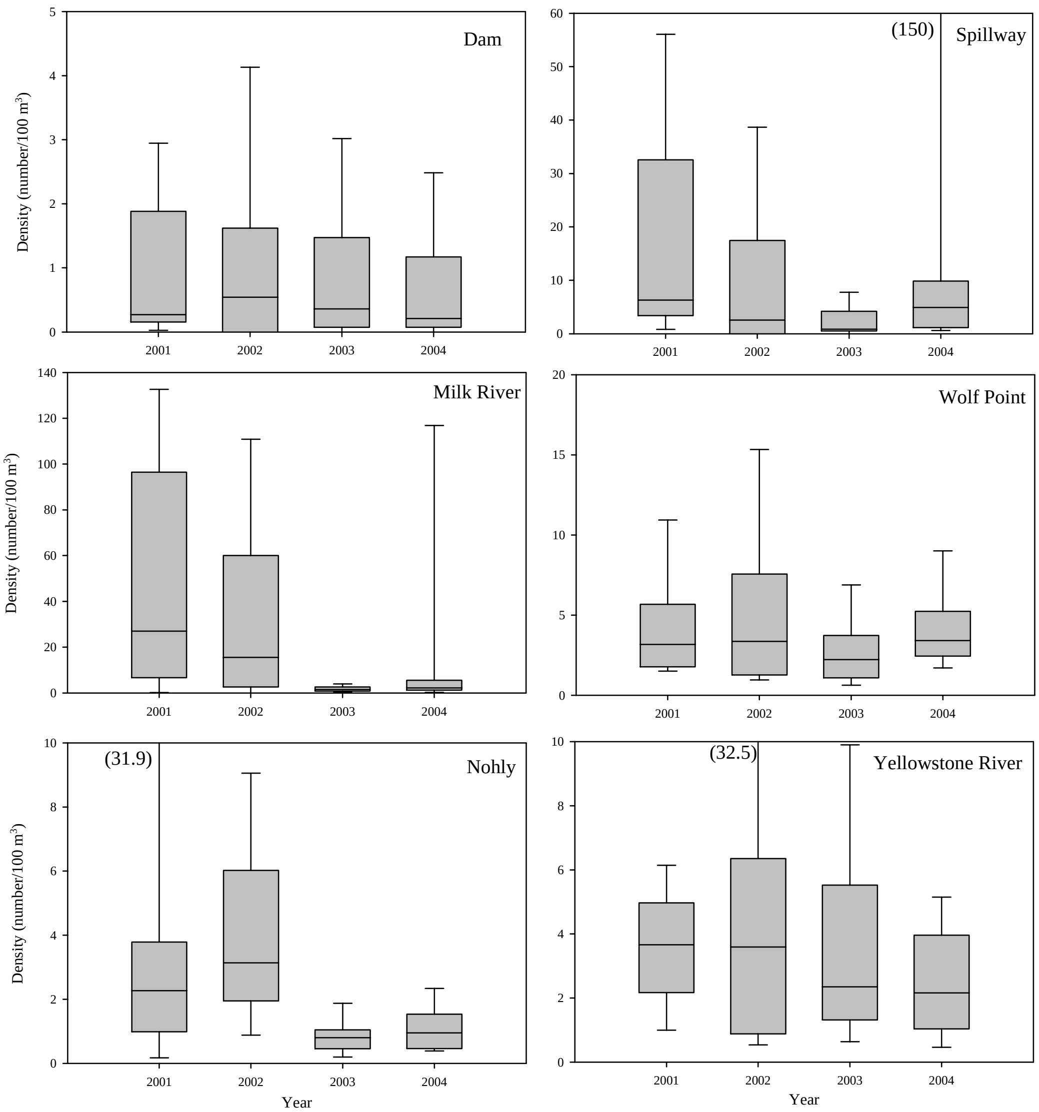


Figure 28. Box and whisker plots of total density (all taxa combined averaged among dates; number/100 m^3) of larval fishes sampled at six sites in 2001, 2002, 2003, and 2004. Boxes delimit the 25th and 75th percentiles of the data, line within the boxes denotes the median, and whiskers delimit the 10th and 90th percentiles. Data span from late May through early August with the exception of 2001 when sampling was terminated in late July.

<u>Monitoring Component 5 – Reproductive success of shovelnose sturgeon and pallid sturgeon.</u>

Young-of-year sturgeon sampling.- A total of 369 trawls were conducted on eight sampling events between July 21 and September 8 (Table 20). Effort was partitioned among the Missouri River ATC (88 trawls), Missouri River BTC (215 trawls), and Yellowstone River (66 trawls). A total of 81 young-of-year sturgeon were sampled. Standard sampling protocols and extra sampling in the Missouri River ATC failed to yield any young-of-year sturgeon. Similarly, no young-of-year sturgeon were sampled from sites in the Yellowstone River. All 81 young-of-year sturgeon sampled during 2004 were collected in the Missouri River BTC. Ninety percent (73 individuals) of the young-of-year sturgeon sampled were obtained from the most downstream site located at the Highway 85 bridge.

Relative abundance of young-of-year sturgeon sampled during 2004 varied among sampling dates (Table 20). Young-of-year sturgeon were sampled on three events between July 21 and August 4 when standard sampling accounted for 10 individuals and targeted sampling accounted for 43 individuals. No young-of-year sturgeon were sampled during the mid-August sampling events, and extra trawl sampling was initiated in an attempt to confirm the lack of sturgeon at the site and attempt to find young-of-year sturgeon in the area. Intensive extra sampling between August 16 and August 19 resulted in only three individuals, and these individuals were found downstream from the Highway 85 study site. Young-of-year shovelnose sturgeon were again present at the Highway 85 study site during late August and early September when standard sampling and targeted sampling resulted in the collection of 8 and 28, individuals, respectively.

Lengths of young-of-year sturgeon sampled varied among sampling dates. Lengths are as follows: July 21 (median = 19.0 mm, minimum = 18.0, maximum = 25.0 mm, N = 6), July 29 (median = 26.5 mm, minimum = 17.0 mm, maximum = 39.0, N = 22), August 4 (median = 41.0 mm, minimum = 18.0, maximum = 59.0 mm, N = 25), August 19 (median = 70.0 mm, minimum = 59.0 mm, maximum = 93.0, N = 3), August 24 (median = 46.0 mm, minimum = 20.0, maximum = 101.0 mm, N = 17), August 31 (median = 64.0 mm, minimum = 42.0 mm, maximum = 85.0, N = 2), September 7 (median = 36.0 mm, minimum = 22.0 mm, maximum = 98.0, N = 6).

Identification of young-of-year sturgeon.-Species designation (i.e., shovelnose sturgeon versus pallid sturgeon) of young-of-year sturgeon sampled in 2004 has not been confirmed to date by genetic testing. However, several individuals sampled during 2004 have been tentatively identified. Tissue samples will be sent to Dr. Ed Heist for genetic testing and final species confirmation.

In 2004, species confirmation results were obtained for young-of-year sturgeon sampled during fall 2003. Genetic testing of 29 individuals sent to Dr. Ed Heist and Aaron Schrey (Southern Illinois University) indicated that two individuals sampled from the Highway 85 bridge site in North Dakota (sample date 8/12/03, length = 22 mm; sample date 8/26/03, length = 21 mm) exhibited a pallid sturgeon genotype (Schrey and Heist 2004). The genotype from the first individual was strongly indicative of a pallid sturgeon as this individual was 210 times more likely to have been generated from a pallid sturgeon gene pool than a shovelnose sturgeon gene pool. Conversely, the second individual was only 1.6 times more likely to have been generated from a pallid sturgeon gene pool. Several individuals also had genetic characteristics suggestive of hybrids. Thus, based on genetic testing, it is highly likely that limited pallid sturgeon reproduction occurred during 2004. In addition, there is strong evidence that some hybridization between pallid sturgeon and shovelnose sturgeon is occurring in the upper Missouri/Yellowstone river systems.

In January 2005, species confirmation results for 39 young-of-year sturgeon sampled in 2003 were received from Dr. Darrel Snyder and Sean Seal (Colorado State University; Snyder and

Seal 2005). This group of young-of-year sturgeon included the 29 individuals sent to Dr. Heist for genetic testing. The morphometric/meristic results identified one individuals as a highly probable pallid sturgeon, several others as tentative pallid sturgeon, and several others as probable hybrids. Similar to the genetic results, results from Snyder and Seal (2005) suggest that pallid sturgeon reproduction occurred during 2003 and that hybridization is also occurring. Unfortunately, results from the genetics and morphometrics/meristics analyses were somewhat contradictory. For example, the individual confirmed as a pallid sturgeon by genetic testing was identified as a shovelnose sturgeon based on morphometrics/meristic characteristics. Other discrepancies were also noted in species designations. Additional investigations are currently being conducted to address the discrepancies.

Table 20. Number of young-of-year sturgeon sampled and sampling effort expended in 2004 by site and date. Sampling protocols include Standard (first trawl only at a specific location), Targeted (additional trawls at a specific location when a young-of-year sturgeon was sampled in the first trawl), and Extra (additional sampling above and beyond the Standard and Targeted sampling). ATC = Missouri River upstream from the Yellowstone River confluence, BTC = Missouri River downstream from the Yellowstone River confluence.

			Date 2004							
Site	**Sampling protocol**	**Metric**	**7/21**	**7/28-7/29**	**8/3-8/4**	**8/10-8/11**	**8/16-8/19**	**8/24-8/25**	**8/31-9/1**	**9/7-9/8**
Missouri River										
ATC	Standard	Sturgeon sampled								
		Number of trawls		12	12	12	12	12	12	12
		Total minutes		46.5	46.0	46.0	48.0	45.0	48.0	48.0
	Extra	Sturgeon sampled								
		Number of trawls					4			
		Total minutes					15.0			
Missouri River										
BTC	Standard	Sturgeon sampled	2	5	3			3	2	3
		Number of trawls	9	12	18	18	18	18	18	18
		Total minutes	35.5	48.0	72.0	72.0	72.0	71.0	72.0	72.0
	Targeted	Sturgeon sampled	4	17	22			14		
		Number of trawls	8	12	16			18	4	6
		Total minutes	32.0	48.0	64.0			72.0	16.0	24.0
	Extra	Sturgeon sampled					3			3
		Number of trawls				1	14		4	3
		Total minutes				4.0	59.75		14.7	12.0
Yellowstone										
River	Standard	Sturgeon sampled								
		Number of trawls			12	12	12	6	12	12
		Total minutes			48.0	48.0	46.0	24.0	48.0	48.0

<u>Component 6 - Assisting in the collection of adult pallid sturgeon for the propagation program.</u>

Crews associated with the Fort Peck Data Collection Plan were successful in capturing adult pallid sturgeon in the lower Yellowstone River and Missouri River downstream from the Yellowstone River confluence. Sampling efforts resulted in the capture of 23 adult pallid sturgeon, and these captures were distributed among April 20 through April 29 (N = 12), June 10 through June 30 (N = 5), and November 9 (N = 6). Some of these individuals included recaptures of fish previously used in the propagation program. Thus, not all of the individuals captured were sent to the hatchery system.

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Funding for this project was provided by the U. S. Army Corps of Engineers (Omaha District, John Palensky, Project Manager). Personnel from the MTFWP involved in this project are commended for their quality performance in the field and laboratory: Nik Anderson, Ben Bailey, Mike Buchheit, Landon Holte, Ryan Lott, Nathan McClenning, Bill Viste, and William Waller. Bill Gardner (MTFWP) provided water temperature data for the Missouri River upstream from Fort Peck Lake. Several other individuals provided logistical support including Fred Ryckman (North Dakota Game and Fish Department), Kevin Kapuscinski (MTFWP), Matt Baxter (MTFWP), Wade King (USFWS), and Ryan Wilson (USFWS).

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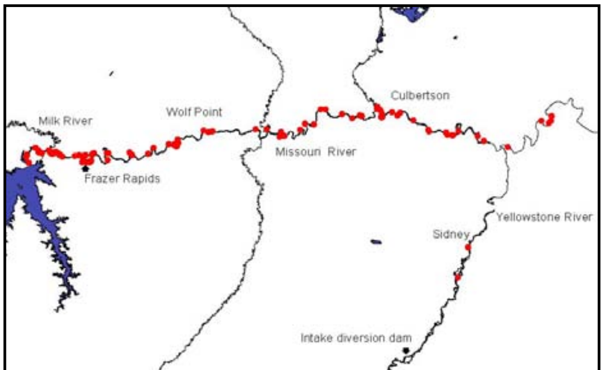
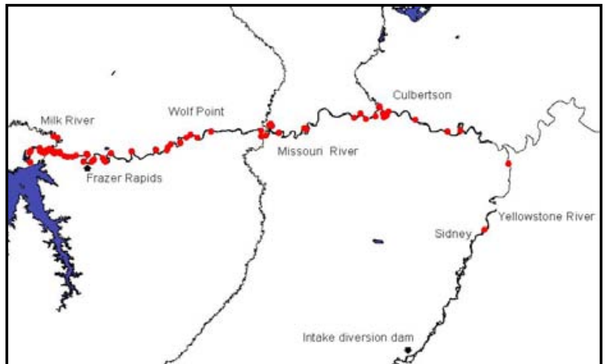
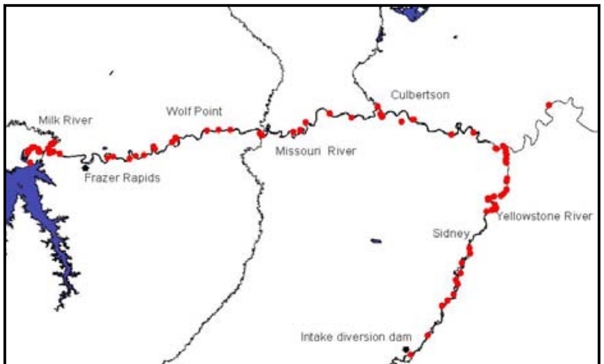
Appendix A. Map extent of blue sucker relocations during 2004.



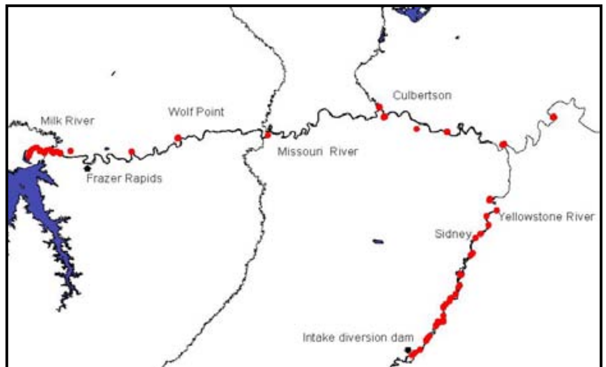
Appendix A.1. Blue sucker relocations in April 2004



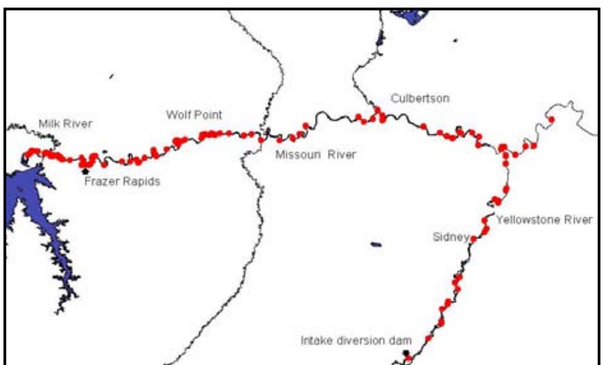
Appendix A.2. Blue sucker relocations in May 2004



Appendix A.3. Blue sucker relocations in June 2004

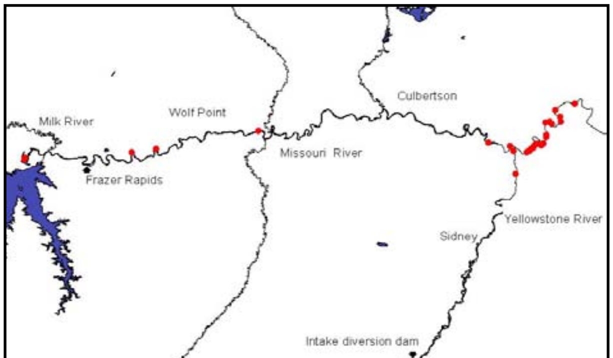


Appendix A.4. Blue sucker relocations in July 2004

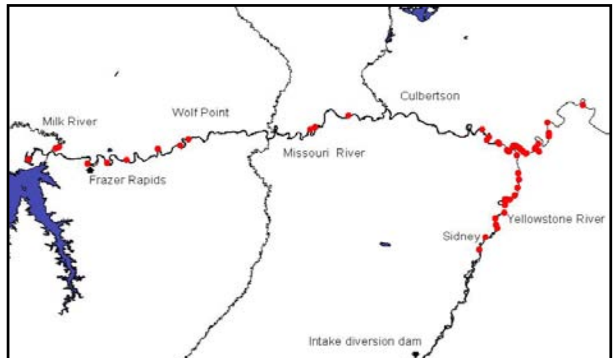


Appendix A.5. Blue sucker relocations in Fall 2004

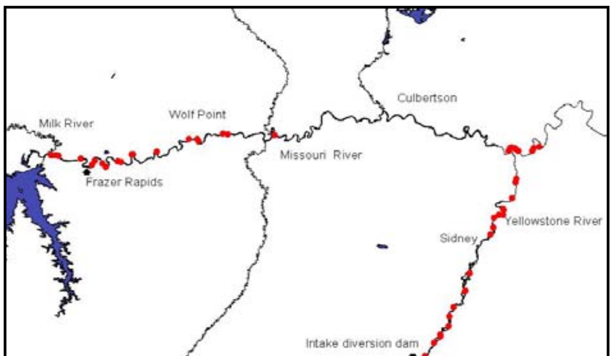
Appendix B. Map extent of paddlefish relocations during 2004.



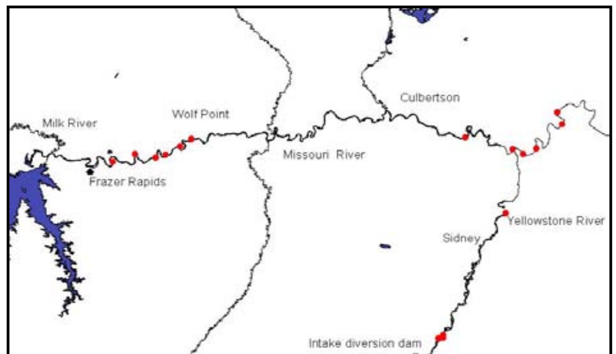
Appendix B.1. Paddlefish relocations in April 2004



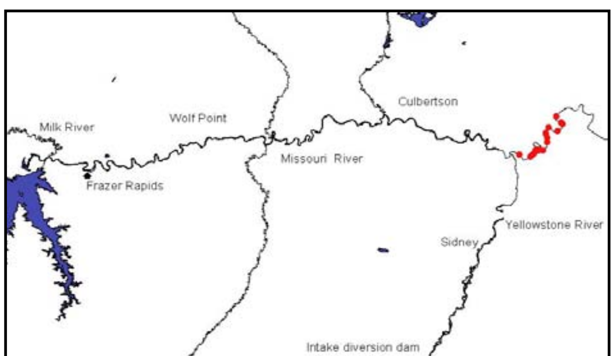
Appendix B.2. Paddlefish relocations in May 2004



Appendix B.3. Paddlefish relocations in June 2004

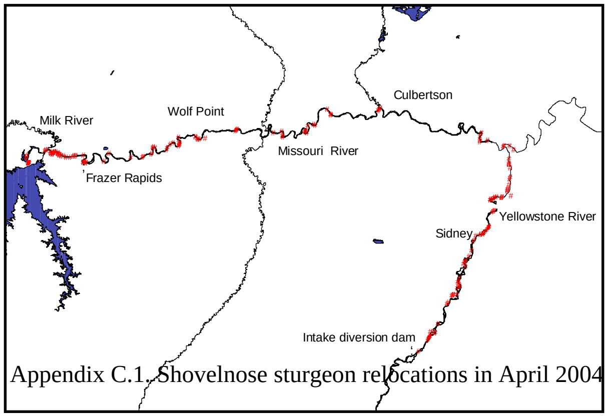


Appendix B.4. Paddlefish relocations in July 2004

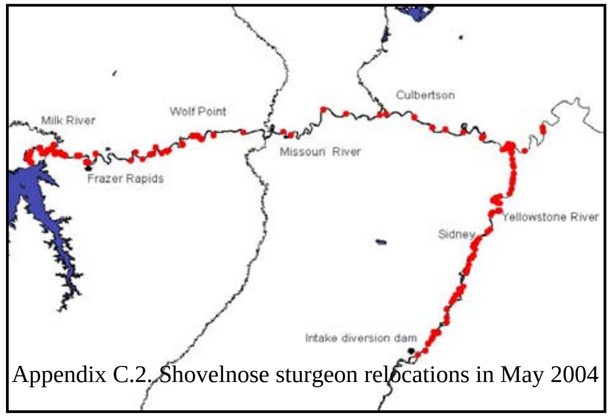


Appendix B.5. Paddlefish relocations in Fall 2004

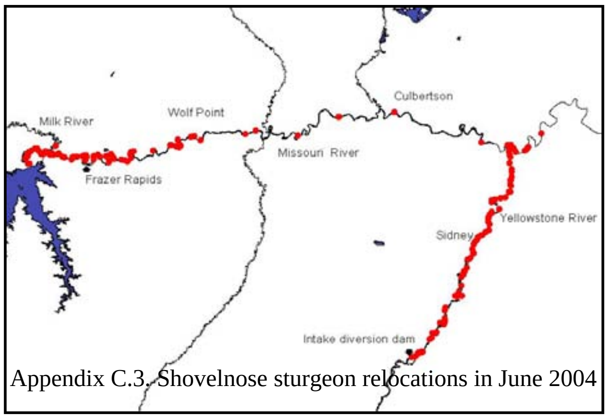
Appendix C. Map extent of shovelnose sturgeon relocations during 2004.



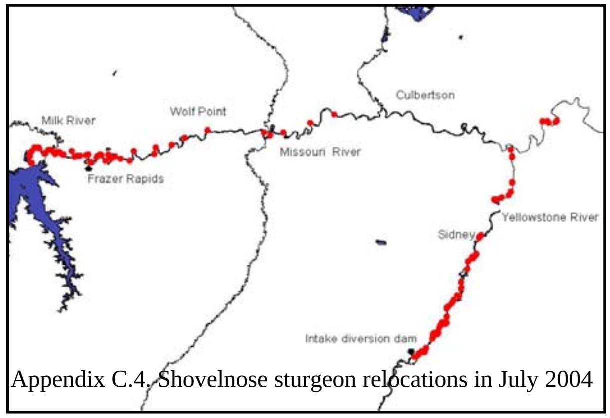
Appendix C.1. Shovelnose sturgeon relocations in April 2004



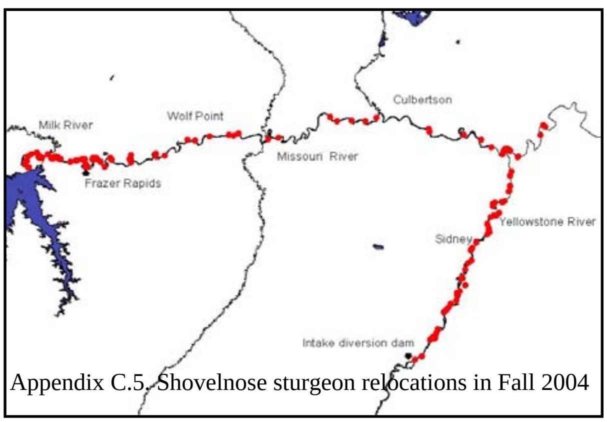
Appendix C.2. Shovelnose sturgeon relocations in May 2004



Appendix C.3. Shovelnose sturgeon relocations in June 2004



Appendix C.4. Shovelnose sturgeon relocations in July 2004



Appendix C.5. Shovelnose sturgeon relocations in Fall 2004

DRAFT
2004 PROGRESS REPORT

Post Spawn Pallid Sturgeon Telemetry Report

US Fish and Wildlife Service
Missouri River Fish and Wildlife Assistance Office
3425 Miriam Ave
Bismarck, ND

STUDY AREA

The study area is encompassed within the parameters of the entire riverine reach of the Missouri River from Fort Peck Dam, Fort Peck, MT., to the head waters of Lake Sakakawea in North Dakota. In addition, approximately 70 river miles of the Yellowstone River from the Confluence of the Yellowstone and Missouri Rivers (~RM 1582) to the Intake Diversion Dam, Intake MT.

METHODS

Manual boat tracking was conducted predominantly in the core study area based around the confluence of the two river systems. The reach on the Missouri River from approximately 10 miles below the Lewis and Clark boat ramp, near Williston, ND to Culbertson, MT was typically sampled on Tuesday; while the riverine reach on the Yellowstone River from the confluence to Intake, MT. was routinely sampled on Wednesdays. These two reaches were tracked weekly from the second week in May to the end of June, and then tracked every other week throughout the summer till the end of October, when fixed data logging stations were removed from the river.

Tracking was traditionally conducted early in the week intentionally so sampling would not coincide with the USGS tracking crews based out of Fort Peck, MT., who typically tracked the identical reaches later in the week. This was done to eliminate redundancy of relocations on fish on the same days in an attempt to get more movement data. Beginning in July, tracking was performed on alternating weeks when the USGS crews were not on the river.

Although the reaches sampled by USFWS crews did not represent the entire study reach, relatively little data was collected outside of the core area tracked. Data from outside of the core area was collected in the reaches of the upper Missouri River by USGS fixed data logging stations and boat crews tracking that reach of river for additional species. All pallid relocation data was pooled with USFWS data.

RESULTS

Twenty-one pallid sturgeon were tracked during the 2004 field season throughout the period of mid-April to November. A total of 643 useable relocations were obtained through manual boat relocations and the fixed data logging stations within the study area.

Twelve post-spawn pallid sturgeon were externally tagged in the fall of 2003 on an experimental basis to supplement our number of fish in the study. Unfortunately, all sturgeon fitted with external radios through the dorsal fin, shed or their tags were tore out and were eliminated from the study. Six of the twelve cart tags were recovered from netted sturgeon and were surgically implanted into post-spawn sturgeon at Garrison Dam National Fish Hatchery and were released back into the river in September of 2004.

Although external radio tag retention through the dorsal fin on white sturgeon has been good-to-excellent, the dorsal fin in pallid sturgeon is not rigid enough to keep tag wire from tearing through the tissue. This was evident from tags that were barely attached by the skin during the netting, which also was a result of the external tag getting caught in the net mesh itself and tearing. The method of external tagging of pallid sturgeon through the dorsal fin should not be attempted in future studies, until a better method is found.

Pallid sturgeon use of the upper Missouri River (see Figure 1) was fairly limited, especially in the reach from Wolf Point to Fort Peck Dam. One male that was spawned in 2001 traveled up the Missouri for a brief period in May to early June. Another fish, with an unknown sex status, was tagged by USGS below Fort Peck Dam in 2003 and was present there in mid-April when telemetry crews started tracking. This fish stayed in this reach until the end of June, when it migrated down the Missouri River and spent a period of time in the Yellowstone and then migrated back up the Missouri above Wolf Point where it was last relocated on November 1, 2004.

Relative abundance in the Wolf Point to the confluence reach was fairly low throughout the field season, usually under 0.03 relocations/km. Although there was a little variance in relative abundance in this reach, it notably increased in late September and early October to 0.054, which is the result of two males that spent the majority of their time in this reach during this time period.

The Yellowstone River held a high relative abundance of pallid sturgeon from mid-April to mid-June (0.25 to 0.43) and then decreased until early July when numbers spiked to above 0.30. Abundance then decreased again to a little below 0.15 relocations per kilometer until early October when relative abundance increased to over 0.30 for a short time. The majority of tagged pallid sturgeon sampled were relocated in the Yellowstone numerous times except for a male that was tagged in 2001, of which he spent the majority of the field season in the lower Missouri River ranging from rivermile 1582 to 1548. Although, during the 2003 field season he was located in the Yellowstone numerous times, where he spent from mid-April till almost the end of June. During the 2002 field season, this fish was never located in the Yellowstone River once. He was located at the confluence in early April and spent the majority of the field season below Erickson Island (~RM 1574).

In the riverine reach of the Missouri River below the Confluence, relative abundance ranged from 0.03 to 0.1 until mid-May, when abundance started increasing up to mid-June to approximately 0.25 and remained relatively high until mid-July. The relative abundance increase during this time frame correlates with the decrease in abundance in the Yellowstone directly. After mid-July, relative abundance notably decreased throughout the rest of the field season. Although, the low relative abundance during this period may be somewhat misleading due to some of the pallids utilizing deeper holes which may have lead to missed relocations.

Movement rates were analyzed by calculating the distance in kilometers between locations and were divided by the fraction of days that transpired. Overall movement rates were generally higher in the Missouri River throughout the tracking season and overall highly variable, especially in the Yellowstone River (Figure 2). Positive net movements were observed throughout mid-May through the end of June indicating fish aggressively moving up the Yellowstone. Starting in July, net movements started decreasing in early July, with fish moving out of the Yellowstone and into the lower Missouri. From mid-July until mid-October, little movement was observed overall.

Pallid sturgeon exhibited fairly high net movements both upstream and downstream in the Missouri River (Figure 3) throughout mid-July. Positive net movements were exhibited in early May through the end of May indicating upstream movements. The first few weeks of June, fish movements notably increased going downstream until August. Overall movement rates decreased from August until October, with no appreciable movements up or down stream until some increased movement upstream was shown in October.

The pooled data was preliminarily analyzed with the assistance of Neal Niemuth, a statistician working for the Habitat and Population Evaluation Team in Bismarck, ND. All data was put into various regression models to test for correlations and responses to flow and temperature. Data was run for individual fish and for all fish located.

In the majority of regression models run on individual fish, there were negative correlations involving movement associated to flow and temperature. Models run on the entire sample of fish for the same parameters were also negative. In both cases, the result is probably skewed due to low-sample numbers.

Unfortunately, due to poor temporal resolution of the responses, the data is too course to statistically validate if any of the movements are direct correlations to flow or temperature. Although the 2004 field season has provided the largest data sample to work with in the study to this point, more relocations need to be taken on a more frequent basis. Relocations will need to be taken possibly on an hourly basis during the prime spring spawning period, to be positive not to miss the exact cues the fish is responding to. The current sampling method is not intense enough, with too large of window of time between relocations, which leads to fish movement without being able to pinpoint what the response is to.

Thus, it is recommended to track a smaller number of fish during the spawning period, and get as many relocations per day/per fish during all conditions to obtain a large enough sample to statistically validate any correlations involved.

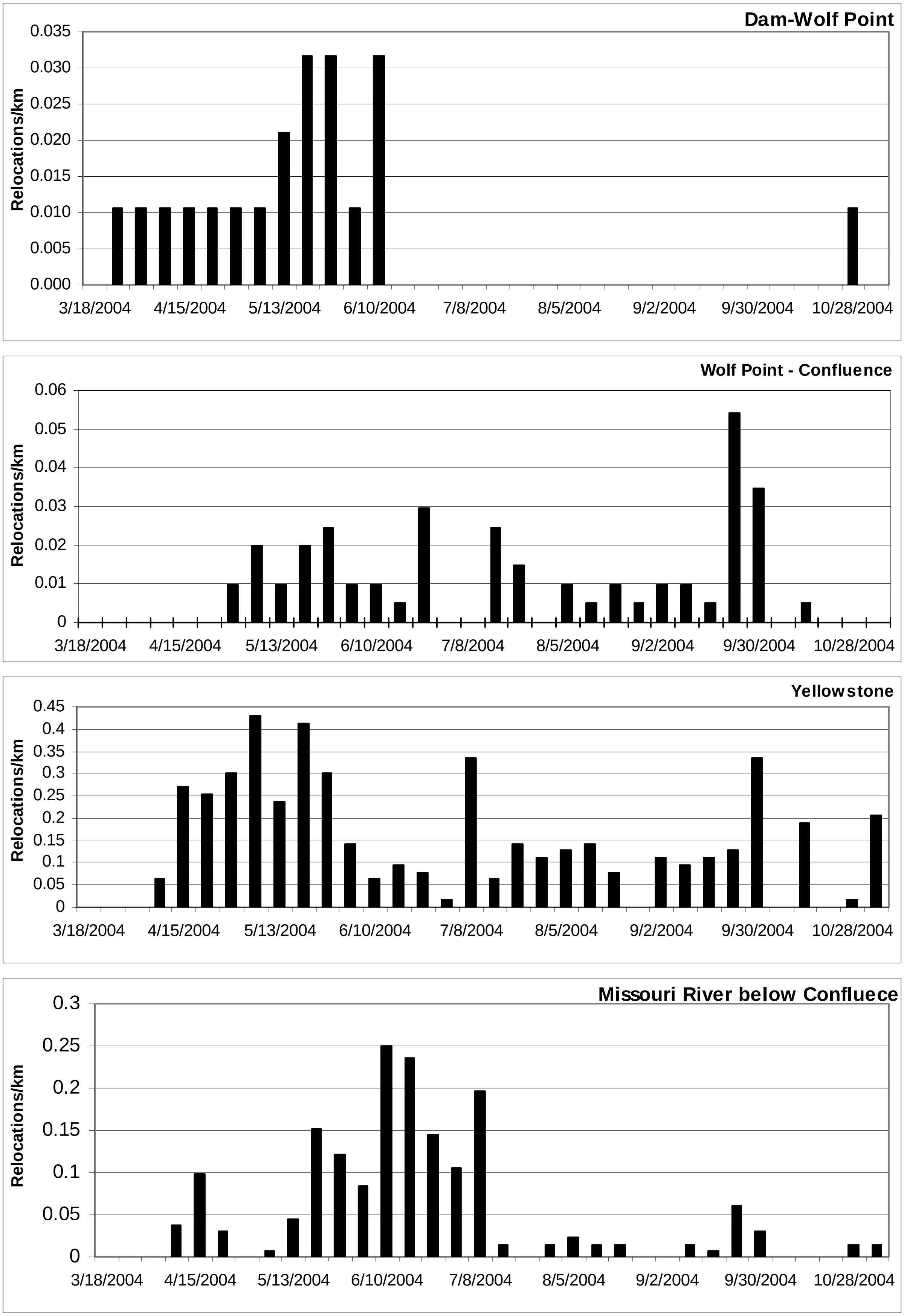


Figure 1. Number of pallid sturgeon relocations per km in study area.

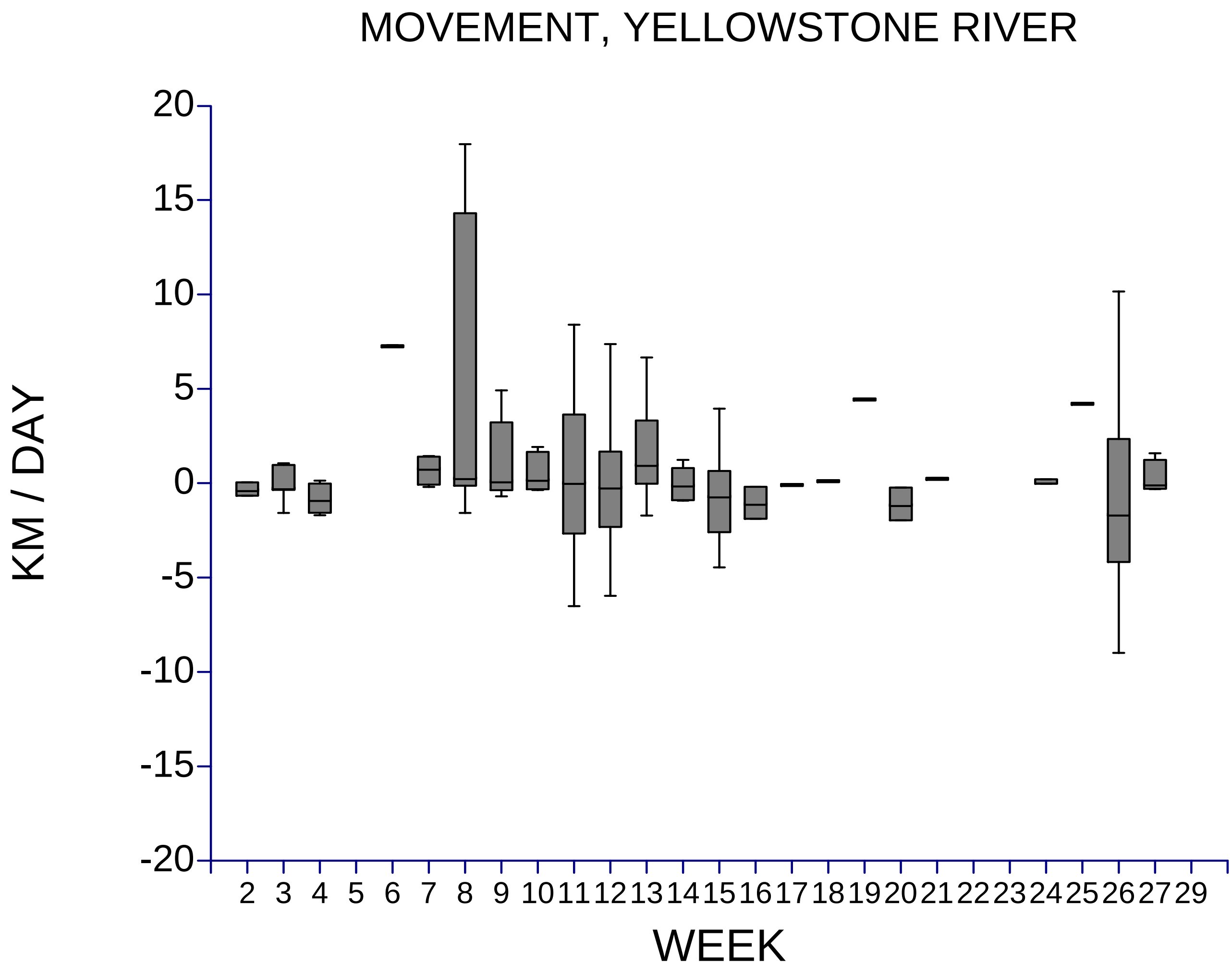


Figure 2. Box and whisker plots of net movement rates (km/day) of pallid sturgeon in the Yellowstone River during the 2004 field season. Median movement rate is denoted as a line within the box. The box delimits 25th and 75th percentiles of the data, and the whiskers delimit the 5th and 95th percentiles. Week numbers correlate to week 1 beginning at April 1, 2004, through week 30, starting on November 1, 2004.

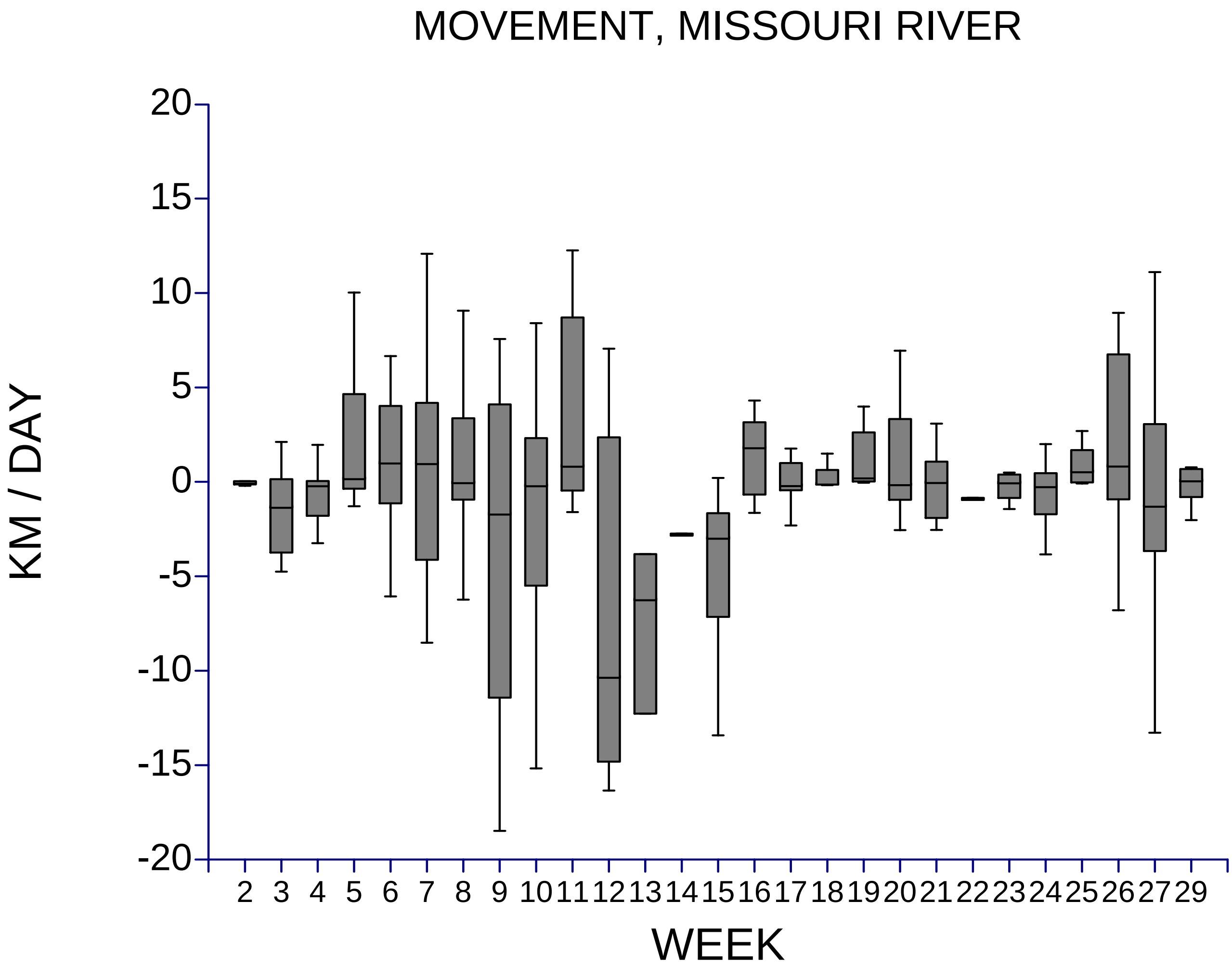


Figure 3. Box and whisker plots of net movement rates (km/day) of pallid sturgeon in the Missouri River during the 2004 field season. Median movement rate is denoted as a line within the box. The box delimits 25th and 75th percentiles of the data, and the whiskers delimit the 5th and 95th percentiles. Week numbers correlate to week 1 beginning at April 1, 2004, through week 30, starting on November 1, 2004.

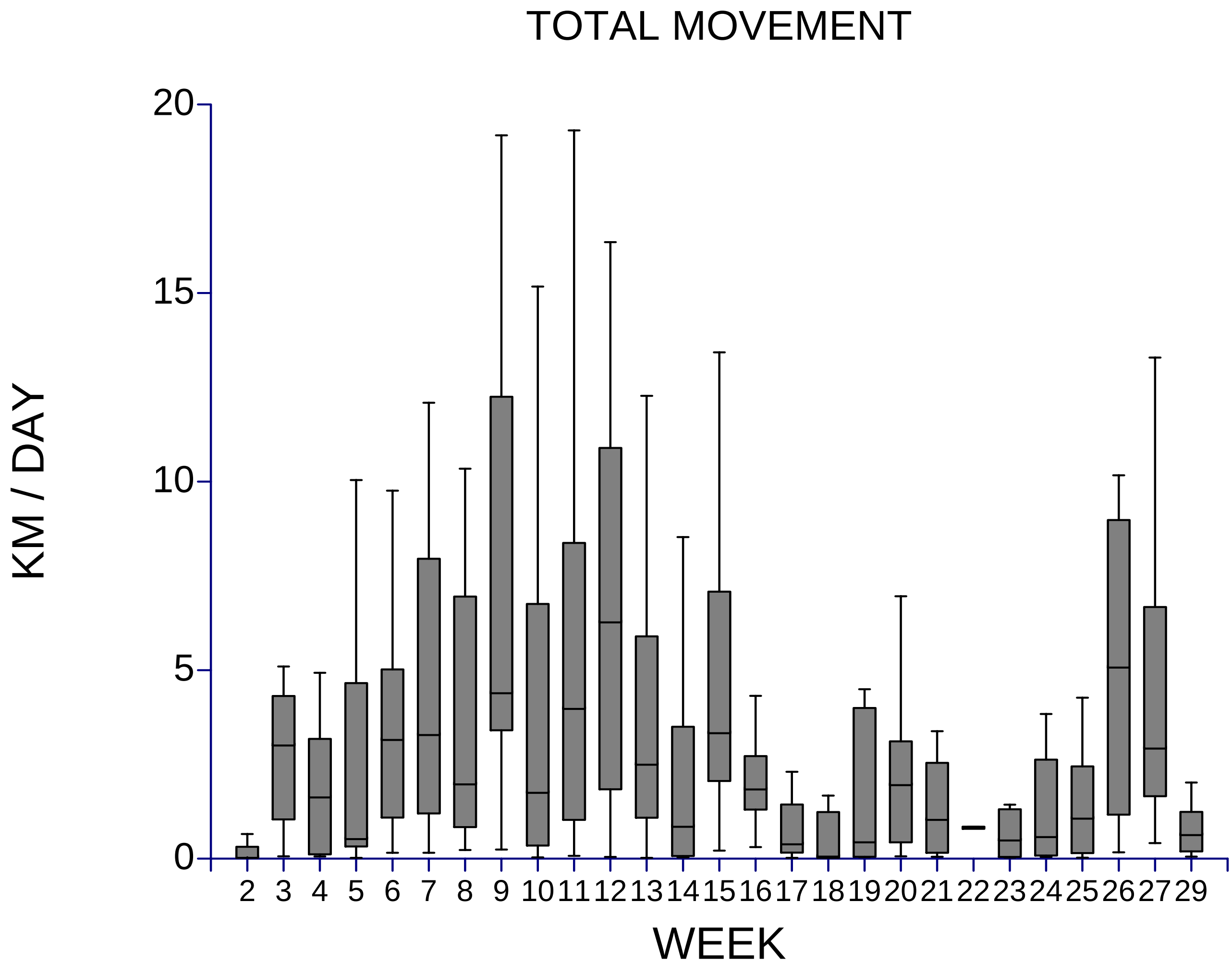


Figure 4. Box and whisker plots of net movement rates (km/day) of pallid sturgeon in the Yellowstone and Missouri Rivers during the 2004 field season. Median movement rate is denoted as a line within the box. The box delimits 25^{th} and 75^{th} percentiles of the data, and the whiskers delimit the 5^{th} and 95^{th} percentiles. Week numbers correlate to week 1 beginning at April 1, 2004, through week 30, starting on November 1, 2004.

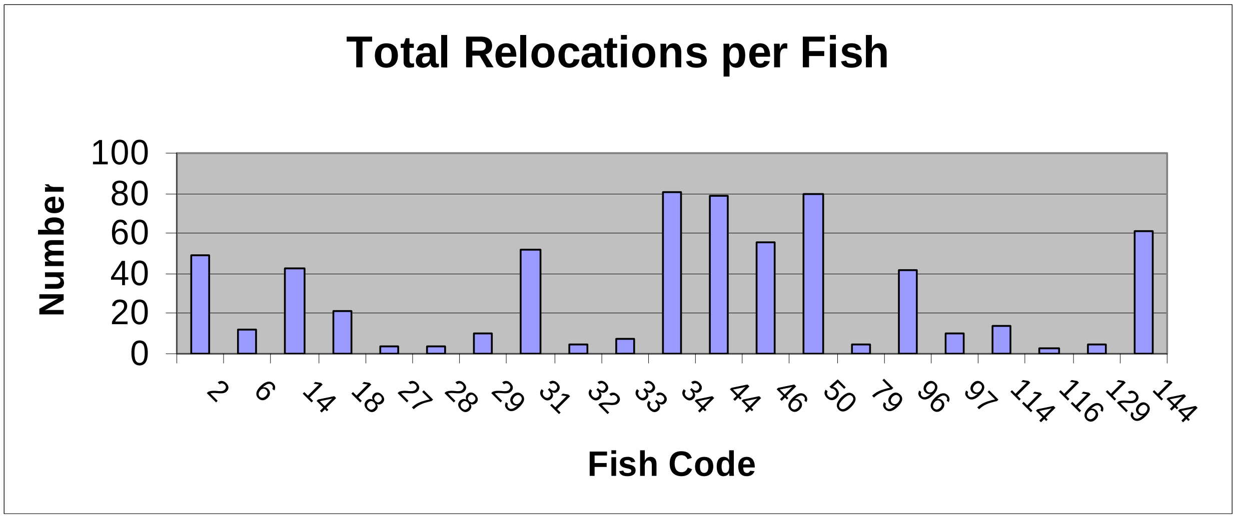
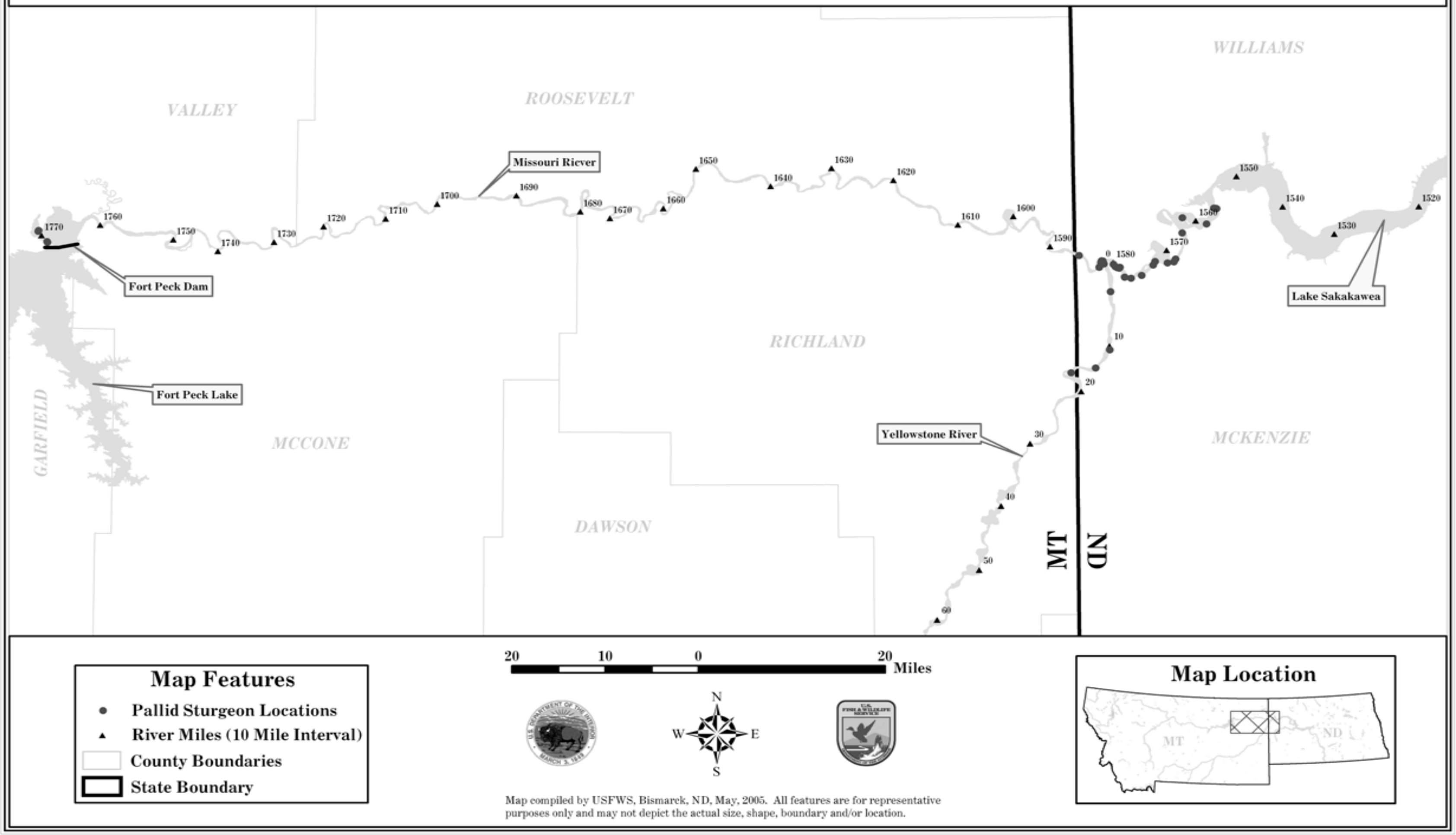
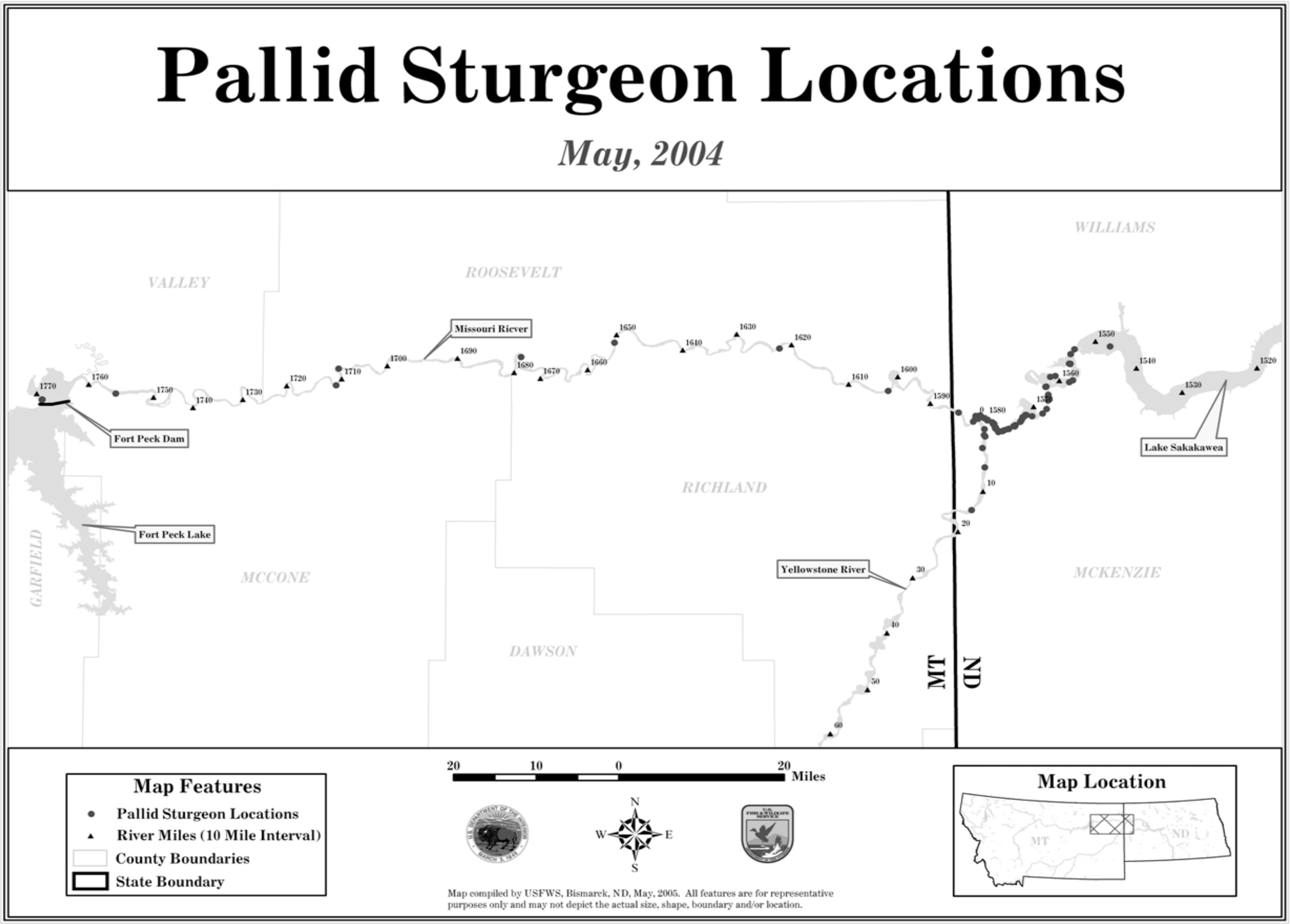


Figure 6. Number of relocations for individual fish codes, 2004.

Pallid Sturgeon Locations

April, 2004




Pallid Sturgeon Locations
May, 2004
VALLEY
ROOSEVELT
WILLIAMS
GARFIELD
MCCONE
RICHLAND
DAWSON
MCKENZIE
Missouri Ricver
Fort Peck Dam
Fort Peck Lake
Yellowstone River
Lake Sakakawea
MT
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10
20
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60
Map Features
Pallid Sturgeon Locations
River Miles (10 Mile Interval)
County Boundaries
State Boundary
20 10 0 20
Miles
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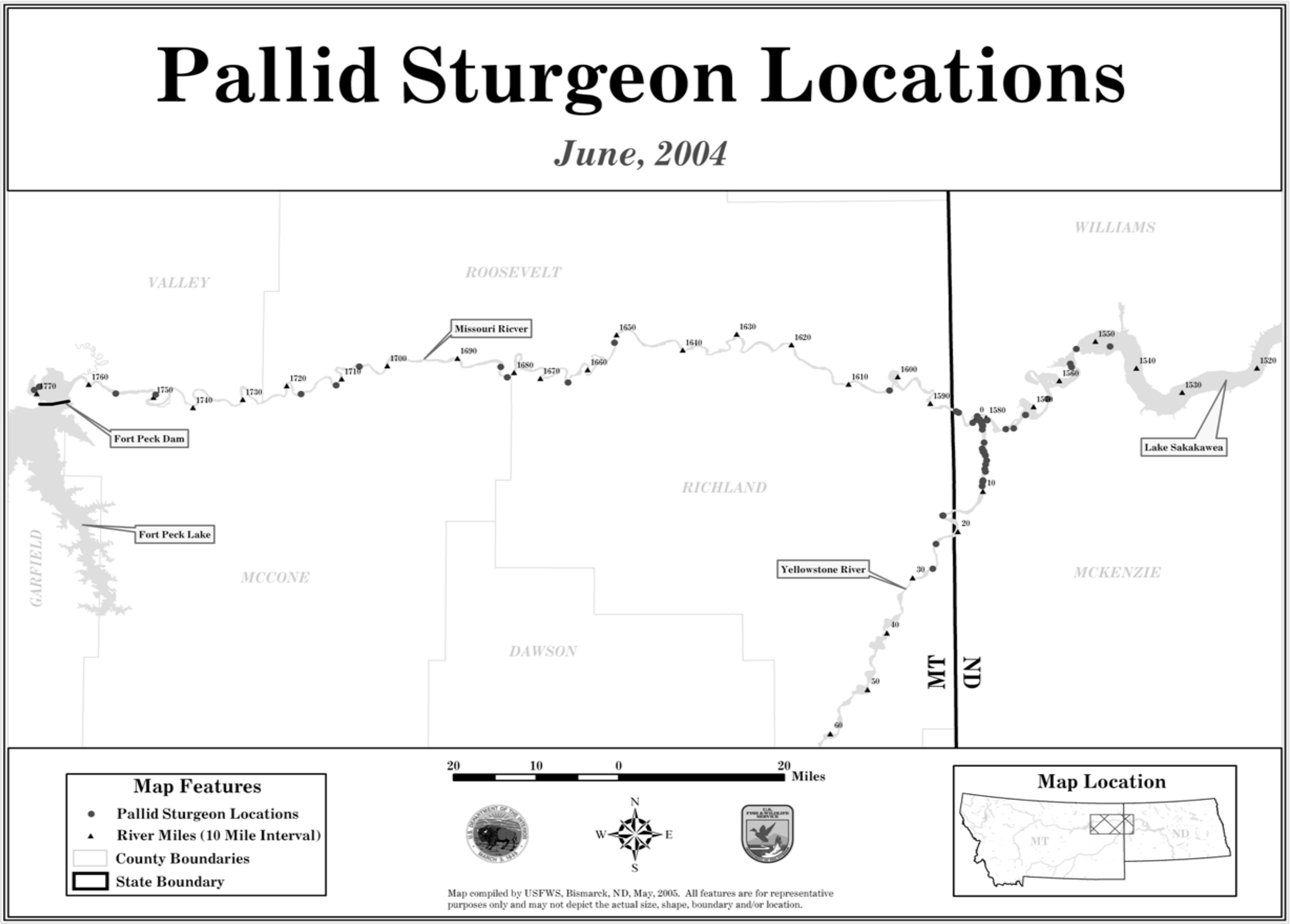
Map compiled by USFWS, Bismarck, ND, May, 2005. All features are for representative purposes only and may not depict the actual size, shape, boundary and/or location.
Map Location
MT
ND


Pallid Sturgeon Locations
June, 2004
VALLEY
ROOSEVELT
WILLIAMS
GARFIELD
MCCONE
RICHLAND
DAWSON
MCKENZIE
Missouri Ricver
Fort Peck Dam
Fort Peck Lake
Yellowstone River
Lake Sakakawea
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50
60
Map Features
Pallid Sturgeon Locations
River Miles (10 Mile Interval)
County Boundaries
State Boundary
20 10 0 20 Miles
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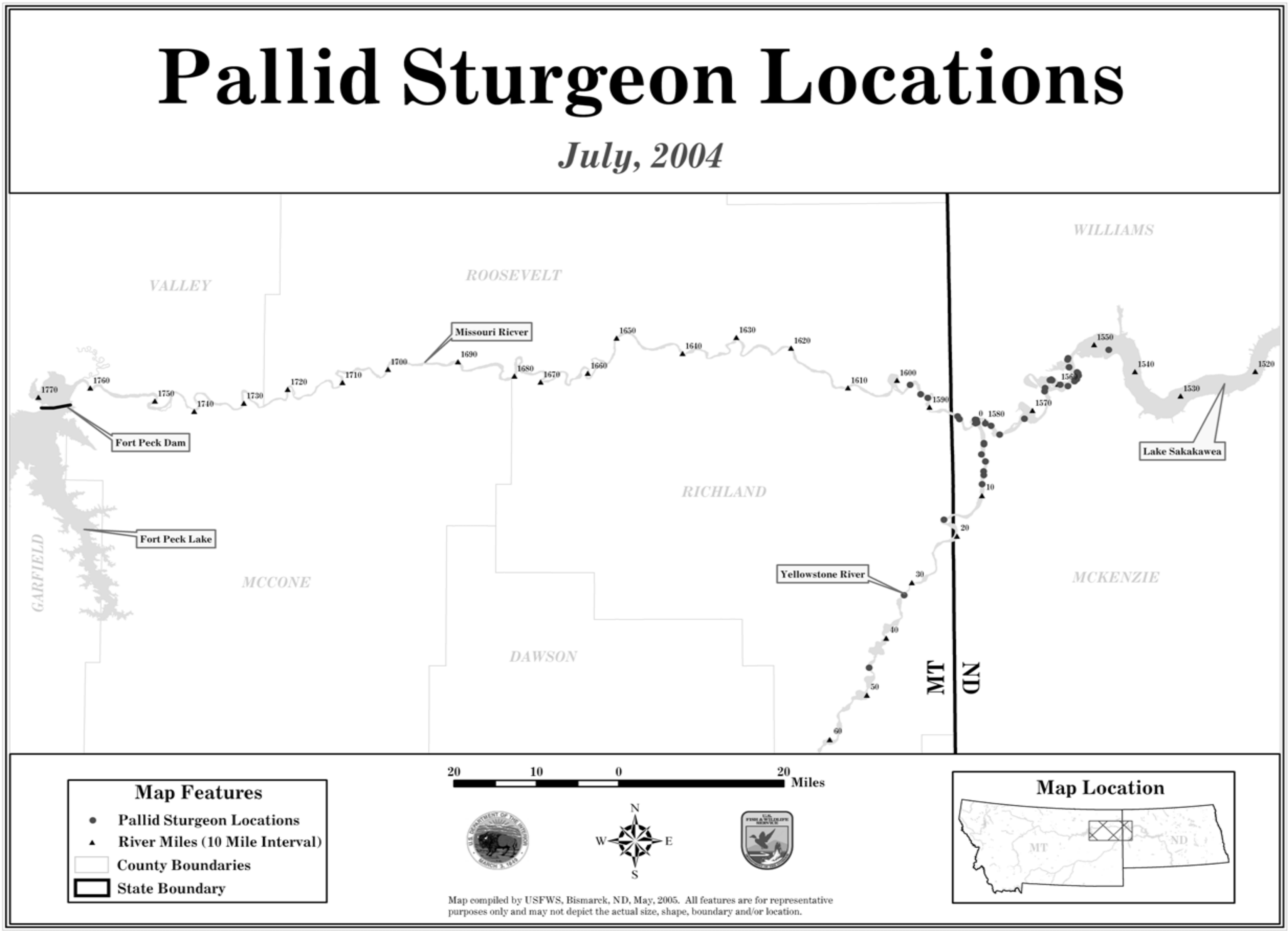
W
Map Location
MT
ND
Map compiled by USFWS, Bismarck, ND, May, 2005. All features are for representative purposes only and may not depict the actual size, shape, boundary and/or location.


Pallid Sturgeon Locations
July, 2004
VALLEY
ROOSEVELT
WILLIAMS
Missouri Ricver
Fort Peck Dam
Fort Peck Lake
GARFIELD
MCCONE
RICHLAND
DAWSON
MCKENZIE
Yellowstone River
Lake Sakakawea
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Map Features
Pallid Sturgeon Locations
River Miles (10 Mile Interval)
County Boundaries
State Boundary
20 10 0 20 Miles
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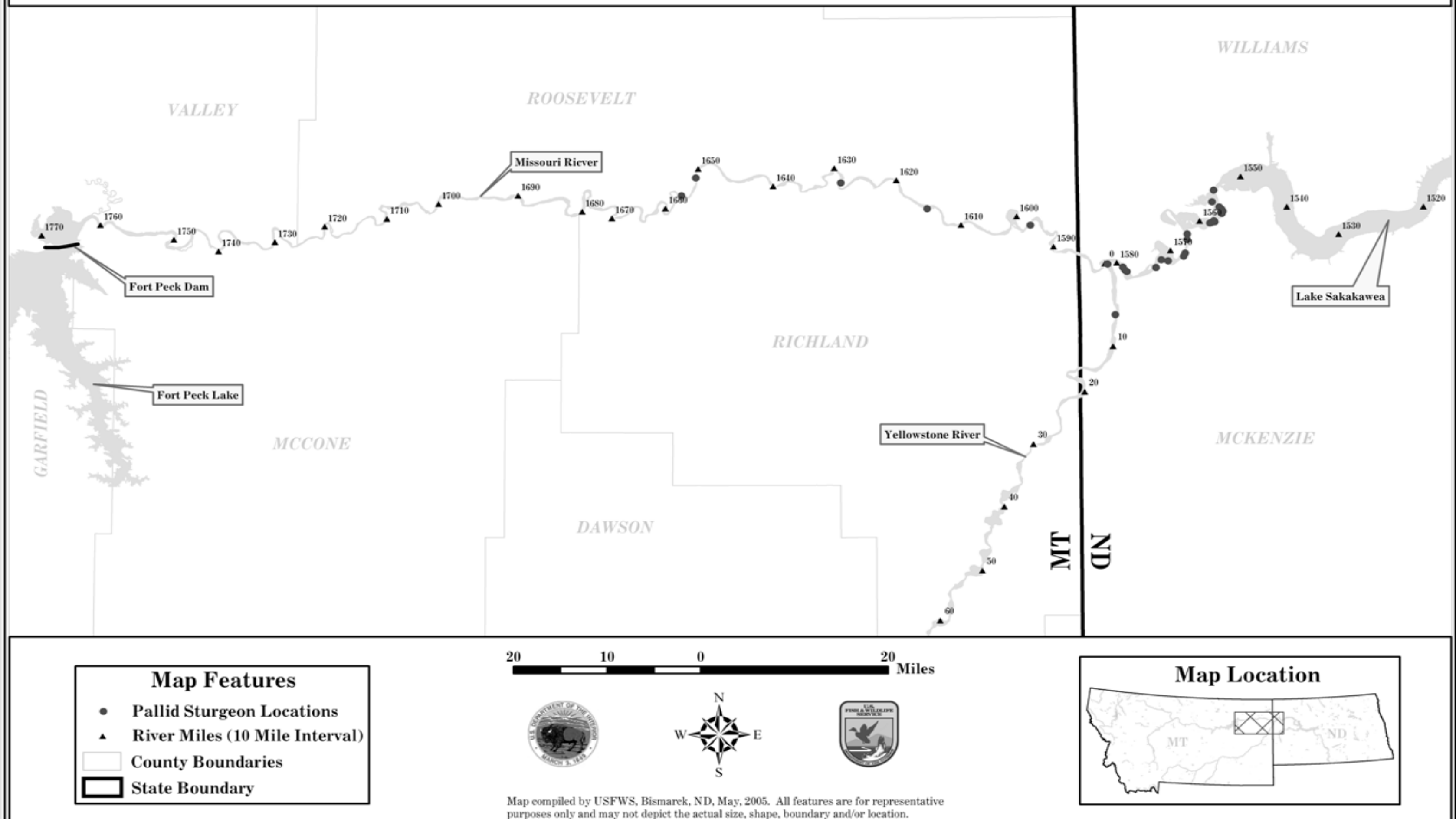
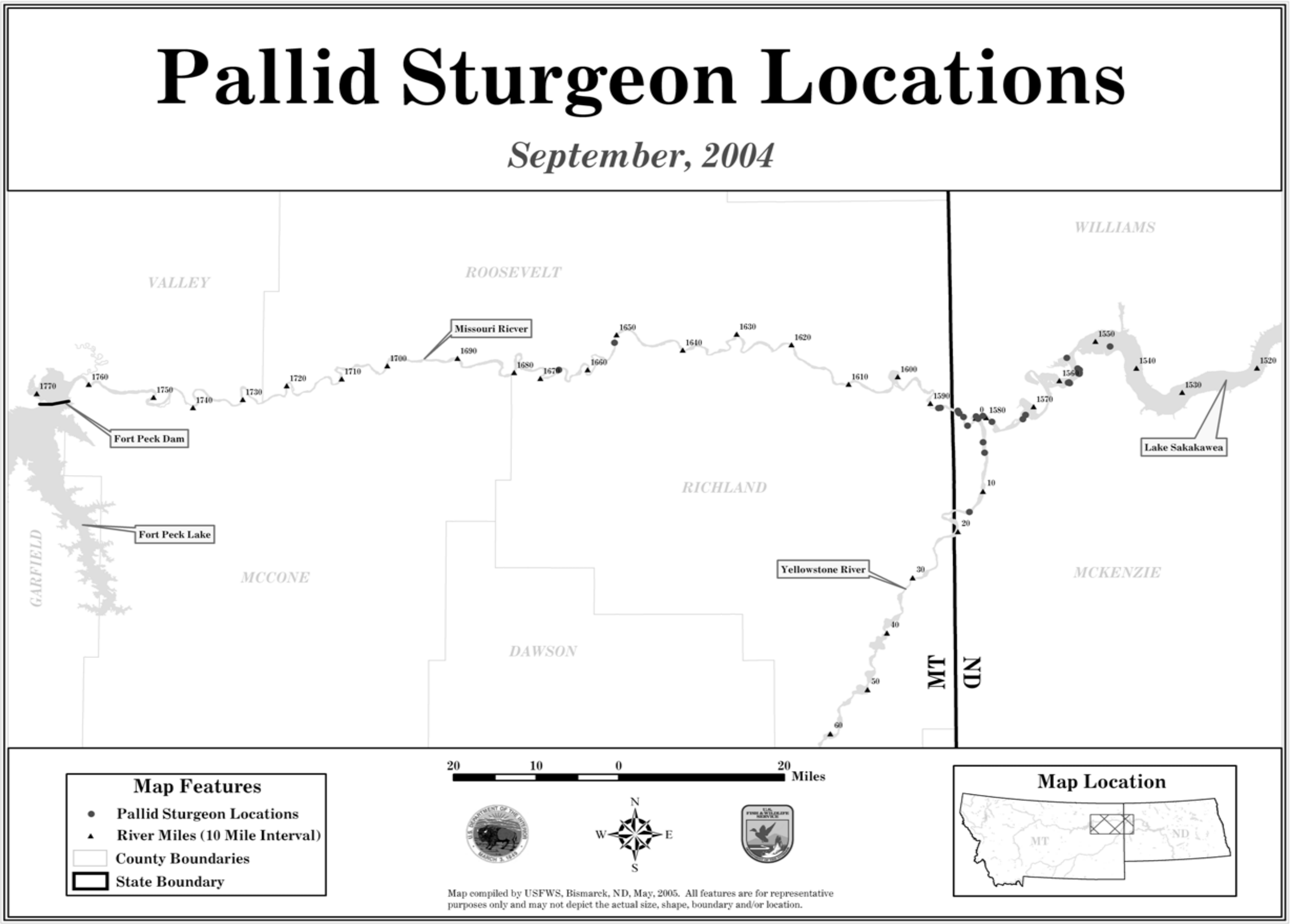
S
Map compiled by USFWS, Bismarck, ND, May, 2005. All features are for representative purposes only and may not depict the actual size, shape, boundary and/or location.
Map Location
MT
ND

Pallid Sturgeon Locations

August, 2004




Pallid Sturgeon Locations
September, 2004
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WILLIAMS
Missouri Ricver
Fort Peck Dam
Fort Peck Lake
GARFIELD
MCCONE
RICHLAND
DAWSON
MCKENZIE
Yellowstone River
Lake Sakakawea
MT
ND
Map Features
Pallid Sturgeon Locations
River Miles (10 Mile Interval)
County Boundaries
State Boundary
20 10 0 20 Miles
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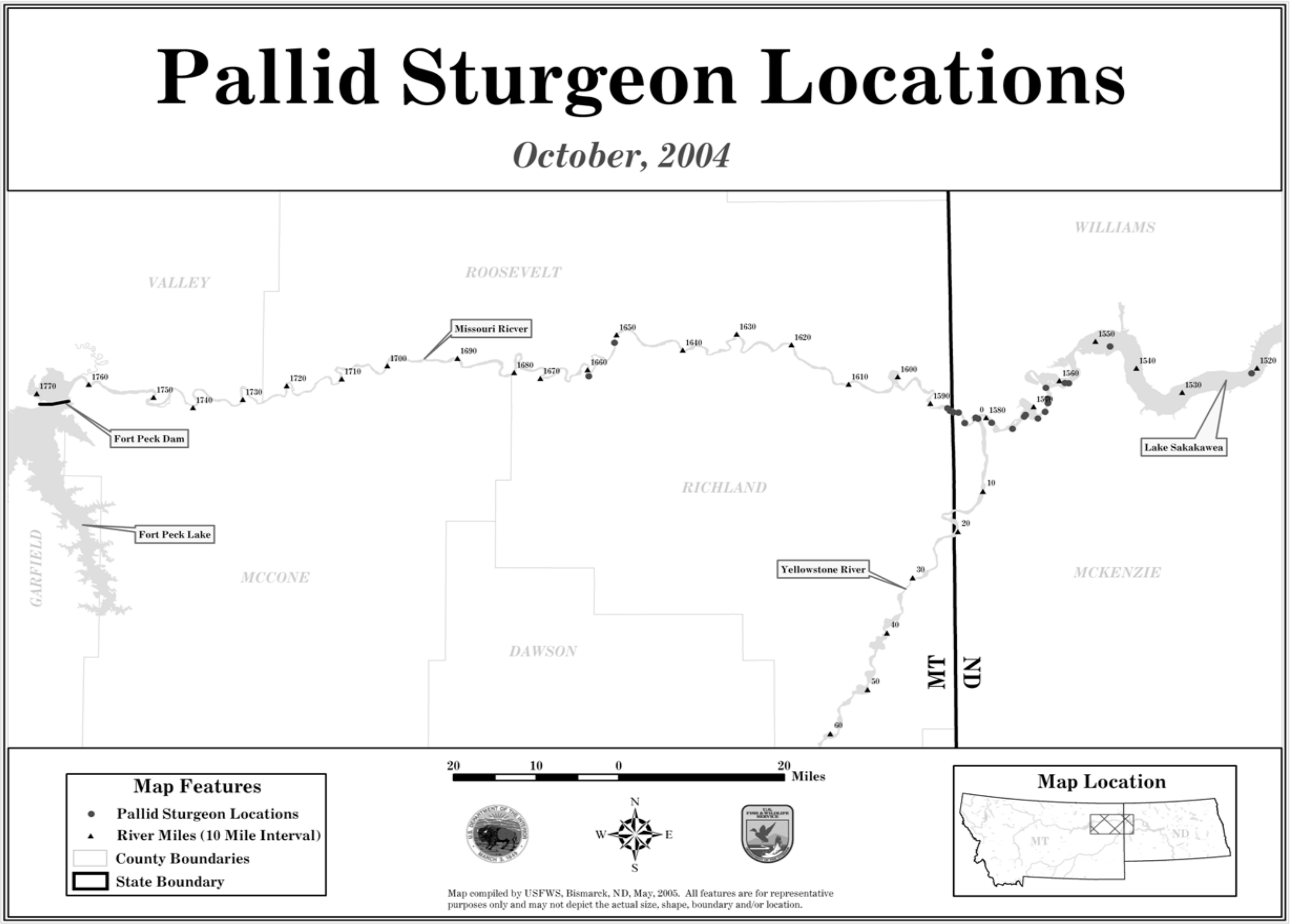
Map compiled by USFWS, Bismarck, ND, May, 2005. All features are for representative purposes only and may not depict the actual size, shape, boundary and/or location.
Map Location
MT
ND


Pallid Sturgeon Locations
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RICHLAND
MCCONE
GARFIELD
DAWSON
MCKENZIE
Missouri Ricver
Fort Peck Dam
Fort Peck Lake
Yellowstone River
Lake Sakakawea
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Map Features
Pallid Sturgeon Locations
River Miles (10 Mile Interval)
County Boundaries
State Boundary
20 10 0 20 Miles
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Map Location
MT
ND
Map compiled by USFWS, Bismarck, ND, May, 2005. All features are for representative purposes only and may not depict the actual size, shape, boundary and/or location.

2004 ANNUAL REPORT

PALLID STURGEON POPULATION ASSESSMENT AND ASSOCIATED FISH COMMUNITY MONITORING FOR THE MISSOURI RIVER: SEGMENTS 5 AND 6

Prepared for the U.S. Army Corps of Engineers – Northwest Division
Kansas City and Omaha Districts
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Yankton, South Dakota 57078

By

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Great Plains Fish and Wildlife Management Assistance Office
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Pierre, South Dakota 57501

July 25, 2005

EXECUTIVE SUMMARY

Pallid sturgeon *Scaphirhynchus albus* and the associated fish community were randomly sampled in the unchannalized Missouri River below Fort Randall Dam to the headwaters of Lewis and Clark Lake (Recovery Priority Management Area #3; [RPMA]) with standardized gear and protocols from fall of 2003 to fall of 2004 (i.e., 2004 season). At least eight randomly selected bends were sampled with a minimum of 8 gear deployments expended in each bend. The confluence of a major tributary, the Niobrara River, delineates segment 5 (upstream of the confluence) from segment 6 (the confluence to the headwaters of Lewis and Clark Lake); however, both segments were pooled for analysis. In 2004, all recaptured pallid sturgeons (n = 28) were of hatchery origin and readable passive integrated transponder (PIT) tags were found in 86% of the fish. Recaptured pallid sturgeon represented five of the six year classes that have been stocked (1997 - 1999 and 2001 - 2003) into RPMA #3 as part of population supplementation efforts. For standardized gears, 12 pallid sturgeon were captured with gillnets and 13 with trammel nets while three additional fish were captured with set lines baited with night crawlers, a non-standard gear. Relative condition of recaptured pallid sturgeons ranged from 0.7 to 0.9 with mean growth of 0.137 mm/d. Spatially, pallid sturgeons were captured throughout most of the length of segments 5 and 6 (river mile 868 to 831) with most fish captured in the channel border mesohabitat of inside bends, outside bends, and channel crossovers. A total of 91 shovelnose sturgeons *S. platorynchus* were captured in 2004: 43 with gillnets, 30 with trammel nets, 5 with beam trawls, 2 with hoopnets, and 11 with set lines. The ratio of pallid to shovelnose sturgeons was 1:3.25.

In addition to sturgeon, nine native Missouri River species were targeted for assessment: speckled chub *Macrhybopsis aestivalis,* sturgeon chub *M. gelida*, sicklefin chub *M. meeki*, Western silvery minnow *Hybognathus* argyritis, plains minnow *H. placitus*, sand shiner *Notropis stramineus*, blue sucker *Cycleptus elongates*, bigmouth buffalo *Ictiobus cyprinellus*, and sauger *Sander canadense*. No plains minnows *Hybognathus spp*., sturgeon chubs, sicklefin chubs, or speckled chubs were captured in 2004. Sand shiners were only captured with seines (n = 137) and mini-fyke nets (n = 33) during summer. A total of 18 blue suckers, 9 bigmouth buffalo, and 72 saugers were caught in 2004. Most blue suckers were captured in hoopnets, a nonstandard gear, during spring (n = 14). Saugers were captured with gillnets (n = 43) primarily during April to June. A total of 38 fish species and one hybrid were caught in segments 5 and 6 of the Missouri River during 2004. None of the four exotic Asian carps, bighead carp *Hypophthalmichthys noblis*, silver carp *H. molitrix*, grass carp *Ctenopharyngodon idella*, and black carp *Mylopharyngodon piceus,* were captured.

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Figure 15. Percent of total sand shiners caught by macrohabitat type in segments 5 and 6 of the Missouri River during two seasons: Fall through Spring and Summer.

Figure 16. Percent of total sand shiners caught by mesohabitat type in segments 5 and 6 of the Missouri River during two seasons: Fall through Spring and Summer.

Figure 17. Length frequency of sand shiners during fall through spring (sturgeon season, black bars) and summer (fish community season, white bars) in segments 5 and 6 of the Missouri River during 2004.

Figure 18. Mean annual catch-per-unit-effort (+/- 2SE) of bigmouth buffalo in segments 5 and 6 of the Missouri River for: A) gill nets, B) trammel nets, and C) beam trawls from fall through spring (sturgeon season) during 2003 - 2004.

Figure 19. Mean annual catch-per-unit-effort (+/- 2SE) bigmouth buffalo in segments 5 and 6 of the Missouri River for: A) trammel nets and B) beam trawls in summer (fish community season) during 2003 - 2004.

Figure 20. Percent of total bigmouth buffalo caught by macrohabitat type in segments 5 and 6 of the Missouri River during two seasons: Fall through Spring and Summer.

Figure 21. Percent of total bigmouth buffalo caught by mesohabitat type in segments 5 and 6 of the Missouri River during two seasons: Fall through Spring and Summer. Habitat abbreviations presented in Appendix B.

Figure 22. Length frequency of bigmouth buffalo during fall through spring (sturgeon season, black bars) and summer (fish community season, white bars) in segments 5 and 6 of the Missouri River during 2004.

Figure 23. Mean annual catch-per-unit-effort (+/- 2SE) of blue suckers in segments 5 and 6 of the Missouri River for: A) gill nets, B) trammel nets, and C) beam trawls from fall through spring (sturgeon season) during 2003 – 2004.

Figure 24. Mean annual catch-per-unit-effort (+/- 2SE) blue suckers in segments 5 and 6 of the Missouri River for: A) trammel nets and B) beam trawls in summer (fish community season) during 2004.

Figure 25. Percent of total blue suckers caught by macrohabitat type in segments 5 and 6 of the Missouri River during two seasons: Fall through Spring and Summer. Macrohabitat abbreviations presented in Appendix B.

Figure 26. Percent of total blue suckers caught by mesohabitat type in segments 5 and 6 of the Missouri River during two seasons: Fall through Spring and Summer.

Figure 27. Length frequency of blue suckers during fall through spring (sturgeon season, black bars) and summer (fish community season, white bars) in segments 5 and 6 of the Missouri River during 2004.

Figure 28. Mean annual catch-per-unit-effort (+/- 2SE) of saugers in segments 5 and 6 of the Missouri River for: A) gill nets, B) trammel nets, and C) beam trawls from fall through spring (sturgeon season) during 2003 – 2004.

Figure 29. Mean annual catch-per-unit-effort (+/- 2SE) saugers in segments 5 and 6 of the Missouri River for: A) trammel nets and B) beam trawls in summer (fish community season) during 2003 - 2004.

Figure 30. Percent of total saugers caught by macrohabitat type in segments 5 and 6 of the Missouri River during two seasons: Fall through Spring and Summer.

Figure 31. Percent of total saugers caught by mesohabitat type in segments 5 and 6 of the Missouri River during two seasons: Fall through Spring and Summer. Habitat abbreviations presented in Appendix B.

Figure 32. Length frequency of saugers during fall through spring (sturgeon season, black bars) and summer (fish community season, white bars) in segments 5 and 6 of the Missouri River during 2004.

Figure 33. Mean annual catch-per-unit-effort (+/- 2 SE) of stocked pallid sturgeon in segments 5 and 6 of the Missouri River for set lines fished during fall through spring (Sturgeon Season) of 2003 - 2004.

Figure 34. Mean annual catch-per-unit-effort (+/- 2 SE) of stocked pallid sturgeon in segments 5 and 6 of the Missouri River for set lines during summer (Fish Community Season) of 2003 - 2004.

Figure 35. Mean annual catch-per-unit-effort (+/- 2 SE) of wild shovelnose sturgeon in segments 5 and 6 of the Missouri River for wild gears: A) hoopnets and B) set lines fished during fall through spring (Sturgeon Season) of 2003 - 2004.

Figure 36. Mean annual catch-per-unit-effort (+/- 2 SE) of wild shovelnose sturgeon in segments 5 and 6 of the Missouri River for wild gears: A) hoopnets and B) set lines fished during the (Fish Community Season) of 2003 - 2004.

Figure 37. Mean annual catch-per-unit-effort (+/- 2 SE) of bigmouth buffalo in segments 5 and 6 of the Missouri River for hoopnets fished during fall through spring (Sturgeon Season) of 2003 - 2004.

Figure 38. Mean annual catch-per-unit-effort (+/- 2 SE) of bigmouth buffalo in segments 5 and 6 of the Missouri River for hoopnets fished during summer (Fish Community Season) of 2003 - 2004.

Figure 39. Mean annual catch-per-unit-effort (+/- 2 SE) of blue suckers in segment 5 and 6 of the Missouri River for hoopnets fished during fall through spring (Sturgeon Season) of 2003 - 2004.

Figure 40. Mean annual catch-per-unit-effort (+/- 2 SE) of blue suckers in segments 5 and 6 of the Missouri River for hoopnets fished during summer (Fish Community Season) of 2003 - 2004.

Figure 41. Mean annual catch-per-unit-effort (+/- 2 SE) of saugers in segments 5 and 6 of the Missouri River for hoopnets fished during summer (Fish Community Season) of 2003 - 2004.

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Appendix L. Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/net night) by mesohabitat within a macrohabitat for all species caught with mini-fyke nets in summer (fish community season) for segments 5 and 6 of the unchannelized Missouri River during 2004.

INTRODUCTION

A team of biologists representing State and Federal resource management agencies was assembled to develop and implement a standardized long term resource monitoring program for the Missouri River. This team is now known as the Pallid Sturgeon Population Assessment Team (Drobish 2005a). The primary goal of this program is monitoring the status and recovery of endangered pallid sturgeon *Scaphirhynchus albus* (Dryer and Sandoval 1993). However, the monitoring program is also directed towards the native riverine fish community (Appendix A). This team developed standardized protocols for habitat classification (Appendix B) gear types and deployment methods (Appendix C), and data reporting (Drobish 2005b). . Four high priority pallid sturgeon recovery management areas (RPMAs), were identified in the recovery plan (Dryer and Sandoval 1993), which encompass nearly 1775 KM (1,100 miles) of the Missouri River system. The Pallid Sturgeon Population Assessment Team selected 14 sampling segments within these RPMAs to implement the monitoring program. Each sampling segment was selected based on a variety of characteristics such as water temperature, turbidity, influence of tributaries, presence of degrading or aggrading stream beds, stream gradient, natural hydrograph, spillway releases and flow fluctuations (Drobish 2005a). Sampling within these segments allows biologists to monitor trends of pallid sturgeon and the associated fish community as well as evaluate mitigation efforts and shallow water habitat restoration projects.

Pallid sturgeon within segments 5 and 6 of the Missouri River, also known as RPMA 3 (Figure 1), have been supplemented through stocking since 2000 (Appendices D and E). During 2000, 2002, 2003 and 2004, a total of 2,373 juvenile pallid sturgeon were released consisting of six year classes (1997, 1998, 1999, 2001, 2002, and 2003) and 9 adult broodstock or rehabilitated fish that were also stocked (Appendix E). These fish were stocked at three locations: the most upstream site was Sunshine Bottoms, the middle site was at the Verdel Boat Ramp, and lower most site was at the Running Water Boat Ramp (Figure 2). The monitoring program will serve to assess the success of hatchery propagated fish and guide future stocking efforts.

Because current pallid sturgeon abundance is extremely low, data collection that solely targets pallid sturgeon likely would not provide adequate information to evaluate restoration projects and flow modifications to the Missouri River. An ecologically based long-term population assessment approach was adopted to address this concern and evaluate the entire warm water benthic fish community in the Missouri River as required by the U. S. Fish & Wildlife Service's (USFWS) 2000 Biological Opinion on operations of the main-stem Missouri River dams (USFWS 2000). Additionally, evaluating responses of other native Missouri River fishes to changes in habitat or flow modifications may be a more sensitive indicator of habitat change. Information derived from this project will be vital for developing sound management recommendations for recovering the native Missouri River fish fauna. Because the pallid sturgeon is a known piscivore (Carlson et al. 1985), assessment of the native benthic Missouri River fish assemblage, which likely serves as pallid sturgeon prey, is also a critical component of the monitoring program. A representative group of 10 native Missouri River fishes was selected as indicator species for detecting improvement in the warm water benthic fish community. The species selected were: shovelnose sturgeon *S. platorynchus*, western silvery minnow *Hybognathus argyritis,* plains minnow *H. placitus,* speckled chub *Macrhybopsis aestivalis,* sturgeon chub *M. gelida,* sicklefin chub *M. meeki,* sand shiner *Notropis stramineus,* blue sucker

Cycleptus elongatus, bigmouth buffalo *Ictiobus cyprinellus,* and sauger *Sander canadense.* All fish collected during population assessment activities are recorded; however, detailed data (weight and age structures such as scales and pectoral fin rays) are only being collected on pallid sturgeon and the representative group of 10 native Missouri River species. No pectoral fin ray clips were taken on shovelnose sturgeon, blue suckers, and bigmouth buffalo in segments 5 and 6 due to biologist's concerns regarding the risk of post-clip mortality.

Goals

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

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

Objectives

Six objectives have been identified for the monitoring program. Detailed hypotheses for each objective can be found in Drobish (2005a).

1. Evaluate annual and long-term trends in pallid sturgeon population abundance and geographic distribution throughout the Missouri River System.
2. Evaluate annual long-term trends of habitat usage by wild and hatchery stocked pallid sturgeon by season and life stage.
3. Evaluate population structure and dynamics of pallid sturgeon in the Missouri River system.
4. Evaluate annual results and long-term trends in native target species population abundance and geographic distribution throughout the Missouri River system.
5. Evaluate annual results and long-term trends of habitat usage of the target native species by season and life stage.
6. Evaluate annual results and long-term trends in all remaining species (minimum of 50 fish collected/species) population abundance and geographic distribution throughout the Missouri River system.

Success Criteria

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

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

STUDY AREA

Lewis and Clark Lake, the most downstream reservoir of the Missouri River, was formed by the closure of Gavins Point Dam in 1955. The head waters of Lewis and Clark Lake (river kilometer [rkm] 1327, river mile [rm] 825) defines the downstream end of segment 6. Lewis and Clark Lake extends to Fort Randall Dam (rkm 1416, rm 880) which also defines the upper end segment 5 (Figure 1). Both dams are operated by the U. S. Army Corps of Engineers (USACE). The primary function of Gavins Point Dam is to level out release fluctuations from upstream dams to serve downstream purposes (i.e., navigation and water supply). The riverine section of Lewis and Clark Lake extends approximately 89 rkm from Fort Randall Dam to Springfield, South Dakota (Figures 1 and 2). Maximum depth of the riverine section of Lewis and Clark Lake is about 12 m and channel width ranges from 45 - 90 m. Downstream of Springfield, Lewis and Clark Lake becomes more like a reservoir. However, sedimentation from the Niobrara River has formed a large braided delta, that starts near rkm 1351. This delta is progressively expanding downriver into the reservoir. The riverine section of Lewis and Clark Lake was selected in the Pallid Sturgeon Recovery Plan (Dryer and Sandoval 1993) as 1 of 4 Recovery Priority Management Areas (RPMAs) in the Missouri River for potential recovery of the species and was designated RPMA 3.

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

Based on the presence of a major tributary, the Niobrara River, the riverine section of Lewis and Clark Lake (RPMA 3) was divided into two sampling segments by the Population Assessment Team. Segment 5 encompasses the riverine section below Fort Randall Dam to the confluence. In this segment, water temperatures are depressed by bottom discharges from Fort Randall Dam and turbidity is low. Segment 6 encompasses the riverine section from the confluence of the Missouri and Niobrara Rivers to the headwaters of Lewis and Clark Lake (Figure 2). This segment has increased water temperatures and turbidity due to inflows from the Niobrara River.

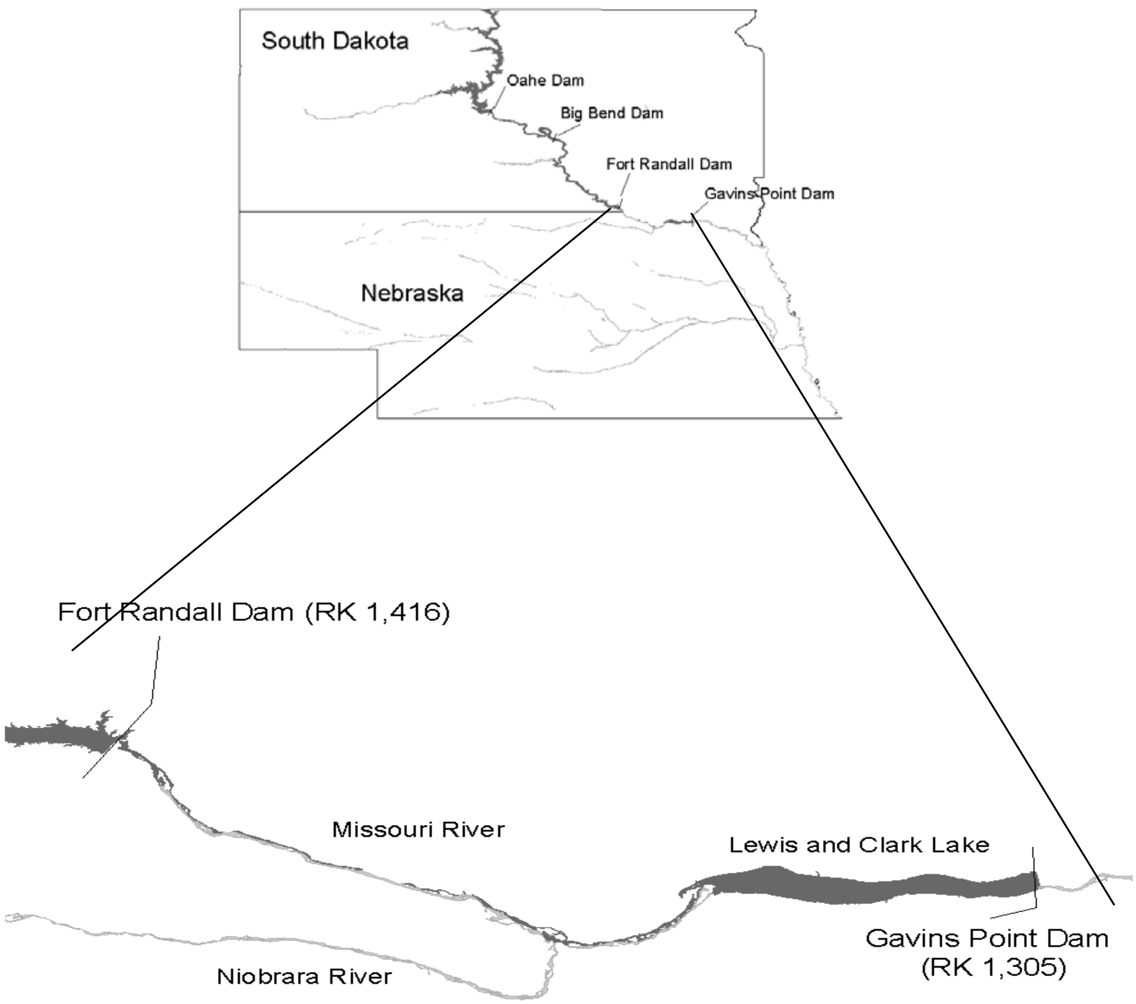

Figure 1. Map of the mainstem Missouri River reservoirs in South Dakota and Nebraska with the Fort Randall to Gavins Point section enlarged**.**

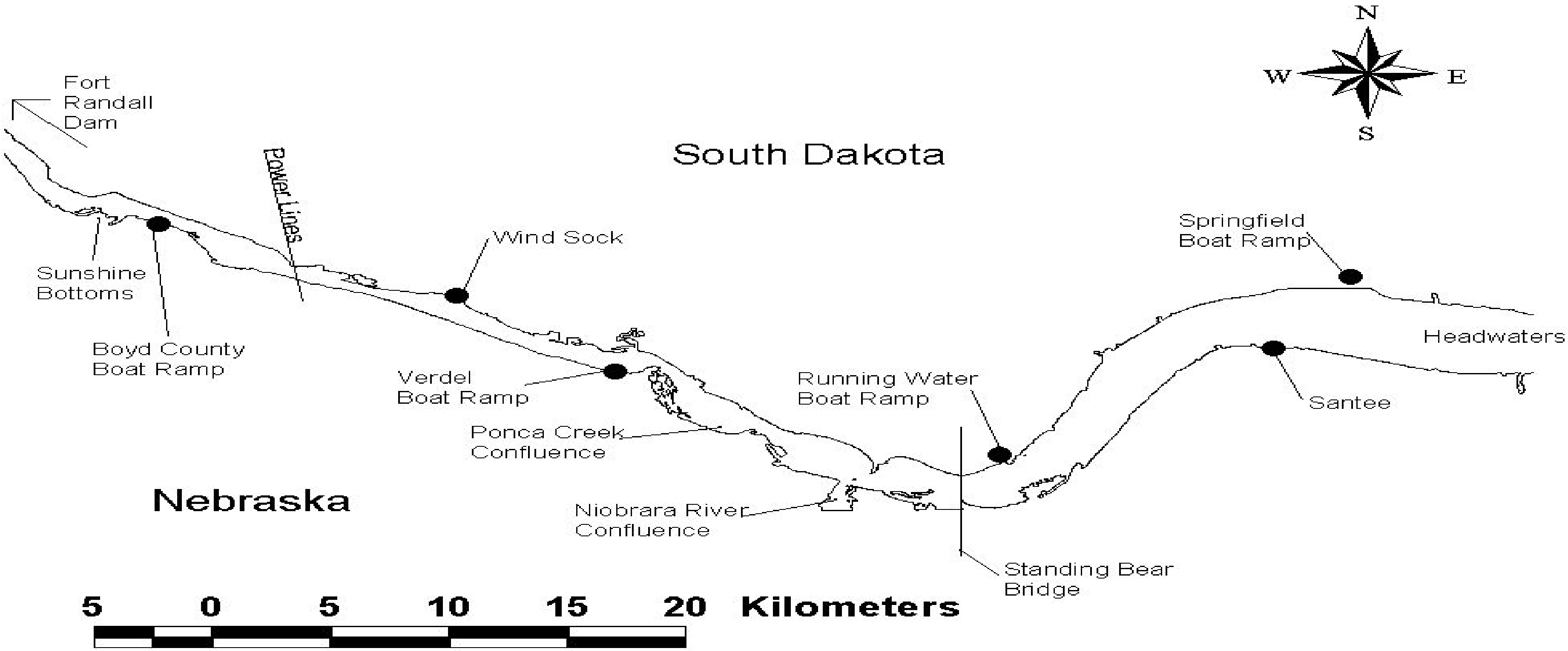

Figure 2**.** Map of the riverine portion of Lewis and Clark Lake with common landmarks. Segment 5 for the long term monitoring program encompassed the area between Fort Randall Dam to the Niobrara River Confluence. Segment 6 for the long term monitoring plan encompassed the area between the Niobrara River Confluence to the headwaters of Lewis and Clark Lake.

METHODS

Our sampling protocol followed the detailed guidelines identified in the "Long Term Pallid Sturgeon and Associated Fish Community Assessment for the Missouri River Guidelines and Standardized Guidelines for Sampling and Data Collection" developed by the Pallid Sturgeon Population Assessment Team (Drobish 2005b). A general summary of those guidelines follows.

Habitat Classification

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

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

Sampling Effort and Gear

All bends within each segment were sequentially numbered, from upstream to downstream, and then eight bends (four per segment) were randomly selected for sampling. An additional two bends, one in each segment, were non-randomly chosen. These non-random bends were the first bend upstream and downstream of the confluence of the Niobrara and Missouri rivers. Following the 2004 sample season, no non-random bends were sampled (i.e., all five bends in each segment were randomly selected. Additional bends to increase sample size were sampled as time allowed. Each mesohabitat within a macrohabitat was sampled using standard gears (Appendices B and C). A minimum of two sub-samples were required for each standard gear type for each habitat within that bend where a particular gear can effectively be deployed. Habitat data (velocity, substrate, turbidity) was collected at each pallid sturgeon capture site and in each bend for one of the two sub-samples. Depth and temperature were collected at all sampling locations. Detailed habitat data collection methods are found in Drobish (2005b).

A minimum number of gear deployments for each standard gear was used, (10 for gillnets and eight for all other gears) to ensure sufficient sample size for comparisons between segments (Tables 1 and 2). The standard gears were selected to sample specific habitats, fish species, and seasons. Some gears were selected to maximize capture of pallid sturgeon, while others targeted the associated fish community. However, gears sampled multiple species despite targeting the capture of pallid sturgeon or the fish community.

The sampling year was divided into two seasons: sturgeon season and fish community season. The sturgeon season encompassed the fall through spring while the fish community season occurred during summer. The sturgeon season focused on the assessment of sturgeon species while collections in the fish community season continued to assess sturgeon but placed additional emphasis and effort towards descriptions of the native fish community. Delineation between the sturgeon and fish community seasons is primarily based on water temperature. Based on the pallid sturgeon collection and handling protocols (USFWS 2002) pallid sturgeon can only be collected with gillnets at water temperatures < 12 °C. Due to the diverse habitats in the river and the longitudinal changes in climate along the Missouri River, a wide time frame was necessary to facilitate comparable sampling effort among the 14 segments. For example, gill netting in the Fork Peck reach of Montana and North Dakota (segments 1 – 4) is typically not feasible throughout winter because of ice. However, lack of ice in the lower reaches of the Missouri River permit gill netting during most of the winter. Additional gears were deployed during the fish community season to assess the main channel and shallow water habitats (< 1.2 m) and their associated fish communities. The fish community season ran between July 1 and October 30 and the intensive sturgeon sampling occurred when possible for the remainder of the year. Focused studies are initiated in conjunction with the fish population assessments program to fulfill unique biological information gaps (e.g., food habits and telemetry projects). However, these specialized studies fall into the focused research category and are not reported here.

Multiple gears were deployed to sample deep and shallow habitats of the Missouri River. Gillnets, trammel nets, and beam trawls are fished in deep waters of the main channel, large secondary connected channels, and large tributaries during the sturgeon season. In the fish community season, trammel nets and beam trawls were again used with the addition of mini-fyke nets and bag seines to sample shallow water habitats (i.e. bars). Multi-filament gillnets (1.8 m deep x 38 m length) consisted of five 8-m long panels with bar mesh sizes of 2.54 cm, 3.81 cm, 5.08 cm, 7.62 cm, and 10.16 cm. Trammel nets were 1.8 m deep X 38 m with outside wall panels of 15.24 cm bar mesh and an inside wall panel of 2.54 cm bar mesh. The benthic beam trawl (0.5 m deep x 2 m width) had an outer chafing mesh of 0.64 cm bar mesh, inner bar mesh of 0.32 cm, and a 2-m long cod end. Mini-fyke nets consisted of a lead set at the bankline (4.5 m long x 0.6 m high) with two 1.2 m wide x 0.6 m high rectangular steel frames (cab) and two 0.6 m diameter circular hoops with 3 mm "ACE" type nylon mesh. Bag seines were constructed of

6.4 mm “ACE” type mesh and were 9.1 m long, 1.8 m high, containing a 1.8 m x 1.8 m x 1.8 m bag. Gillnets and mini-fyke nets were set overnight for a maximum of 18 hour and CPUE was calculated as the number of fish per net night. Trammel nets were drifted and beam trawls were pulled on the river bottom for a minimum distance of 75 m and a maximum distance of 300 m. A global positioning system (GPS) was used to quantify distance sampled for trammel nets and beam trawls with CPUE measured as numbers of fish per 100 m of distance deployed. Deployment technique and seine width were used to quantify numbers of fish per m^2. All gear deployments followed the detailed standard operating procedures (SOP) outlined in Drobish (2005b).

In addition to the required standard gears, set lines and hoopnets, were used during both sampling seasons to target juvenile pallid sturgeon and shovelnose sturgeon. These additional gears are considered “wild” in the SOP (Drobish 2005b). Each set line contained two Mustad Tuna Circle hooks (sizes 10/0 and 12/0) and was held fast to the river bottom with a 1.8 kg collapsible anchor. Hooks were staged at 1m intervals from the anchor. Hoop nets were 4.8 m in length with 3.8 cm bar mesh and consisted of seven tapered 1.2 m diameter hoops. Hoop nets were used in areas where flow velocities were sufficient to maintain the net in a deployed position. Both setlines and hoop nets were marked with a float attached to a 40-ft line and set overnight for a maximum of 18 h. Hoop net and setline CPUE was calculated as the numbers of fish per net or hook night respectively. All target species captured with wild gears were used in calculating percents of the catch by habitat (macro- and meso- levels), length frequency histograms, and relative stock density (RSD) indices when applicable.

Calculations

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

Indices of fish condition (health) were calculated for pallid sturgeon and three native target Missouri River species: shovelnose sturgeon, bigmouth buffalo, and sauger. Relative condition factor (Kn) was calculated to assess the condition of pallid sturgeon and used the weight-length relation in Keenlyne and Evanson (1993). Relative weight (Wr) calculations require a length-specific standard weight derived from an overall standard weight-length relation encompassing multiple populations across a species’ range. Standard weight relations have been derived for shovelnose sturgeon (Quist et al. 1998), bigmouth buffalo (Bister et al. 2000), and sauger (Guy et al. 1989). Detailed equations for calculating Kn, and Wr are found in (Anderson and Newman 1996).

Incremental relative stock density (RSD) was calculated to describe the population size-structure of pallid sturgeon, shovelnose sturgeon, bigmouth buffalo, and sauger using methods proposed by Gabelhouse (1984). For pallid sturgeon, length categories proposed by Shuman et al. (in review) were used to determine relative stock densities (RSD). These length categories are stock-quality (330 – 629 mm), quality-preferred (630 - 839 mm), preferred-memorable (840 - 1039 mm), memorable-trophy (1040 - 1269 mm), and trophy (≥ 1270 mm). Length categories exist in the literature for three target species of the population assessment program: shovelnose sturgeon (Quist et al. 1998), bigmouth buffalo (Bister et al. 2000) and sauger (Gablehouse 1984). For these four species, we calculated the percents of < stock, stock, and > stock sized fish captured in each macrohabitat and mesohabitat type. Detailed calculations of RSD are found in Anderson and Newman (1996).

Table 1. Number of bends sampled, mean effort per bend (as deployments of each gear type), and total gear deployments by macrohabitat for segments 5 and 6 in the Missouri River during fall through spring (sturgeon season) and summer (fish community season) in 2004. Macrohabitat definitions and abbreviations are presented in Appendix B.

Gear	Number of bends	Mean effort/bend	Macrohabitat								
			OSB	ISB	CHXO	SCCL	SCCS	SCN	TRML	TRMS	CONF
Fall through Spring - Sturgeon Season											
Gillnet	10	20	69	73	25	23		4			
Trammel net	14	7.6	33	24	26	6					
Beam Trawl	10	8.1	20	19	19	6	2				
Hoop net	10	8	24	18	18	3	1				
Set lines	12	26.2	94	83	81	25	6				
Summer – Fish Community Season											
Bag seine	11	19.2	60	71	2	75		3			
Mini-fyke	10	10.5	30	36	2	35	1	1			
Trammel net	10	8.8	18	16	20	8					
Beam Trawl	10	8	16	15	15	8	2				
Hoop net	10	8.4	16	15	15	10					2
Set lines	10	24.9	60	52	55	26					

Table 1 (extended).

Gear	Number of bends	Mean effort/bend	Macrohabitat BRAD	Macrohabitat DEND	Macrohabitat DRNG	Total deployments
Fall through Spring - Sturgeon Season						
Gillnet	10	20	6			200
Trammel net	14	7.6	15			106
Beam Trawl	10	8.1	15			81
Hoop net	10	8	16			80
Set lines	12	26.2	25			314
Summer – Fish Community Season						
Bag seine	11	19.2				211
Mini-fyke	10	10.5				105
Trammel net	10	8.8	26			88
Beam Trawl	10	8	24			80
Hoop net	10	8.4	26			84
Set lines	10	24.9	56			249

Table 2. Number of bends sampled, mean effort per bend (as deployments of each gear type), and total gear deployments by mesohabitat for segment 5 and 6 in the Missouri River during fall through spring (sturgeon season) and summer (fish community season) in 2004. Mesohabitat definitions and abbreviations are presented in Appendix B.

Gear	Number of bends	Mean effort/bend	Mesohabitat					Total deployments
			BAR	POOL	CHNB	TLWG	ITIP	
Fall through Spring - Sturgeon Season								
Gillnet	10	20		37	155		8	200
Trammel net	14	7.6		6	98			104
Beam Trawl	10	8.1		2	79			81
Hoop net	10	8		10	70			80
Set lines	12	26.2		39	275			314
Summer – Fish Community Season								
Bag seine	11	19.2	211					211
Mini-fyke	10	10.5	105					105
Trammel net	10	8.8		1	87			88
Beam Trawl	10	8			80			80
Hoop net	10	8.4		8	76			84
Set Lines	10	24.9		14	235			249

RESULTS

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

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

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

Pallid sturgeon

A total of 28 pallid sturgeons were captured during the 2004 season with 25 fish caught in standard gears: gillnets (n = 12) and trammel nets (n = 13). Catch per unit effort was greatest for gill nets (0.066 fish/net night) followed by trammel nets (Figures 3 and 4). The mean CPUE of pallid sturgeon with gillnets was essentially the same in 2003 and 2004; whereas, mean CPUE for trammel nets in 2004 was double that seen in 2003 during the sturgeon season (fall through spring). Trammel net mean CPUE during the fish community season (summer) was similar in both years. As expected, the variability in mean CPUE for all gears was high to due the high incidence of zero catches, 95% for gillnets and 97% for trammel nets. The majority of pallid sturgeons were captured during the sturgeon season (n = 21); only 7 fish were captured during the fish community season. No pallid sturgeons were captured with beam trawls during either the sturgeon or fish community seasons. Mini-fyke nets and seines also caught no pallid sturgeon during the fish community season.

Pallid sturgeons were captured throughout segments 5 and 6 demonstrating no affinity towards a specific bend (Figure 5). Macrohabitats where pallid sturgeons were captured included outside bends, inside bends, channel crossovers, and large secondary connected channels (Figure 6). During the fish community season, pallid sturgeon were also captured in the braided macrohabitat. However, 2004 season was the first time the braided, deranged, and dendritic macrohabitat categories were used. Channel borders were the mesohabitat where most pallid sturgeon were captured (Figure 7).

All pallid sturgeon captured were considered to be of hatchery origin. Recaptured pallid sturgeon either had detectable marks or were similar in size to stocked fish (Tables 3 and 4). Pit tag retention was 86%. Eight recaptured fish, most from the 1999 year class, lost weight while at liberty, while all fish added length (Table 5). The mean relative condition factor ranged from 0.66 to 0.91 for all year classes and declined since stocking.

Fork lengths (FL) of pallid sturgeon ranged from 310 – 750 mm in segments 5 and 6 during 2004 (Figure 8). There was no evidence of recruitment by wild pallid sturgeon. Most pallid sturgeon were of stock-quality length with only one fish smaller than stock size (Table 6). Incremental RSD for pallid sturgeon during the sturgeon season was generally similar to the fish community season. No hybrid *Scaphirhynchus* (pallid x shovelnose sturgeon) were captured and the ratio of pallid to shovelnose sturgeon was 1:3.25 (Table 7).

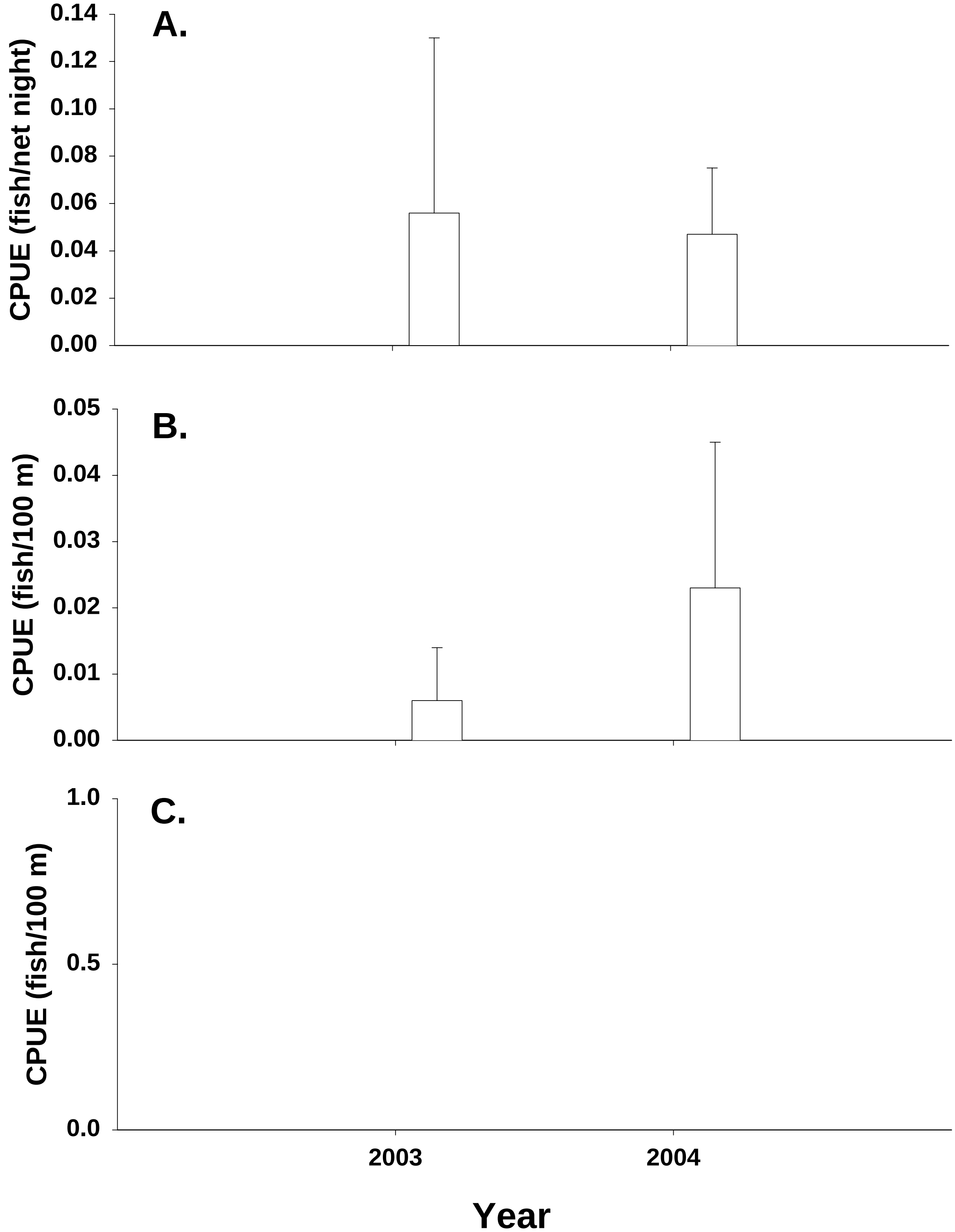

Figure 3. Mean annual catch-per-unit-effort (+/- 2SE) of wild (black bars) and stocked (white bars) pallid sturgeon in segments 5 and 6 of the Missouri River for: A) gill nets, B) trammel nets, and C) beam trawls from fall through spring (Sturgeon season) during 2003 - 2004.

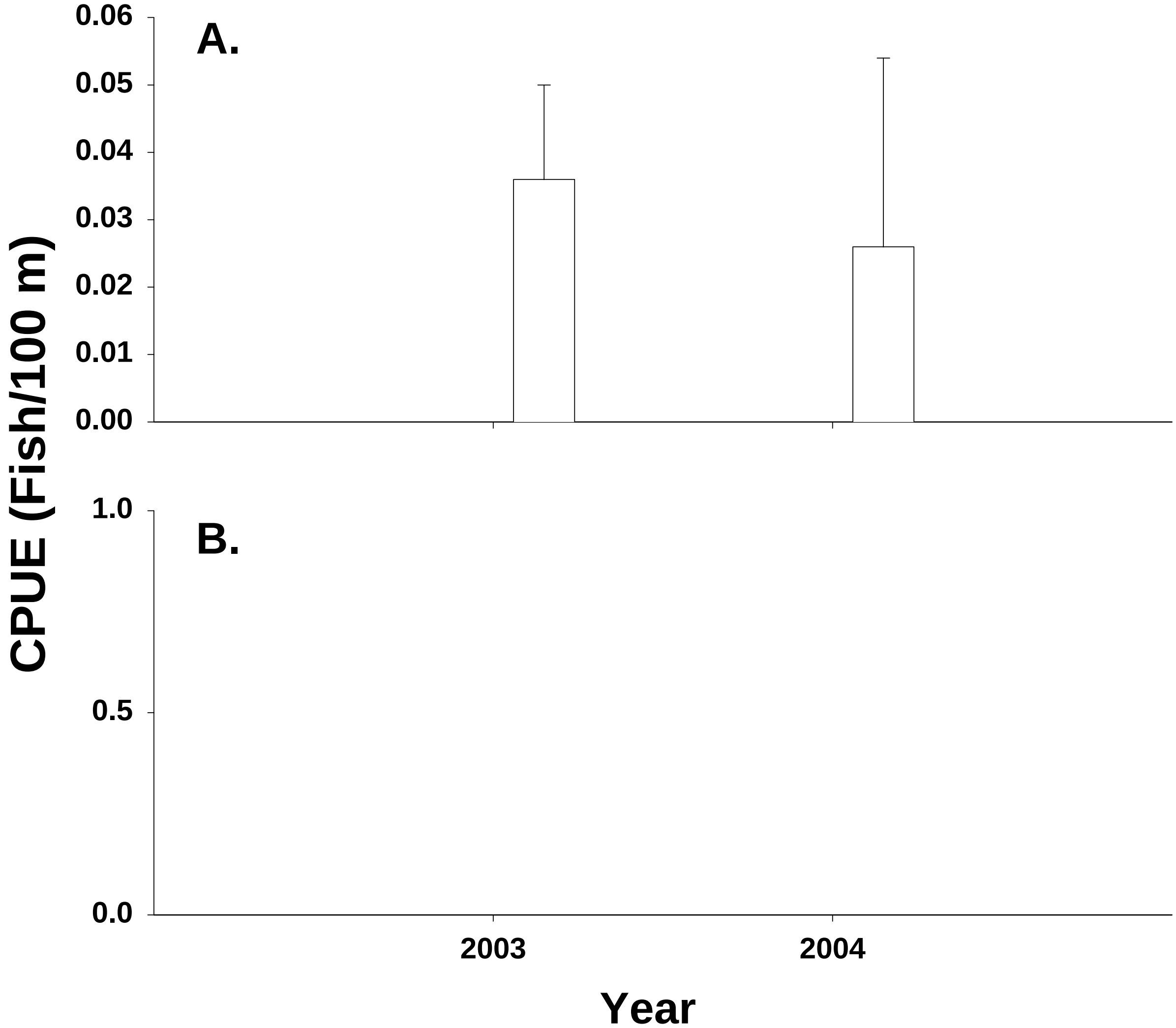

Figure 4. Mean annual catch-per-unit-effort (+/- 2 SE) of wild (black bars) and stocked (white bars) pallid sturgeon in segments 5 and 6 of the Missouri River for: A) trammel nets and B) beam trawls in summer (Fish Community Season) during 2003 -2004.

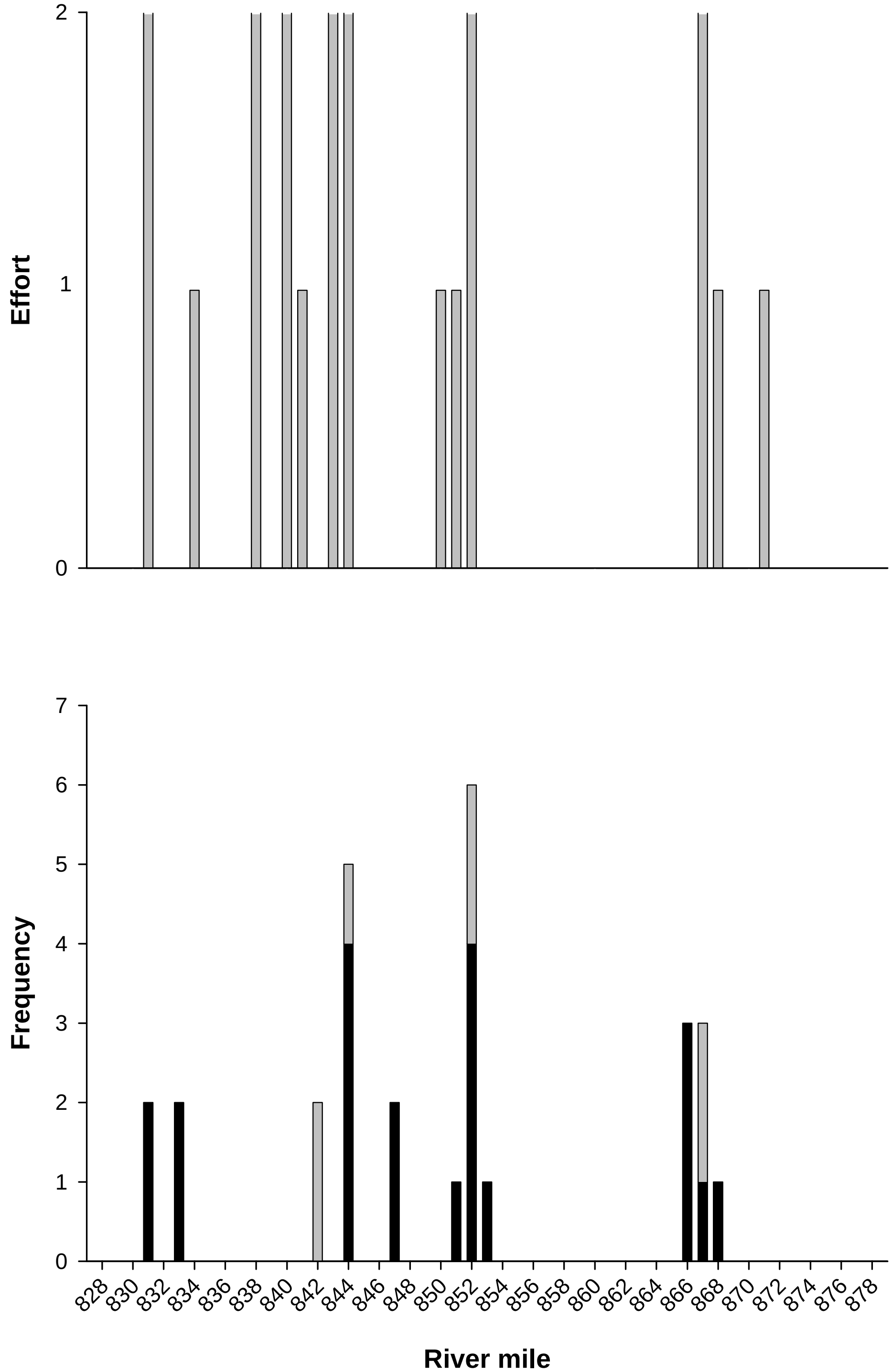

Figure 5. Distribution of: A) sampling effort and B) pallid sturgeon catch by river mile for segments 5 and 6 of the Missouri River during 2003 - 2004. Sampling effort of 2 indicates river miles sampled in both the fall to spring (Sturgeon season) and summer (Fish Community Season), Sampling effort of 1 indicates that river mile was only sampled in one season.

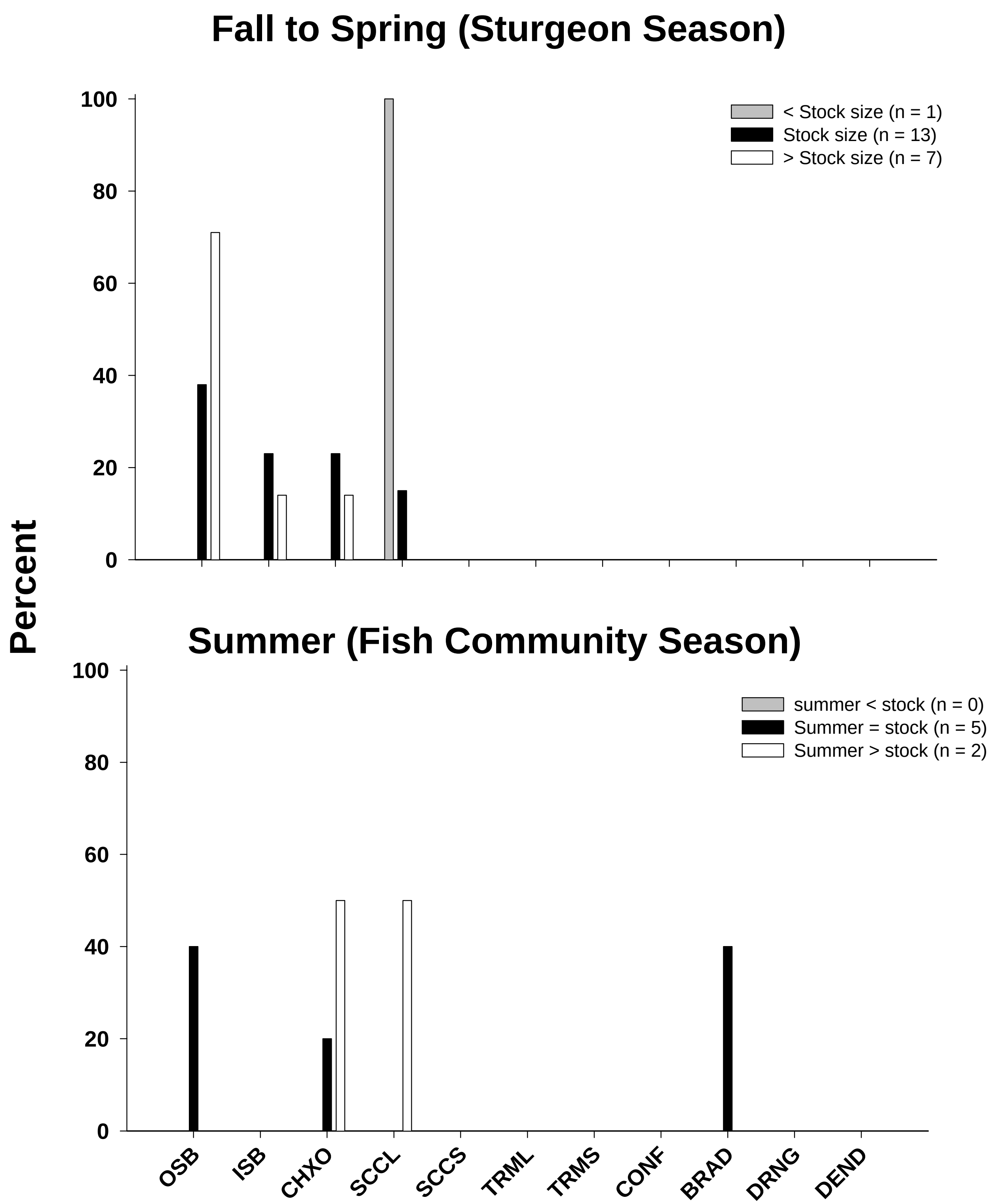

Figure 6. Percent of total pallid sturgeon for three size classes caught by macrohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

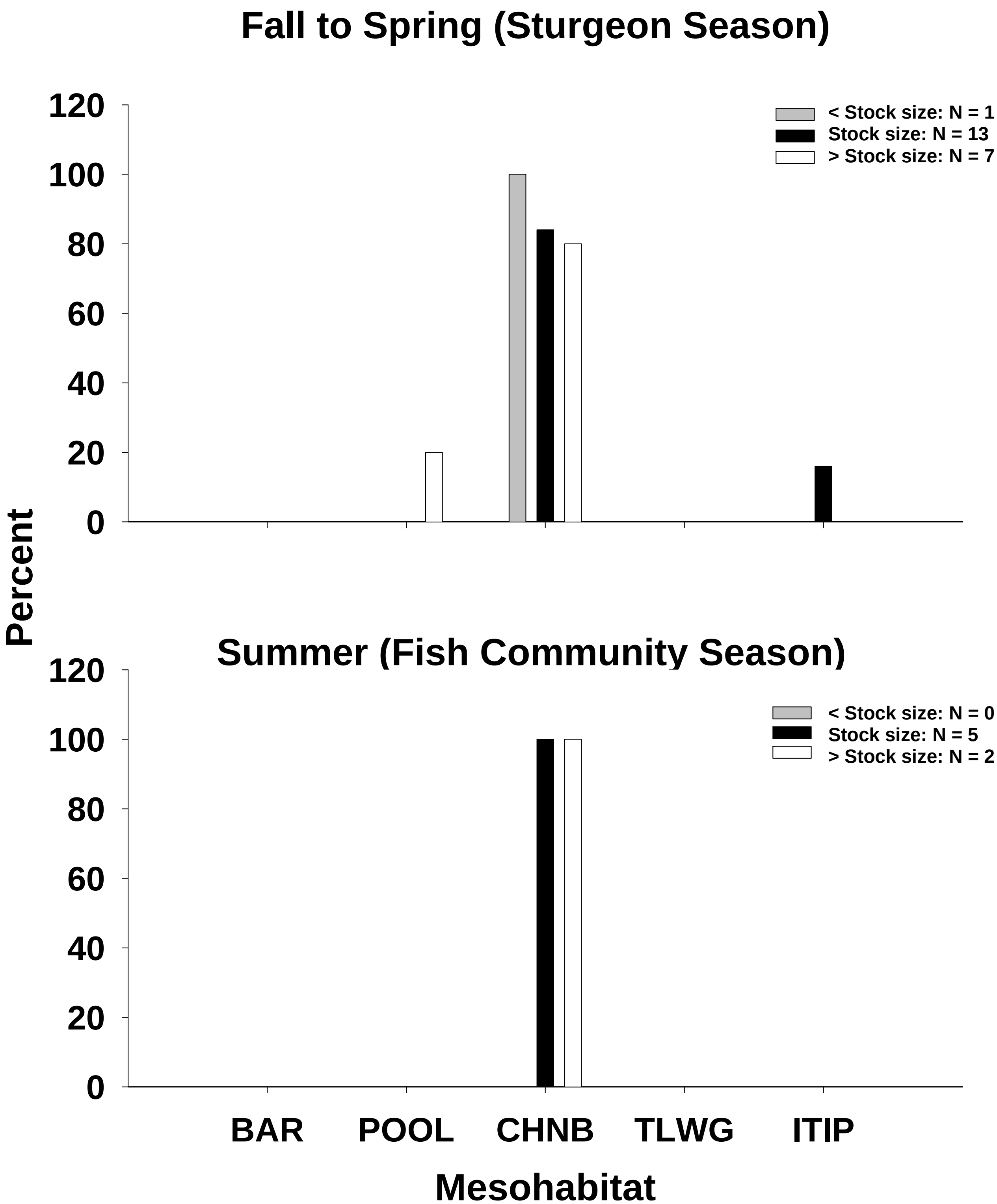

Figure 7. Percent of total pallid sturgeon for three size classes caught by mesohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

Table 3. Pallid sturgeon (PDSG) and hybrid sturgeon (SNPD) capture locations and habitat characteristics for segments 5 and 6 of the Missouri River during 2004. ID number links habitat information with individual fish length, weight, and tagging data in Table 4. Gear codes presented in Appendix C. Habitat definitions and codes presented in Appendices B.

						Habitat								
Species	Date	Gear	Latitude (°)	Longitude (°)	River mile	Macro-	Meso-	Micro-	Water Temp (°C)	Turb[a] (NTU)	Depth[b] (m)	Bottom velocity (m/s)	Substrate[c] (silt/sand/gravel)	ID#
PDSG	10/23/2003	GN14	42.83709	-98.1705	853	OSB	CHNB	STPS	14	6	4.1	0.44	0/100/0	1
PDSG	10/26/2003	GN41	42.84314	-97.8435	831	OSB	CHNB	STPS	11	19	6.3	0.45	10/90/0	2
PDSG	11/18/2003	GN14	42.92811	-98.4334	868	ISB	CHNB	.	8	5	4.2	0.68	0/100/0	3
PDSG	11/18/2003	GN41	42.92754	-98.4184	866	OSB	CHNB	.	8	6	4.9	0.43	0/100/0	4
PDSG	11/18/2003	GN41	42.92754	-98.4184	866	OSB	CHNB	.	8	6	4.9	0.43	0/100/0	5
PDSG	11/18/2003	GN41	42.92754	-98.4184	866	OSB	CHNB	.	8	6	4.9	0.43	0/100/0	6
PDSG	11/19/2003	GN41	42.77507	-98.0481	844	CHXO	CHNB	.	8	.	4.8	.		7
PDSG	11/19/2003	GN41	42.77695	-98.05	844	ISB	ITIP	.	8	9	3.8	0.37	0/100/0	8
PDSG	11/19/2003	GN41	42.77695	-98.05	844	ISB	ITIP	.	8	9	3.8	0.37	0/100/0	9
PDSG	4/14/2004	GN41	42.84396	-97.8424	831	ISB	CHNB	.	9	14	2.4	0.45	90/10/0	10
PDSG	4/15/2004	GN41	42.83599	-98.1639	852	OSB	CHNB	.	6	2	2.6	0.3	30/60/10	11
PDSG	4/19/2004	SL	42.92591	-98.4249	867	OSB	CHNB	.	7	3	3.9	0.36	0/100/0	12
PDSG	4/22/2004	GN41	42.83449	-98.1391	851	CHXO	CHNB	.	8	2	3.5	0.1	0/100/0	13
PDSG	4/22/2004	TN	42.83788	-98.1645	852	SCCL	CHNB	.	7	3	2.5	0.37	0/100/0	14
PDSG	4/22/2004	TN	42.83788	-98.1645	852	SCCL	CHNB	.	8	3	2.5	0.37	0/100/0	15
PDSG	4/22/2004	TN	42.83788	-98.1645	852	SCCL	CHNB	.	8	3	2.5	0.37	0/100/0	16
PDSG	4/22/2004	TN	42.78352	-98.0663	846	CHXO	CHNB	.	8	3	6.4	0.27	0/100/0	17
PDSG	5/13/2004	TN	42.79987	-98.0863	847	OSB	POOL	.	13	6	9	0.55	0/90/10	18
PDSG	5/18/2004	SL	42.80446	-98.0964	847.5	CHXO	CHNB	.	15	3	3.5	0.44	10/90/0	19
PDSG	5/19/2004	TN	42.8437	-97.863	833	OSB	CHNB	.	16	12	3.2	0.78	0/95/5	20
PDSG	5/19/2004	TN	42.8437	-97.863	833	OSB	CHNB	.	16	12	3.2	0.78	0/95/5	21
PDSG	7/13/2004	TN	42.83067	-98.156	851.7	CHXO	CHNB	.	20	3	7.4	0.33	0/95/5	22
PDSG	7/13/2004	TN	42.83067	-98.156	851.7	CHXO	CHNB	.	20	3	7.4	0.33	0/95/5	23
PDSG	7/14/2004	SL	42.79046	-98.0533	844	SCCL	CHNB	.	21	9	2.6	0.46	0/100/0	24
PDSG	7/23/2004	TN	42.76494	-97.9999	841.8	BRAD	CHNB	.	21	12	1.9	0.51	0/100/0	25
PDSG	7/23/2004	TN	42.76494	-97.9999	841.8	BRAD	CHNB	.	21	12	1.9	0.51	0/100/0	26
PDSG	10/6/2004	TN	42.92361	-98.4192	867	OSB	CHNB	.	17	4	1.7	0.62	0/100/0	27
PDSG	10/7/2004	TN	42.92361	-98.4192	867	OSB	CHNB	.	17	4	1.7	0.62	0/100/0	28

[a]Turb = turbidity.
[b]Depths presented are the average of the starting, middle, and ending depths measured during gear deployment.
[c]Substrates are percents determined visually and by feel in the field.

Table 4. Pallid and hybrid sturgeon captured in segments 5 and 6 of the Missouri River during 2004. Recapture data includes: lengths (fork length [FL]), weights (wt), morphometric character index (CI) (Sheehan et al. 1999), status (H = hatchery, W = wild), tags found, elastomer tags (color, position, and orientation), and if tags were inserted in the field. Stocking history (if applicable) for each fish includes: year class, stocking length, weight, site, and hatchery source. The fish ID number links individual fish data with location and habitat data in Table 3.

	Recapture data								Stocking data				
ID #	FL (mm)	Wt (g)	CI	Status	Tags found[a]	Tag Number(s)[b,d]	Elastomer[c]	Marked in field?[d]	Year class	FL (mm)	Wt (g)	Site	Source
1	670	900		H	P,D	406E5F130F	Green	NO	1997	545	715	VER	GAV
2	680	1074		H	P,D	411A694D40	Blue	NO	1997	545	605	VER	GAV
3	581	612		H	P	424E680D67		NO	1999	519	697	SUN	GAV
4	555	522		H	P	423C127A3F		NO	1999	523	625	SUN	GAV
5	533	422		H	P	424F181402		NO	1999	463	523	SUN	GAV
6	593	584		H	P	4250041B1D		NO	1999	515	671	SUN	GAV
7	665	1000		H	.	.	.	NO	.	.	.	.	.
8	560	620		H	.	.	.	NO	.	.	.	.	.
9	578	607		H	.	.	.	NO	.	.	.	.	.
10	760	1253		H	.	.		NO	.	.	.	.	.
11	546	420		H	P,D	411B5A5E45		NO	1998	487	491	VER	GAV
12	538	458		H	P	424D2B1821		NO	1999	488	472	SUN	GAV
13	627	712		H	P	411B0F732C		NO	1997	530	635	VER	GAV
14	385	142		H	P	4323482363		NO	2001	220	.	VER	GAR
15	439	268		H	P	424B35301F		NO	1999	356	123	SUN	GAV
16	324	104.8		H	P	4442674279		NO	2002	210	33	SBB	GAV
17	617	435		H	P,D	411B724227		NO	1997	566	709	VER	GAV
18	664	881		H	P	411B4C467A		NO	1997	567	900	VER	GAV
19	571	532		H	P	435E347D73		YES					
20	648	908		H	P	41102D3C77	Orange	NO	1997	551	564	VER	GAV
21	706	1152		H	P	411B6C795B	Green	NO	1997	600	1000	VER	GAV
22	362	145		H	P	431C3B023A		NO	2001	210	.	VER	GAR
23	635	794		H	P	406E612022	Orange	NO	1997	528	512	VER	GAV
24	686	1010		H	P	424F0B6C5F		NO	1998	586	909	VER	GAV
25	494	391		H	P	435F15582E		YES					
26	458	326		H	P	431C7A291D		NO	2001	210	.	VER	GAR
27	368	160		H	P	42573D4C60		NO	2002	246	61	SBB	GAV

Table 4. (continued).

ID #	Recapture data								Stocking data				
	FL (mm)	Wt (g)	CI	Status	Tags found[a]	Tag Number(s)[b,d]	Elastomer[c]	Marked in field?[d]	Year class	FL (mm)	Wt (g)	Site	Source
28	359	134		H	P	4255792565		NO	2002	247	61	SUN	GAV

[a]Tag types include: coded wire tag (C), dangler tag (D), elastomer (E), floy (F), jaw tag (J), passive integrated transponder tag, i.e., PIT tag (P), and self piercing tag (S).
[b]Tag type in parentheses after number.
[c]Postitons and orientations listed after each color can include: fish's right (R), fish's left (L), center of rostrum (C), vertical (V), and horizontal (H).
[d]If fish marked in the field, tag number corresponds to new tag and the type is in parentheses next to the tag number.
[e]Stocking site codes found in Appendix yy.
[f]Hatchery sources: BOZ = Bozeman Fish Technology Center in MT, BPY = Blind Pony State Hatchery in MO, GAR = Garrison Dam National Fish Hatchery (NFH) in ND, GAV = Gavins Point Dam NFH in SD, MCY = Miles City State Fish Hatchery in MT, NAT = Natchitoches NFH in LA, NEO = Neosho NFH in MO and PEC = Fort Peck Dam State Fish Hatchery in MT.

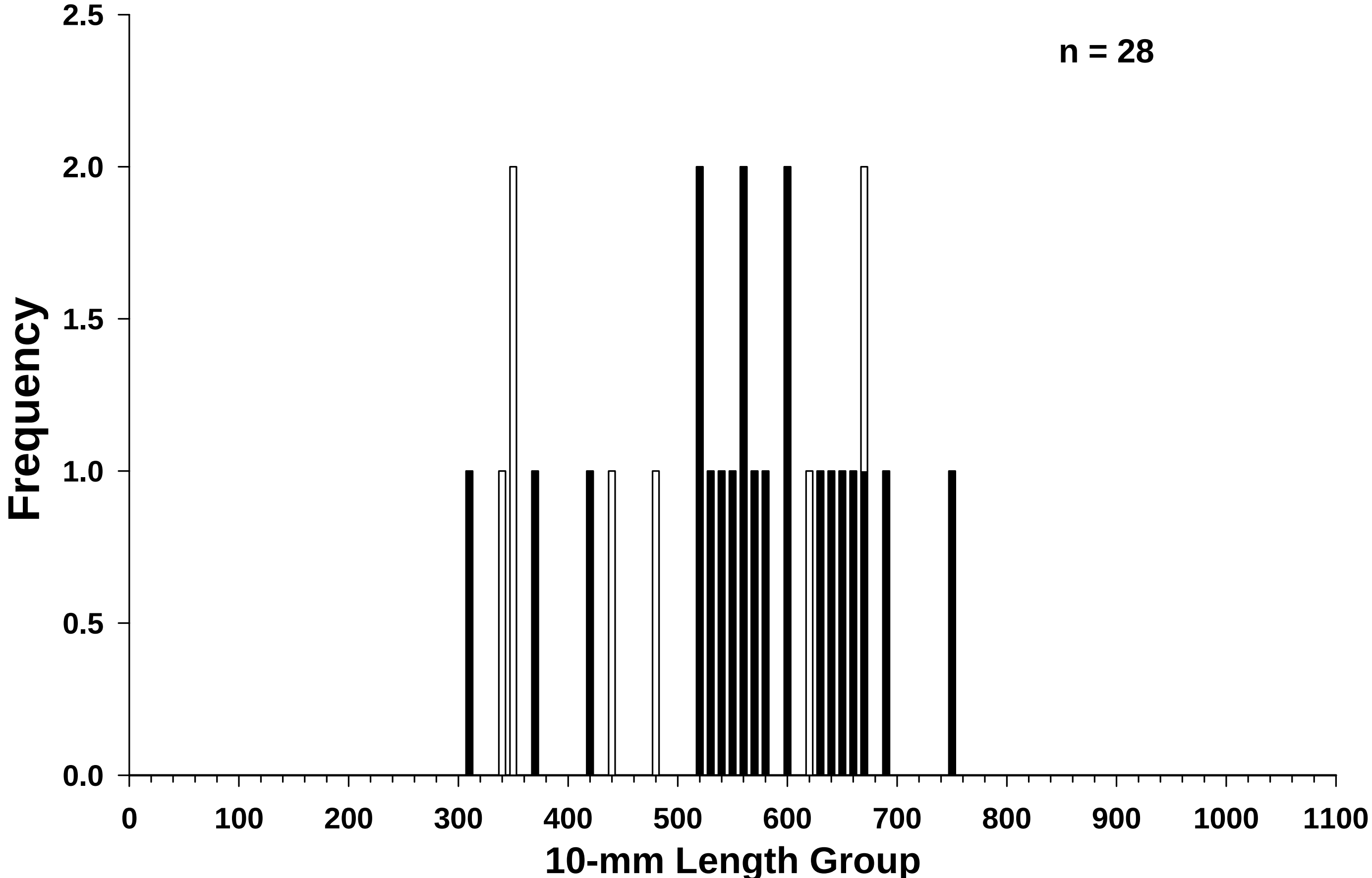

Figure 8. Length frequency of pallid sturgeon during fall through spring (sturgeon season, black bars) and summer (fish community season, white bars) in segments 5 and 6 of the Missouri River during 2004.

Table 5. Mean fork length (+/- 2 SE), weight (+/- 2 SE), mean relative condition factor (Kn) (+/- 2 SE) and growth rates of juvenile hatchery-reared pallid sturgeon by year class at the time of stocking and recapture in 2004 for segments 5 and 6 of the Missouri River. Relative condition factor was calculated using the equation in Keenlyne and Evanson (1993).

		Stocking			Recapture				
Year class	N	Length (mm)	Weight (g)	Kn	Length (mm)	Weight (g)	Kn	Growth (mm/d)	Growth (g/d)
1997	8	554 (17)	705 (119)	1.03 (0.09)	656 (21)	857 (156)	0.7 (1.41)	0.082 (0.020)	0.120 (0.120)
1998	2	537 (99)	700 (418)	1.11 (0.01)	616 (140)	715 (590)	0.69 (0.08)	0.057 (0.029)	0.010 (0.122)
1999	6	477 (52)	519 (173)	1.16 (0.17)	540 (45)	478 (102)	0.76 (0.05)	0.101 (0.026)	-0.079 (0.122)
2001	3	213 (7)	.	.	402 (58)	204 (122)	0.84 (0.13)	0.235 (0.116)	.
2002	3	234 (24)	52 (19)	1.33 (0.07)	350 (27)	133 (32)	0.91 (0.06)	0.309 (0.114)	0.213 (0.068)

Table 6. Incremental relative stock density (RSD)[a] by length category for wild and stocked pallid sturgeon in segments 5 and 6 of the Missouri River captured during 2004. Length categories[b] determined by Shuman et al. (in review).using the methods proposed by Gablehouse (1984).

Length Category	Wild N	Wild RSD	Stocked N	Stocked RSD
Fall through Spring (Sturgeon Season)				
Sub stock[c]	0		1	
Stock -quality	0	0	13	64
Quality - preferred	0	0	8	36
Preferred - memorable	0	0	0	0
Memorable -trophy	0	0	0	0
Trophy	0	0	0	0
Summer (Fish Community Season)				
Sub stock[c]	0		0	
Stock -quality	0	0	5	71
Quality - preferred	0	0	2	29
Preferred - memorable	0	0	0	0
Memorable -trophy	0	0	0	0
Trophy	0	0	0	0

[a]RSD = number of fish ≥ specified length ÷ number of fish ≥ minimum stock length x 100.
[b]Length categories based on Shuman et al. (in review): sub-stock FL < 330 mm, Stock FL = 330 – 629 mm, Quality FL = 630 – 839 mm (36 - 45%), Preferred FL = 840 – 1039 mm, Memorable FL = 1040 – 1269 mm, Trophy FL ≥ 1270 mm.
[c]RSD not calculated for sub stock sized fish.

Table 7. Ratios of pallid sturgeon to shovelnose sturgeon, pallid sturgeon to hybrids (pallid x shovelnose), and stocked pallid sturgeon to wild pallid sturgeon captured in segments 5 and 6 of the Missouri River during 2004.

Pallid:Shovelnose	Pallid:Hybrid	Stocked:Wild
1:3.25	n/c	n/c

n/c = could not calculate ratio due to zero catches of hybrids and wild pallid sturgeon.

MISSOURI RIVER FISH COMMUNITY

Targeted Native Missouri River Species

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

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

Shovelnose sturgeon

A total of 91 shovelnose sturgeons were sampled in 2004 with 78 captured in standard gears. Most shovelnose sturgeon were captured with gillnets (n = 43) and trammel nets (n = 30). Only 5 shovelnose sturgeons were captured in the beam trawl. Catch per unit effort of shovelnose sturgeon (Figures 9 and 10) was greatest in gillnets (0.24 fish/net night). The CPUE by trammel net in the sturgeon season (0.06 fish/100 m) was similar to the fish community season CPUE (0.05 fish/100 m). Mean CPUE in gillnets increased three fold in 2004 compared to 2003; whereas, mean CPUE with trammel nets was essentially the same in both years (Figure 9). No shovelnose sturgeon were captured in the beam trawl during 2003. Seventy-three shovelnose sturgeons were captured during the sturgeon season while 18 were captured during the fish community season. No shovelnose sturgeon were captured in the mini-fyke nets or bag seines.

Shovelnose sturgeon were found in all macrohabitats that were sampled. Most fish were captured from outside bend (34%), inside bend, (31%), and channel crossover (24%) macrohabitats during the sturgeon season. During the fish community season, 83% of shovelnose sturgeon were captured in braided (44%) and outside bend (39%) macrohabitats (Figure 11). Nearly all shovelnose sturgeon captured were caught in the channel boarder mesohabitat, with the exception of five fish collected from pools (Figure 12).

Fork lengths of shovelnose sturgeon ranged from 528– 725 mm with 70% of the fish between the 590 – 670 mm (Figure 13). No shovelnose sturgeon of quality length and smaller were captured. Incremental RSD for shovelnose sturgeon in both seasons indicated an ageing population with little recruitment. No fish smaller than the preferred size group were caught (Table 8). Shovelnose sturgeon during the sturgeon (n = 64) and fish community seasons (n = 18) exhibited a mean Wr of 97 and 91, respectively. Relative weights of shovelnose sturgeon had similar ranges during the sturgeon (72 – 126) and fish community (75 – 114).

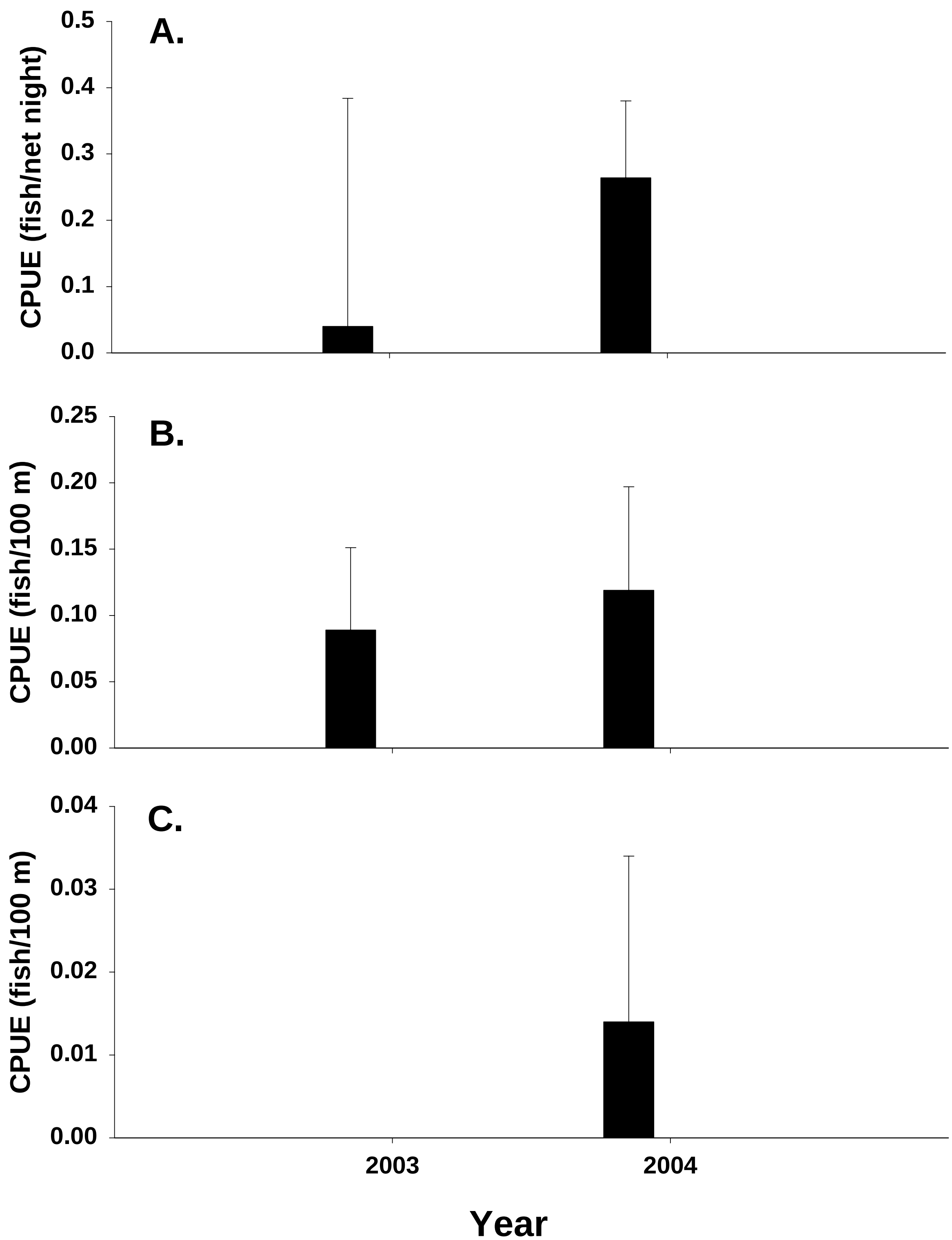

Figure 9. Mean annual catch-per-unit-effort (+/- 2SE) of wild (black bars) and stocked (white bars) shovelnose sturgeon in segments 5 and 6 of the Missouri River for: A) gill nets, B) trammel nets, and C) beam trawls from fall through spring (Sturgeon season) during 2003- 2004

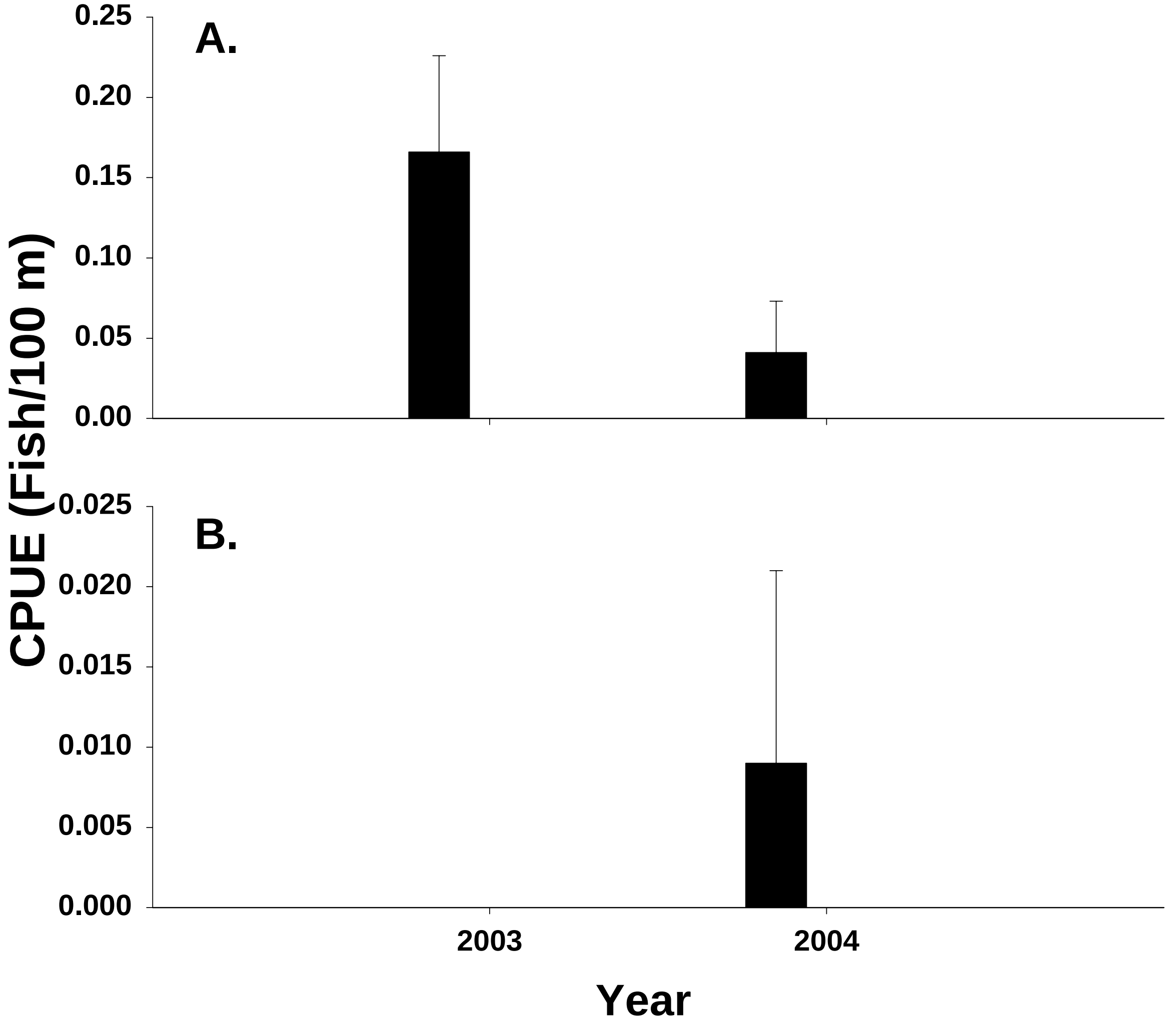

Figure 10. Mean annual catch-per-unit-effort (+/- 2 SE) of wild (black bars) and stocked (white bars) shovelnose sturgeon in segments 5 and 6 of the Missouri River for: A) trammel nets and B) beam trawls in summer (Fish Community Season) during 2003 - 2004.

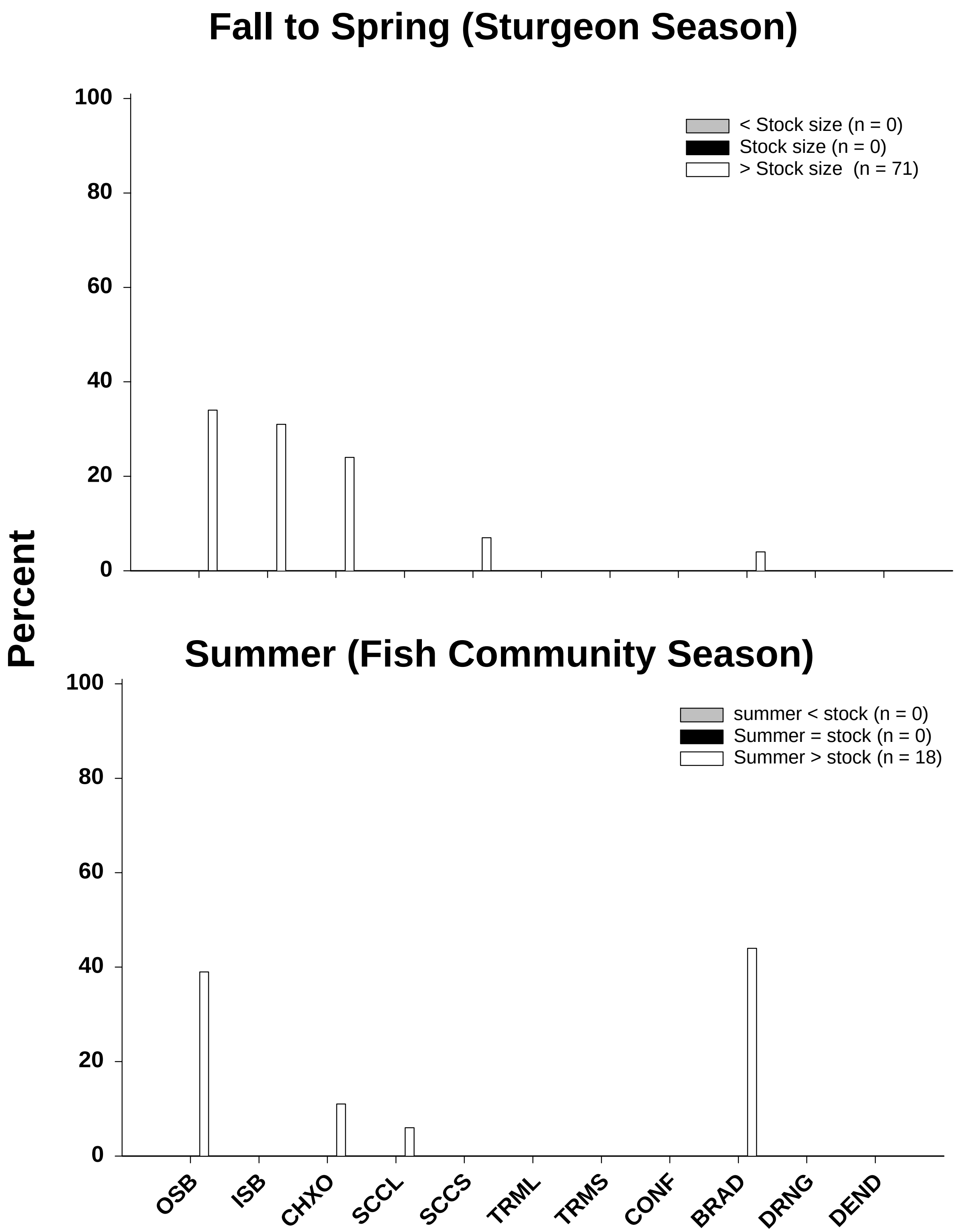

Figure 11. Percent of total shovelnose sturgeon for three size classes caught by macrohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

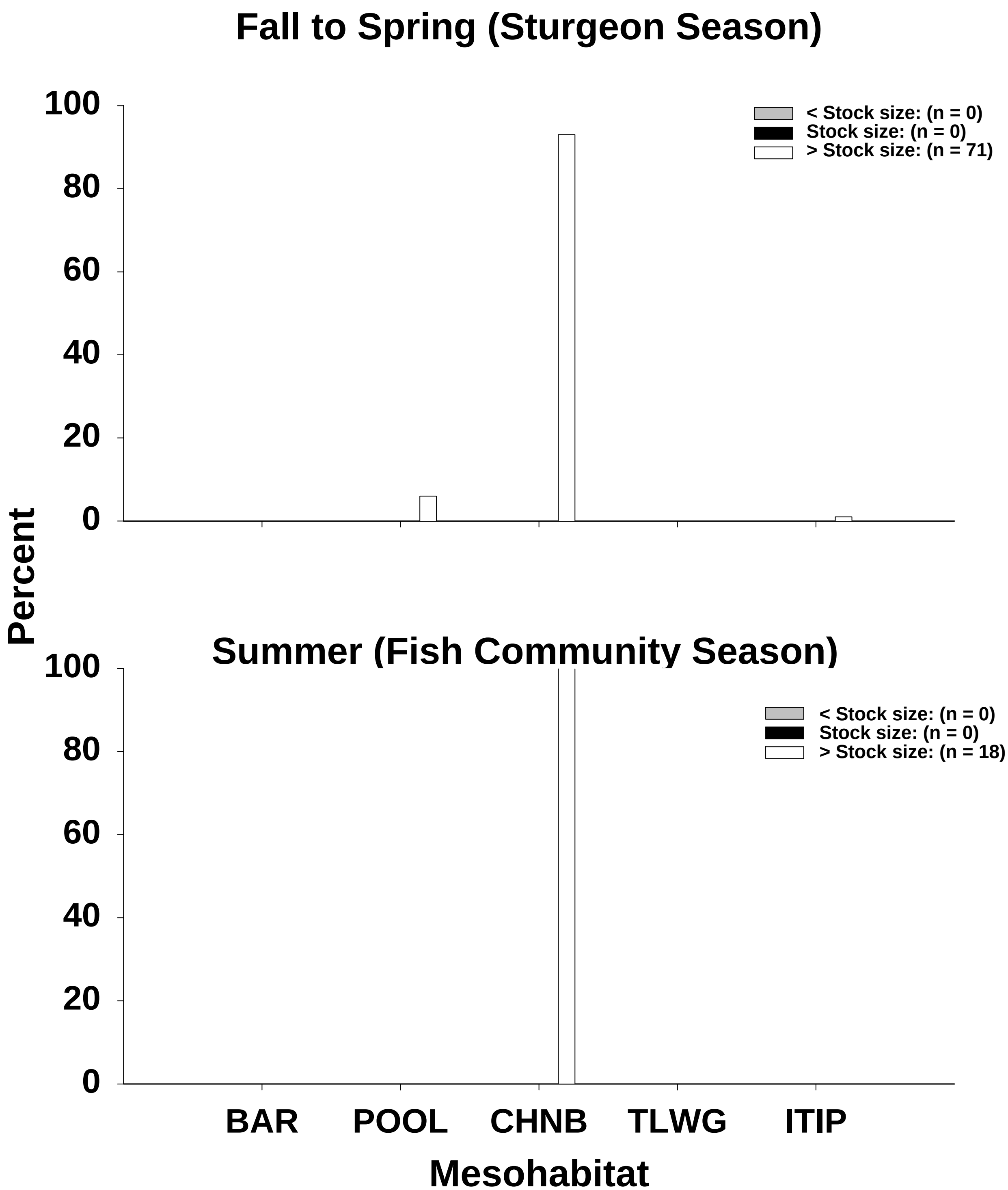

Figure 12. Percent of total shovelnose sturgeon for three size classes caught by mesohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

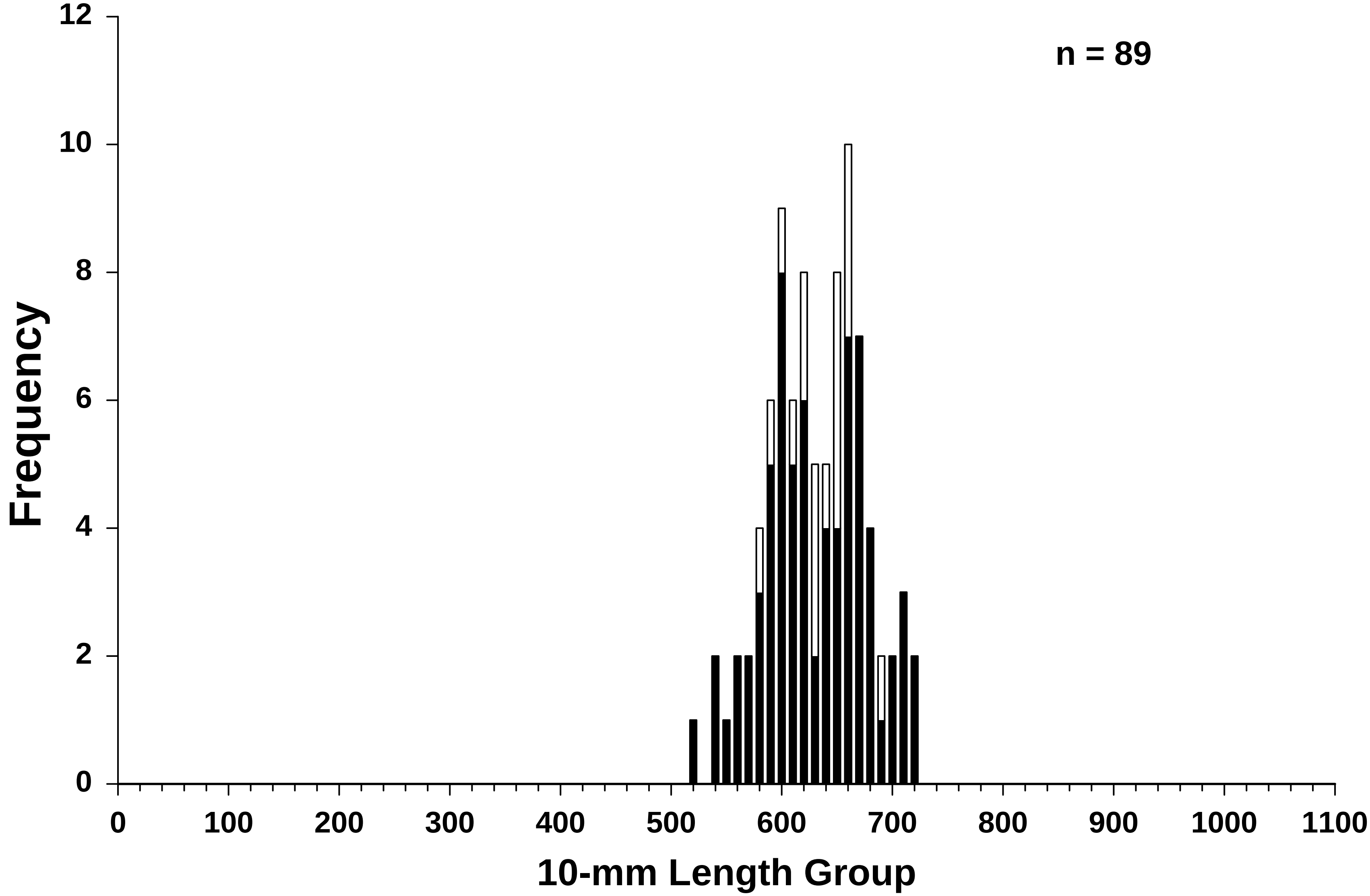

Figure 13. Length frequency of shovelnose sturgeon during fall through spring (sturgeon season, black bars) and summer (fish community season, white bars) in segments 5 and 6 of the Missouri River during 2004.

Table 8. Incremental relative stock density (RSD)[a] by length category of shovelnose sturgeon in segments 5 and 6 of the Missouri River captured during 2004. Length categories[b] based on the system proposed by Quist et al. (1998).

Length category	N	RSD
Fall through Spring (Sturgeon Season)		
Sub stock	0	
Stock -quality	0	0
Quality - preferred	0	0
Preferred - memorable	37	51
Memorable -trophy	34	47
Trophy	0	0
Summer (Fish Community Season)		
Sub stock	0	
Stock -quality	0	0
Quality - preferred	0	0
Preferred - memorable	9	50
Memorable -trophy	9	50
Trophy	0	0

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

NATIVE CYPRINIDS

Sturgeon chub
No sturgeon chubs were captured during the 2004 sampling season.

Sicklefin chub
No sicklefin chubs were captured during the 2004 sampling season.

Speckled chub
No speckled chubs were captured during the 2004 sampling season.

Hybognathus spp.
No plains or Western silvery minnows (*Hybognathus spp*.) were captured during the 2004 sampling season.

Sand shiner
A total of 206 sand shiners were captured in mini-fyke nets (n = 33) and bag seines (n = 173) during the 2004 sampling season. No sand shiners were captured during the sturgeon season or while beam trawling. Annual catch per unit effort (Figure 14) was greatest for mini-fyke nets (1.65 fish/net night) followed by bag seines (0.25 fish/m^2). Over 60% of the fish were captured were from the inside and outside bends with the remainder captured in secondary channel connected channels (Figure 15). The bar mesohabitat was the only habitat were sand shiners were collected (Figure 16). Over 70% of sand shiners were between the 50 – 69 mm total length (Figure 17).

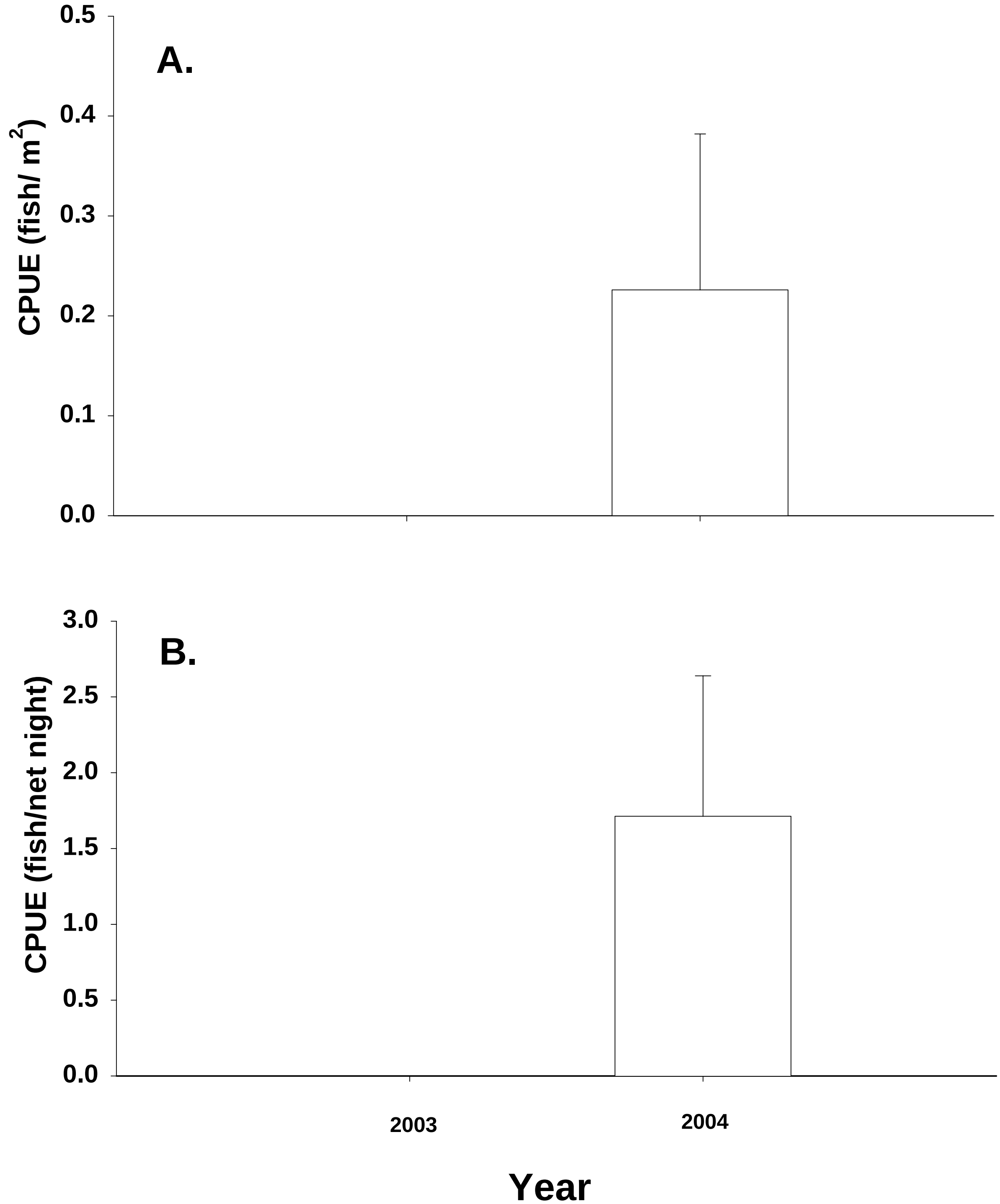

Figure 14. Mean annual catch-per-unit-effort (+/- 2SE) of sand shiners in segments 5 and 6 of the Missouri River for: A) beach seine, and B) mini-fyke from summer (fish community season) during 2004.

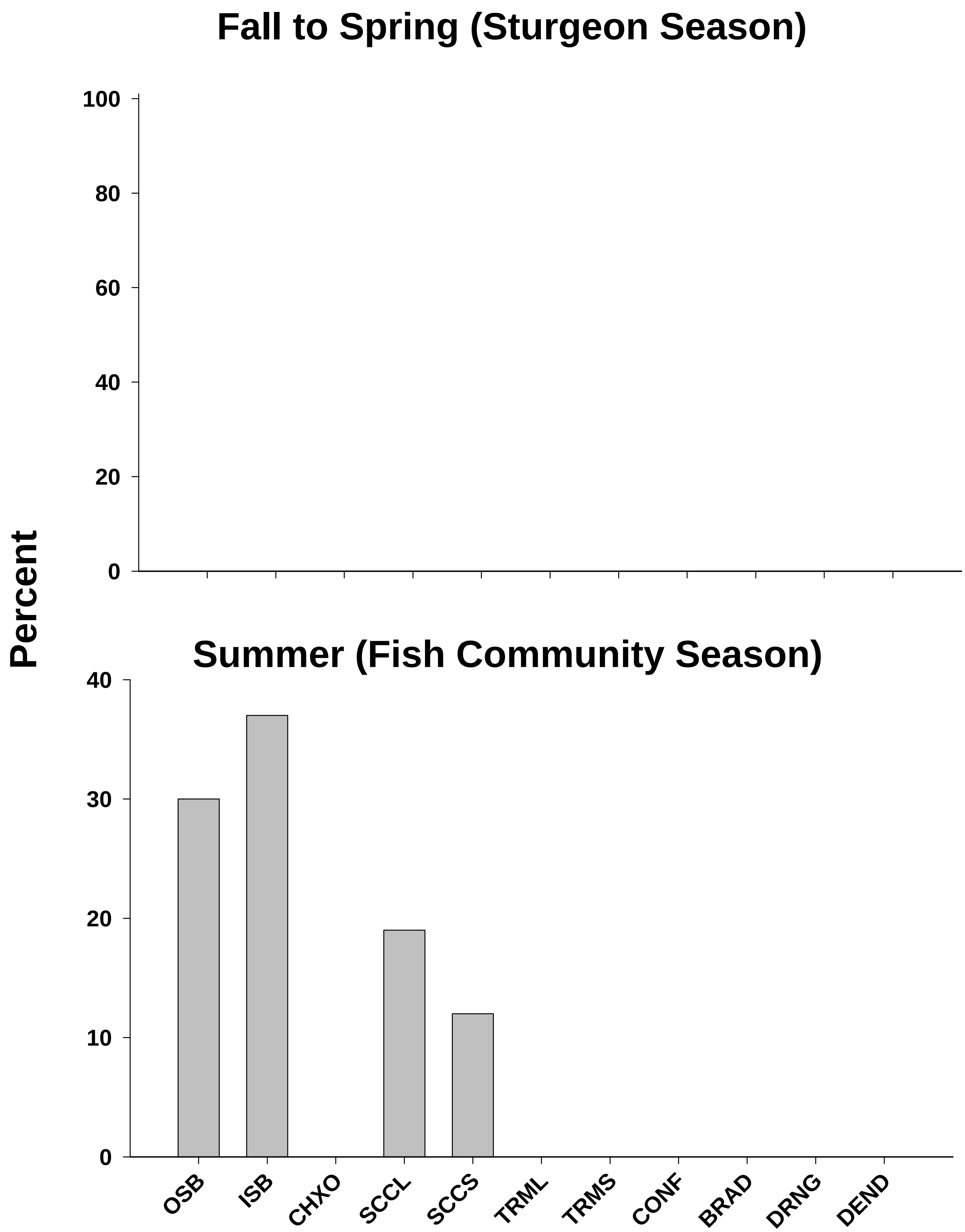

Figure 15. Percent of total sand shiners caught by macrohabitat type in segments 5and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer.

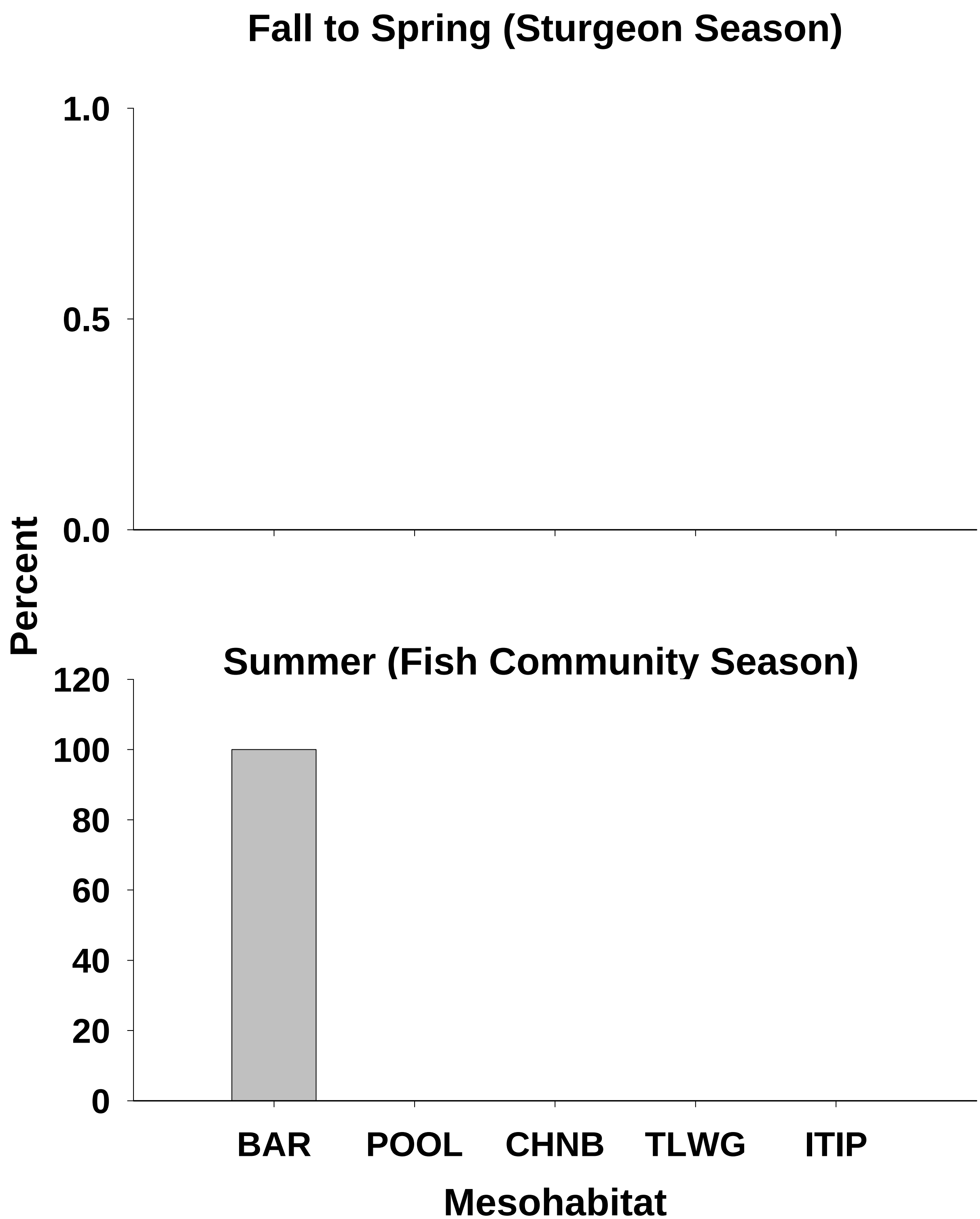

Figure 16. Percent of total sand shiners caught by mesohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer.

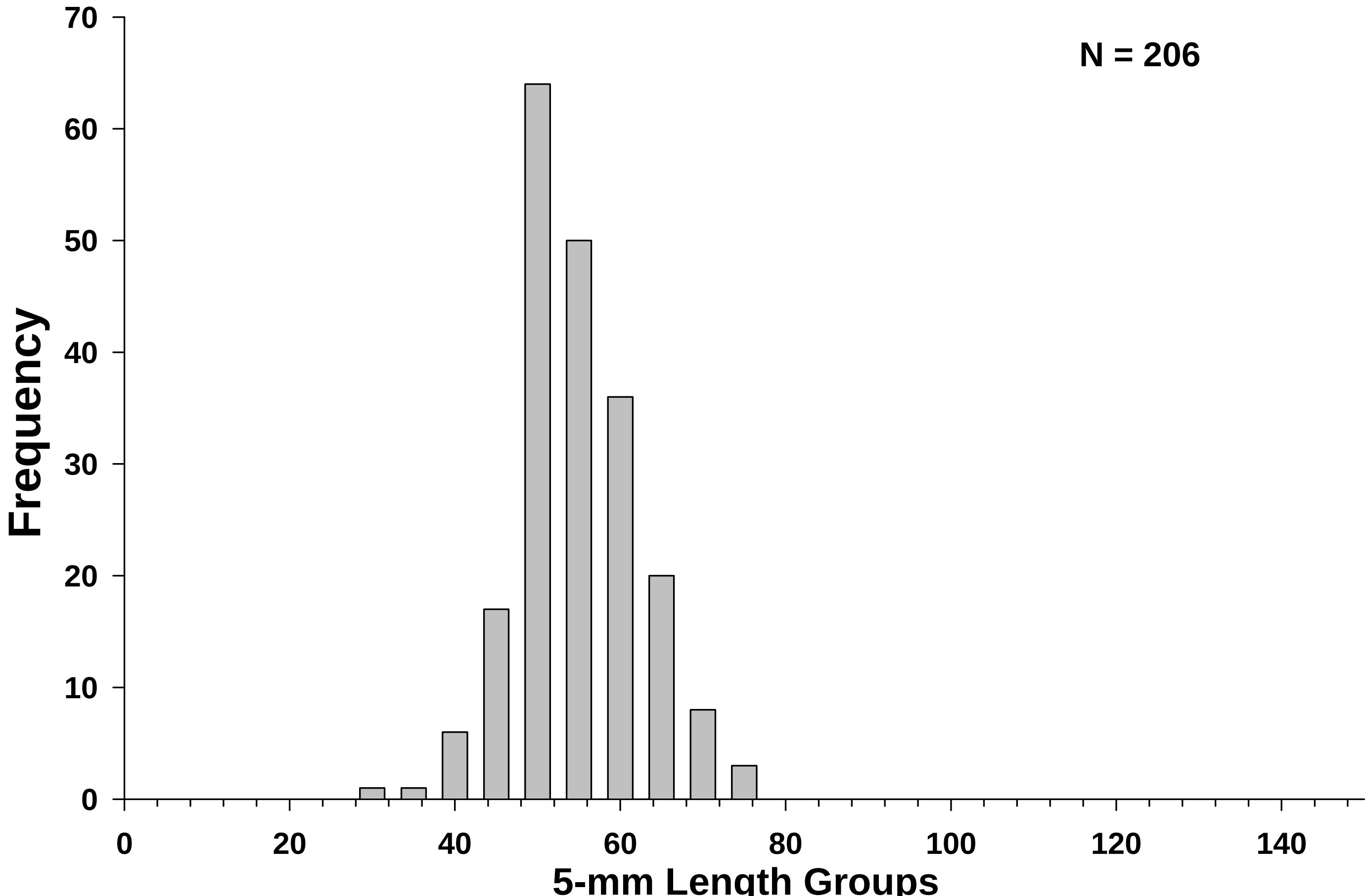

Figure 17. Length frequency of sand shiners during the summer (fish community season), in segments 5 and 6 of the Missouri River during 2004.

NATIVE CATASTOMIDS

Bigmouth buffalo

The total catch of bigmouth buffalo in 2004 was small, precluding analysis of habitat use and population size structure. A total of 9 bigmouth buffalo were caught with seven fish captured in standard gears: gillnets (n = 5) and mini-fyke nets (n = 2). No bigmouth buffalo were captured with trammel nets, the beam trawl, and bag seines. Seventy eight percent of our bigmouth buffalo were captured during the sturgeon season with gillnets and CPUE doubled from 2003 to 2004 (Figure 18). Gillnets and mini-fyke nets caught different size categories of bigmouth buffalo with larger fish captured in gillnets (Figures 18 and 19). Macrohabitat use may be segregated by life stage with adult bigmouth buffalo captured in inside and outside bends while small, likely juvenile fish, were captured only in small secondary connected channels (Figure 20). During the sturgeon season, most bigmouth buffalo were caught in the channel border and pool mesohabitats, while during the fish community season young fish were only caught on bars (Figure 21). The length frequency distribution identifies some reproduction in segments 5 and 6, but capture success or recruitment is low (Figure 22). Relative weights for bigmouth buffalo (n = 4) ranged from 76 – 87 with a mean of 82.

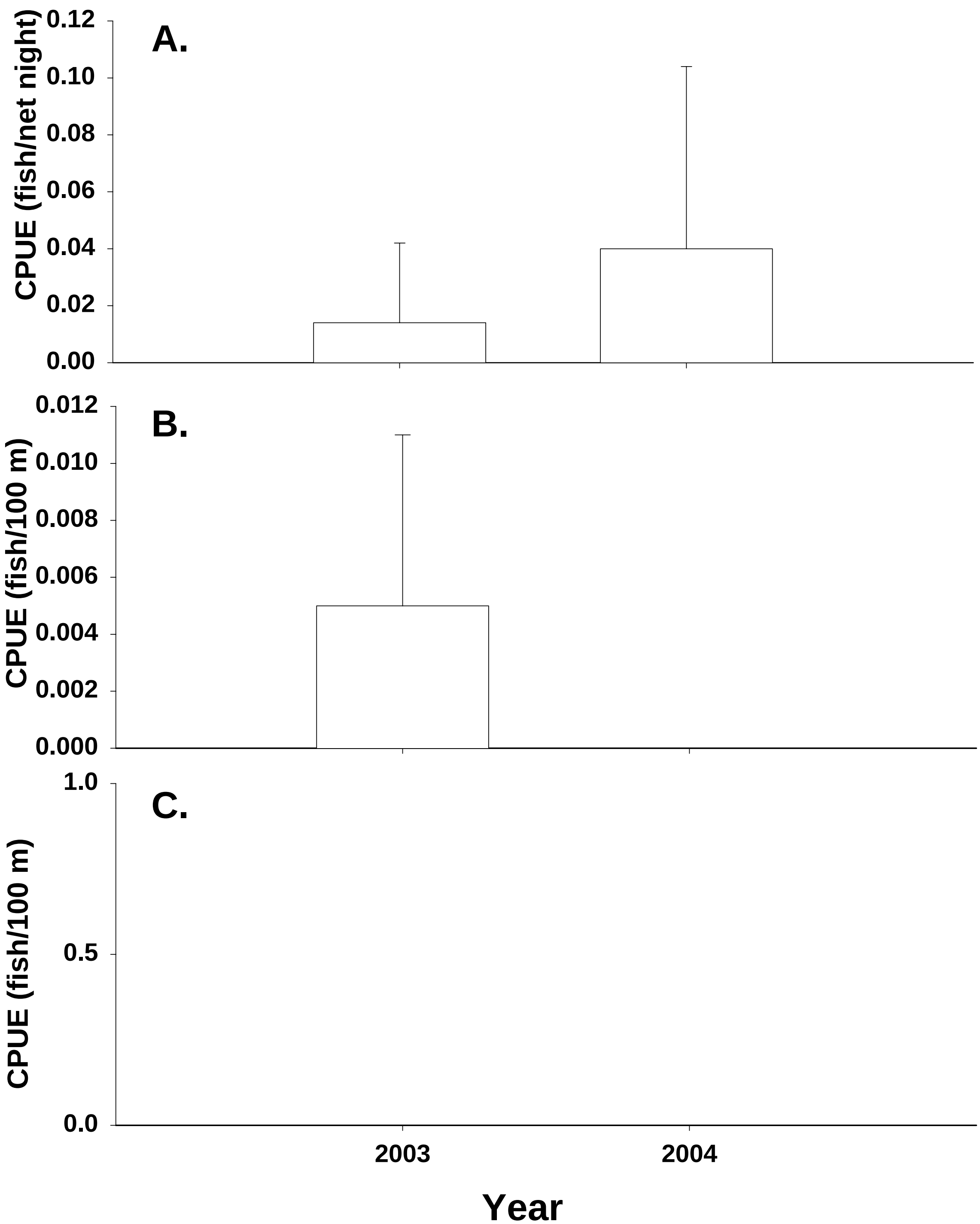

Figure 18. Mean annual catch-per-unit-effort (+/- 2SE) of bigmouth buffalo in segments 5 and 6 of the Missouri River for: A) gill nets, B) trammel nets, and C) beam trawls from fall through spring (Sturgeon season) during 2003 - 2004.

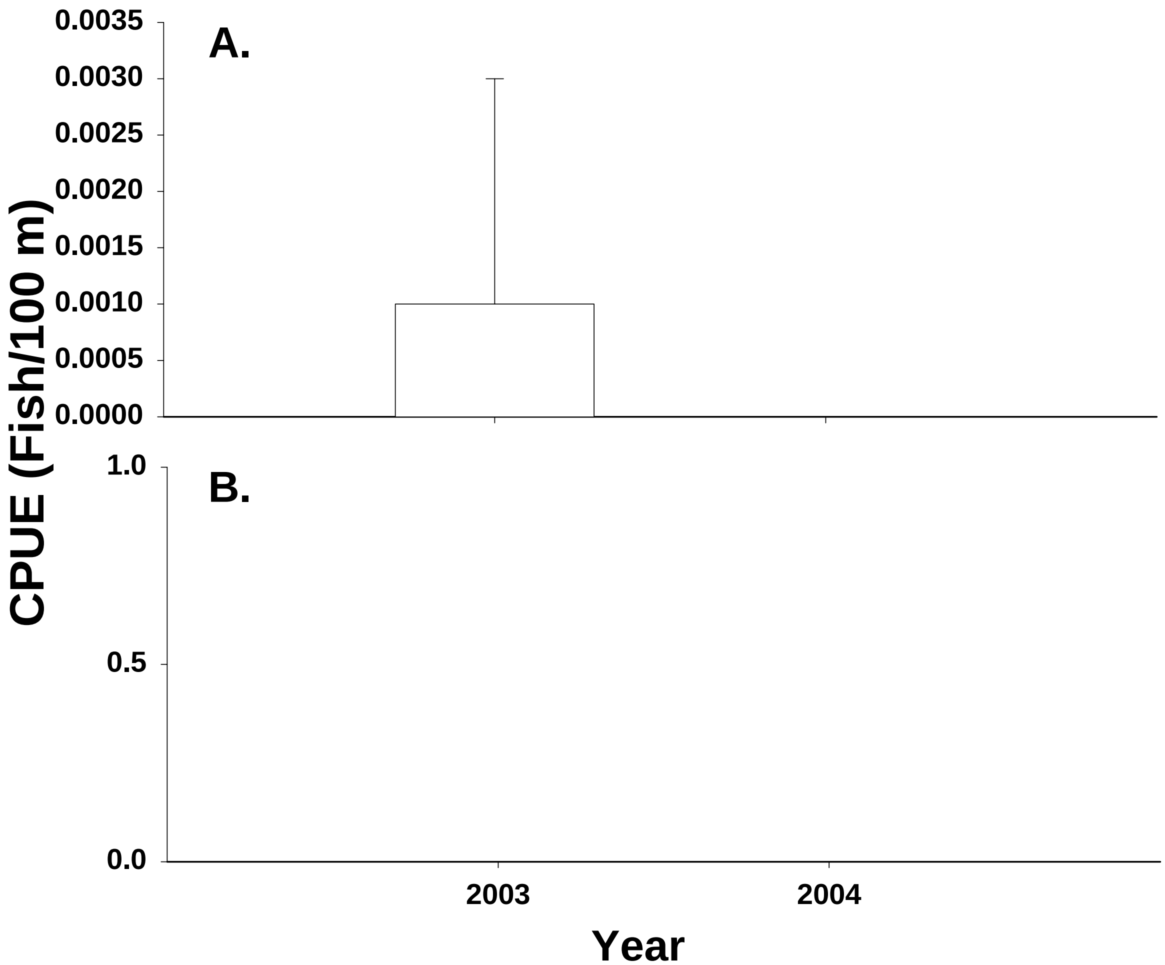

Figure 19. Mean annual catch-per-unit-effort (+/- 2SE) of big mouth buffalo in segments 5 and 6 of the Missouri River for: A) trammel nets and B) beam trawls in summer (Fish Community Season) during 2003 - 2004.

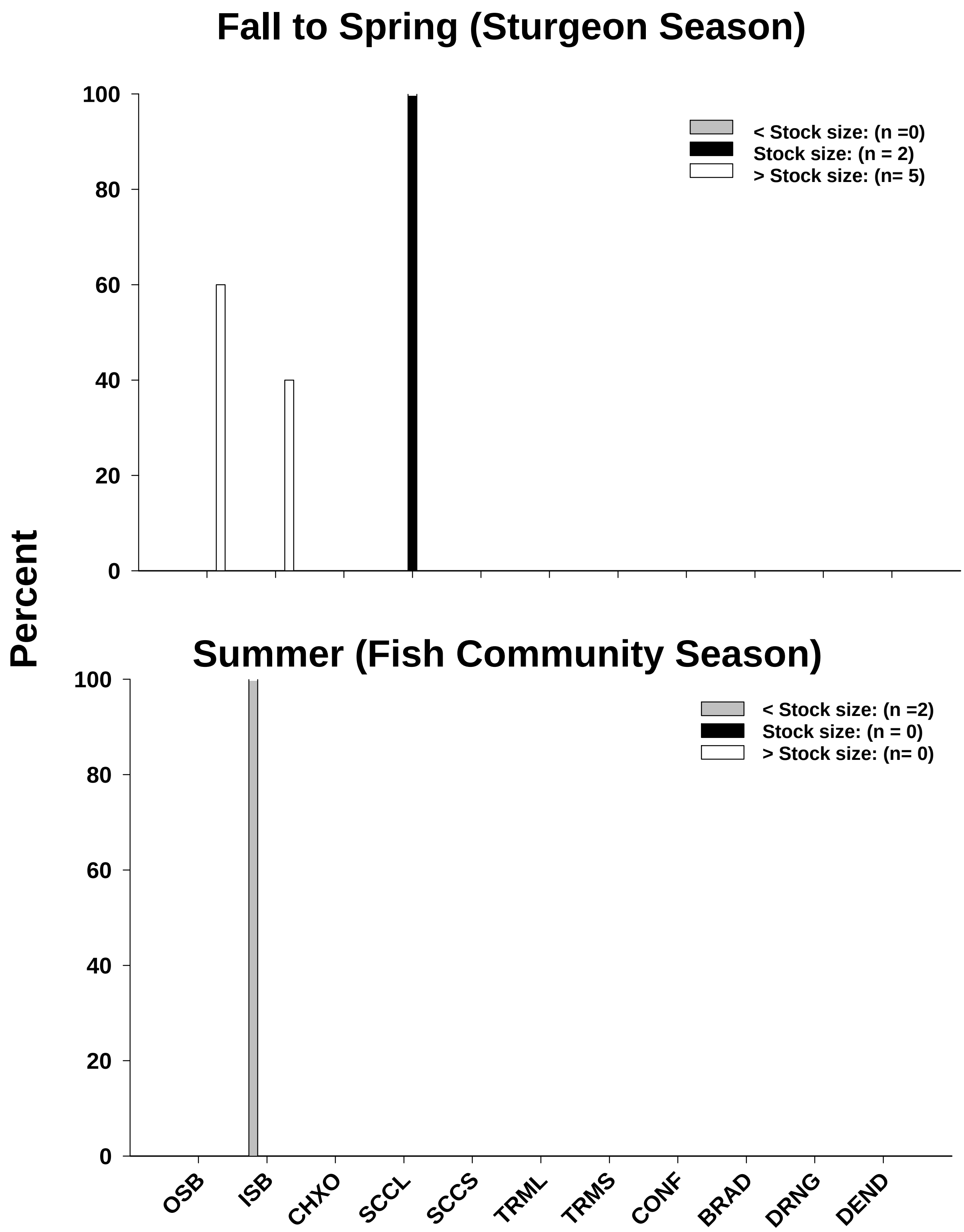

Figure 20. Percent of total bigmouth buffalo for three size classes caught by macrohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

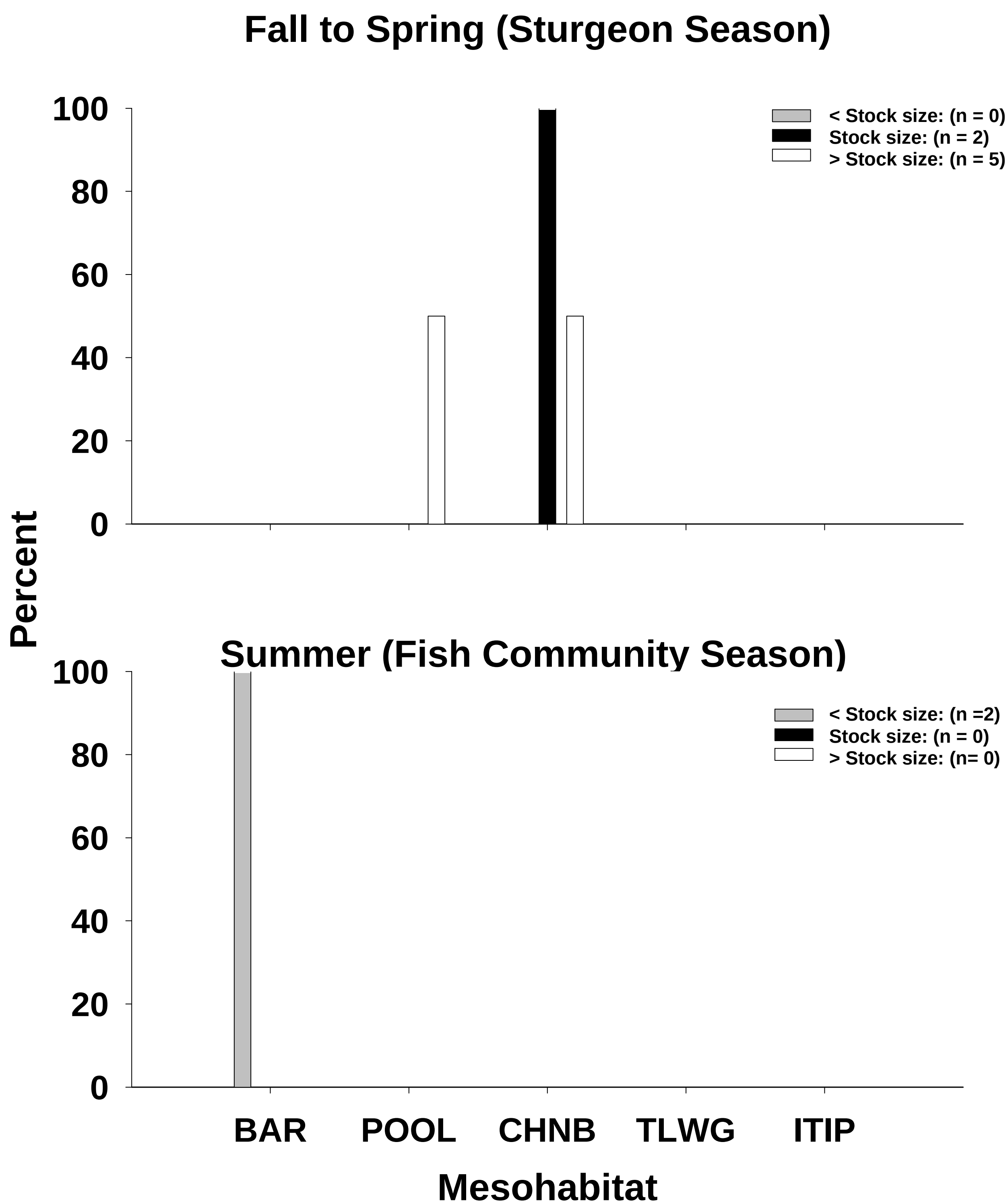

Figure 21. Percent of total bigmouth buffalo for three size classes caught by mesohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

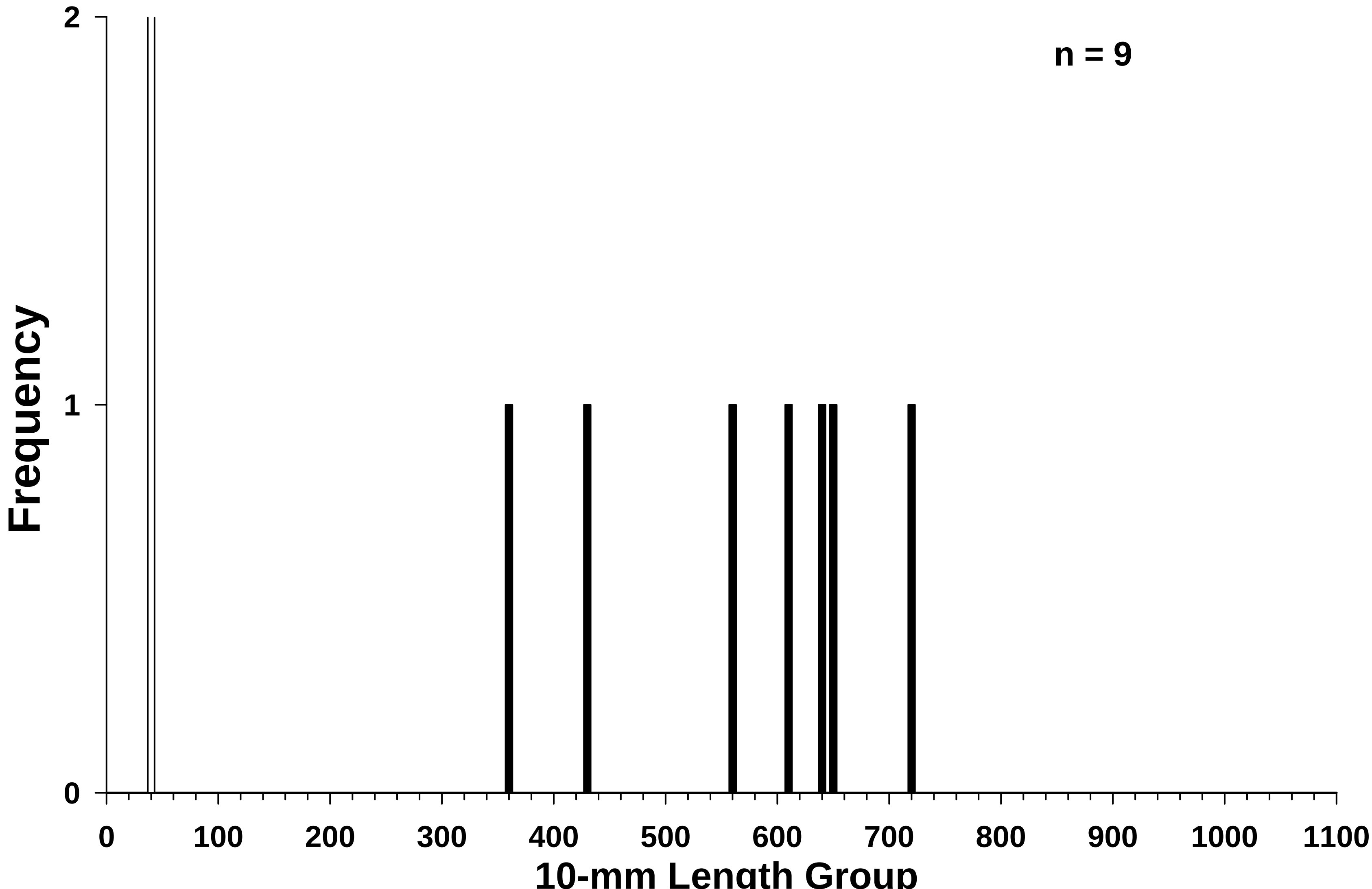

Figure 22. Length frequency of bigmouth buffalo during fall through spring (sturgeon season, black bars) and summer (fish communit season, white bars) in segments 5 and 6 of the Missouri River during 2004.

Blue sucker

The total catch of blue suckers in 2004 was small, precluding analysis of habitat use and population size structure. A total of 18 blue suckers were sampled and only three fish were captured with a standard gear (gillnets). No blue suckers were captured with trammel nets, bag seines, mini-fyke nets, or beam trawls (Figures 23 and 24). Over 90% of blue suckers were captured from outside bends during the sturgeon season (Figure 25). The only fish captured during the fish community season was captured in a braided macrohabitat. Channel borders were the primary mesohabitat for the collection of blue suckers (Figure 26). Over 100% of the blue suckers captured were over 709 mm TL indicating a likely ageing population with no evidence of recruitment in segments 5 and 6 or poor sampling efficiency for small blue suckers (Figure 27).

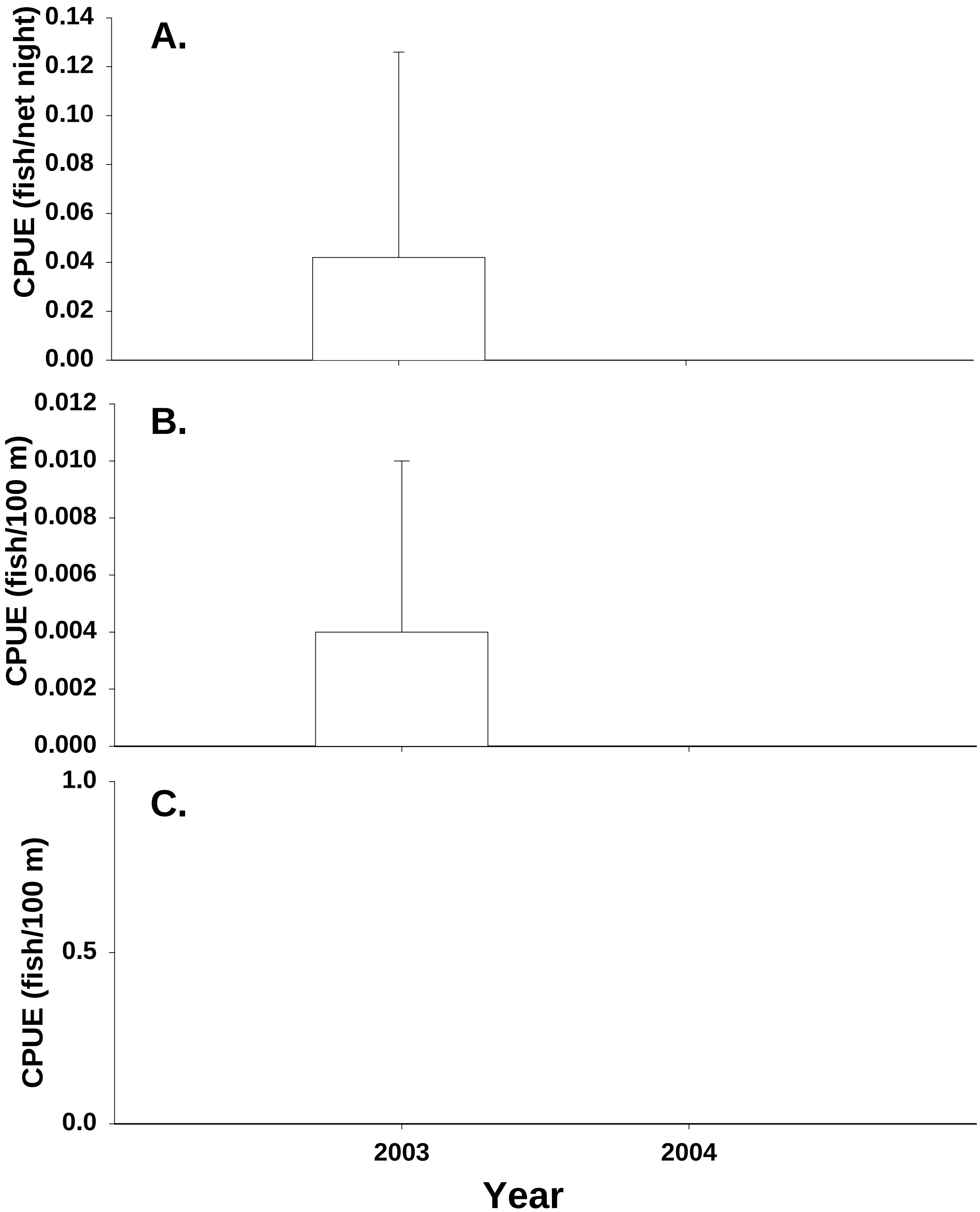

Figure 23. Mean annual catch-per-unit-effort (+/- 2SE) of blue suckers in segments 5 and 6 of the Missouri River for: A) gill nets, B) trammel nets, and C) beam trawls from fall through spring (Sturgeon season) during 2003 - 2004.

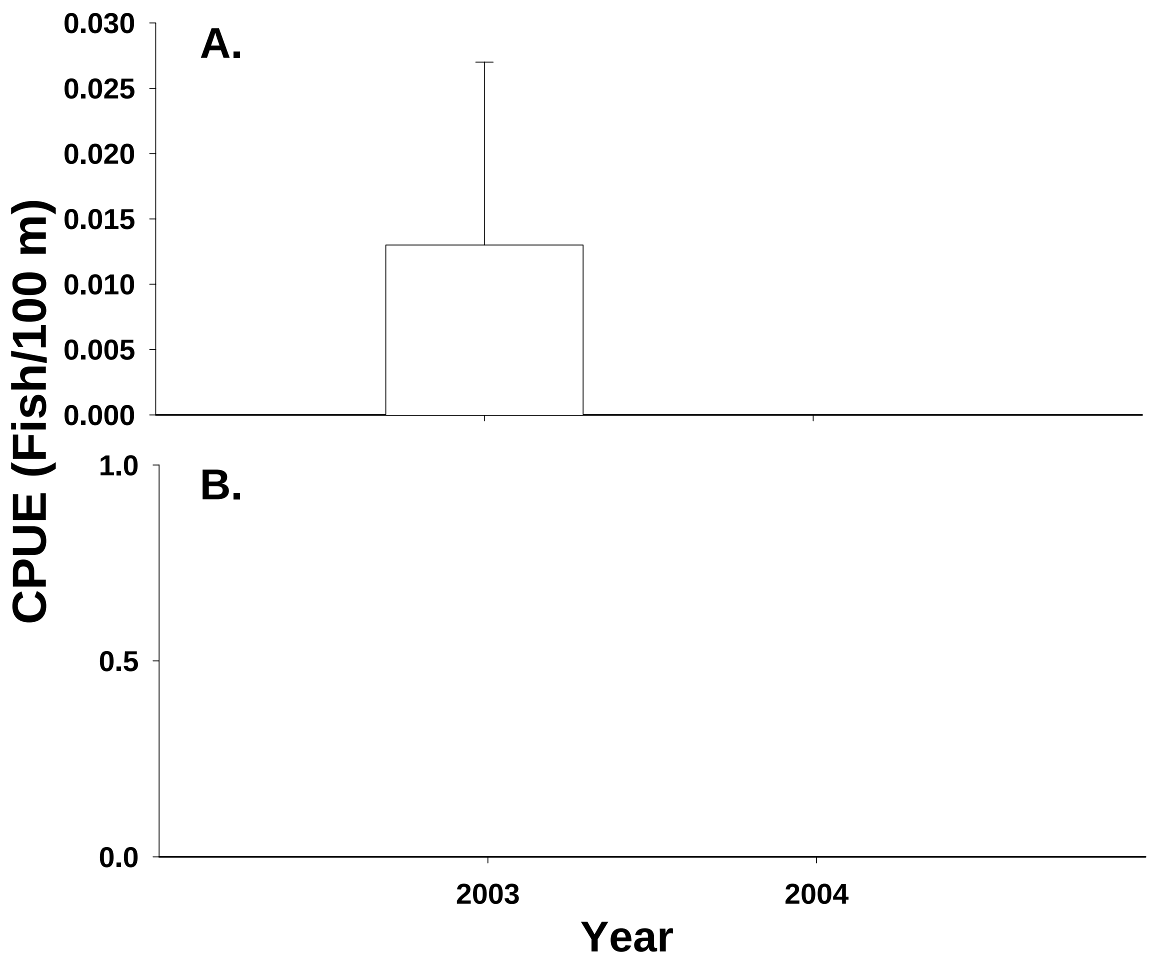

Figure 24. Mean annual catch-per-unit-effort (+/- 2SE) of blue suckers in segments 5 and 6 of the Missouri River for: A) trammel nets and B) beam trawls in summer (Fish Community Season) during 2003 - 2004.

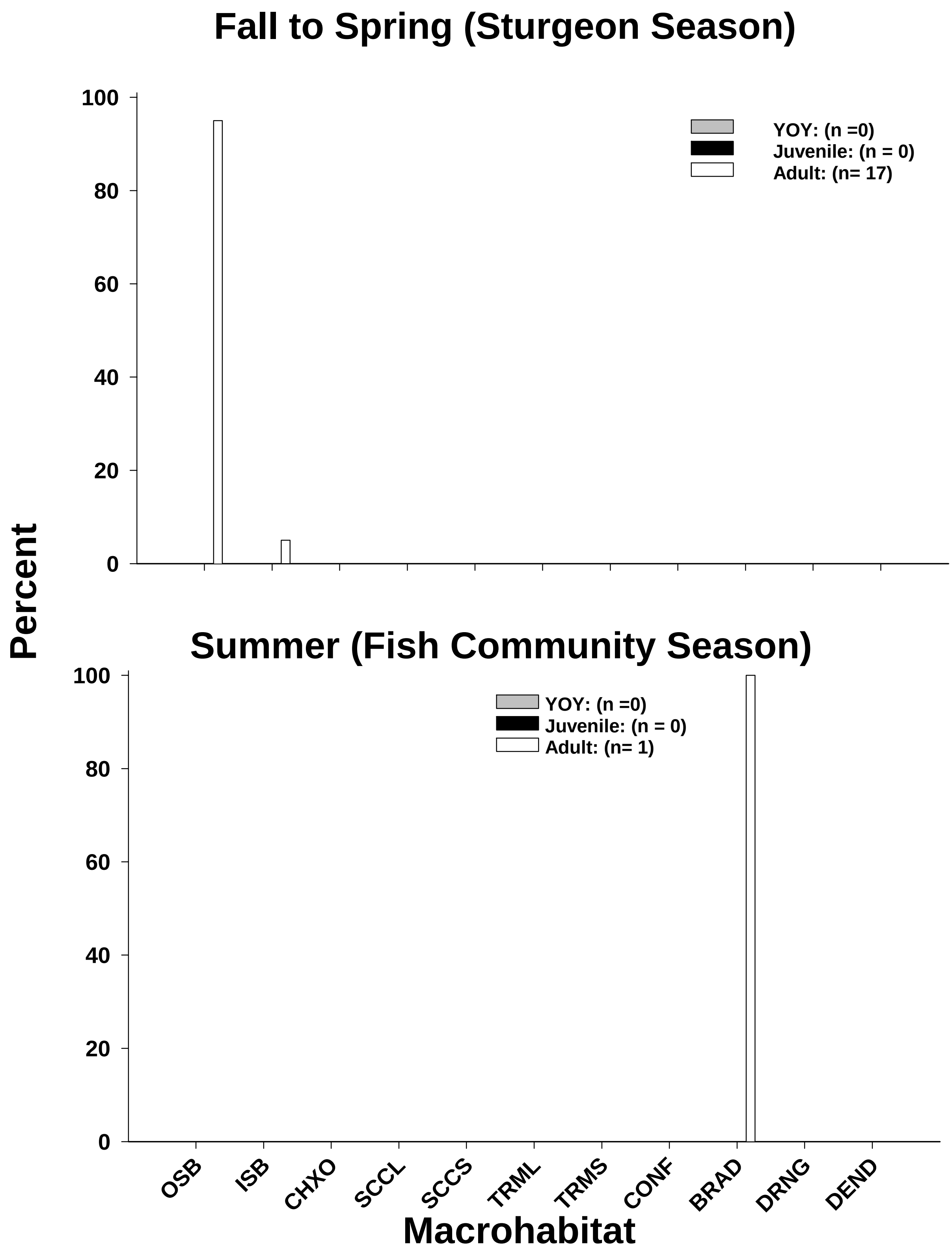

Figure 25. Percent of total blue suckers for three size classes caught by macrohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

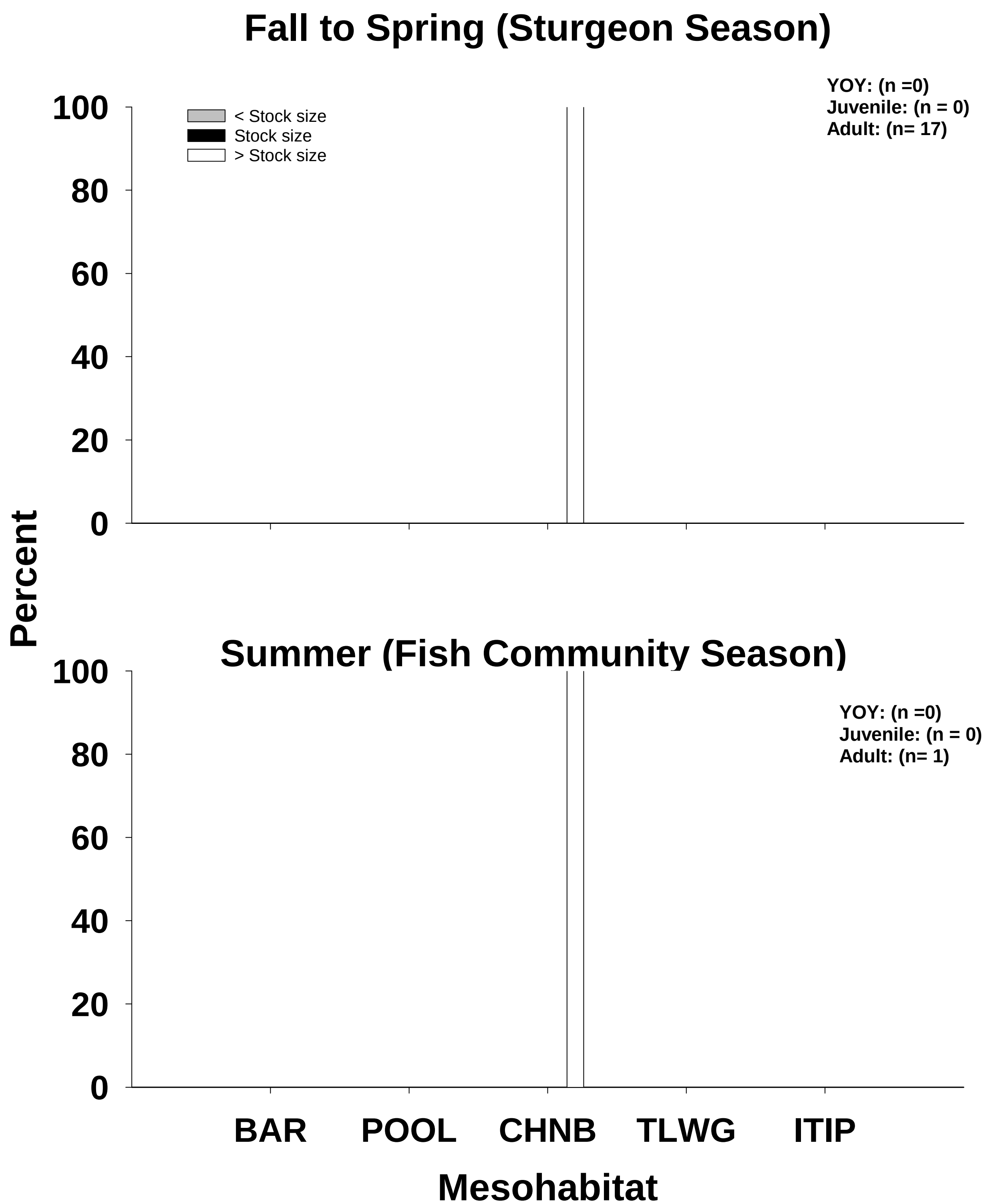

Figure 26. Percent of total blue suckers for three size classes caught by mesohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

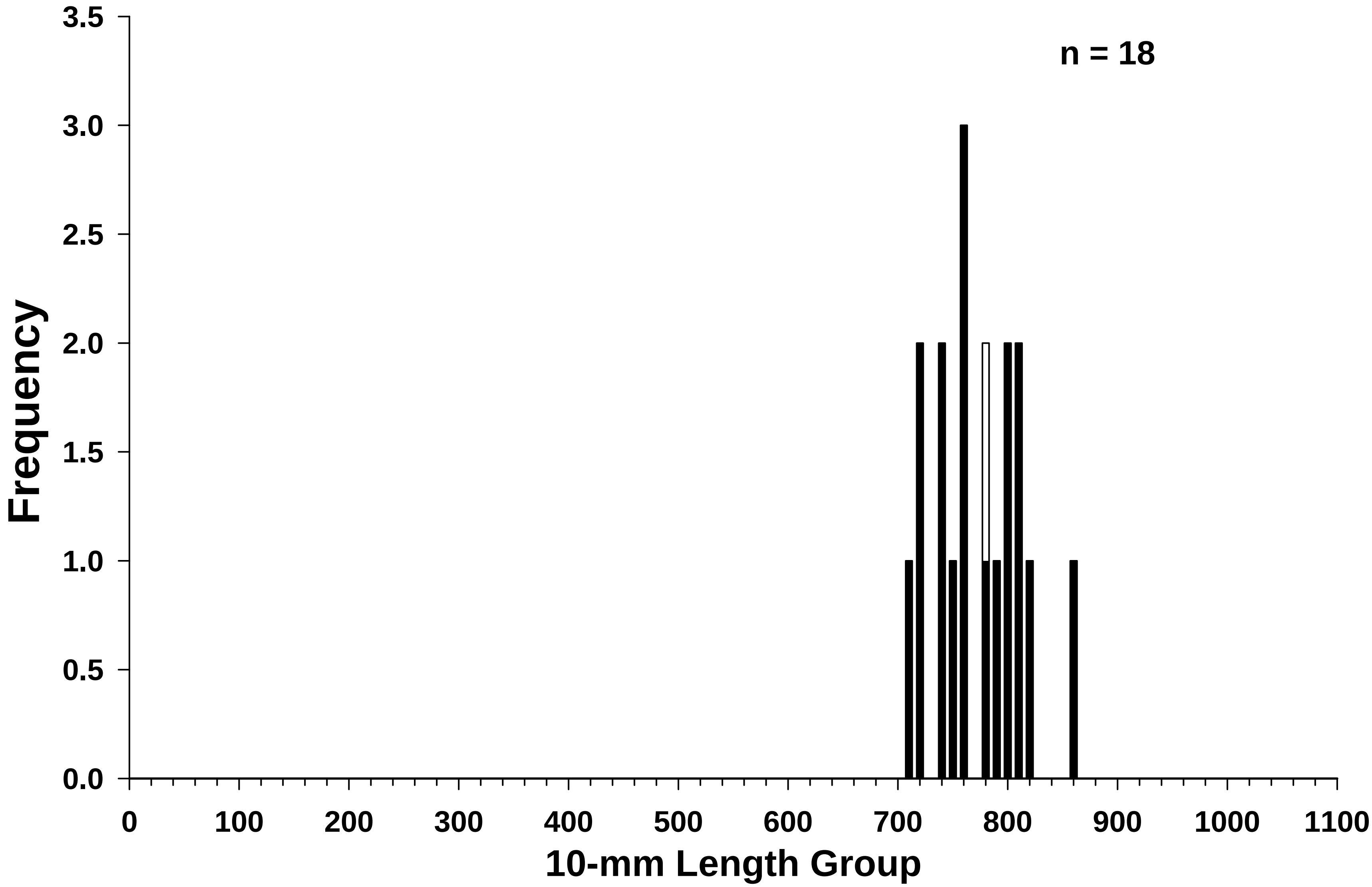

Figure 27. Length frequency of blue suckers during fall through spring (sturgeon season, black bars) and summer (fish community season, white bars) in segments 5 and 6 of the Missouri River during 2004.

NATIVE PERCIDS

Sauger

A total of 72 saugers were sampled in segments 5 and 6 during 2004 with 71 fish captured in standard gears: gillnets (n = 43) trammel nets (n = 23), beam trawl (n = 1), mini-fyke nets (n = 2), and bag seines (n = 2). Gillnet CPUE declined from 2003 to 2004 (Figure 28). However, changes in trammel net CPUE from 2003 to 2004 were equivocal; CPUE was similar during the sturgeon season but declined from 2003 to 2004 during the fish community season (Figures 28 and 29). Trammel net catches of saugers were approximately 10 times greater during the sturgeon season (fall through spring) compared to the fish community season (summer). Most saugers during both seasons were caught in the outside and inside bend macrohabitats (Figure 30). Saugers were caught in four mesohabitats with most fish captured in channel borders (Figure 31). Over 65% of saugers were between the 320 - 409 mm TL; however, catches of fish < 160 mm TL indicate some reproduction occurred (Figure 32). Mean relative weights for saugers during the sturgeon and fish community seasons were 80 and 77, respectively. The range of relative weights was wider during the sturgeon season (58 - 96) compared to the fish community season (70 - 82) likely due to ripe and spent fish caught during the spawning season in spring.

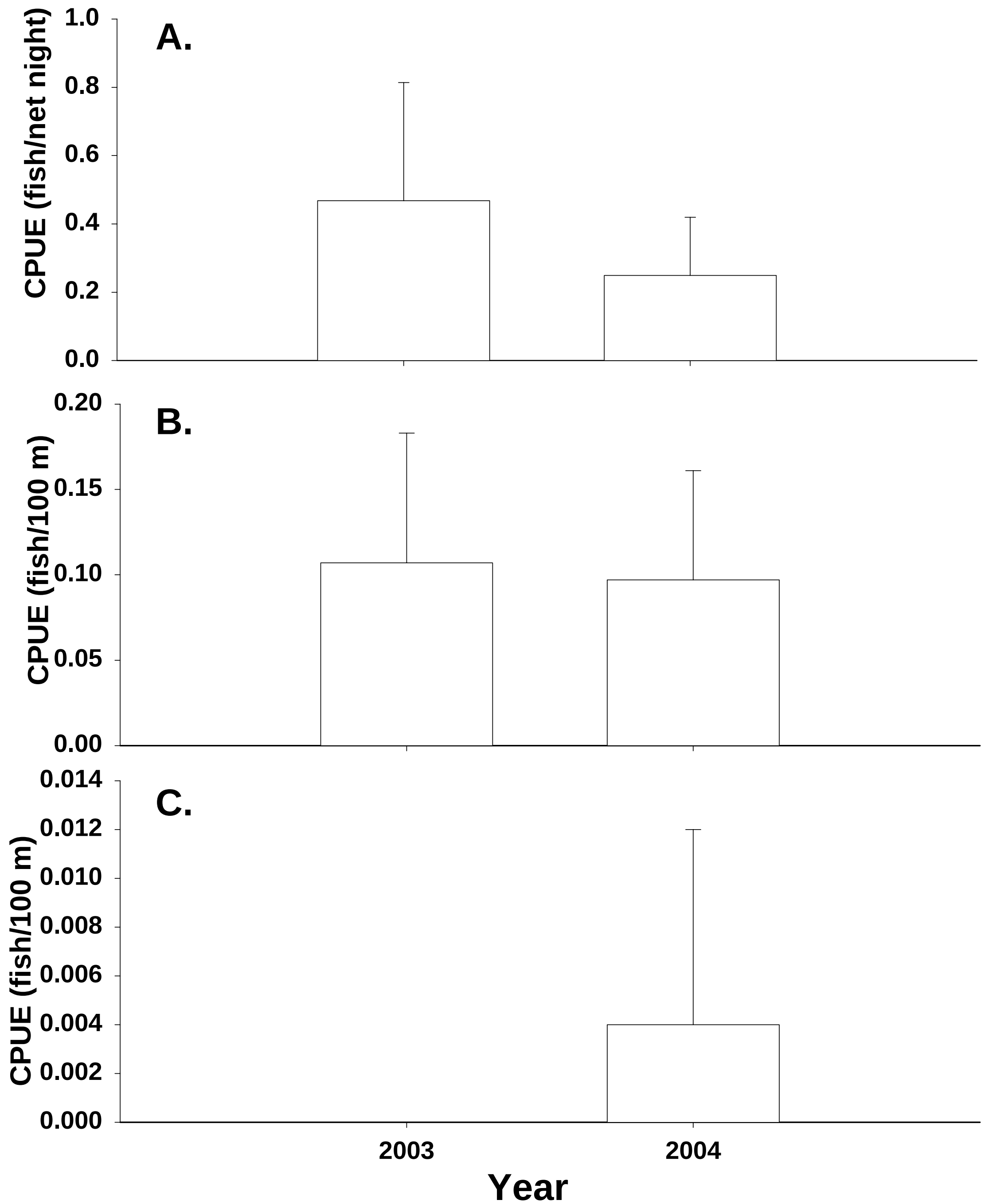

Figure 28. Mean annual catch-per-unit-effort (+/- 2SE) of saugers in segments 5 annd 6 of the Missouri River for: A) gill nets, B) trammel nets, and C) beam trawls from fall through spring (Sturgeon season) during 2003 - 2004.

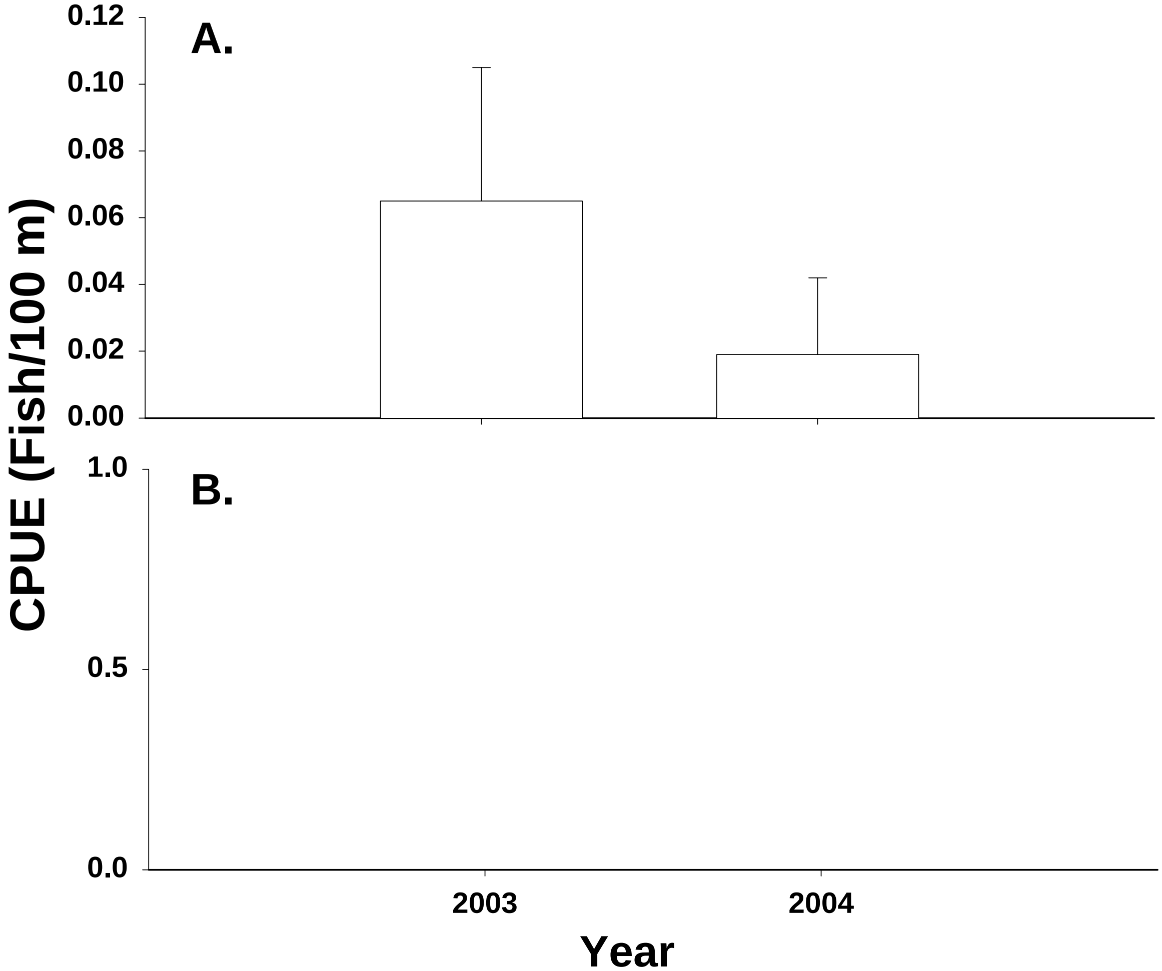

Figure 29. Mean annual catch-per-unit-effort (+/- 2SE) of saugers in segments 5 and 6 of the Missouri River for: A) trammel nets and B) beam trawls in summer (Fish Community Season) during 2003 - 2004.

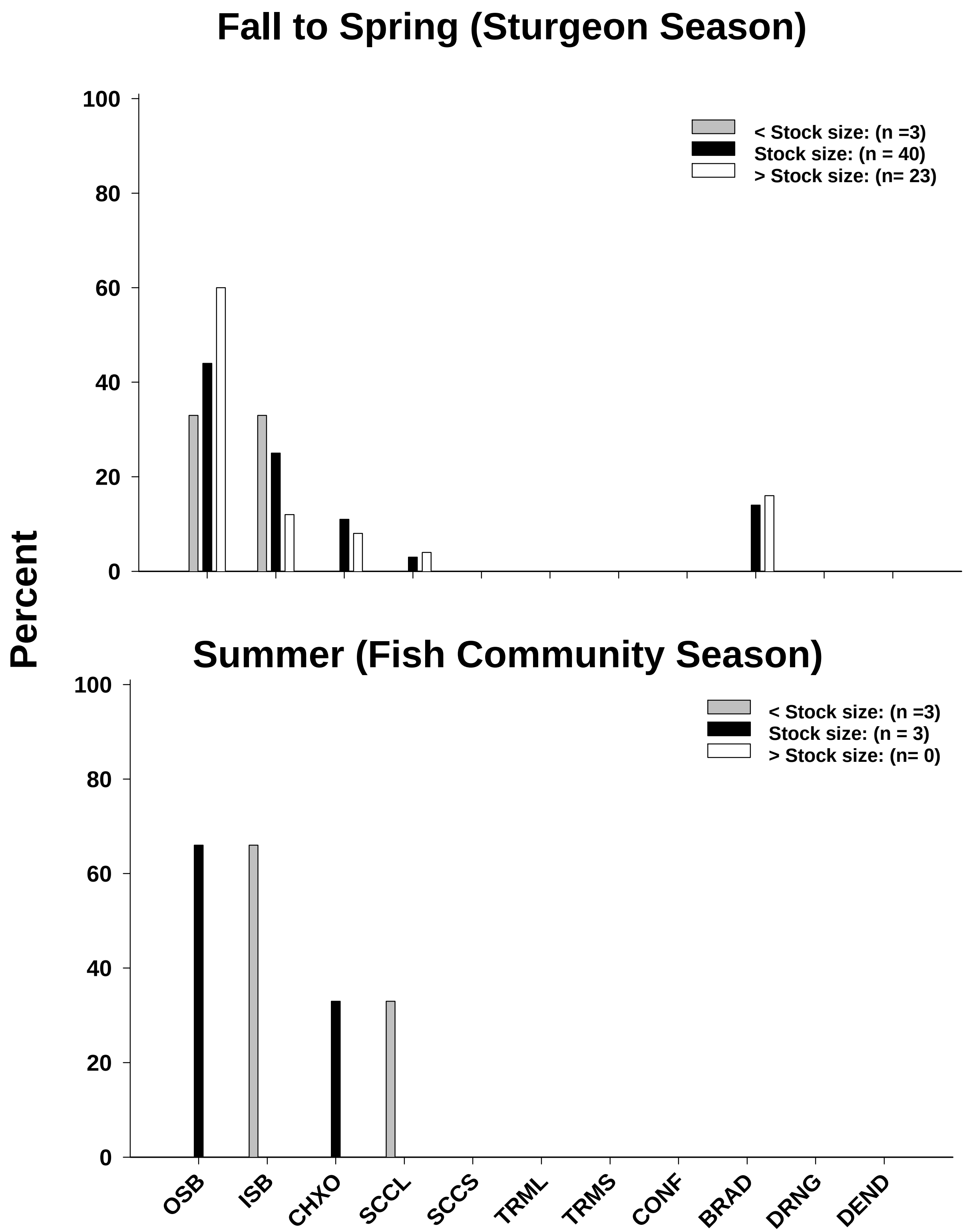

Figure 30. Percent of total saugers for three size classes caught by macrohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

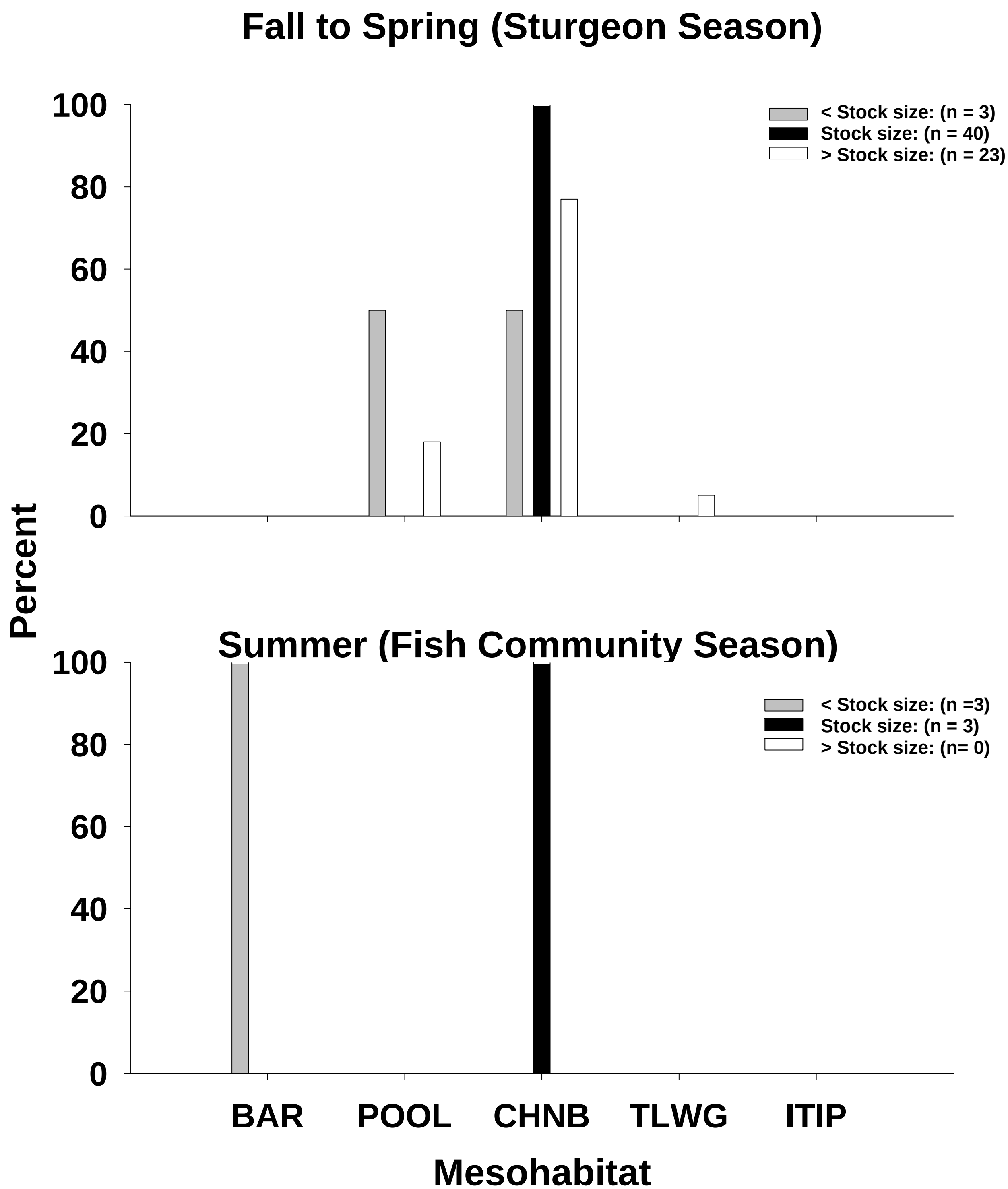

Figure 31. Percent of total saugers for three size classes caught by mesohabitat type in segments 5 and 6 of the Missouri River during 2004 for two seasons: Fall through Spring and Summer. Size classes defined in the text and habitat abbreviations presented in Appendix B.

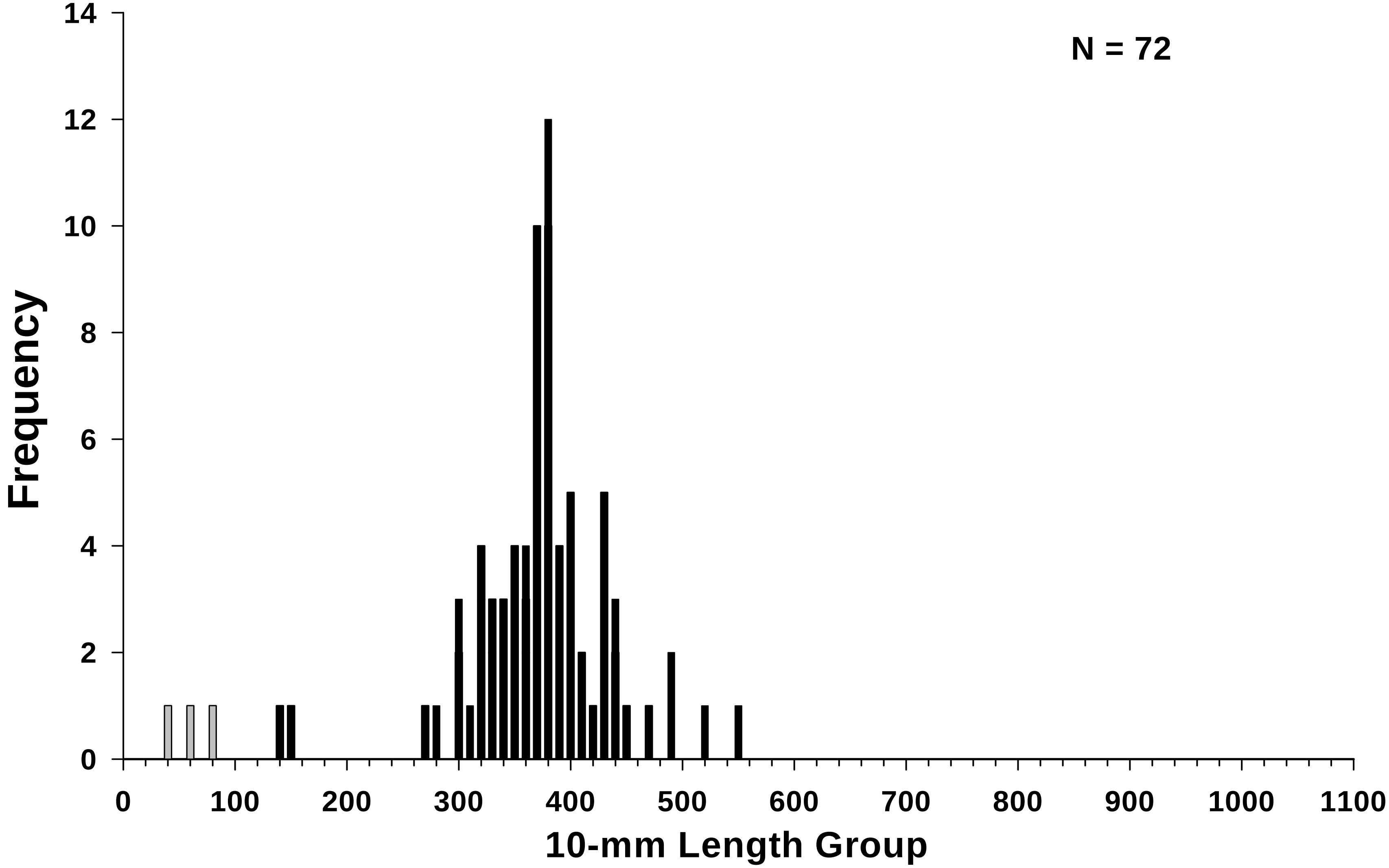

Figure 32. Length frequency of saugers during fall through spring (sturgeon season, black bars) and summer (fish community season, white bars) in segments 5 and 6 of the Missouri River during 2004.

ADDITIONAL EFFORT – WILD GEARS

Wild gears (i.e., non-standard) used in 2003 -2004 consisted of hoopnets and setlines during the sturgeon and fish community seasons. Hoop nets in the past were considered a standard gear but since completion of the 2003 season were not required. Therefore, hoop net catches are included in this section. During the sturgeon season an average of 26 setlines/bend were deployed in 12 bends, while an average of 25 deployments/bend were set in 10 bends during the fish community season (Tables 2 and 3). An average of 8 hoop nets/bend was deployed in 10 bends during both seasons (Tables 2 and 3).

Pallid and shovelnose sturgeon catches with set lines and hoop nets were low during 2004. Three pallid sturgeon were caught with setlines and mean annual CPUE was 0.006 fish/hook night and 0.004 fish/hook night for the sturgeon season and fish community seasons respectively (Figures 33 and 34). Set line CPUE for pallid sturgeon with set lines was generally similar in 2003 and 2004 with large variances due to the prevalence of zero catches. No pallid sturgeon were caught with hoop nets during 2004. Eleven shovelnose sturgeons were caught on set lines during 2004 and CPUE was 0.035 fish/hook night during the sturgeon season. No set lines caught shovelnose sturgeon during the fish community season (summer). Few shovelnose sturgeon (n = 2) were caught in hoop nets with a CPUE of 0.01 fish/net night in both seasons (Figures 35 and 36).

Hoop nets had varied success in capturing targeted native Missouri River fishes; whereas, set lines failed to capture any target species other than shovelnose sturgeon. Few bigmouth buffalo (n = 2), and saugers (n = 1) were captured in hoop nets. Mean annual CPUE of big mouth buffalo declined from 2003 to 2004 (Figure 37). Hoop nets caught more blue suckers (n = 15) than any other target species and relative abundance remained unchanged from 2003 to 2004 (Figures x). However, eleven of 18 blue suckers were captured in a single hoop net on 06 May 2004.

GENERAL MISSOURI RIVER FISH COMMUNITY

A total of 4,489 fish comprised of 38 species and one hybrid (Sauger x walleye) were captured during the 2004 sampling season in segments 5 and 6 of the Missouri River. Greatest numbers of fishes were captured during the summer with seines (n = 1,664) and mini-fyke nets (n = 2,281). These summer catches consisted mainly of small bodied cyprinids and young-of-the-year (YOY) catastomids, centrarchids, and percids. Gears with the greatest percentage of their catch comprised of pallid sturgeon and the ten targeted native fish species were gillnets (39%), trammel nets during the sturgeon season (33%), and trammel nets during the fish community season (43%). The beam trawl captured low percentages of sturgeon and the targeted native species in spring through fall (8%) and summer (0%). Sand shiners were the only target species captured with seines (2%) and mini-fyke nets (5%). Collectively for all standard gears > 50 individuals were captured for the following 14 species: shovelnose sturgeon (n = 91), gizzard shad *Dorosoma cepedianum* (n = 77), spotfin shiner *Cyprinella spiloptera* (n = 993), emerald shiner *Notropis atherinoides* (n = 1,172), spottail shiner *Notropis hudsonius* (n = 51), sand shiner (n = 206), shorthead redhorse *Moxostoma macrolepidotum* (n = 73), channel catfish *Ictalurus punctatus* (n = 167), smallmouth bass *Micropterus dolomieu* (n = 814), largemouth bass *M. salmo*ides (n = 55), Johnny darter *Etheostoma nigrum* (n = 106), yellow perch *Perca flavescens* (n = 101), sauger (n = 72), and walleye *Sander vitreum* (n = 64). Only 33 positively identified river carpsuckers *Carpiodes carpio* were captured; however, 45 YOY unidentified carpsuckers (*Carpiodes* spp.) were caught with seines. Most gizzard shad, largemouth bass, smallmouth bass, and yellow perch were YOY collected with mini-fyke nets and bag seines. Five species were represented in the collective catches by only one specimen: longnose gar *Lepisosteus osseus*, goldeye *Hiodon alosoides*, quillback *Carpiodes cyprinus*, white perch *Morone Americana*, and orange spotted sunfish *Lepomis humilis*.

For gears targeting large fish in deep water habitats, channel catfish, shorthead redhorse, and walleye were the three most common non-targeted species. Only five species, shovelnose sturgeon, shorthead redhorse, channel catfish, sauger, and walleye had gillnet CPUE > 0.2 fish/net night during 2004 (Appendix F). In the sturgeon season, CPUE of shovelnose sturgeon, channel catfish and sauger were the only species with a trammel net CPUE > 0.1 fish/100 m with the relative abundance of catfish three times greater than that of shovelnose sturgeon and sauger (Appendix G). For trammel nets in the fish community season, only channel catfish had a CPUE > 0.1 fish/100 m (Appendix I). Channel catfish were the most abundant species captured with the beam trawl during both seasons (Appendices H and J).

The greatest numbers of fish species were captured in shallow water habitats with bag seines (n = 25) and mini-fyke nets (n = 31). Only two species captured with bag seines had densities > 1 fish/m^2, spotfin shiner (3.7 fish/m^2) and emerald shiner (5.4 fish/m^2) during 2004 (Appendix K). The most abundant species captured in mini-fyke nets were smallmouth bass (6.8 fish/net night) and spotfin shiner (4.7 fish/net night). Only two other species had CPUE > 1 fish/net night with mini-fyke nets: emerald shiner (4.3 fish/net night) and sand shiner (1.6 fish/net night).

Seven exotic species were captured in segments 5 and 6 during 2004 and five of these species are sport fishes that were intentionally introduced: northern pike *Esox lucius*, white bass *Morone chrysops*, smallmouth bass, largemouth bass (Bailey and Allum 1954). Additonal exotic species encountered in 2004 were common carp *Cyprinus carpio*, white perch *M. americana* and rainbow smelt *Osmerus mordax*. Based on high CPUE in mini-fyke nets, smallmouth bass were the most abundant exotic species seen in segments 5 and 6 during 2004. None of the four exotic Asian carps, bighead carp *Hypophthalmichthys noblis*, silver carp *H. molitrix*, grass carp *Ctenopharyngodon idella*, or black carp *Mylopharyngodon piceus*, were captured or seen within segments 5 and 6 during 2004. Additonally, no zebra mussels *Dreissena polymorpha* were observed while working in segments 5 and 6 during 2004 despite the identification of larval zebra mussels (veligers) from samples at the Verdel Boat Ramp in 2003.

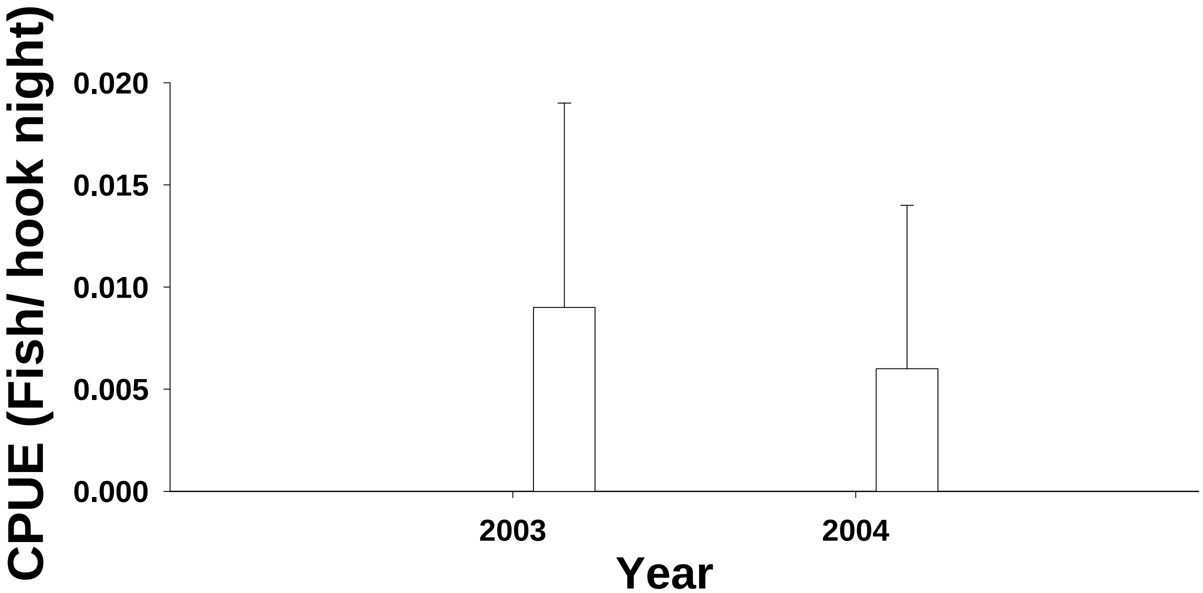

Figure 33. Mean annual catch-per-unit-effort (+/- 2 SE) of stocked pallid sturgeon in segments 5 and 6 of the Missouri River for set lines fished during fall through spring (Sturgeon Season) during 2003 - 2004.

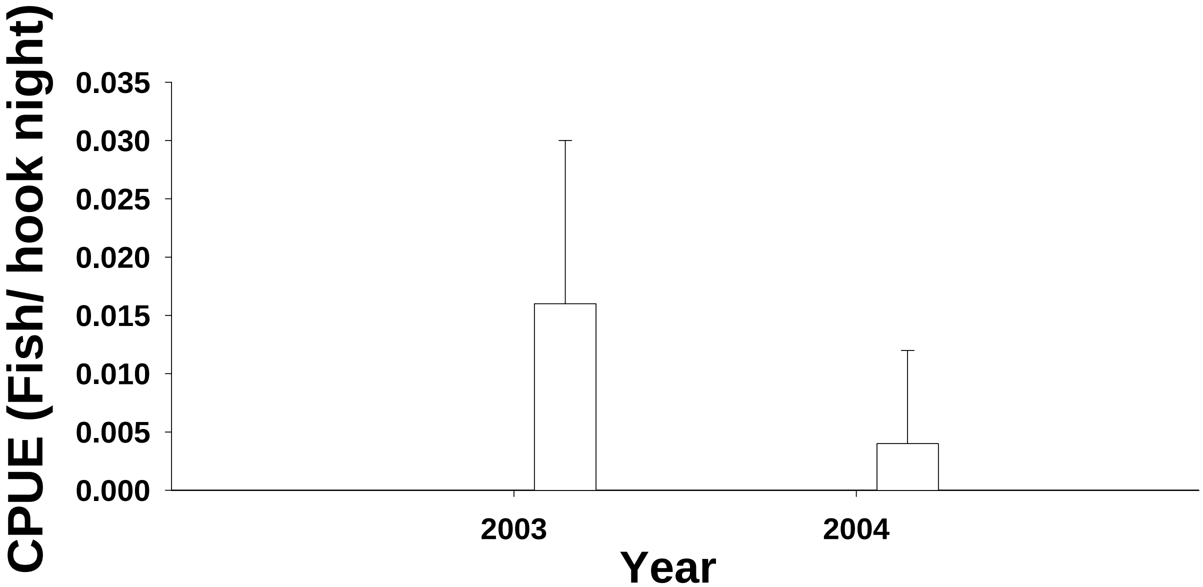

Figure 34. Mean annual catch-per-unit-effort (+/- 2 SE) of stocked pallid sturgeon in segments 5 and 6 of the Missouri River for set lines during summer (Fish Community Season) during 2003 - 2004.

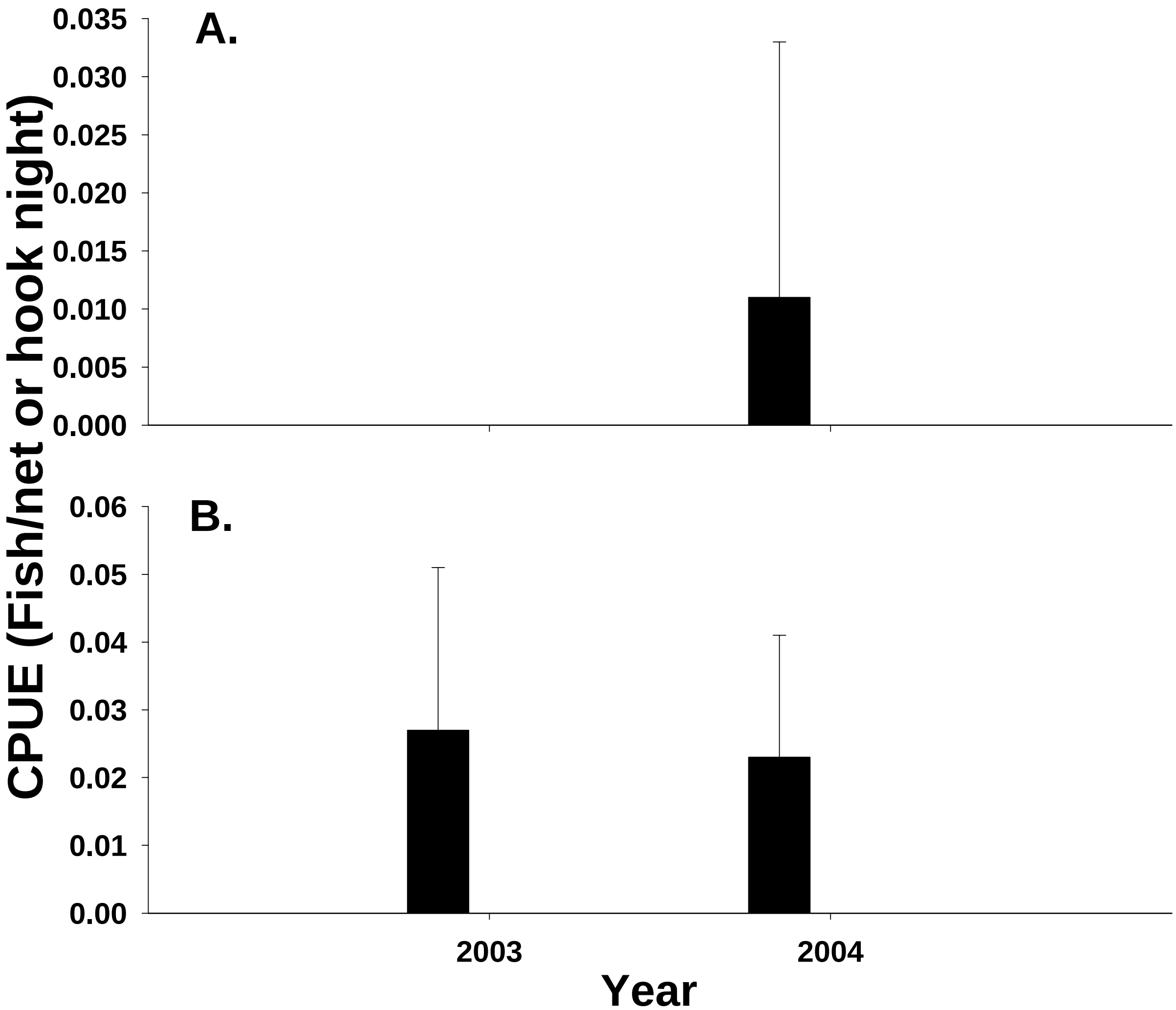

Figure 35. Mean annual catch-per-unit-effort (+/- 2 SE) of shovelnose sturgeon in segments 5 and 6 of the Missouri River for wild gears: A: hoop nets and B: set lines fished during fall through spring (Sturgeon Season) during 2003 - 2004.

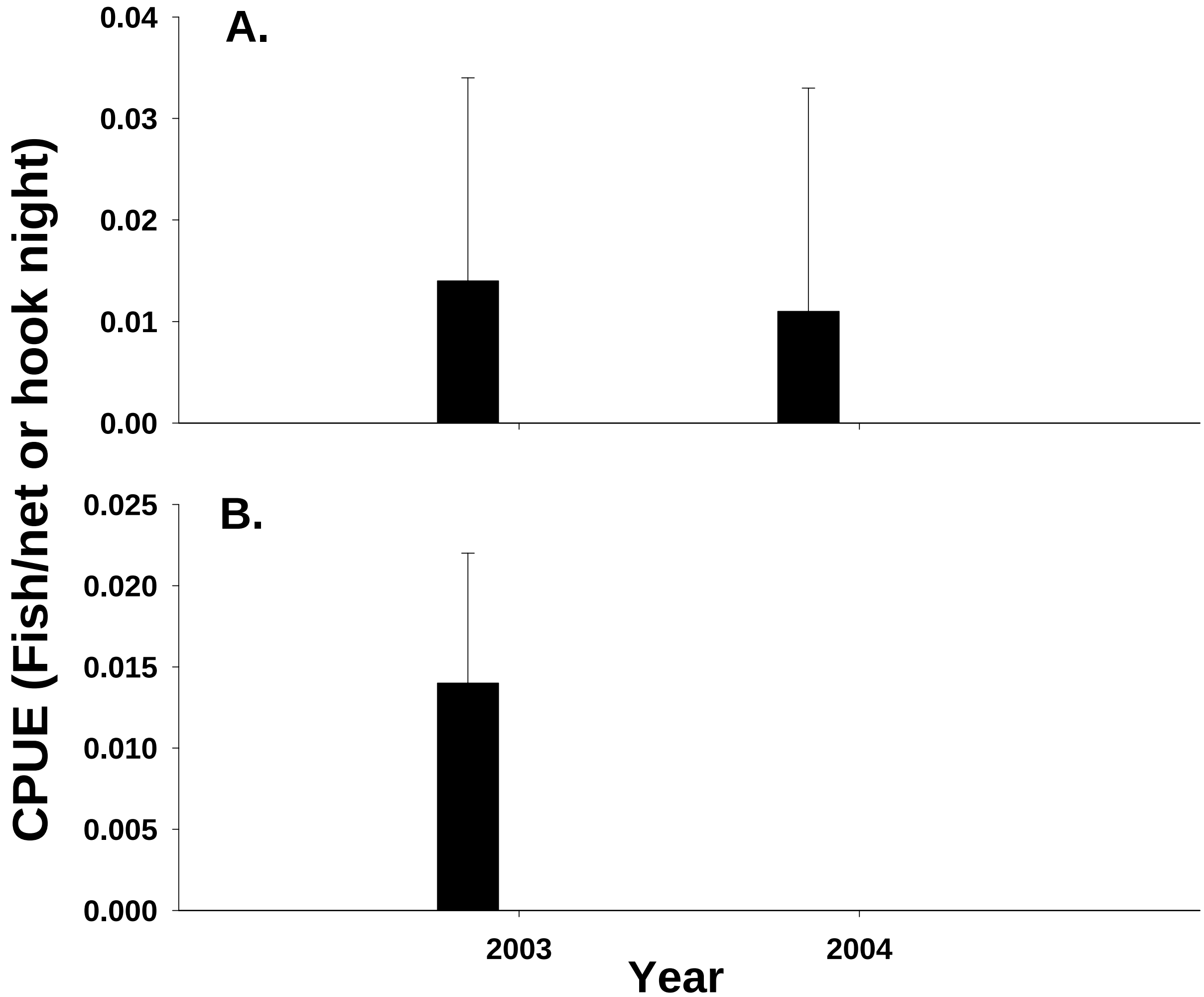

Figure 36. Mean annual catch-per-unit-effort (+/- 2 SE) of shovelnose sturgeon in segments 5 and 6 of the Missouri River for wild gears: A: hoop nets and B: set lines fished during summer (Fish Community Season) during 2003 - 2004.

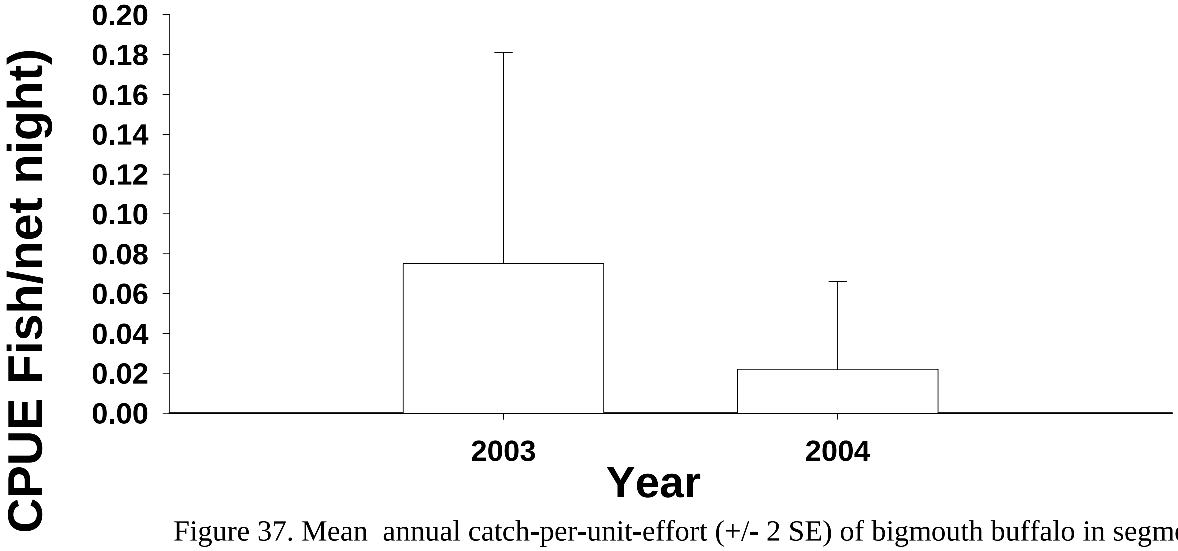

Figure 37. Mean annual catch-per-unit-effort (+/- 2 SE) of bigmouth buffalo in segments 5 and 6 of the Missouri River for hoop nets fished during fall through spring (Sturgeon Season) during 2003 - 2004.

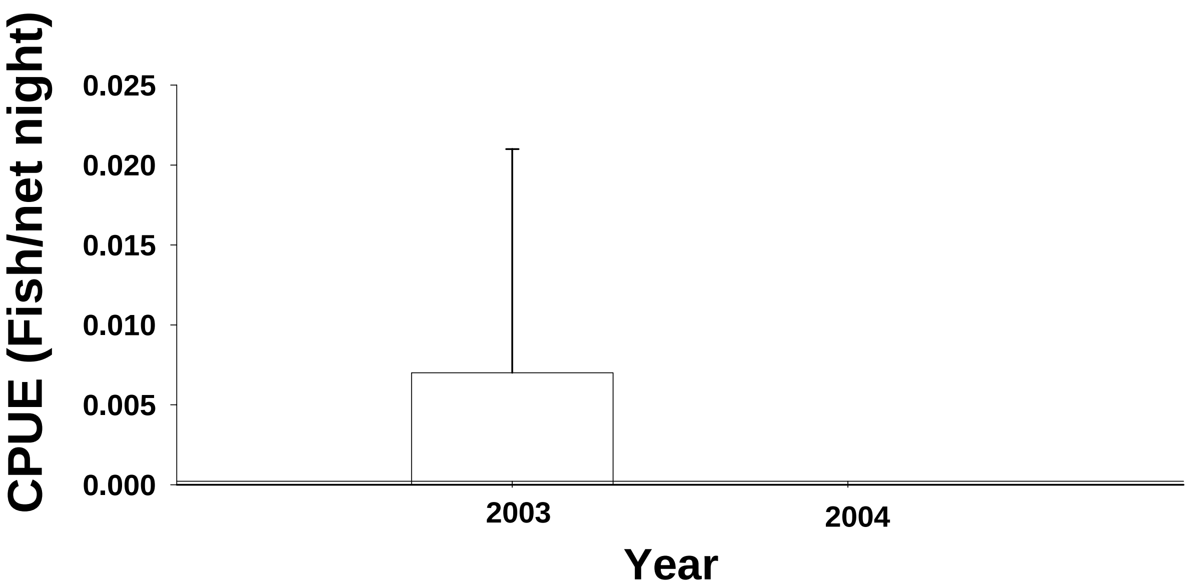

Figure 38. Mean annual catch-per-unit-effort (+/- 2 SE) of bigmouth buffalo in segments 5 and 6 of the Missouri River for hoop nets fished during summer (Fish Community Season) during 2003 - 2004.

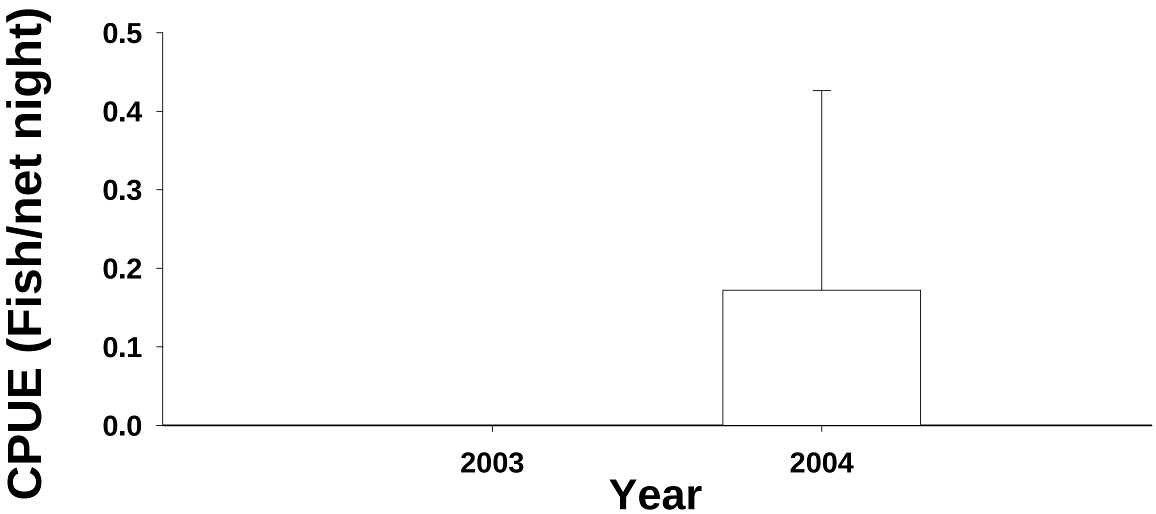

Figure 39. Mean annual catch-per-unit-effort (+/- 2 SE) of blue suckers in segment 5 and 6 of the Missouri River for hoop nets fished during fall through spring (Sturgeon Season) during 2003 - 2004.

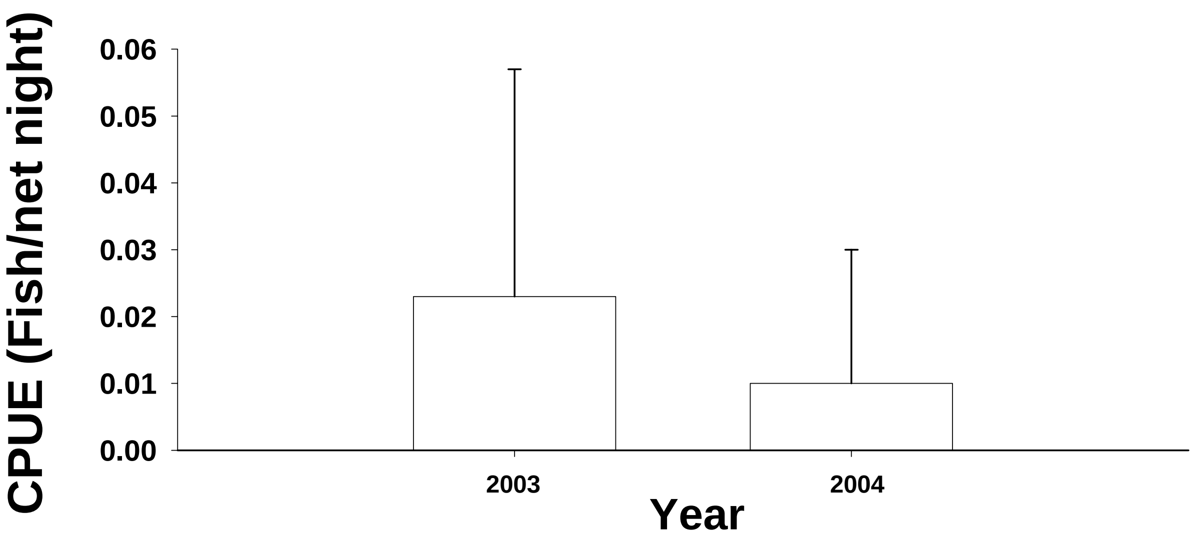

Figure 40. Mean annual catch-per-unit-effort (+/- 2 SE) of blue suckers in segments 5 and 6 of the Missouri River for hoop nets fished during summer (Fish Community Season) during 2003 - 2004.

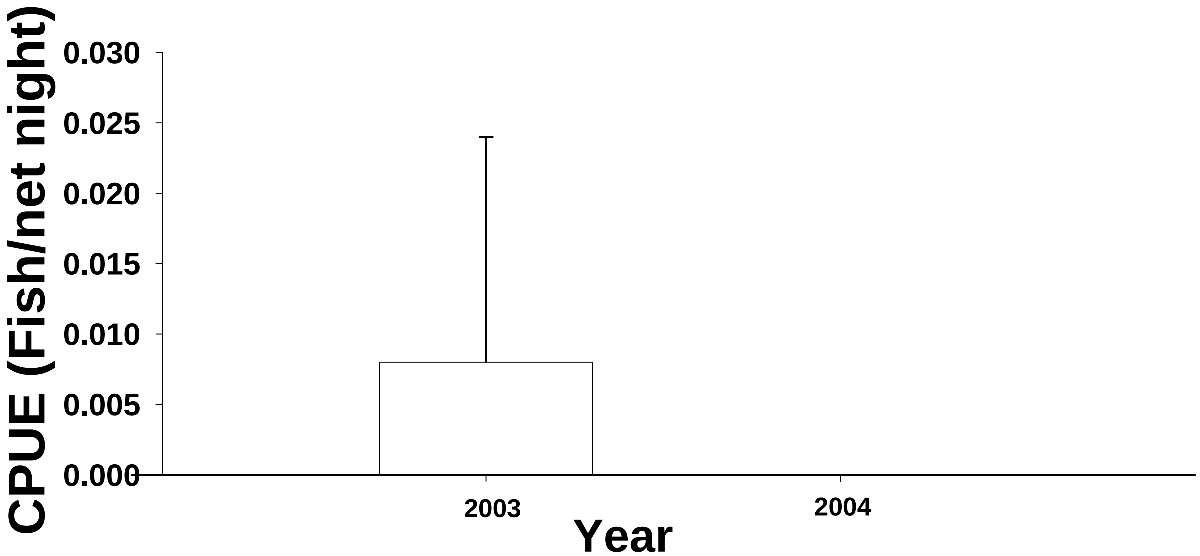

Figure 41. Mean annual catch-per-unit-effort (+/- 2 SE) of sauger in segments 5 and 6 of the Missouri River for hoop nets fished during summer (Fish Community Season) during 2003 - 2004.

DISCUSSION

Pallid sturgeons were captured in all three continuous macrohabitats with the greatest number captured from outside bends with all fish captured within channel border mesohabitats (Figures 6 and 7). Stock and sub-stock length pallid sturgeon were also captured in the discrete macrohabitats, secondary channel connected large and braided channels. However, braided macrohabitats were only first distinguished as a habitat type in 2004 and greater effort (4 bends) in the Niobrara Delta region of segment 6 will be expended during the 2005 season to assess use of this habitat by juvenile pallid sturgeon. Habitats where pallid sturgeon were caught in 2004 corresponded with habitats where fish were relocated during a telemetry study in segments 5 and 6 during 2000 – 2002 (Jordan et al. in review). Most sonic-tagged age-3 pallid sturgeon were relocated in the main channel (91%) with few fish found in secondary connected channels (4%).

Gill nets and trammel nets were the most effective gears for catching pallid and shovelnose sturgeon in segments 5 and 6 of the Missouri River during 2004. There does not appear to be major seasonal differences in effectiveness of trammel nets to capture sturgeon with similar CPUE in the fall through spring and summer of 2004 (Figures 3, 4, 9 and 10). Initial samples with a new 16-ft otter trawl have captured both sturgeon species in the early part of the 2005 season. The beam trawl, hoop nets, and set lines caught few to zero sturgeon. However, set lines are easy to deploy and may be an effective method to increase samples for diet, age assessment, growth, contaminant, and stable isotope studies that require larger numbers of fish. Detailed analyses of monthly sampling effort in 2003 are ongoing and may indicate specific times where set lines are most effective at capturing sturgeon (Greg Wanner, unpublished data).

Although pallid sturgeons were captured in almost all bends sampled during 2004 there was evidence of fish aggregating within specific river miles (Figure 5). During 2004, seven pallid sturgeon were captured within river miles 842 to 844 and five fish were captured with rm 851 to 852. Evidence of aggregations by age-3 pallid sturgeon was also seen in a telemetry study in segments 5 and 6 during 2000 to 2002 (Jordan et al. in review). Aggregations of > 2 sonic-tagged pallid sturgeon within a river kilometer were observed on 20 dates from 2000 to 2002 with most aggregations found at river mile 847 (rkm 1363) (Jordan et al. in review). River mile 847 contains the deepest habitat (11 m) within segments 5 and 6 (known as the "deep pump hole") and is located down river of the Ponca Creek confluence on the South Dakota side of the main channel. The bend containing the deep pump hole was randomly selected for sampling in 2005 so further study of potential aggregations of pallid sturgeon in this area will be possible.

The mean relative condition of all stocked pallid sturgeon year classes declined since release (Table 5). Condition of most fish was > 1.0 at the time of release which may have provided excess energy reserves to better enable the transition from the hatchery to a natural environment, thereby increasing survival. The decrease in condition of hatchery-reared pallid sturgeons may also reflect a lack of sufficient prey resources. For the 1999 year class, 5 of 6 fish lost weight; however, all 6 fish gained in length (Table 5). For the oldest cohort, the 1997 year class, 6 of 8 recaptured fish had positive growth rates in terms of weight and all fish increased in length. A macroinvertebrate study was initiated in 2005 to compare prey availability in segments 5 and 6 at Sunshine Bottoms, Verdel Boat Ramp, and in the Niobrara Delta at Santee, Nebraska and Springfield, South Dakota (Figure 2).

The lack of shovelnose sturgeon within the stock and quality length categories indicated no recent recruitment has occurred within segments 5 and 6 of the Missouri River (Table 8). Fish within the preferred and memorable length classes were in good relative condition (Wr = 97), thus these fish should be physically capable of reproduction. Personal observations also identified exceptionally rotund shovelnose sturgeon, most likely females in later stages of egg development. The standardized gears (gill nets, otter trawl, and trammel nets) have captured smaller shovelnose sturgeon (i.e. < 200 mm FL) from the channelized Missouri River in the states of Nebraska (segments 8, NGPC 2004) and Missouri (segments 13 and 14, Doyle and Starostka 2004). These catches further indicate that shovelnose sturgeon in segments 5 and 6 are failing to either spawn due lack of habitat or have poor larval and juvenile survival. However, failure to effectively sample YOY shovelnose sturgeon with these standard gears in the unchannelized Missouri River remains a possibility. Initiation of sampling in the unchannelized Missouri River below Gavins Point Dam (segment 7) by the South Dakota Department of Game, Fish and Parks in 2005 should further assist in determining effectiveness of standard gears to sample young shovelnose sturgeon in the unchannelized river.

Failure to capture sturgeon, sicklefin, and speckled chubs could also be due to lack of recruitment, but more likely is due to ineffective sampling efficiency of benthic fishes in the main channel of the Missouri River. However, the beam trawl did capture a few silver chubs in the sturgeon (n = 11) and fish community (n = 1) seasons during 2004. The beam trawl caught low numbers ($n \leq 4$) of all targeted chub species in segment 9 in Nebraska with greater numbers (n = 6 – 52) captured with the otter trawl (NGPC 2004). All three chub species were captured with the otter trawl (n = 4 – 166) in segments 13 and 14 of the Missouri River in 2003 and sicklefin and speckled chubs were also captured with bag seines and mini-fyke nets (Doyle and Starostka 2004). Initial use of a new 16-ft otter trawl in segments 5 and 6 will hopefully help to identify the presence of the three chub species in segments 5 and 6.

No *Hybognathus* spp. were captured in segments 5 and 6 of the Missouri River in 2004 indicating possible extirpation of these species or ineffective sampling with the chosen standard gears. However, *Hybognathus* spp. were captured in the lower Missouri River during 2003 with bag seines and mini-fyke nets in Nebraska (NGPC 2004) and Missouri (Doyle and Starostka 2004).

No small blue suckers (< 700 mm TL) were captured in segments 5 and 6 during 2004 with few fish overall being captured with the standard gears (gill nets, trammel nets, beam trawl). At present, blue suckers appear to not be successfully reproducing or survival of early life stages is low in segments 5 and 6. Few small (< 200 mm TL) blue suckers have also been captured in the lower segments of the Missouri River in Nebraska (NGPC 2004). These de low catch rates of small blue suckers in the channelized and unchannelized segments of the Missouri River highlight that habitats used by early life stages are poorly known. Therefore, ineffective sampling with either inefficient gears or in habitats not inhabited by the early life stages of blue suckers may also explain the lack of evidence of recruitment. Hoop nets in spring caught the majority of blue suckers in segments 5 and 6 with most caught in a single net set in May. Efficiency of capturing blue suckers with gill nets and trammel nets in the unchannelized Missouri River may be lower that in the channelized segments. Use of hoop nets was continued in 2005 to further address sampling issues for this species.

The population assessment program is adaptive, allowing for changes in standard gear types and experimentation with the effectiveness of non-standard gears. Hoop nets and setlines will continue to be used during the 2005 season to evaluate the effectiveness of these gears and determine appropriate time frames when they are most effective at capturing sturgeon and other native species. Beam trawling was discontinued in 2005 as a standard gear due to extremely low catches for all fish species during 2003 and 2004. In 2005, a 16-ft. otter trawl will be tested in the sturgeon and fish community seasons as a new standard gear for deep water, benthic habitats. This new otter trawl shows great promise. During the early 2005 sampling season, the otter trawl has captured pallid and shovelnose sturgeons.

ACKNOWLEDGEMENTS

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APPENDIX A.

Phylogenetic list of Missouri River fishes with corresponding letter and numeric codes used in the long-term pallid sturgeon and associated fish community sampling program. The phylogeny follows that used by the American Fisheries Society, Common and Scientific Names of Fishes from the United States and Canada, 5th edition (AFS 1991). Asterisks and bold type denote targeted native Missouri River species.

Scientific name	Common name	Letter Code
	CLASS CEPHALASPIDOMORPHI-LAMPREYS ORDER PETROMYZONTIFORMES	
Petromyzontidae – lampreys		
Ichthyomyzon castaneus	Chestnut lamprey	CNLP
Ichthyomyzon fossor	Northern brook lamprey	NBLP
Ichthyomyzon unicuspis	Silver lamprey	SVLP
Ichthyomyzon gagei	Southern brook lamprey	SBLR
Petromyzontidae	Unidentified lamprey	ULY
Petromyzontidae larvae	Unidentified larval lamprey	LVLP
	CLASS OSTEICHTHYES – BONY FISHES ORDER ACIPENSERIFORMES	
Ascipenseridae – sturgeons		
Acipenser fulvescens	Lake sturgeon	LKSG
Scaphirhynchus spp.	Unidentified Scaphirhynchus	USG
Scaphirhynchus albus	Pallid sturgeon	**PDSG***
Scaphirhynchus platorynchus	Shovelnose sturgeon	**SNSG***
S. albus X S. platorynchus	Pallid-shovelnose hybrid	SNPD
Polyodontidae – paddlefishes		
Polyodon spathula	Paddlefish	PDFH
	ORDER LEPISOSTEIFORMES	
Lepisosteidae – gars		
Lepisosteus oculatus	Spotted gar	STGR
Lepisosteus osseus	Longnose gar	LNGR
Lepisosteus platostomus	Shortnose gar	SNGR
	ORDER AMMIFORMES	
Amiidae – bowfins		
Amia calva	Bowfin	BWFN
	ORDER OSTEOGLOSSIFORMES	
Hiodontidae – mooneyes		
Hiodon alosoides	Goldeye	GDEY
Hiodon tergisus	Mooneye	MNEY
	ORDER ANGUILLIFORMES	
Anguillidae – freshwater eels		
Anguilla rostrata	American eel	AMEL

APPENDIX A. (CONTINUED).

Scientific name	Common name	Code
	ORDER CLUPEIFORMES	
Clupeidae – herrings		
Alosa alabame	Alabama shad	ALSD
Alosa chrysochloris	Skipjack herring	SJHR
Alosa pseudoharengus	Alewife	ALWF
Dorosoma cepedianum	Gizzard shad	GZSD
Dorosoma petenense	Threadfin shad	TFSD
D. cepedianum X D. petenense	Gizzard-threadfin shad hybrid	GSTS
	ORDER CYPRINIFORMES	
Cyprinidae – carps and minnows		
Campostoma anomalum	Central stoneroller	CLSR
Campostoma oligolepis	Largescale stoneroller	LSSR
Carassus auratus	Goldfish	GDFH
Carassus auratus X Cyprinius carpio	Goldfish-Common carp hybrid	GFCC
Couesis plumbens	Lake chub	LKCB
Ctenopharyngodon idella	Grass carp	GSCP
Cyprinella lutrensis	Red shiner	RDSN
Cyprinella spiloptera	Spotfin shiner	SFSN
Cyprinus carpio	Common carp	CARP
Erimystax x-punctatus	Gravel chub	GVCB
Hybognathus argyritis	Western slivery minnow	**WSMN***
Hybognathus hankinsoni	Brassy minnow	BSMN
Hybognathus nuchalis	Mississippi silvery minnow	SVMW
Hybognathus placitus	Plains minnow	**PNMW***
Hybognathus spp.	Unidentified Hybognathus	HBNS
Hypophthalmichthys molitrix	Silver carp	SVCP
Hypophthalmichthys nobilis	Bighead carp	BHCP
Luxilus chrysocephalus	Striped shiner	SPSN
Luxilus cornutus	Common shiner	CMSN
Luxilus zonatus	Bleeding shiner	BDSN
Lythrurus unbratilis	Western redfin shiner	WRFS
Macrhybopsis aestivalis	Speckled chub	**SKCB***
Macrhybopsis gelida	Sturgeon chub	**SGCB***
Macrhybopsis meeki	Sicklefin chub	**SFCB***
Macrhybopsis storeriana	Silver chub	SVCB
M. aestivalis X M. gelida	Speckled-Sturgeon chub hybrid	SPST
M. gelida X M. meeki	Sturgeon-Sicklefin chub hybrid	SCSC
Macrhybopsis spp.	Unidentified chub	UHY
Margariscus margarita	Pearl dace	PLDC
Mylocheilus caurinus	Peamouth	PEMT
Nocomis biguttatus	Hornyhead chub	HHCB
Notemigonus crysoleucas	Golden shiner	GDSN
Notropis atherinoides	Emerald shiner	ERSN
Notropis blennius	River shiner	RVSN
Notropis boops	Bigeye shiner	BESN
Notropis buchanani	Ghost shiner	GTSN

APPENDIX A. (CONTINUED).

Scientific name	Common name	Letter Code
Cyprinidae – carps and minnows		
Notropis dorsalis	Bigmouth shiner	BMSN
Notropis greenei	Wedgespot shiner	WSSN
Notropis heterolepsis	Blacknose shiner	BNSN
Notropis hudsonius	Spottail shiner	STSN
Notropis nubilus	Ozark minnow	OZMW
Notropis rubellus	Rosyface shiner	RYSN
Notropis shumardi	Silverband shiner	SBSN
Notropis stilbius	Silverstripe shiner	SSPS
Notropis stramineus	Sand shiner	**SNSN***
Notropis topeka	Topeka shiner	TPSN
Notropis volucellus	Mimic shiner	MMSN
Notropis wickliffi	Channel shiner	CNSN
Notropis spp.	Unidentified shiner	UNO
Opsopoeodus emiliae	Pugnose minnow	PNMW
Phenacobius mirabilis	Suckermouth minnow	SMMW
Phoxinus eos	Northern redbelly dace	NRBD
Phoxinus erythrogaster	Southern redbelly dace	SRBD
Phoxinus neogaeus	Finescale dace	FSDC
Pimephales notatus	Bluntnose minnow	BNMW
Pimephales promelas	Fathead minnow	FHMW
Pimephales vigilas	Bullhead minnow	BHMW
Platygobio gracilis	Flathead chub	FHCB
P. gracilis X M. meeki	Flathead-sicklefin chub hybrid	FCSC
Rhinichthys atratulus	Blacknose dace	BNDC
Rhinichthys cataractae	Longnose dace	LNDC
Richardsonius balteatus	Redside shiner	RDSS
Scardinius erythrophtalmus	Rudd	RUDD
Semotilus atromaculatus	Creek chub	CKCB
	Unidentified Cyprinidae	UCY
Catostomidae - suckers		
Carpiodes carpio	River carpsucker	RVCP
Carpiodes cyprinus	Quillback	QLBK
Carpiodes velifer	Highfin carpsucker	HFCS
Carpiodes spp.	Unidentified Carpiodes	UCS
Catostomus catostomus	Longnose sucker	LNSK
Catostomus commersoni	White sucker	WTSK
Catostomus platyrhyncus	Mountain sucker	MTSK
Catastomus spp.	Unidentified *Catastomus* spp.	
Cycleptus elongates	Blue sucker	**BUSK***
Hypentelium nigricans	Northern hog sucker	NHSK
Ictiobus bubalus	Smallmouth buffalo	SMBF
Ictiobus cyprinellus	Bigmouth buffalo	**BMBF***
Ictiobus niger	Black buffalo	BKBF
Ictiobus spp.	Unidentified buffalo	UBF
Minytrema melanops	Spotted sucker	SPSK
Moxostoma anisurum	Silver redhorse	SVRH
Moxostoma carinatum	River redhorse	RVRH

APPENDIX A. (CONTINUED).

Scientific name	Common name	Letter Code
Catostomidae - suckers		
Moxostoma duquesnei	Black redhorse	BKRH
Moxostoma erythrurum	Golden redhorse	GDRH
Moxostoma macrolepidotum	Shorthead redhorse	SHRH
Moxostoma spp.	Unidentified redhorse	URH
	Unidentified Catostomidae	UCT
	ORDER SILURIFORMES	
Ictaluridae – bullhead catfishes		
Ameiurus melas	Black bullhead	BKBH
Ameiurus natalis	Yellow bullhead	YLBH
Ameiurusnebulosus	Brown bullhead	
Ameiurus spp.	Unidentified bullhead	
Ictalurus furcatus	Blue catfish	BLCF
Ictalurus punctatus	Channel catfish	CNCF
I. furcatus X I. punctatus	Blue-channel catfish hybrid	BCCC
Ictalurus spp.	Unidentified *Ictalurus* spp.	
Noturus exilis	Slender madtom	SDMT
Noturus flavus	Stonecat	STCT
Noturus gyrinus	Tadpole madtom	TPMT
Noturus nocturnes	Freckled madtom	FKMT
Pylodictis olivaris	Flathead catfish	FHCF
	Unidentified – not *Ictalurus*	UCF
	ORDER SALMONIFORMES	
Esocidae - pikes		
Esox americanus vermiculatus	Grass pickerel	GSPK
Esox lucius	Northern pike	NTPK
Esox masquinongy	Muskellunge	MSKG
E. lucius X E. masquinongy	Tiger Muskellunge	
Umbridae - mudminnows		
Umbra limi	Central mudminnow	
Osmeridae - smelts		
Osmerus mordax	Rainbow smelt	RBST
Salmonidae - trouts		
Coregonus artedi	Lake herring or cisco	CSCO
Coregonus clupeaformis	Lake whitefish	LKWF
Oncorhynchus aguabonita	Golden trout	GDTT
Oncorhynchus clarki	Cutthroat trout	CTTT
Oncorhynchus kisutch	Coho salmon	CHSM
Oncorhynchus mykiss	Rainbow trout	RBTT
Oncorhynchus nerka	Sockeye salmon	SESM
Oncorhynchus tshawytscha	Chinook salmon	CNSM
Prosopium cylindraceum	Bonniville cisco	BVSC
Prosopium williamsoni	Mountain whitefish	MTWF

APPENDIX A. (CONTINUED).

Scientific name	Common name	Letter Code
Salmonidae - trouts		
Salmo trutta	Brown trout	BNTT
Salvelinus fontinalis	Brook trout	BKTT
Salvelinus namaycush	Lake trout	LKTT
Thymallus arcticus	Arctic grayling	AMGL
	ORDER PERCOPSIFORMES	
Percopsidae – trout-perches		
Percopsis omiscomaycus	Trout-perch	TTPH
	ORDER GADIFORMES	
Gadidae – cods		
Lota lota	Burbot	BRBT
	ORDER ATHERINIFORMES	
Cyprinodontidae – killifishes		
Fundulus catenatus	Northern studfish	NTSF
Fundulus daphanus	Banded killifish	BDKF
Fundulus notatus	Blackstripe topminnow	BSTM
Fundulus olivaceus	Blackspotted topminnow	BPTM
Fundulus sciadicus	Plains topminnow	PTMW
Fundulus zebrinus	Plains killifish	PKLF
Poeciliidae – livebearers		
Gambusia affinis	Western mosquitofish	MQTF
Atherinidae – silversides		
Labidesthes sicculus	Brook silverside	BKSS
	ORDER GASTEROSTEIFORMES	
Gasterosteidae – sticklebacks		
Culea inconstans	Brook stickleback	BKSB
	ORDER SCORPAENIFORMES	
Cottidae – sculpins		
Cottus bairdi	Mottled sculpin	MDSP
Cottus carolinae	Banded sculpin	BDSP
	ORDER PERCIFORMES	
Percichthyidae – temperate basses		
Morone americana	White perch	WTPH
Morone chrysops	White bass	WTBS
Morone mississippiensis	Yellow bass	YWBS

APPENDIX A. (CONTINUED).

Scientific name	Common name	Letter Code
Percichthyidae – temperate basses		
Morone saxatilis	Striped bass	SDBS
M. saxatilis X M. chrysops	Striped-white bass hybrid	
Centrarchidae - sunfishes		
Ambloplites rupestris	Rock bass	RKBS
Archoplites interruptus	Sacremento perch	
Lepomis cyanellus	Green sunfish	GNSF
Lepomis gibbosus	Pumpkinseed	PNSD
Lepomis gulosus	Warmouth	WRMH
Lepomis humilis	Orangespotted sunfish	OSSF
Lepomis macrochirus	Bluegill	BLGL
Lepomis magalotis	Longear sunfish	LESF
Lepomis microlophus	Redear sunfish	
L. cyanellus X L. macrochirus	Green sunfish-bluegill hybrid	GSBG
L. cyanellus X L. spp?	Unknown Green sunfish hybrid	GN*?
L. cyanellus X L. humilis	Green-orangespotted sunfish hybrid	GSOS
L. macrochirus X L. microlophus	Bluegill-redear sunfish hybrid	
Lepomis spp.	Unidentified *Lepomis*	ULP
Micropterus dolomieu	Smallmouth bass	SMBS
Micropterus punctatus	Spotted sunfish	STBS
Micropterus salmoides	Largemouth bass	LMBS
Micropterus spp.	Unidentified *Micropterus* spp.	
Pomoxis annularis	White crappie	WTCP
Pomoxis nigromaculatus	Black crappie	BKCP
Pomoxis spp.	Unidentified crappie	
P. annularis X P. nigromaculatus	White-black crappie hybrid	
Centrarchidae	Unidentified centrarchid	UCN
Percidae - perches		
Ammocrypta asprella	Crystal darter	CLDR
Etheostoma blennioides	Greenside darter	GSDR
Etheostoma caeruleum	Rainbow darter	RBDR
Etheostoma exile	Iowa darter	IODR
Etheostoma flabellare	Fantail darter	FTDR
Etheostoma gracile	Slough darter	SLDR
Etheostoma microperca	Least darter	LTDR
Etheostoma nigrum	Johnny darter	JYDR
Etheostoma punctulatum	Stippled darter	STPD
Etheostoma spectabile	Orangethroated darter	OTDR
Etheostoma tetrazonum	Missouri saddled darter	MSDR
Etheostoma zonale	Banded darter	BDDR
Etheostoma spp.	Unidentified Etheostoma spp.	UET
Perca flavescens	Yellow perch	YWPH
Percina caproides	Logperch	LGPH
Percina cymatotaenia	Bluestripe darter	BTDR
Percina evides	Gilt darter	GLDR
Percina maculate	Blackside darter	BSDR

APPENDIX A. (CONTINUED).

Scientific name	Common name	Letter Code
Percidae - perches		
Percina phoxocephala	Slenderhead darter	SHDR
Percina shumardi	River darter	RRDR
Percina spp.	Unidentified Percina spp.	UPN
	Unidentified darter	UDR
Sander canadense	Sauger	**SGER***
Sander vitreum	Walleye	WLEY
S. canadense X S. vitreum	Sauger-walley hybrid/Saugeye	SGWE
Sander spp.	Unidentified *Zander* (formerly *Stizostedion*) spp.	UST
Percidae	Unidentified percidae	UPC
Sciaenidae - drums		
Aplodinotus grunniens	Freshwater drum	FWDM
	NON-TAXONOMIC CATEGORIES	
	Age-0/Young-of-year fish	YOYF
	Lab fish for identification	LAB
	No fish caught	NFSH
	Unidentified larval fish	LVFS
	Unidentified	UNID

APPENDIX B.

Definitions and codes used to classify standard Missouri River habitats in the long-term pallid sturgeon and associated fish community sampling program. Three habitat scales were used in the hierarchical habitat classification system: macrohabitats, mesohabitats, and microhabitats.

Habitat	Scale	Definition	Code
Main channel cross over	Macro	The inflection point of the thalweg where the thalweg crosses from one concave side of the river to the other concave side of the river, (i.e., transition zone from one-bend to the next bend). The upstream CHXO for a respective bend is the one sampled.	CHXO
Main channel outside bend	Macro	The concave side of a river bend	OSB
Main channel inside bend	Macro	The convex side of a river bend	ISB
Secondary channel-connected large	Macro	A side channel, open on upstream and downstream ends, with less flow than the main channel, large indicates this habitat can be sampled with trammel nets and trawls based on width and/or depths > 1.2 m	SCCL
Secondary channel-connected small	Macro	A side channel, open on upstream and downstream ends, with less flow than the main channel, small indicates this habitat cannot be sampled with trammel nets and trawls based on width and/or on depths < 1.2 m	SCCS
Non-connected secondary channels	Macro	A side channel, open on the upstream or downstream end, with minimal flow.	SCN
Tributary small mouth	Macro	Mouth of entering tributary whose mean annual discharge is < 20 m^3/s, mouth width is > 6 m wide and the sample area extends 300 m into the tributary	TRMS
Tributary large mouth	Macro	Mouth of entering tributary whose mean annual discharge is > 20 m^3/s, and the sample area extends 300 m into the tributary	TRML
Tributary confluence	Macro	Area immediately downstream, extending up to one bend in length, from a junction of a large tributary and the main river where this tributary has influence on the physical features of the main river	CONF
Braided channel	Macro	Riverine area with multiple channels separated by sand bar complexes, no well-defined main channel exists	BRAD
Deranged channel	Macro	Where a braided channel coalesces into a single well-defined main channel	DRNG
Dendritic channel	Macro	Where a single well-defined main channel separates into a braided channel, opposite of deranged channel	DEND

APPENDIX B. (CONTINUED).

Habitat	Scale	Definition	Code
Dam tailwaters	Macro	Area immediately downstream of a dam	DTWT
Bars	Meso	Sandbar or shallow bank-line areas with depth < 1.2 m	BAR
Pools	Meso	Areas immediately downstream from sandbars, dikes, snags, or other obstructions with a formed scour hole > 1.2 m	POOL
Channel border	Meso	Area in the channelized river between the toe and the thalweg, area in the unchannelized river between the toe and the maximum depth	CHNB
Thalweg	Meso	Main channel between the channel borders conveying the majority of the flow	TLWG
Island tip	Meso	Area immediately downstream of a bar or island where two channels converge with water depths > 1.2 m	ITIP
Steep	Micro	Area where water depth increases by 1.2 m or more within a 3 m distance. Does not necessarily have to be associated with a bank-line or bar	ST

APPENDIX C.

List of standard and wild gears (type), their corresponding codes in the database, seasons deployed (Fall-Spring, Summer, or all), years used, and catch-per-unit-effort units for collection of Missouri River fishes in segments 5 and 6 for the long-term pallid sturgeon and associated fish community sampling program. Long-term monitoring began in 2003 for segments 5 and 6.

Gear	Code	Type	Season	Years deployed	CPUE units
Trammel net	TN	standard	all	2003 - present	fish/100 m drift
Gillnet – 4 meshes, small mesh set upstream	GN14	standard	fall - spring	2003 - present	fish/net night
Gillnet – 4 meshes, large mesh set upstream	GN41	standard	fall - spring	2003 - present	fish/net night
Otter trawl – 16 ft head rope	OT16	standard	all	2005	fish/100 m trawled
Beam trawl	BT	standard	all	2003 - 2004	fish/100 m trawled
Hoop net	HN	wild	all	2003 - 2005	fish/net night
Set line	SL	wild	all	2003 - 2005	fish/hook night
Bag Seine – quarter arc method pulled upstream	BSQU	standard	summer	2003 - present	fish/m^2
Bag Seine – quarter arc method pulled downstream	BSQD	standard	summer	2003 - present	fish/m^2
Bag Seine – half arc method pulled upstream	BSHU	standard	summer	2003 - present	fish/m^2
Bag Seine – half arc method pulled downstream	BSHD	standard	summer	2003 - present	fish/m^2
Bag seine – rectangular method pulled upstream	BSRU	standard	summer	2003 - present	fish/m^2
Bag seine – rectangular method pulled upstream	BSRD	standard	summer	2003 - present	fish/m^2
Mini-fyke net	MF	standard	summer	2003 - present	fish/net night

Gillnets in 2003 - 2005 had a fifth experimental panel of 1 inch (2.54 cm) bar mesh.
Hoopnets were considered a standard gear during 2003 and 2004 but changed to a wild gear in 2005 due to low catch rates of sturgeon.

APPENDIX D.

Stocking locations and codes for pallid sturgeon by Recovery Priority Management Area (RPMA) in the Missouri River Basin.

State(s)	RPMA	Site Name	Code
MT	2	Wolf Point	WFP
MT	2	Culbertson	CBS
MT	2	Milk	MLK
MT	2	Brockton	BRK
MT	2	Poplar	POP
MT	2	Intake – Yellowstone River	INT
MT	2	Sidney – Yellowstone River	SID
MT	2	Fairview – Yellowstone River	FRV
MT	2	Above Intake – Yellowstone River	AIN
SD/NE	3	Sunshine Bottoms	SUN
SD/NE	3	Verdel Boat Ramp	VER
SD/NE	3	Standing Bear Bridge/Running Water Boat Ramp	SBB
SD/NE	4	Mulberry Bend	MUL
NE/IA	4	Sioux City	SIO
NE/IA	4	Bellevue – Platte River Confluence	BEL
NE/IA	4	Rulo	RLO
NE/MO/KS	4	Kansas River	KSR
MO	4	Grand River	GDR
MO	4	Boonville	BOO
MO	4	Jefferson City	JEF
MO	4	Mokane	MOK
MO	4	Herman	HER

APPENDIX E.

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

Year	Stocking Site	Number Stocked	Year Class	Stock Date	Avg. Length (mm)	Primary mark	Secondary Mark
2000	Verdel	416	1997	6/6/2000	516	PIT Tag	Elastomer
	Verdel	98	1998	9/20/2000	473	PIT Tag	
	Verdel	4	*	7/6/2000		PIT Tag	Sonic Tag
	Verdel	3	*	9/20/200		PIT Tag	2 w/ sonic
	Running Water	2	*	7/6/2000		PIT Tag	
2002	Verdel	561	2001			PIT Tag	Elastomer
	Sunshine Bottoms	182	1999			PIT Tag	Elastomer
2003	Running Water	300	2002			PIT Tag	Elastomer
	Sunshine Bottoms	301	2002			PIT Tag	Elastomer
2004	Sunshine Bottoms	244	2003			PIT Tag	Elastomer
	Running Water	271	2003			PIT Tag	Elastomer

* indicates broodstock and rehabilitated fish (originally captured from Lake Sharpe) stocked due to iridovirus issues.

APPENDIX F.

Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/net night) by mesohabitat within a macrohabitat for all species caught with gillnets from fall through spring (sturgeon season) for segments 5 and 6 of the unchannelized Missouri River during 2004. Species captured are listed phylogenetically and their codes are presented in Appendix A. Asterisks with bold type indicate targeted native Missouri River species and habitat abbreviations are presented in Appendix B. Double asterisks indicate sample size < 5 (i.e. < 5 bends with that particular habitat) and SE was not calculated.

Species	Total catch	Overall CPUE								
Macro-			OSB		ISB		CHXO		CONF	
Meso-			CHNB	POOL	CHNB	POOL	CHNB	POOL	CHNB	POOL
				Ascipenseridae - sturgeons						
PDSG*	12	0.077	0.081		0.034		0.058			
		(0.056)	(0..096)		(0.048)		(0.078)			
SNSG*	43	0.250	0.321		0.233	0.333	0.300	1.0		
		(0.086)	(0.204)		(0.156)	(0.334)	(0.204)	(**)		
				Lepisosteidae – gars						
SNGR	2	0.013								
		(0.018)								
				Hiodontidae – mooneyes						
GDEY	1	0.006	0.026							
		(0.012)	(0.052)							
				Clupeidae – herrings						
GZSD	1	0.006				0.083				
		(0.012)				(0.167)				
				Cyprinidae – carps and minnows						
CARP	6	0.032	0.026			0.167				
		(0.028)	(0.051)			(0.333)				
				Catostomidae – suckers						
RVCS	14	0.083	0.108		0.028	0.417				
		(0.052)	(0.160)		(0.056)	(0.402)				
QLBK	1	0.006								
		(0.012)								
BMBF*	5	0.026				0.167				
		(0.036)				(0.333)				
SHRH	41	0.256	0.221		0.392	0.5		1.0		
		(0.057)	(0.182)		(0.322)	(0.366)		(**)		

APPENDIX F. (CONTINUED).

Species Macro- Meso-	Total catch	Overall CPUE	OSB		ISB		CHXO		CONF	
			CHNB	POOL	CHNB	POOL	CHNB	POOL	CHNB	POOL
Ictaluridae – bullhead catfishes										
CNCF	42	0.234	0.074		0.083	1.833	0.242			
		(0.164)	(0.088)		(0.112)	(2.894)	(0.346)			
FHCF	1	0.006	0.010							
		(0.012)	(0.020)							
Esocidae – pikes										
NTPK	1	0.006	0.038							
		(0.012)	(0.076)							
Centrarchidae – sunfishes										
SMBS	1	0.006	0.011							
		(0.012)	(0.022)							
Percidae – perches										
SGER*	43	0.239	0..196		0.167	0.417	0.250			
		(0.086)	(0.180)		(0.188)	(0.654)	(0.230)			
WLEY	46	0.269	0.571			0.167	0.342	1.0		
		(0.214)	(0.760)			(0.210)	(0.390)	(**)		
SGWE	5	0.032	0.026				0.1	1.0		
		(0.034)	(0.052)				(0.200)	(**)		

APPENDIX F. (EXTENDED).

Species Macro Meso	TRML	SCCL CHNB	SCCL POOL	SCCL ITIP	BRAD CHNB	BRAD POOL	DEND CHNB	DEND POOL	DRNG CHNB	DRNG POOL
Ascipenseridae – sturgeons										
PDSG*										
SNSG*			0.500 (1.00)							
Lepisosteidae – gars										
SNGR										
Hiodontidae – mooneyes										
GDEY										
Clupeidae – herrings										
GZSD										
Cyprinidae – carps and minnows										
CARP						0.250 (0.500)				
Catostomidae – suckers										
RVCS		0.222 (0.254)				0.500 (0.578)				
QLBK										
BMBF*		0.111 (0.222)								
SHRH		0.167 (0.333)		1.0 (**)						
Ictaluridae – bullhead catfishes										
CNCF			0.500 (0.578)			0.750 (1.500)				
FHCF										
Esocidae – pikes										
NTPK										
Centrarchidae – sunfishes										
SMBS										
Percidae – perches										
SGER*						0.750 (1.500)				
WLEY		0.389 (0.400)								

APPENDIX G.

Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/100 m) by mesohabitat within a macrohabitat for all species caught with trammel nets from fall through spring (sturgeon season) for segments 5 and 6 of the unchannelized Missouri River during 2004. Species captured are listed phylogenetically and their codes are presented in Appendix A. Asterisks with bold type indicate targeted native Missouri River species and habitat abbreviations are presented in Appendix B. Double asterisks indicate sample size < 5 (i.e. < 5 bends with that particular habitat) and SE was not calculated.

Species	Total catch	Overall CPUE								
Macro-			OSB		ISB		CHXO		CONF	
Meso-			CHNB	POOL	CHNB	POOL	CHNB	POOL	CHNB	POOL
					Ascipenseridae - sturgeons					
PDSG*	7	0.031	0.012	0.190			0.018			
		(0.026)	(0.024)	(**)			(0.036)			
SNSG*	25	0.123	0.063		0.170		0.079			
		(0.058)	(0.070)		(0.116)		(0.084)			
					Cyprinidae – carps and minnows					
CARP	8	0.039	0.056		0.042		0.042			
		(0.032)	(0.074)		(0.084)		(0.060)			
					Catostomidae – suckers					
RVCS	9	0.040	0.010		0.064		0.089			
		(0.032)	(0.020)		(0.090)		(0.108)			
SMBF	2	0.008	0.025							
		(0.012)	(0.050)							
SHRH	6	0.026		0.190	0.069		0.018			
		(0.026)		(**)	(0.092)		(0.036)			
					Ictaluridae – bullhead catfishes					
CNCF	71	0.294	0.510	1.714	0.101		0.329			
		(0.154)	(0.518)	(**)	(0.110)		(0.430)			
					Percichthyidae – temperate basses					
WTBS	4	0.019			0.042		0.039			
		(0.024)			(0.084)		(0.056)			
					Centrarchidae – sunfishes					
SMBS	1	0.005					0.016			
		(0.010)					(0.032)			
					Percidae – perches					
SGER*	23	0.102	0.108	0.571	0.019		0.100			
		(0.064)	(0.150)	(**)	(0.038)		(0.096)			
WLEY	11	0.053	0.088	0.190	0.053	0.5	0.016			
		(0.040)	(0..144)	(**)	(0.054)	(1.0)	(0.032)			

APPENDIX G. (CONTINUED).

Species Macro- Meso-	Total catch	Overall CPUE	OSB CHNB	 POOL	ISB CHNB	 POOL	CHXO CHNB	 POOL	CONF CHNB	 POOL
SGWE	2	0.008 (0.012)	0.010 (0.020)							

APPENDIX G. (EXTENDED).

Species Macro- Meso-	TRML	SCCL CHNB	 POOL	 ITIP	BRAD CHNB	 POOL	DEND CHNB	 POOL	DRNG CHNB	 POOL
Ascipenseridae - sturgeons										
PDSG*		0.159 (0..318)								
SNSG*		0.593 (1.185)			0.193 (0.028)					
Cyprinidae – carps and minnows										
CARP					0.045 (0.089)					
Catostomidae - suckers										
RVCS										
SMBF										
SHRH										
Ictaluridae – bullhead catfishes										
CNCF		0.037 (0.743)			0.124 (0.248)					
Percichthyidae – temperate basses										
WTBS										

Centrarchidae - sunfishes	
SMBS	
Percidae - perches	
SGER*	0.219 (0.218)
WLEY	0.045 (0.089)
SGWE	0.045 (0.089)

APPENDIX H.

Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/100 m) by mesohabitat within a macrohabitat for all species caught with a beam-trawl fall through spring (sturgeon season) for segments 5 and 6 of the unchannelized Missouri River. Species captured are listed phylogenetically and their codes are presented in Appendix A. Asterisks with bold type indicate targeted native Missouri River species and habitat abbreviations are presented in Appendix B. Double asterisks indicate sample size < 5 (i.e. < 5 bends with that particular habitat) and SE was not calculated.

Species	Total catch	Overall CPUE								
Macro-			OSB		ISB		CHXO		CONF	
Meso-			CHNB	POOL	CHNB	POOL	CHNB	POOL	CHNB	POOL
Ascipenseridae - sturgeons										
SNSG*	3	0.014 (0.016)	0.028 (0.056)		0.021 (0.042)					
Cyprinidae – carps and minnows										
SVCB	11	0.055 (0.038)	0.042 (0.056)		0.021 (0.042)	1.00 (**)	0.107 (0.170)			
Catostomidae - suckers										
SHRH	1	0.004 (0.008)	0.014 (0.028)							
Ictaluridae – bullhead catfishes										

CNCF	20	0.086 (0.076)	0.203 (0.322)		0.045 (0.058)		0.020 (0.040)
FHCF	2	0.010 (0.014)	0.028 (0.056)				
Centrarchidae - sunfishes							
SMBS	1	0.004 (0.008)					0.020 (0.040)
Percidae - perches							
SGER*	1	0.004 (0.008)					

APPENDIX H. (EXTENDED).

Species Macro- Meso-	TRML	SCCL CHNB	SCCL POOL	SCCL ITIP	BRAD CHNB	BRAD POOL	DEND CHNB	DEND POOL	DRNG CHNB	DRNG POOL
Ascipenseridae – sturgeons										
SNSG*										
Cyprinidae – carps and minnows										
SVCB										
Catostomidae – suckers										
SHRH										
Ictaluridae – bullhead catfishes										
CNCF										
FHCF										
Centrarchidae – sunfishes										
SMBS										
Percidae – perches										
SGER*					0.021 (0.042)					

APPENDIX I.

Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/100 m) by mesohabitat within a macrohabitat for all species caught with trammel nets in summer (fish community season) for segments 5 and 6 of the unchannelized Missouri River during 2004. Species captured are listed phylogenetically and their codes are presented in Appendix A. Asterisks with bold type indicate targeted native Missouri River species and habitat abbreviations are presented in Appendix B. Double asterisks indicate sample size < 5 (i.e. < 5 bends with that particular habitat) and SE was not calculated.

Species Macro- Meso-	Total catch	Overall CPUE	OSB CHNB	OSB POOL	ISB CHNB	ISB POOL	CHXO CHNB	CHXO POOL	CONF CHNB	CONF POOL
Ascipenseridae – sturgeons										
PDSG*	6	0.028	0.024				0.032			
		(0.022)	(0.048)				(0.064)			
SNSG*	15	0.078	0.088				0.016			
		(0.050)	(0.138)				(0.032)			
Lepisosteidae – gars										
SNGR	2	0.012			0.073					
		(0.024)			(0.146)					
Catostomidae – suckers										
RVCS	1	0.006			0.037					
		(0.012)			(0.074)					
SHRH	4	0.028	0.041				0.070			
		(0.034)	(0.082)				(0.108)			
Ictaluridae – bullhead catfishes										
CNCF	22	0.146	0.077		0.351		0.169			
		(0.088)	(0.118)		(0.564)		(0.138)			
Centrarchidae – sunfishes										
SMBS	1	0.006			0.037					
		(0.012)			(0.074)					
Percidae – perches										
SGER*	3	0.020	0.056				0.032			
		(0.024)	(0.112)				(0.064)			
WLEY	2	0.022					0.041			

(0.032) (0.082)

APPENDIX I. (EXTENDED).

Species										
Macro-	TRML	SCCL			BRAD		DEND		DRNG	
Meso-		CHNB	POOL	ITIP	CHNB	POOL	CHNB	POOL	CHNB	POOL
					Ascipenseridae - sturgeons					
PDSG*					0.036 (0.072)					
SNSG*		0.093 (0.186)			0.138 (0.236)					
					Lepisosteidae – gars					
SNGR										
					Catostomidae - suckers					
RVCS										
SHRH										
					Ictaluridae – bullhead catfishes					
CNCF		0.053 (0.107)			0.070 (0.140)					
					Centrarchidae - sunfishes					
SMBS										
					Percidae - perches					
SGER*										
WLEY		0.130 (0.260)								

APPENDIX J.

Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/100 m) by mesohabitat within a macrohabitat for all species caught with beam trawl in summer (fish community season) for segments 5 and 6 of the unchannelized Missouri River during 2004. Species captured are listed phylogenetically and their codes are presented in Appendix A. Asterisks with bold type indicate targeted native Missouri River species and habitat abbreviations are presented in Appendix B. Double asterisks indicate sample size < 5 (i.e. < 5 bends with that particular habitat) and SE was not calculated.

Species Macro- Meso-	Total catch	Overall CPUE	OSB CHNB	OSB POOL	ISB CHNB	ISB POOL	CHXO CHNB	CHXO POOL	CONF CHNB	CONF POOL
Ascipenseridae - sturgeons										
SNSG*	2	0.008 (0.012)	0.016 (0.032)							
Cyprinidae – carps and minnows										
SVCB	1	0.004 (0.008)	0.016 (0.032)							
ERSN	3	0.013 (0.018)								
SFSN	1	0.008 (0.016)			0.029 (0.058)					
Catostomidae - suckers										
RVCS	1	0.004 (0.008)	0.024 (0.048)							
Ictaluridae – bullhead catfishes										
CNCF	5	0.024 (0.024)	0.024 (0.048)							
Centrarchidae - sunfishes										
SMBS	1	0.004 (0.008)			0.024 (0.048)					
WTCP	1	0.004 (0.008)	0.024 (0.048)							

APPENDIX J. (EXTENDED).

Species Macro- Meso-	TRML	SCCL			BRAD		DEND		DRNG	
		CHNB	POOL	ITIP	CHNB	POOL	CHNB	POOL	CHNB	POOL
					Ascipenseridae - sturgeons					
SNSG*					0.014 (0.032)					
					Cyprinidae – carps and minnows					
SVCB										
ERSN					0.016 (0.032)					
					Catostomidae - suckers					
RVCS										
					Ictaluridae – bullhead catfishes					
CNCF		0.068 (0.136)			0.043 (0.046)					
					Centrarchidae - sunfishes					
SMBS										
WTCP										

APPENDIX K.

Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/m^2) by mesohabitat within a macrohabitat for all species caught with bag seines in the summer (fish community season) for segment 5 and 6 of the unchannelized Missouri River during 2004. Species captured are listed phylogenetically and their codes are presented in Appendix A. Asterisks with bold type indicate targeted native Missouri River species and habitat abbreviations are presented in Appendix B. Double asterisks indicate sample size < 5 (i.e. < 5 bends with that particular habitat) and SE was not calculated.

Species Macro- Meso-	Total catch	Overall CPUE	OSB BAR	ISB BAR	CHXO BAR	SCCL BAR	SCCS BAR	SCN BAR	TRML BAR	TRMS BAR	CONF BAR
					Lepisosteidae – gars						
SNGR	1	0.007				0.015					
		(0.014)				(0.030)					
					Clupeidae - herrings						
GZSD	77	0.568	1.797	0.346		0.239					
		(0.410)	(2.348)	(0.612)		(0.282)					
					Cyprinidae – carps and minnows						
RDSN	12	0.087	0.039	0.178							
		(0.080)	(0.077)	(0.206)							
SFSN	502	3.697	1.578	6.802		1.233					
		(3.980)	(2.368)	(7.686)		(0.184)					
ERSN	678	5.411	7.976	4.666		7.695		11.275			
		(1.476)	(3.598)	(3.174)		(8.550)		(**)			
RVSN	2	0.015		0.028							
		(0.030)		(0.056)							
BMSN	2	0.015		0.014							
		(0.020)		(0.028)							
STSN	20	0.146	0.402	0.014		0.103					
		(0.140)	(0.508)	(0.028)		(0.146)					

SNSN*	33	0.250	0.471	0.259		0.107					
		(0.134)	(0.490)	(0.288)		(0.142)					
BNMW	3	0.022	0.096			0.079					
		(0.032)	(0.192)			(0.128)					
Catostomidae - suckers											
RVCS	6	0.044		0.094							
		(0.062)		(0.128)							

APPENDIX K. (CONTINUED).

Species Macro- Meso-	Total catch	Overall CPUE	OSB BAR	ISB BAR	CHXO BAR	SCCL BAR	SCCS BAR	SCN BAR	TRML BAR	TRMS BAR	CONF BAR
UCS	**45**	0.328	0.646	0.211		0.058					
		(0.320)	(0.732)	(0.346)		(0.096)					
SHRH	13	0.095	0.288	0.014		0.088					
		(0.082)	(0.404)	(0.028)		(0.126)					
URH	31	0.226	0.164	0.014		0.420					
		(0.216)	(0.218)	(0.028)		(0.414)					
Esocidae – pikes											
NTPK	1	0.007		0.014							
		(0.014)		(0.028)							
Osmeridae – smelts											
RBST	2	0.015				0.018					
		(0.030)				(0.036)					
Percichthyidae – temperate basses											
WTPH	1	0.007				0.009					
		(0.014)				(0.018)					
WTBS	13	0.113	0.100	0.033		0.105					
		(0.080)	(0.122)	(0.044)		(0.142)					
Centrarchidae – sunfishes											
RKBS	4	0.029	0.135								

		(0.046)	(0.228)								
GNSF	3	0.022		0.019		0.057					
		(0.26)		(0.038)		(0.096)					
BLGL	13	0.095	0.545	0.119							
		(0.074)	(0.548)	(0.166)							
SMBS	98	0.714	1.313	0.912		0.628					
		(0.340)	(1.238)	(1.198)		(0.466)					
LMBS	26	0.190	0.031	0.197		0.195		0.513			
		(0.130)	(0.042)	(0.186)		(0.222)		(**)			
WTCP	3	0.022	0.116			0.048					
		(0.026)	(0.082)			(0.096)					

APPENDIX K. (CONTINUED).

Species Macro- Meso-	Total catch	Overall CPUE	OSB BAR	ISB BAR	CHXO BAR	SCCL BAR	SCCS BAR	SCN BAR	TRML BAR	TRMS BAR	CONF BAR
						Percidae - perches					
YWPH	49	0.357	0.096	0.313		0.598					
		(0.238)	(0.154)	(0.272)		(0.636)					
JYDR	22	0.160	0.197	0.384							
		(0.178)	(0.242)	(0.508)							
WLEY	2	0.015		0.014		0.048					
		(0.020)		(0.028)		(0.096)					
UST	2	0.015				0.096					
		(0.030)				(0.192)					

APPENDIX K. (EXTENDED).

Species Macro- Meso-	SCCL BAR	SCCL ITIP	SCCS BAR	SCCS ITIP	BRAD BAR	DEND BAR	DRNG BAR
Lepisosteidae – gars							
SNGR							
Clupeidae - herrings							
GZSD							
Cyprinidae – carps and minnows							
RDSN							
SFSN							
CARP							
ERSN							
RVSN							
BMSN							
STSN							
SNSN*							
BNMW							
Catostomidae - suckers							
RVCS							
UCS							
SHRH							
URH							
Esocidae - pikes							
NTPK							
MSKG							
TGMG							
Osmeridae - smelts							
RBST							

			Percichthyidae – temperate basses				
WTPH							
WTBS							

APPENDIX K. (EXTENDED).

Species Macro- Meso-	SCCL BAR	SCCL ITIP	SCCS BAR	SCCS ITIP	BRAD BAR	DEND BAR	DRNG BAR
			Centrarchidae - sunfishes				
RKBS							
GNSF							
BLGL							
SMBS							
LMBS							
WTCP							
			Percidae - perches				
JYDR							
YWPH							
SGER*							
WLEY							
UST							

APPENDIX L.

Total catch, overall mean catch per unit effort (± 2 SE), and mean CPUE (fish/net night) by mesohabitat within a macrohabitat for all species caught with mini-fyke nets in summer (fish community season) for segments 5 and 6 of the unchannelized Missouri River during 2004. Species captured are listed phylogenetically and their codes are presented in Appendix A. Asterisks with bold type indicate targeted native Missouri River species and habitat abbreviations are presented in Appendix B. Double asterisks indicate sample size < 5 (i.e. < 5 bends with that particular habitat) and SE was not calculated.

Species	Total catch	Overall CPUE									
Macro-			OSB	ISB	CHXO	SCCL	SCCS	SCN	TRML	TRMS	CONF
Meso-			BAR	BAR	BAR	BAR	BAR	BAR	BAR	BAR	BAR
Lepisosteidae – gars											
LNGR	1	0.010	0.03								
		(0.020)	(0.062)								
SNGR	14	0.133	0.062	0.139	1.000	1.943					
		(0.086)	(0.088)	(0.142)	(2.000)	(5.592)					
Clupeidae - herrings											
GZSD	5	0.048	0.125	0.083							
		(0.056)	(0.250)	(0.122)							
Cyprinidae – carps and minnows											
RDSN	23	0.219	0.135	0.389		0.086					
		(0.184)	(0.208)	(0.446)		(0.096)					
SFSN	491	4.676	5.004	5.694		3.286	7.00				
		(1.328)	(3.168)	(2.506)		(10.244)	(**)				
CARP	4	0.038	0.046			0.057					
		(0.046)	(0.060)			(0.676)					
ERSN	447	4.257	3.631	5.472	0.500	3.686	1.000	1.000			
		(1.248)	(1.512)	(2.596)	(1.000)	(11.860)	(**)	(**)			
STSN	31	0.295	0.083	0.500		0.286					
		(0.212)	(0.126)	(0.544)		(0.266)					
SNSN*	173	1.648	1.379	1.861		0.800	25.000	4.000			
		(0.834)	(1.280)	(1.432)		(3.354)	(**)	(**)			
BNMW	18	0.171	0.565	0.083		0.029					

		(0.140)	(0.654)	(0.094)		(0.338)					
UCY	14	0.133	0.056	0.306		0.029					
		(0.102)	(0.074)	(0.274)		(0.058)					

APPENDIX L. (CONTINUED).

Species Macro- Meso-	Total catch	Overall CPUE	OSB BAR	ISB BAR	CHXO BAR	SCCL BAR	SCCS BAR	SCN BAR	TRML BAR	TRMS BAR	CONF BAR
Catostomidae - suckers											
RVCS	2	0.019	0.050								
		(0.038)	(0.100)								
UCS	2	0.019		0.056							
		(0.038)		(0.112)							
BMBF*	2	0.019									
		(0.038)									
SHRH	8	0.076	0.031	0.194							
		(0.088)	(0.062)	(0.250)							
URH	44	0.419	0.417	0.694		0.114					
		(0.426)	(0.229)	(1.138)		(0.136)					
Ictaluridae – bullhead catfishes											
BKBH	2	0.019		0.056							
		(0.026)		(0.078)							
CNCF	7	0.067	0.042	0.167							
		(0.082)	(0.084)	(0.232)							
STCT	3	0.029		0.056							
		(0.032)		(0.078)							
Osmeridae - smelts											
RBST	3	0.029	0.031	0.056							
		(0.032)	(0.062)	(0.078)							

Species Macro- Meso-	Total catch	Overall CPUE	OSB BAR	ISB BAR	CHXO BAR	SCCL BAR	SCCS BAR	SCN BAR	TRML BAR	TRMS BAR	CONF BAR
Percichthyidae – temperate basses											
WTBS	16	0.152 (0.160)	0.063 (0.250)	0.194 (0.388)		0.200 (0.256)					
Centrarchidae - sunfishes											
RKBS	8	0.076 (0.070)		0.056 (0.078)		0.057 (0.080)					
GNSF	7	0.067 (0.056)	0.063 (0.126)	0.056 (0.078)		0.114 (0.136)					
OSSF	1	0.010 (0.020)			0.500 (1.000)						
BLGL	22	0.210 (0.124)	0.306 (0.318)	0.278 (0.272)		0.086 (0.126)					
SMBS	711	6.771 (10.118)	17.808 (33.204)	1.972 (1.208)		1.943 (0.946)	2.00 (**)				
LMBS	39	0.371 (0.290)	0.156 (0.162)	0.556 (0.786)		0.371 (0.272)					
WTCP	27	0.257 (0.158)	0.067 (0.092)	0.556 (0418)	0.500 (1.000)	0.114 (0.136)					
BKCP	11	0.105 (0.140)	0.033 (0.066)	0.083 (0.122)		0.200 (0.400)					
Percidae - perches											
JYDR	84	0.800 (0.314)	0.333 (0.222)	1.000 (0.602)		1.000 (0.662)	3.000 (**)				
YWPH	52	0.495 (0.362)	0.267 (0.406)	0.806 (0.886)		0.429 (0.474)					
SGER*	2	0.019 (0.026)		0.028 (0.056)		0.029 (0.058)					
WLEY	3	0.029 (0.032)	0.067 (0.092)		0.500 (1.000)						

				Sciaenidae - drums	
FWDM	4	0.038 (0.060)		0.083 (0.166)	0.500 (1.000)

APPENDIX L. (EXTENDED).

Species Macro- Meso-	SCCL BAR	SCCL ITIP	SCCS BAR	SCCS ITIP	BRAD BAR	DEND BAR	DRNG BAR
			Lepisosteidae – gars				
LNGR							
SNGR							
			Clupeidae - herrings				
GZSD							
			Cyprinidae – carps and minnows				
RDSN							
SFSN							
CARP							
ERSN							
STSN							
SNSN*							
BNMW							
UCY							
			Catostomidae - suckers				
RVCS							
UCS							
BMBF*							
SHRH							
URH							

Ictaluridae – bullhead catfishes

BKBH
CNCF
STCT

Osmeridae - smelts

RBST

Percichthyidae – temperate basses

WTBS

APPENDIX L. (EXTENDED).

Species Macro- Meso-	SCCL BAR	SCCL ITIP	SCCS BAR	SCCS ITIP	BRAD BAR	DEND BAR	DRNG BAR
			Centrarchidae - sunfishes				
RKBS							
GNSF							
OSSF							
BLGL							
SMBS							
LMBS							
WTCP							
BKCP							
			Percidae - perches				
JYDR							
YWPH							
SGER*							
WLEY							
			Sciaenidae - drums				
FWDM							

CONTINUED DEVELOPMENT OF A BIOENERGETICS MODEL FOR JUVENILE PALLID STURGEON

by
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PROJECT ACCOMPLISHMENTS 2004

During 2004, experiments were continued to derive the relation of routine metabolism with body weight and water temperature for juvenile and larval pallid sturgeon. Experiments in 2004 expanded the range of body sizes tested and included the first measurements of larval pallid sturgeon metabolism. The maximum water temperature tested was also increased 2.5 ºC to 24 ºC. Seventeen experiments were completed in 2004 using 115 fish from two year classes: 70 juveniles from the 2001 year class at the Bozeman Fish Technology Center and 45 larvae from the 2004 year class at Garrison Dam National Fish Hatchery. To facilitate oxygen measurements on large juvenile pallid sturgeon (i.e. 150 – 650 g wet weight), six series of 5 to 6 50-gal tanks per series were used which allowed simultaneous measurements of metabolism at 6 water temperatures (13, 16, 18, 20, 22, 24 ºC). To date, a total of 36 trials have been completed with measurements made on 254 individual pallid sturgeon. Mortality was low; a total of 10 fish died during experimentation from 2003 to 2004.

Multiple regression analysis was used to derive the relation of routine metabolism with body weight and temperature. Compared to two *Ascipenser* spp. (Atlantic and shortnose sturgeon), the relation of pallid sturgeon metabolism with body weight and water temperature differed and was more strongly influenced by warmer water temperatures (20 and 25 C) for juvenile fish > 20 g (Figure 1). Data analysis is ongoing and initial results have been presented in Dec 2003 at the 64th Midwest Fish and Wildlife Conference in Kansas City, Missouri and at the 2004 annual meeting of the Dakota Chapter of the American Fisheries Society in Pierre, South Dakota.

REFERENCES

Niklitschek, E.J. 2001. Bioenergetics modeling and assessment of suitable habitat for juvenile Atlantic and shortnose sturgeons in the Chesapeake Bay. Doctoral Dissertation. University of Maryland Center for Environmental Science. 278 pp.

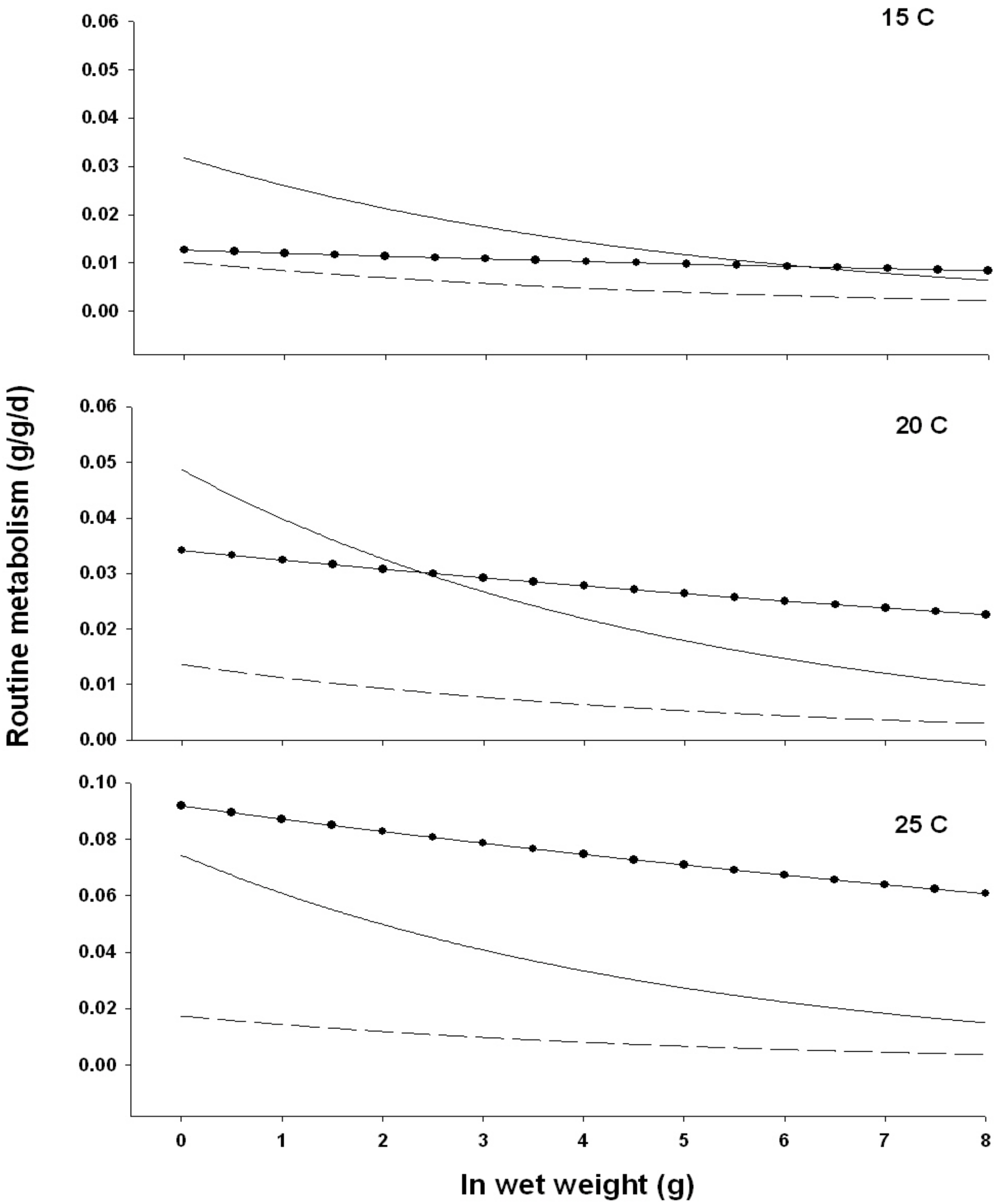

Figure 1. Comparison of routine metabolism of pallid sturgeon (line with circles), shortnose sturgeon (solid line) and Atlantic sturgeon (dashed line) versus weight at three temperatures. Atlantic and shortnose sturgeon data from Niklitschek (2001). Note increase in y-axis scale for 25 C.

Nebraska Game and Parks Commission 2004 Update

Nebraska Game and Parks Commission is currently participating in the Pallid Sturgeon Population Assessment efforts on the Missouri River. Currently, no sturgeon sampling efforts are occurring in RPA #3. However, efforts in RPA #4, include the reach of the Missouri River from Lower Ponca Bend (RM 753.0) to the Kansas River (RM 367.5). NGPC has received funding from the U.S. Army Corps of Engineers until 2009 to continue work in RPA #4 on the Pallid Sturgeon Population Assessment and the Pallid Sturgeon Habitat Assessment grants.

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