Fort Peck Flow Modification Biological Data Collection Plan

Summary of 2007 Activities

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Extended Summary

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 initiated 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 have been conducted annually since 2001.

During 2007, the USACE supported the Fort Peck Data Collection Plan to include the following activities: 1) measure water temperature and turbidity at several locations in the Missouri River downstream from Fort Peck Dam and in off-channel and tributary locations, 2) implant adult pallid sturgeon, paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus* with radio transmitters, examine movements, and relocate these species in the Yellowstone River and Missouri River between Fort Peck Dam and Lake Sakakawea, 3) quantify larval fish distribution and abundance at sites in the Missouri River below Fort Peck Dam, selected tributaries, and off-channel areas, 4) quantify the reproductive success of shovelnose sturgeon and pallid sturgeon based on captures of young-of-year sturgeon, and 5) assist in the collection of adult pallid sturgeon for the pallid sturgeon propagation and augmentation program. Activities associated with the Fort Peck Data Collection Plan were 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 2006, proposed flow modifications were not implemented in 2007 due to inadequate precipitation and insufficient water levels in Fort Peck Reservoir.

For research component 1, water temperature loggers were deployed from April through October 2007. In the free-flowing Missouri River upstream from Fort Peck Reservoir at Robinson Bridge, mean water temperature was 17.6°C and maximum water temperature was 27.6°C. Below Fort Peck Dam, water temperature averaged 12.2°C and maximum water temperature reached 17.0°C. Thus, river impoundment and hypolimnetic releases suppressed mean water temperature in the river downstream from the dam by an average of 5.4°C and maximum water temperature by 10.6°C. Mean water temperature increased as distance from the dam increased, and reached 16.4°C at a site 290 km downstream from the dam. This site was the most downstream Missouri River location prior to receiving inputs from the Yellowstone River. Across all sites, mean water temperature was greatest at Robinson Bridge in the free-flowing reach upstream from Fort Peck Reservoir (17.6°C), followed by the site downstream from the Yellowstone River (17.2°C), near Williston, North Dakota (17.1°C), and in the Yellowstone River (17.0°C). The site below Fort Peck Dam represented the coldest site (mean = 12.2°C).

Turbidity loggers were deployed between April through August 2007. Turbidity (nephelometric turbidity units, NTU) tended to be greater in the Yellowstone River (median = 243 NTU; 25-75% quartiles 65-566 NTU) than in the Missouri River (median = 132 NTU; 25-75% quartiles 76-322 NTU). Turbidity in both rivers varied substantially during the deployment

period, and exhibited the tendency to increase during elevated discharges and decrease during periods of declining or low flows.

Under research component 2, extensive radio tracking of the Missouri River from Fort Peck Dam to the headwaters of Lake Sakakawea and in the lower Yellowstone River was conducted between April and November 2007. Manual tracking and ground based telemetry stations resulted in a total of 1,144 relocations of blue suckers, 298 relocations of paddlefish, and 881 relocations of shovelnose sturgeon. In addition, a total of 620 relocations of pallid sturgeon were obtained from this project and from a companion study. Seasonal movements and relocations for shovelnose sturgeon, blue suckers, paddlefish, and pallid sturgeon are presented. Five pallid sturgeon were implanted during spring brood stock collection efforts. During September 2007, radio transmitters were implanted in an additional 15 shovelnose sturgeon and 16 blue suckers. 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.

Intensive larval fish sampling associated with research component 3 was conducted between late May and early August 2007 at six sites (Missouri River below Fort Peck Dam, Missouri River near Wolf Point, Missouri River near Nohly, Milk River, Yellowstone River, and spillway channel of Fort Peck Dam). A total of 2,011 larval fish samples and 8,525 larvae were obtained between late May and early August. Ten fish families were identified in the samples. Taxa from Catostomidae, Cyprinidae, and Hiodontidae composed 61%, 22%, and 9% of all larvae, respectively. A total of 298 Acipenseriform larvae were sampled across sites, and these represented 28 *Scaphirhynchus sp*. larvae, 263 Polyodontidae larvae, and 7 larvae that could not definitively be distinguished as *Scaphirhynchus sp*. or Polyodontidae. Larval *Scaphirhynchus sp.* were sampled from the Yellowstone River and two sites (Wolf Point, Nohly) in the Missouri River.

Reproductive success of shovelnose sturgeon and pallid sturgeon was assessed under research component 4 from mid-July through early September 2007. A total of 504 trawls was conducted on nine sampling events between July 11 and September 6. A total of 126 young-of-year *Scaphirhynchus sp*.was sampled across all sites: 2 individuals were sampled in the Missouri River upstream from the Yellowstone River confluence, 107 individuals were sampled in the Missouri River downstream from the Yellowstone River confluence, and 17 young-of-year sturgeon were sampled in the Yellowstone River. Genetic analysis indicated that 116 of the young-of-year *Scaphirhynchus sp*. were wild-produced shovelnose sturgeon. The remaining 10 young-of-year *Scaphirhynchus sp*. were pallid sturgeon. These individuals represented survivors of larvae originally released at 5- or 6- days post-hatch as part of the 2007 mainstem larval drift study.

As part of research component 5, assistance was provided during spring 2007 to catch adult pallid sturgeon for the propagation and augmentation program. Adult pallid sturgeon captured in the Yellowstone River and Missouri River downstream from the Yellowstone River confluence were assessed by hatchery personnel and reproductive physiology experts to determine suitability for propagation.

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 modification will occur with a maximum of 537.7 m^3/s (19,000 ft^3/s) released 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 flow modifications are dependent on adequate water levels in the reservoir. Specifically, a minimum water surface elevation of 2230 feet msl is required to provide adequate head at the spillway gates (2225 feet msl).

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 - 2007 precluded conducting these tests. As a consequence, physical and biological data collected during the initial seven years of this study represent baseline conditions under existing dam operations (see Braaten and Fuller 2002, 2003, 2004, 2005, 2006) and Braaten et al. (2007).

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. Similar to previous years, primary research activities of the multi-year Fort Peck Data Collection Plan during 2007 included: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements and relocating adult pallid sturgeon, paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus* in the Missouri River between Fort Peck Dam and Lake Sakakawea, and in the lower Yellowstone River, 3) quantifying larval fish distribution and abundance, 4) quantifying the reproductive success of shovelnose sturgeon and pallid sturgeon based on captures of young-of-year sturgeon, and 5) 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 to near the headwaters of Lake Sakakawea (Figure 1). The headwater region of Lake Sakakawea varies depending on water levels in the reservoir, but is approximately near rkm

2,471 (Figure 1). The study area also includes the lower 26 rkm of the Yellowstone River. 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.

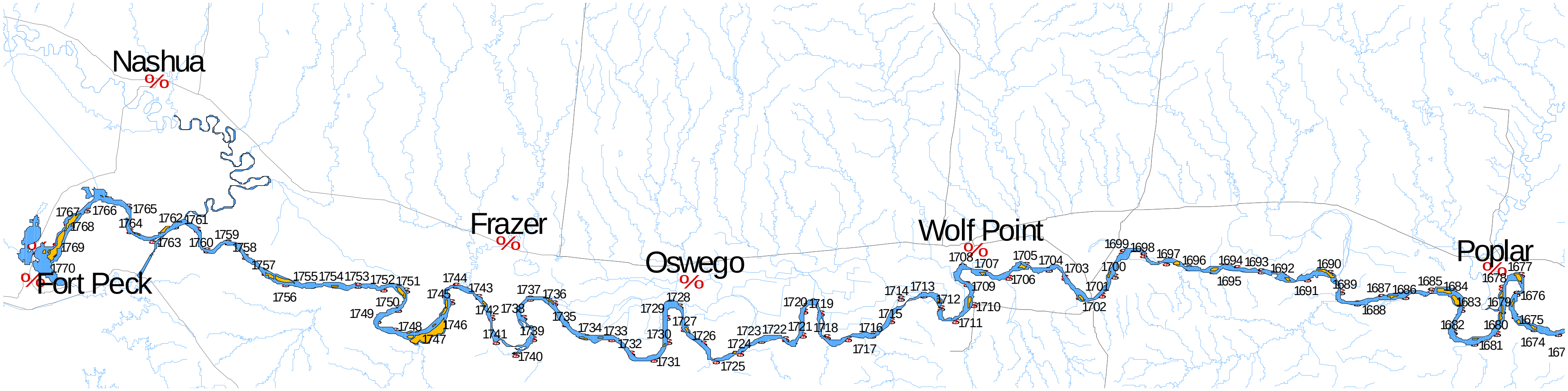
Methods

Component 1 – Water temperature and turbidity

Field measurements of water temperature.- Water temperature loggers were deployed at 17 locations (38 total loggers) in the Missouri River, tributaries, off-channel areas, and in Fort Peck reservoir between early April and late October 2007 (Table 1). All loggers except the logger deployed in the free-flowing Missouri River upstream from Fort Peck reservoir were deployed and maintained by the Fort Peck crew; the logger in the Missouri River upstream from Fort Peck reservoir was deployed and maintained by Bill Gardner (MTFWP fisheries biologist in Lewiston, Montana). At most sites, loggers were deployed on opposite sides of the river on the river bed to assess lateral variations in water temperature that may result from tributary inputs and incomplete lateral mixing of the water. The deployment scheme used in 2007 differed slightly from previous years in that two types of water temperature loggers were deployed at most sites during 2007. Prior to the 2007 field season, the manufacturer of the temperature loggers indicated that the old logger model used during the 2001-2006 field studies (Onset Computer Corporation, Optic StowAway, operation range -5^{o} to 37^{o}C, 4 min response time, accuracy ± 0.2^{o}C) was discontinued and replaced with a new logger model (Onset Computer Corporation, HOBO Water Temp Pro v2, operation range -20^{o} to 70^{o}C operation range, 5 min response time, accuracy ± 0.2^{o}C). Thus, both logger types were deployed to compare accuracy of water temperatures obtained with the old and new logger models.

Assessment of water temperature logger precision.- With the exception of the logger deployed in the free-flowing Missouri River upstream from Fort Peck reservoir, precision and accuracy of water temperature loggers was assessed prior to and following deployment in the field. Loggers were subjected to a series of common water bath treatments that included a cold treatment (< 10^{o}C, tailwater of Fort Peck Dam), cool treatment (10 – 20^{o}C, laboratory water bath), and warm treatment (> 20^{o}C, laboratory water bath). Pre- and post-deployment accuracy and precision was assessed with univariate statistics (mean, minimum, maximum, range) computed across all loggers. 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 any "suspect" logger(s), univariate statistics were computed again to assess precision.

Field measurements of turbidity.- Turbidity (nephelometric turbidity units; NTU) was measured from late-April through August 2007 at three sites on the Missouri River (near Frazer Rapids, Poplar, Nohly) and one in the Yellowstone River. Turbidity loggers (HydroLab DataSonde 4a, serial numbers 39046, 39047, 39048, 39049, measurement range 0-1000 NTU, accuracy ± 2%) were programmed to record turbidity at 3-hr intervals. The 3-hr recording interval deviated from past years (1-hr interval); however, the 3-hr interval enabled us to obtain turbidity information for about 1-month longer without exhausting memory capacity of the loggers.



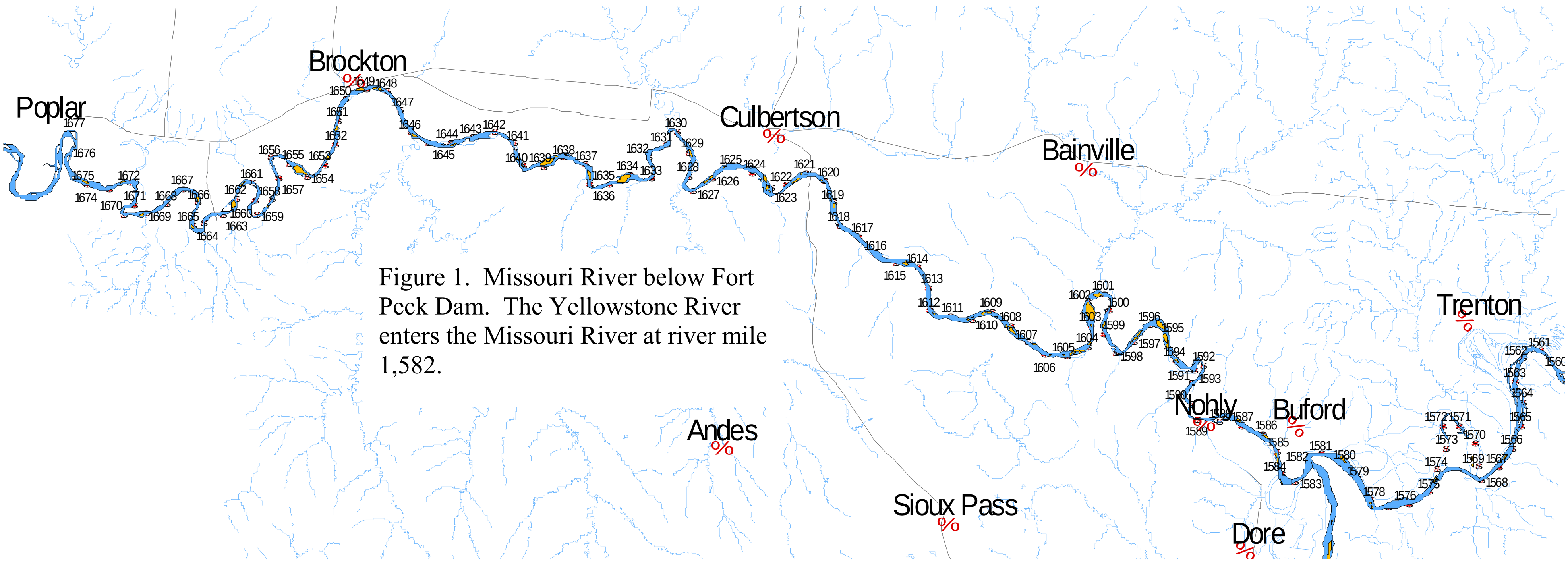


Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

Table 1. Sites, approximate river km (distance upstream from the Missouri River-Mississippi River confluence or distance upstream in a specified tributary), lateral bank location (north, south; old = old logger type), serial numbers, and dates of deployment for water temperature loggers deployed in the Missouri River and adjacent areas during 2007.

Site	RM	Bank Location	Latitude	Longitude	Logger serial no.	Deploy date	Retrieval Date
Above Fort Peck Lake	3,093		47.63116	108.68534	440580	4/6	10/29
Fort Peck Lake					1101888	5/14	11/5
Downstream from	2,842	North	48.05557	106.36459	1101899	4/2	10/31
Fort Peck Dam		South	48.06224	106.37863	1101887		
		South-old	48.06224	106.37863	947708		
Spillway	2,838		48.03992	106.34100	1101873	4/2	10/31
Milk River	6.4	South	48.06691	106.30307	1101870	4/2	10/31
		South-old	48.06691	106.30307	947717		
Nickels Ferry	2,832	North	48.04527	106.28739	1101902	4/2	10/31
		South	48.04449	106.28637	1101911		
Nickels Rapids	2,829	North	48.03436	106.24840	1101897	4/6	10/31
		South	48.03524	106.25476	1101892		
		North-old	48.03436	106.24840	947731		
Frazer Rapids	2,813	North	48.00667	106.12797	1101865	4/6	10-31
		South	48.00642	106.12885	1101879		
		North-old	48.00667	106.12797	947713		
Grandchamps	2,808	North	48.03539	106.08557	1101909	4/6	10/31
		South	48.03448	106.08240	1101880		
		South-old	48.03448	106.08240	947727		
Frazer Pump	2,795	North	48.03444	106.00771	1101868	4/6	10/31
		South	48.03330	106.00909	1101900		
		South-old	48.03330	106.00909	947725		
Wolf Point	2,739	North	48.08467	105.51813	1101874	4/3	10/31
		South	48.07808	105.52102	1101878		
		South-old	48.07808	105.52102	947724		
Poplar	2,705	North	48.06610	105.20692	1101863	4/3	11/1
		South	48.06262	105.21551	1101884		
Culbertson	2,608	North	48.09967	104.44691	1101895	4/3	11/1
		South	48.09214	104.43983	1101861		
		North-old	48.09967	104.44691	947732		
Nohly	2,562	North	48.02249	104.09610	1101906	4/3	11/1
		South	48.01680	104.10574	1101903		
		North-old	48.02249	104.09610	947710		
Yellowstone River	53		47.61193	104.18692	1101901	4/3	11/1
	3.2		47.94945	103.96236	1101914		
Below	2,539	North	47.95840	103.90993	1101877	4/4	11/1
Yellowstone River		South	47.95948	103.89246	1101913		
Highway 85	2,500	North	48.10500	103.72510	1101908	4/4	11/1

Assessments of turbidity logger precision and accuracy.- Turbidity loggers were subjected to a series of standardized formazin NTU treatments (20, 200, 800 NTU) prior to and following deployments in the field. Each logger was programmed to record 5-10 measurements in each NTU treatment.

Component 2 – Flow- and temperature-related movements of paddlefish, blue suckers, shovelnose sturgeon, and pallid sturgeon.

Manual tracking of implanted fish.- Manual tracking by boat of fish implanted with transmitters from 2001 - 2006 was initiated in April 2007. The Missouri River between Fort Peck Dam and the Highway 85 bridge near Williston, N.D. (342 km), was tracked at weekly intervals from April through July, and biweekly from August through October. The Yellowstone River from the confluence with the Missouri River to Intake Diversion (116 km) was tracked at different intervals by the Fort Peck Flow Modification crew and Matt Jaeger (MTFWP Biologist on the Yellowstone River). Two radio frequencies (149.760 MHz, 149.620 MHz) were simultaneously monitored during the boat-tracking run using two 4-element Yagi antennae. Occasionally, a hydrophone was used to scan acoustic frequencies (65.6 kHz, 76.8 kHz) in deep areas of the Missouri River. Several variables (radio/acoustic frequency, fish code, latitude, longitude, river mile, conductivity, habitat type, water temperature, turbidity, time-of-day) were recorded at fish locations.

Stationary telemetry logging stations.- Stationary telemetry logging stations were deployed in April 2007 at four sites (Milk River, rkm 4.0; Nickels, rkm 2,828; near Wolf Point, rkm 2,755; near Culbertson, rkm 2,603). Two stations, one near Fort Buford, rkm 2,533, and the Yellowstone River station, rkm 1, were left in place year-round. The logging stations were placed on shore with two 4-element Yagi antennae. 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 antenna 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 blue suckers and shovelnose sturgeon for transmitter implantation was conducted in September 2007. Pallid sturgeon were implanted in the spring during broodstock collection. Species were sampled using drifted trammel nets. Our goal was to extend flow- and temperature-related movement inferences to all areas of the Missouri River between Fort Peck Dam and Lake Sakakawea. Therefore, species were collected in several areas between rkm 2,850 and rkm 2,545; Figure 1). The three species were implanted with radio tags (MCFT-3L tags, 16 mm x 73 mm, air weight = 26 g, 1,624-day longevity, 5-second pulse interval, 149.760 or 149.620 Mhz, Lotek Wireless Incorporated, New Market, Ontario). The coded signal emitted by each tag is unique to facilitate identification of individual fish.

Surgical implantation of transmitters was conducted after 1-5 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 released immediately after the surgery.

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. 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 from Fort Peck Dam to Williston (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 Williston (230 km), and the Yellowstone River (116 km). For paddlefish the reaches consisted of the Missouri River above the confluence of the Yellowstone River (ATC; 302 km), the Milk River (184 km), and the Yellowstone River (116 km). Pallid sturgeon 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). Comparisons were between the 2004 through 2007 tracking seasons. During these years, additional ground based telemetry stations were deployed at various reach breaks. This provided information of when individuals immigrated or emigrated out of a particular reach.

Component 3 – Distribution and Abundance of 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 - 2006, 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 two nets fished on the bottom. Thus, each replicate was comprised of four bottom 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 2007 sampling events. Abbreviations for net location are as follows: B = bottom, S = surface (0.5 - 1.0 m below the surface).

Site	Approximate river km	Replicates	Samples per replicate	Net location
Missouri River below Fort Peck Dam	2838 - 2843	3	4	B
Spillway channel	2837.6	2	4	S
Milk River	0.8 - 5.6	5	4	S
Missouri River near Wolf Point	2739 - 2750	5	4	B
Missouri River near Nohly	2549 - 2563	5	4	B
Yellowstone River	0.4 - 3.2	5	4	B

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 species in some instances, and enumerated. Damaged individuals that could not be identified were classified as unknown. Eggs were identified as paddlefish/sturgeon or other, and enumerated.

Component 4 – Young-of-year sturgeon

Sampling for young-of-year sturgeon (*Scaphirhynchus* sp.) was conducted with a benthic (beam) trawl between mid-July and early September 2007 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, 2005; 2006; 2007), thus intensive sampling was conducted at this location. The targeted sampling protocol was followed at this site. Young-of-year sturgeon were measured in the field (total length, mm, excluding the caudal filament). One of the pectoral fins or fin buds was clipped and placed in alcohol for subsequent genetic identification. After fin clipping, the fish was placed in a 5-10% formalin solution.

Table 3. Young-of-year sturgeon sampling sites for 2007. ATC = above the Yellowstone River confluence, BTC = below the Yellowstone River confluence. River km sites denotes distance upstream from the mouth.

Site	Replicate	River km
Missouri River ATC	1	2552
	2	2555
	3	2558
	4	2563
Missouri River BTC	1	2499.5
	2	2507
	3	2537
	4	2546
Yellowstone River	1	0.4
	2	1.2
	3	3.2
	4	6.4

Component 5 - Assisting in the collection of adult pallid sturgeon for the propagation program.

For this component, crews assisted the USFWS in capturing adult pallid sturgeon for the hatchery propagation program. Crews were involved in sampling the Missouri River and Yellowstone River during April 2007. Pallid sturgeon were sexed and staged, and selected individuals were transported to hatcheries.

Results and Discussion

Hydrologic conditions

Discharge conditions in the Milk River during 2007 were unique among the seven years of the Fort Peck study. Following a period of low flows during early spring, discharge rapidly increased during late-May, and remained high (> 40 m^3/s) for a 1-month period between late May and late June (Figure 2). During this time period, three major and one minor discharge pulses occurred. Median discharge between April and September (4.81 m^3/s) was greater than other study years with the exception of 2004 when median discharge was 5.77 m^3/s.

Discharge in the Missouri River during 2007 exhibited characteristics of regulated releases from Fort Peck Dam and inputs from the Milk River (Figure 2). Discharge was relatively stable during April then increased during early May. Inputs from the Milk River contributed to elevated flow conditions and discharge pulses between late-May and late-June. As discharge decreased in the Milk River after June, discharge in the Missouri River remained relatively stable through early September. Median discharge between April and September was 188 m^3/s during 2007 which was slightly greater than during 2001 and 2005, but less than the other years of study.

Median discharge in the Yellowstone River during 2007 (214 m^3/s) was greater than the other study years with the exception of 2006 when median discharge was 242 m^3/s (Figure 2). Flows in the Yellowstone River initially increased in early May, remained elevated, then peaked in early June. Although median discharge tended to be greater in 2007 than most other years, greater maximum discharges occurred in 2002, 2003, and 2005.

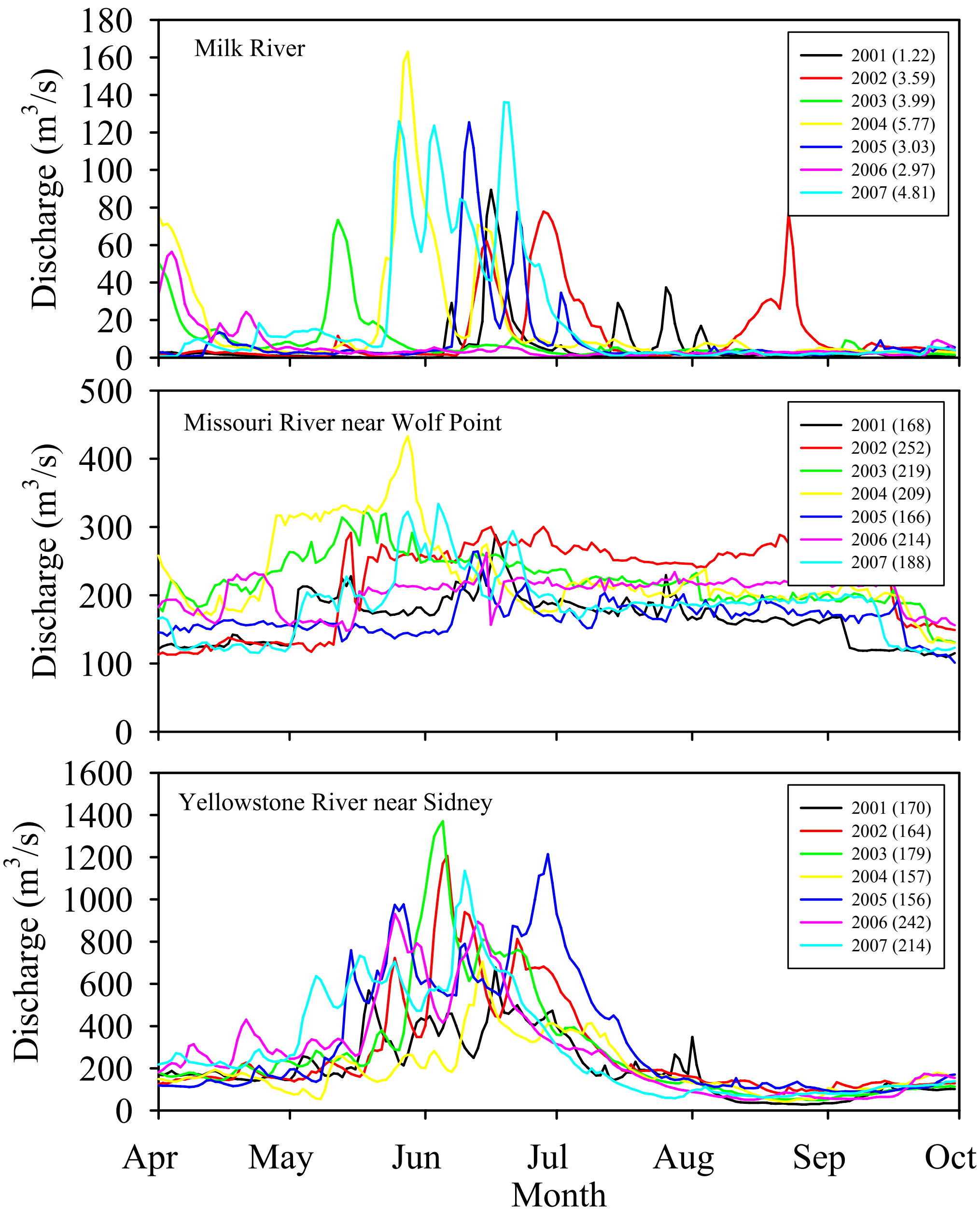


Figure 2. Mean daily discharge in the Milk River (gage 06174500), Missouri River at Wolf Point, Montana (gage 06177000), and in the Yellowstone River at Sidney, Montana (gage 06329500) during 2001-2007. Values listed in parentheses represent median daily discharge between April 1 and September 30. Note change in the ordinate among graphs.

Component 1 – Water temperature and turbidity

General comments on water temperature loggers.- All water temperature loggers deployed during 2007 were retrieved at the end of the deployment period. Hourly temperature data were obtained from all loggers with the exception of the old-type logger at Nohly for which the data would not download. The temperature logger at Frazer Rapids on the north side of the river was partially out-of-water after early September. Loggers positioned on the north side of the Missouri River at Culbertson and below the Yellowstone River exhibited lower temperatures and did not exhibit diel variations characteristic of loggers on the opposite side of the river. Due to this artifact, these loggers were not included in water temperature comparisons.

Pre- and post-deployment assessments of water temperature precision and accuracy.- Water temperature loggers deployed during 2007 exhibited good precision and accuracy during pre- and post-deployment tests (Tables 4, 5). The range of water temperatures across all loggers was less than 1.0°C for all temperature trials with the exception of one pre-deployment “warm” trial when the range was 1.01°C. Based on this information, water temperatures recorded by the loggers during deployments in 2007 accurately reflected temperature conditions at all sites.

Comparisons of old-type and new-type loggers.- Old-type and new-type loggers were deployed at nine sites during 2007; however, the old-type logger deployed at Nohly did not download. For the remaining eight sites, water temperature recorded by the old- and new-type loggers at each site did not differ significantly (t-tests, $P \geq 0.78$ for all comparisons). Differences in mean water temperatures between the old- and new-type loggers varied minimally from 0 – 0.1°C. Based on this information, water temperature data recorded by the new-type loggers is similar to that recorded by the old-type loggers. As a result, data obtained from the new-type loggers from this point forward can be compared to data obtained from the old-type loggers in previous years of the Fort Peck project.

Table 4. Pre-deployment summary statistics for water temperature (°C) comparisons among 65 water temperature loggers in common water bath treatments for 2007.

Treatment	Sample	Mean	Minimum	Maximum	Range
Cold	1	5.7	5.65	5.95	0.30
(< 10°C)	2	5.8	5.58	6.00	0.42
	3	6.3	6.04	6.56	0.52
	4	6.3	6.04	6.48	0.44
	5	6.6	6.36	6.81	0.45
Cool	1	19.3	19.02	19.46	0.44
(10-20°C)	2	19.3	19.02	19.46	0.44
	3	19.3	19.02	19.46	0.44
	4	19.3	19.02	19.46	0.44
	5	19.3	19.02	19.46	0.44
Warm	1	26.1	25.70	26.50	0.80
(> 20°C)	2	25.8	25.35	26.24	0.89
	3	25.5	25.01	25.99	0.98
	4	25.3	24.82	25.74	0.92
	5	25.0	24.49	25.50	1.01

Table 5. Post-deployment summary statistics for water temperature (^{o}C) comparisons among 36 water temperature loggers in common water bath treatments for 2007.

Treatment	Sample	Mean	Minimum	Maximum	Range
Cold	1	5.5	5.11	5.64	0.53
(< 10^{o}C)	2	5.3	4.95	5.41	0.46
	3	5.2	4.95	5.33	0.38
	4	5.1	4.95	5.21	0.26
	5	4.9	4.67	5.02	0.35
Cool	1	19.5	19.33	19.56	0.23
(10-20^{o}C)	2	19.0	18.96	19.17	0.21
	3	18.7	18.52	18.85	0.33
	4	18.3	18.20	18.48	0.28
	5	18.0	17.88	18.16	0.28
Warm	1	25.9	25.48	26.25	0.77
(> 20^{o}C)	2	24.5	24.12	24.89	0.77
	3	23.5	23.11	23.76	0.65
	4	22.5	22.20	22.80	0.60
	5	21.7	21.45	21.96	0.51

Lateral comparisons of water temperature.- Water temperature differed significantly between north and south banks of the river at the three upper-most sites including the site closest to Fort Peck Dam, Nickels Ferry, and Nickels Rapids (Table 6). Whereas warmer inputs from adjacent Nelson Dredge may have contributed to slightly warmer water on the north bank of the river at the site downstream from Fort Peck Dam, contributions of warm water from the Milk River contributed to elevated temperatures on the north side of the river at the Nickels Ferry and Nickels Rapids sites (Figure 3). Low discharge from the Milk River during early April minimally increased water temperature at the Nickels Ferry and Nickels Rapids sites. As Milk River discharge increased substantially in late May through late June, water temperature was greater on the north bank of the river than south bank of the river at these sites, indicating incomplete lateral mixing of warm Milk River water and cold water from Fort Peck Dam (i.e., inflow from the Milk River tended to remain adjacent to the north one-half of the river). However, lateral mixing of the water increased as the distance downstream from the Milk River increased as evidenced by the finding that the difference between water temperature on the north and south river bank was greater at the Nickels Ferry site than at the Nickels Rapids site. Lateral mixing of the water column was nearly complete by Frazer Rapids as water temperature was nearly identical on the north and south banks of the river at this site.

Table 6. Summary statistics (mean; standard deviation, STD; minimum,Min; maximum, Max) and probability values (P-value from t-tests) for comparisons of mean daily water temperature (^oC) among loggers located on the north and south banks of the Missouri River during 2007.

Site	Logger location	Number of days	Mean	STD	Min.	Max.	P-value
Below Fort Peck Dam	North	213	12.5	3.7	2.4	17.1	0.013
	South		11.6	3.8	2.1	16.8	
Nickels Ferry	North	213	13.6	4.0	2.2	20.8	0.001
	South		12.4	3.7	2.5	16.8	
Nickels Rapids	North	209	13.2	3.6	2.6	18.4	0.009
	South		12.3	3.2	2.7	15.8	
Frazer Rapids	North	158	13.5	4.1	2.7	18.2	0.747
	South		13.6	4.0	2.9	18.2	
Grand Champs	North	209	13.5	3.7	2.8	18.4	0.837
	South		13.6	3.7	2.8	18.5	
Frazer Pump	North	209	13.4	3.6	2.9	18.2	0.549
	South		13.6	3.6	2.9	18.7	
Wolf Point	North	212	14.6	4.1	2.4	20.4	0.743
	South		14.8	4.7	2.4	22.6	
Poplar	North	213	15.1	5.1	2.5	24.0	0.717
	South		14.9	5.3	2.6	24.0	
Nohly	North	213	16.1	5.9	2.7	27.7	0.925
	South		16.1	6.0	2.7	27.8	

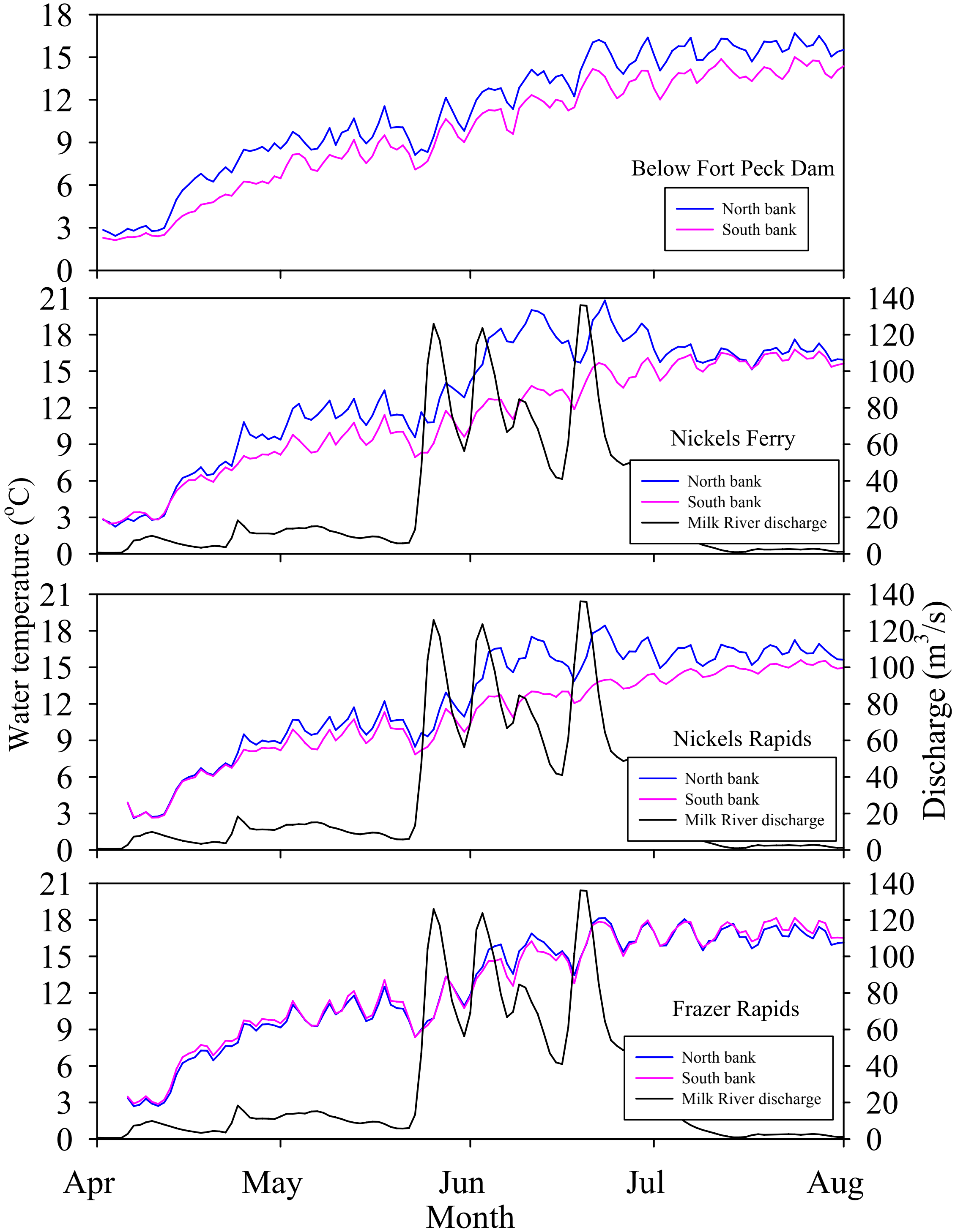


Figure 3. Mean daily water temperature regimes for water temperature loggers positioned on the north and south banks of the river at four sites on the Missouri River during 2007. Panels from top to bottom represent sites progressing from upstream to downstream. The Milk River enters between the Fort Peck Dam site and Nickels Ferry site; thus, discharge inputs from the Milk River do not influence temperature regimes at the site below Fort Peck Dam.

Longitudinal water temperature patterns.- Water temperature during 2007 varied greatly among monitoring sites throughout the common deployment period of April 6 – October 29 (Table 7; Figure 4). In the free-flowing Missouri River upstream from Fort Peck Reservoir at Robinson Bridge, mean water temperature was 17.6^{o}C and maximum water temperature was 27.6^{o}C. Below Fort Peck Dam, water temperature averaged 12.2^{o}C and maximum water temperature reached 17.0^{o}C. Thus, river impoundment and hypolimnetic releases suppressed mean water temperature by an average of 5.4^{o}C and maximum water temperature by 10.6^{o}C. Mean water temperature increased as the distance from the dam increased, and attained 16.4^{o}C at the Nohly site (290 km downstream, most downstream Missouri River site prior to receiving inputs from the Yellowstone River). Across all sites, mean water temperature was greatest at Robinson Bridge (17.6^{o}C), followed by the site downstream from the Yellowstone River (17.2^{o}C), near Williston at the Highway 85 site (17.1^{o}C), and the Yellowstone River (17.0^{o}C).

The release of cold hypolimnetic water through Fort Peck Dam is implicated as a major factor diminishing the suitability of the Missouri River downstream from the dam for pallid sturgeon spawning (USFWS 2000). To increase suitability, spillway releases from Fort Peck Dam are targeted to enhance water temperature to 18^{o}C at Frazer Rapids as listed under reasonable and prudent alternatives in the Missouri River Biological Opinion (USFWS 2000). In the absence of a spillway release during 2007, water temperature reached 18^{o}C at Frazer Rapids on June 22 and was greater than 17^{o}C on several dates between June 21 and July 29 (Table 7; Figure 3, 4). Inflows from the Milk River during late June likely contributed to the initial attainment of 18^{o}C at Frazer Rapids, but temperature remained elevated despite a declining Milk River hydrograph in early July (Figure 3).

Inter-annual comparisons of water temperature within sites.- Inter-annual variations in water temperature occurred among all sites (Table 8). In general, mean water temperature was greatest during 2007 at 10 Missouri River sites downstream from Fort Peck (below Fort Peck Dam, spillway, Nickels Ferry, Nickels Rapids, Frazer Rapids, Grandchamps, Frazer Pump, Wolf Point, Poplar, Culbertson). At five sites (Missouri River at Robinson Bridge upstream from Fort Peck Reservoir, in Fort Peck Reservoir, and Missouri River at Nohly, below the Yellowstone River, and near Williston), mean water temperature tended to be greater during 2006 than other years. Comparatively, water temperature in the two tributaries (Milk River, Yellowstone River) tended to be greater during 2003. Mean water temperature tended to be lowest during 2002 at 8 sites (Robinson Bridge, below Fort Peck Dam, spillway, Grandchamps, Frazer pump, Wolf Point, Culbertson, and Missouri River downstream from the Yellowstone River confluence), during 2003 at 5 sites (Nickels Ferry, Nickels Rapids, Frazer Rapids, Frazer Pump, Poplar), and during 2004 at 4 sites (Fort Peck Reservoir, Milk River, Nohly, Yellowstone River).

Table 7. Mean daily water temperature (^oC) statistics (mean; minimum, Min.; maximum, Max.; standard deviation, SD; coefficient of variation, CV) for locations on the mainstem Missouri River and off-channel areas during 2007. Summary statistics were calculated for common deployment dates (April 6 – October 29, 207 days) for all sites except Fort Peck Reservoir (May 14 – October 29; 169 days). Mainstem Missouri River sites are listed from upstream to downstream. See Figure 4 for a graphical representation of mean daily water temperatures.

Location	Site	Mean	Min.	Max.	SD	CV
Missouri River mainstem	Robinson Bridge	17.6	4.7	27.6	5.9	33
	Below Fort Peck Dam	12.2	2.6	17.0	3.5	29
	Nickels Ferry	13.3	2.8	18.2	3.5	26
	Nickels Rapids	12.8	2.7	16.3	3.4	26
	Frazer Rapids	13.4	2.8	18.0	3.7	27
	Grandchamps	13.6	2.8	18.3	3.7	27
	Frazer Pump	13.6	2.9	18.1	3.6	26
	Wolf Point	14.9	2.8	21.5	4.1	28
	Poplar	15.3	2.8	24.0	4.9	32
	Culbertson	16.3	2.8	27.3	5.5	34
	Nohly	16.4	2.8	27.8	5.7	35
	Below Yellowstone	17.2	3.2	28.4	5.8	34
	Highway 85	17.1	3.1	28.4	5.9	34
Off-channel or tributary	Fort Peck Reservoir	17.7	8.4	25.5	4.2	24
	Spillway	16.4	4.1	24.3	4.7	29
	Milk River	16.9	4.1	26.4	5.6	33
	Yellowstone River	17.0	3.4	25.0	5.2	31

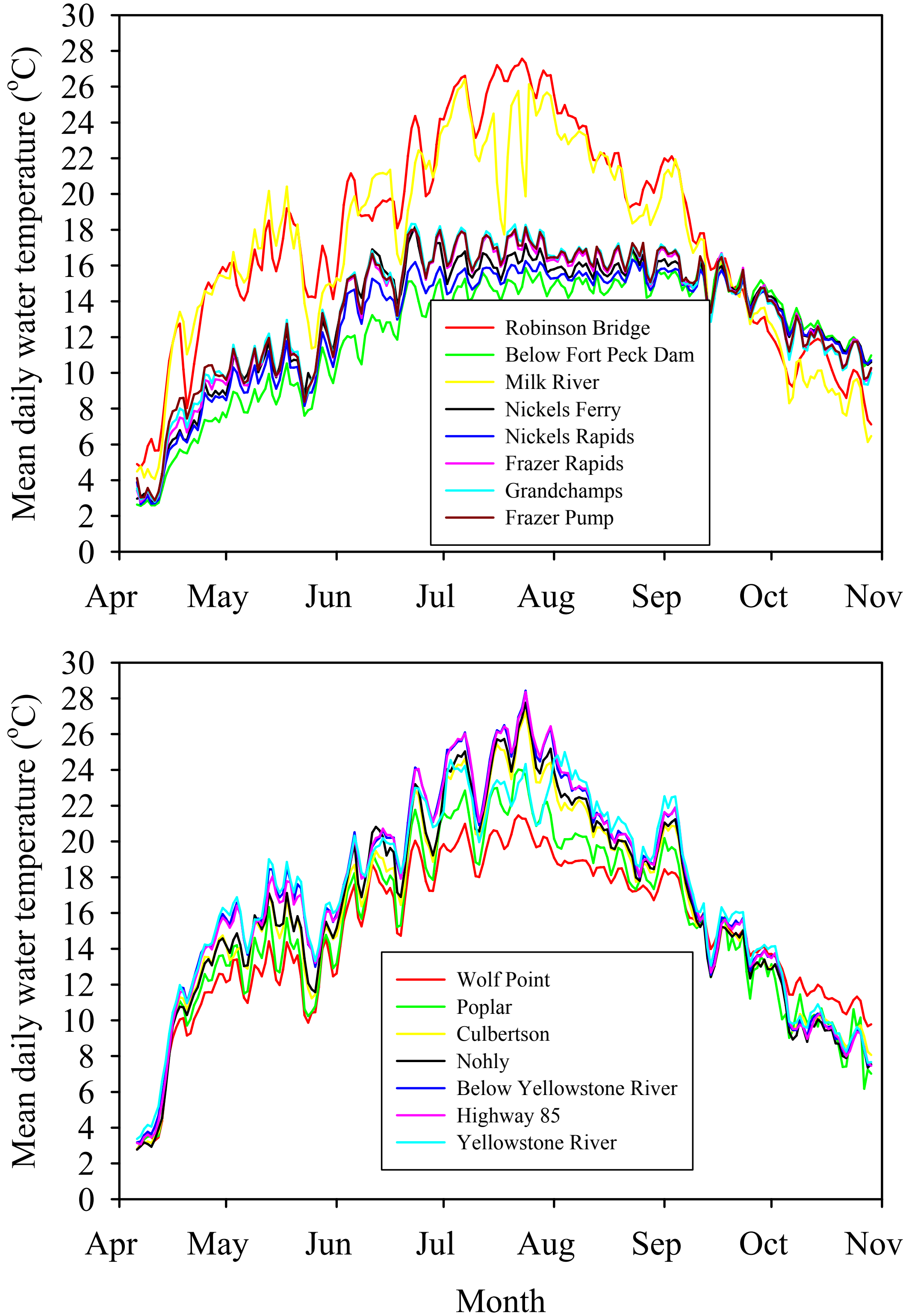


Figure 4. Mean daily water temperature (^{o}C) at sites on the mainstem Missouri River, tributaries, and off-channel sites during 2007.

Table 8. Summary statistics (mean, °C; minimum, maximum, standard deviation, SD; coefficient of variation, CV) for comparisons of mean daily water temperature among 2001 - 2007 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 (5/17 – 8/29; 105 days) and Milk River in 2005 (5/17 – 9/17, N = 124 days).

Site	Year	Mean	Minimum	Maximum	SD	CV
Missouri R. above Fort Peck Lake (Robinson Bridge)	2001	20.1	10.3	25.8	3.7	18.4
	2002	18.7	9.2	26.7	4.2	22.5
	2003	19.3	11.4	25.2	4.0	20.5
	2004	18.7	10.8	26.7	3.9	20.9
	2005	19.0	8.9	25.7	3.9	20.7
	2006	20.5	10.4	26.9	3.9	19.1
	2007	20.1	9.2	27.6	4.7	23.2
Fort Peck Lake	2003	19.0	8.4	23.6	3.8	20.2
	2004	16.4	7.9	22.0	3.6	22.3
	2006	19.1	9.8	24.5	3.9	20.2
	2007	19.0	8.4	25.5	4.3	22.8
Below Fort Peck Dam	2001	13.0	8.2	15.2	1.5	11.6
	2002	12.2	6.3	15.4	2.0	16.6
	2003	12.4	7.5	15.5	1.7	13.7
	2004	13.5	8.0	16.3	1.8	13.5
	2005	13.4	9.1	16.8	1.8	13.2
	2006	13.5	9.2	15.6	1.7	12.5
	2007	13.9	7.6	17.0	1.9	14.0
Spillway	2001	18.4	10.7	23.8	3.0	16.6
	2002	15.7	8.6	20.0	2.7	16.9
	2003	16.9	11.5	22.5	3.0	17.9
	2004	17.0	9.7	21.4	2.8	16.3
	2005	17.6	8.3	22.3	2.8	15.7
	2006	18.0	9.7	22.8	2.8	15.3
	2007	18.4	9.0	24.3	3.4	18.5
Milk River	2001	19.1	9.9	26.2	3.8	19.6
	2002	18.9	8.4	26.9	4.5	23.8
	2003	20.3	10.9	27.4	4.7	23.2
	2004	18.4	10.7	27.4	3.7	20.2
	2005	20.3	15.0	26.4	2.9	14.2
	2006	19.7	9.3	25.7	3.9	19.6
	2007	19.2	8.3	26.4	4.3	22.4
Nickels Ferry	2001	13.4	8.3	18.4	1.8	13.6
	2002	13.2	6.5	19.1	2.5	18.7
	2003	12.5	8.5	15.3	1.5	11.7
	2004	14.5	9.1	17.1	1.6	10.8
	2005	14.4	10.2	19.5	1.8	12.2
	2006	14.4	10.3	16.5	1.5	10.7
	2007	15.0	8.8	18.2	1.8	12.0
Nickels Rapids	2001	13.5	8.5	16.6	1.7	12.5
	2002	12.9	6.7	16.1	2.2	16.9
	2003	12.8	8.1	15.9	1.6	12.3
	2004	13.8	8.6	16.7	1.7	12.6
	2005	13.9	10.3	16.9	1.6	11.4
	2006	14.0	9.8	16.0	1.6	11.1
	2007	14.4	8.2	16.3	1.7	11.9

Table 8. continued.

Site	Year	Mean	Minimum	Maximum	SD	CV
Frazer Rapids	2001	13.8	8.3	17.3	1.8	13.3
	2002	13.1	7.1	17.1	2.3	17.2
	2003	12.9	8.1	15.7	1.5	11.8
	2004	14.3	8.6	17.1	1.9	13.0
	2005	14.8	10.5	18.5	1.8	12.3
	2006	14.8	10.5	17.3	1.7	11.3
	2007	15.3	8.4	18.0	2.1	13.6
Grandchamps	2001	14.4	8.5	18.1	2.0	14.1
	2002	13.5	7.5	17.3	2.3	16.9
	2003	13.6	8.3	17.4	1.8	13.4
	2004	14.6	8.6	17.5	2.0	13.3
	2005	15.1	10.3	18.9	1.9	12.6
	2006	14.9	10.2	17.7	1.7	11.4
	2007	15.4	8.5	18.3	2.2	14.0
Frazer Pump	2001	13.9	8.5	17.0	1.8	13.2
	2002	13.3	7.1	17.9	2.3	17.6
	2003	13.3	8.5	16.9	1.7	12.6
	2004	14.4	9.0	17.2	1.8	12.5
	2005	14.7	10.6	18.6	1.8	12.0
	2006	14.8	10.4	17.2	1.7	11.2
	2007	15.4	8.4	18.1	2.1	13.7
Wolf Point	2001	16.5	9.4	22.7	3.1	18.7
	2002	15.0	9.3	19.4	2.8	18.8
	2003	15.6	9.0	21.2	2.9	18.4
	2004	15.8	8.9	20.9	2.6	16.2
	2005	16.7	8.1	22.3	2.9	17.1
	2006	16.8	8.7	20.7	2.5	15.0
	2007	16.9	9.9	21.5	2.8	16.3
Poplar	2001	16.8	9.9	21.2	2.8	16.8
	2003	16.3	9.4	22.3	3.2	19.9
	2004	16.3	9.2	22.2	2.8	17.2
	2005	17.4	7.8	24.0	3.2	18.5
	2007	17.5	9.0	24.0	3.7	21.0
Culbertson	2001	17.9	9.7	24.0	3.5	19.3
	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
	2005	18.3	6.5	25.5	3.9	21.3
	2006	18.5	9.2	23.7	3.5	19.0
	2007	18.6	9.4	27.3	4.2	22.7
Nohly	2001	18.9	11.4	25.3	3.8	20.0
	2002	17.5	7.7	25.4	4.3	24.6
	2003	18.2	10.2	25.0	4.2	23.0
	2004	17.1	10.1	23.9	3.2	18.7
	2005	18.6	6.1	25.6	4.1	22.0
	2006	19.1	9.2	24.5	3.8	19.9
	2007	18.9	8.9	27.8	4.4	23.2

Table 8. continued.

Site	Year	Mean	Minimum	Maximum	SD	CV
Yellowstone River	2001	19.3	10.7	26.6	4.2	21.7
	2002	19.3	8.4	27.9	4.8	24.7
	2003	20.1	11.1	27.2	4.7	23.1
	2004	18.7	11.1	26.3	3.4	18.3
	2005	19.4	6.1	25.6	4.3	22.1
	2006	19.8	9.5	25.9	4.0	20.4
	2007	19.3	9.8	25.0	3.7	19.2
Below Yellowstone River	2001	19.4	9.8	26.0	4.1	20.9
	2002	18.8	8.2	27.3	4.5	24.2
	2003	18.9	10.6	27.8	4.4	23.2
	2005	19.1	6.2	25.5	4.1	21.8
	2006	20.0	9.9	25.7	4.0	20.1
	2007	19.6	9.5	28.4	4.4	22.5
Highway 85 (Williston, ND)	2006	19.9	10.5	25.8	4.0	19.9
	2007	19.6	9.5	28.4	4.4	22.6

Pre- and post-deployment accuracy of turbidity loggers.- Turbidity accuracy in the formazin NTU standards varied among the four turbidity loggers, and attempts to calibrate loggers to one standard frequently resulted in decreased accuracy at another NTU. For example, all loggers prior to deployment could be calibrated fairly accurately to 200 NTU, but accuracy diminished at 20 NTU and 800 NTU (Table 9). Following field deployments, accuracy decreased as the Poplar, Nohly, and Yellowstone River loggers tended to record turbidities exceeding the 200 and 800 NTU standards. At 20 NTU, accuracy of these three loggers increased as recorded values were more similar to the NTU standard than prior to deployments. Thus, the loggers exhibited "turbidity drift" during deployments. The logger deployed at Frazer Rapids experienced a major malfunction during the 2007 deployment, thus this logger would not operate during post-deployment tests.

Table 9. Pre- and post-deployment turbidity assessments for 2007 of turbidity loggers subjected to common formazin turbidity (nephelometric turbidity units; NTU) treatments.

Formazin NTU	Deployment test	Frazer	Poplar	Nohly	Yellowstone
20	Pre	40.0	35.1	29.6	32.7
	Post		24.0	22.5	20.5
200	Pre	212.3	220.3	201.7	199.5
	Post		241.5	220.0	209.3
800	Pre	949.6	1000	905.8	900.3
	Post		1000	995.7	981.2

Field turbidity measurements.- Turbidity data were not obtained from loggers deployed at Frazer Rapids and Poplar. The Frazer Rapids logger malfunctioned, and would not communicate with the computer or download. The logger deployed at Poplar recorded data for two dates (April 23, 24) then experienced a malfunction, producing no data after these dates. However, loggers in the Yellowstone River and Missouri River at Nohly yielded data for the entire deployment period (Figure 5). During the April 23-August 31 deployment period of the Nohly logger, turbidity exceeded 1000 NTU (maximum value measured by the loggers) during entire dates or during time-specific measurement periods in May (22, 27, 29, 31), June (1-9, 14, 15, 28), and July (5). During deployment in the Yellowstone River between April 25-August 31, turbidity exceeded 1000 NTU at times or dates in May (6-18), June (2, 8, 10-13), and July (5, 10-12). Because loggers did not record turbidity exceeding 1000 NTU, estimates of mean daily turbidity are conservative and preclude quantitative statistical comparisons across spatial and temporal scales. Therefore, only general trends in turbidity are reported.

Turbidity during the late-April thought August deployment period tended to be greater in the Yellowstone River (median = 243 NTU, 25-75% quartile = 65-566 NTU) than Missouri River at Nohly (median = 132 NTU; 25-75% quartile = 76-322 NTU). Turbidity in both rivers varied substantially during the deployment period, and exhibited the tendency to increase during elevated discharges and decrease during periods of declining or low flows (Figure 5). However, exceptions to this pattern occurred in both rivers. For example, a period of declining and low turbidity occurred in the Missouri River during late June despite rising and elevated discharge conditions during this time. In the Yellowstone River, elevated turbidity occurred during early July and early August despite a low and declining hydrograph.

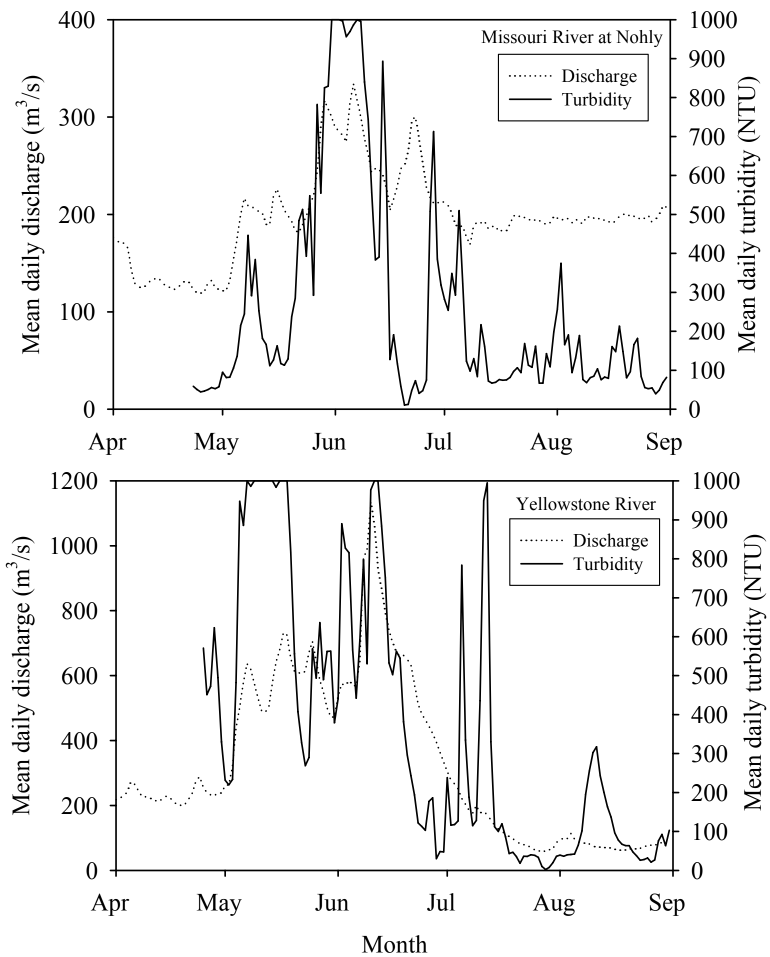


Figure 5. Mean daily discharge (m^3/s) and turbidity (nephelometric turbidity units; NTU) in the Missouri River near Nohly and in the Yellowstone River during 2007.

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

Blue sucker relocations and movements.

The distribution and relative abundance of blue suckers (N = 50) varied among rivers through time (Figure 6). During April, blue suckers primarily used (98% of individuals) 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 dropped to 45% in early July and then began to increase. The increased relative abundance of blue suckers in the reach from late July to late-September was 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 6) was dependant on discharge. Approximately 10% of blue suckers entered the Milk River in late April: however, most forays were of short duration. Many fish entered the Milk River as indicated by our ground based telemetry station during a large pulse of water in late May (Figure 3). The residence time of blue suckers in the Milk River spanned up to four weeks for some individuals as evidenced by ground station information and was directly related to the decrease in flow. Ground stations indicated that 31% 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 6). Relative abundance of blue suckers in the Yellowstone River was low in April (2%) but steadily increased through May and June. The highest numbers of fish (48%) were found in the Yellowstone River in early July. Individuals began emigrating out of the Yellowstone River in mid-July and continued their emigration through October.

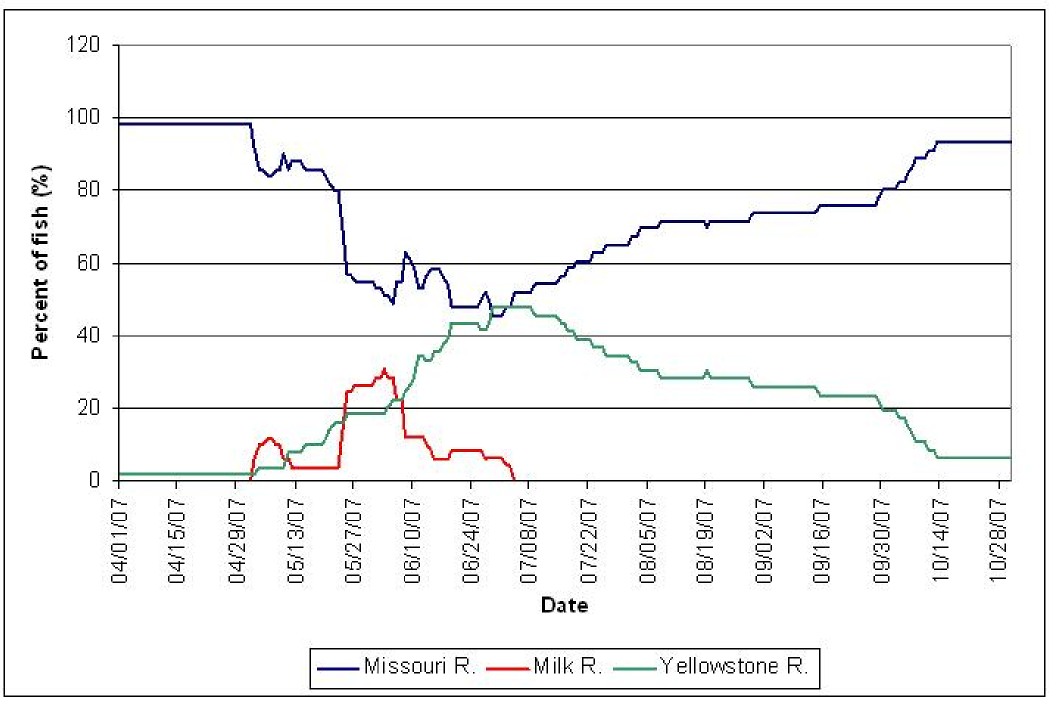


Figure 6. Percent (%) of blue suckers relocated in the Milk, Missouri, and Yellowstone Rivers in 2007 by date.

Inter-annual trends in blue sucker relocations.-The Missouri River was a concentration area for blue suckers during 2004-2007, but use of this reach varied temporally (Figure 7). 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 47% in 2004, 37% in 2005, 40% in 2006, 48% in 2007). Although similar immigration and emigration dynamics among rivers occurred during these four years, the timing of movement dynamics varied slightly between years. These differences are 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).

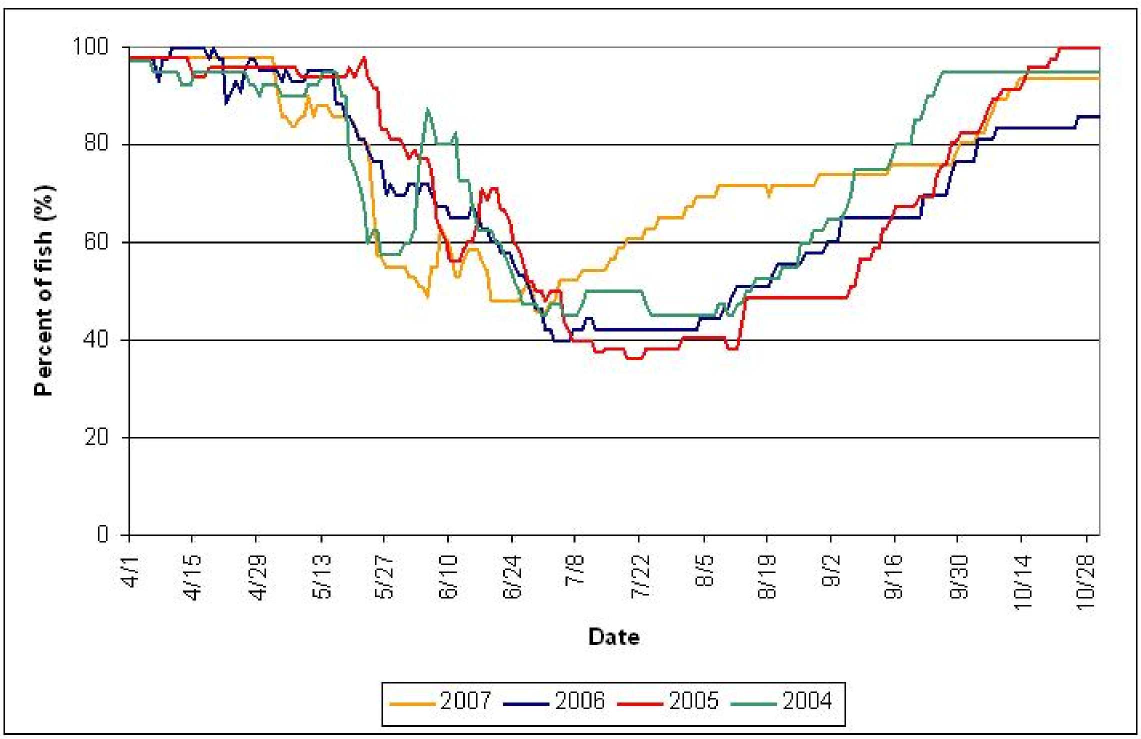


Figure 7. Percent blue suckers relocated in the Missouri River from 2004-2007 by date.

Blue suckers exhibited limited seasonal use of the Milk River in 2004-2007 (Figure 8). Individuals migrated up the Milk River in all years when there was an increase in the hydrograph (maximum 35% in 2004, 22% in 2005, 12 % in 2006, 31% in 2007; 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 early July in all years. Temporal use of the Milk River was not consistent between years. The lack of consistency is most likely attributed temporal differences in Milk River discharge among years, and the subsequent influence of discharge as a stimuli for blue sucker movement in the Milk River.

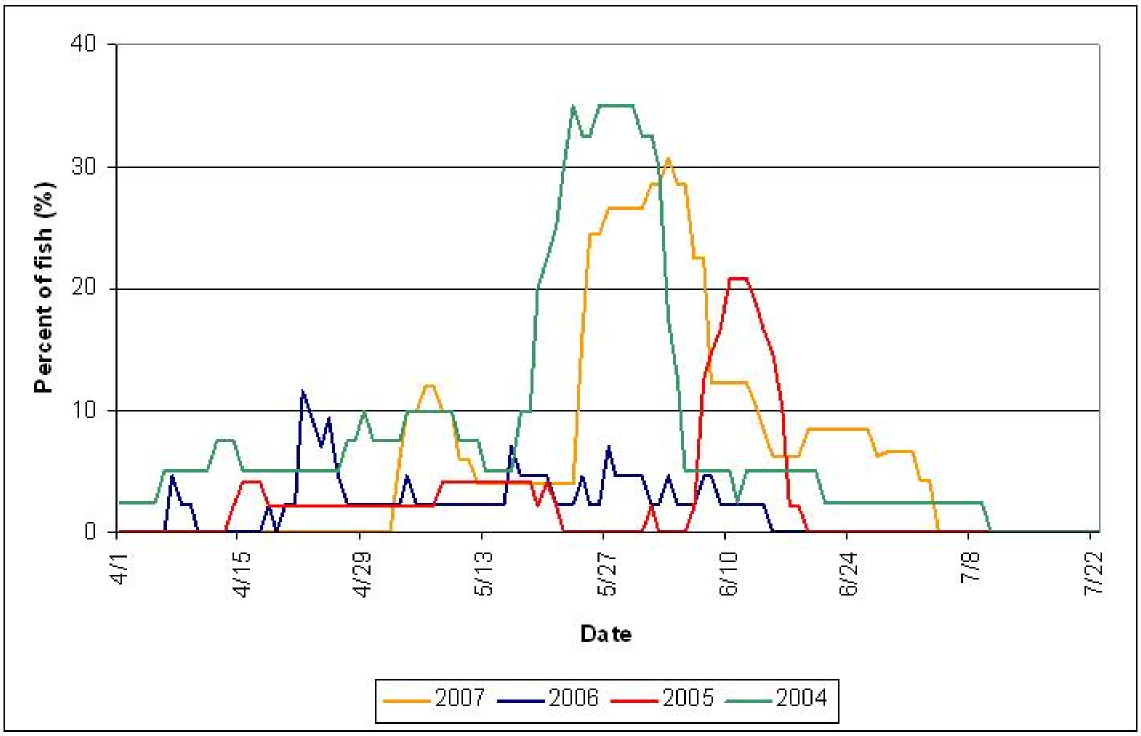


Figure 8. Percent of implanted blue suckers relocated in the Milk River from 2004 - 2007 by date.

The Yellowstone River was rarely used during April and early May by blue suckers during 2004-2007 (Figure 9). Use of the Yellowstone River rapidly increased in early June and reached a maximum in July (55% in 2004, 64% in 2005, 61% in 2006, and 48% in 2007). Fish began emigrating out of the Yellowstone River in early August in 2004-2006. However, in 2007, fish began emigrating out of the Yellowstone River by early July. Use of the Yellowstone River was low after mid-October in all years. Thus, these results suggest that use patterns of the Yellowstone River by blue suckers are 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.

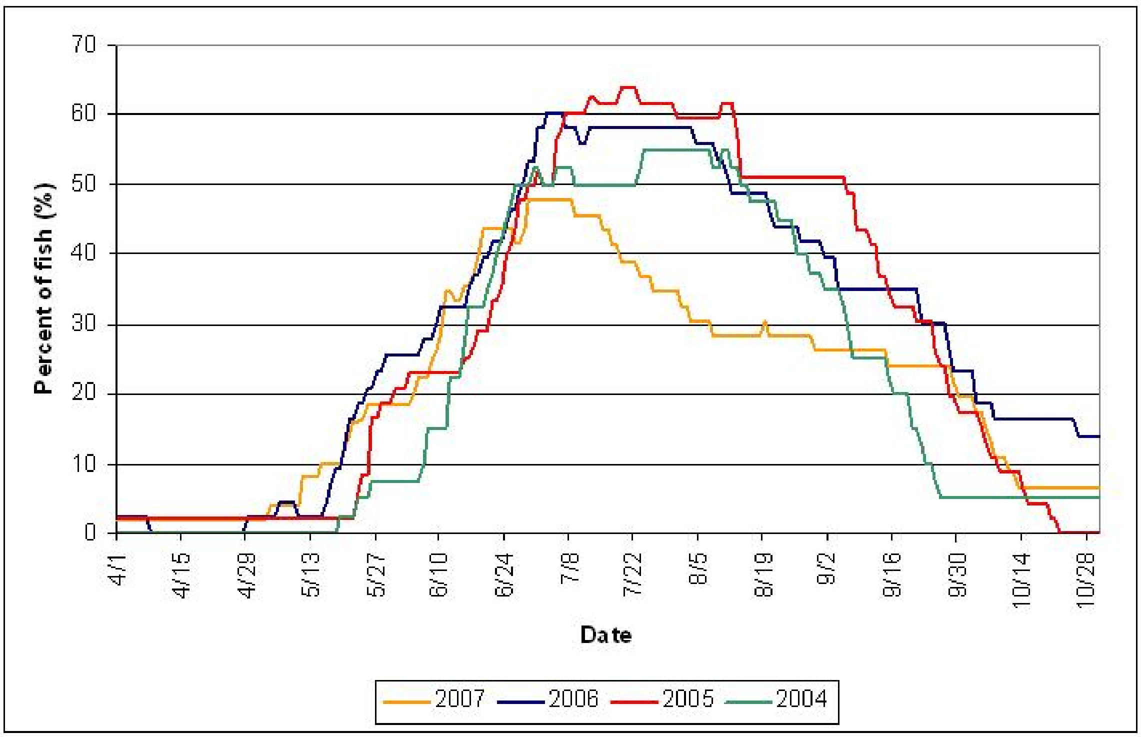


Figure 9. Percent of blue suckers relocated in the Yellowstone River from 2004 - 2007 by date.

Shovelnose sturgeon relocations and movements.

Use of the Missouri River between Fort Peck Dam and Wolf Point by shovelnose sturgeon (N = 42) was stable through April and May (Figure 10). Use of this reach declined slightly in June and early July, and increased slightly throughout the remainder of the tracking season. However, a minimum of 31% of the 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 (Figure 10). Less than 10% of implanted individuals were relocated in this reach in May and June. A maximum of 46% was found during early September as most shovelnose sturgeon had emigrated out of the Yellowstone River.

The percentage of shovelnose sturgeon relocations in the Yellowstone River steadily increased from early April (26%) through late July (62%; Figure 10). Use of this reach declined in August to 22% of individuals, then increased slightly through the end of the tracking season.

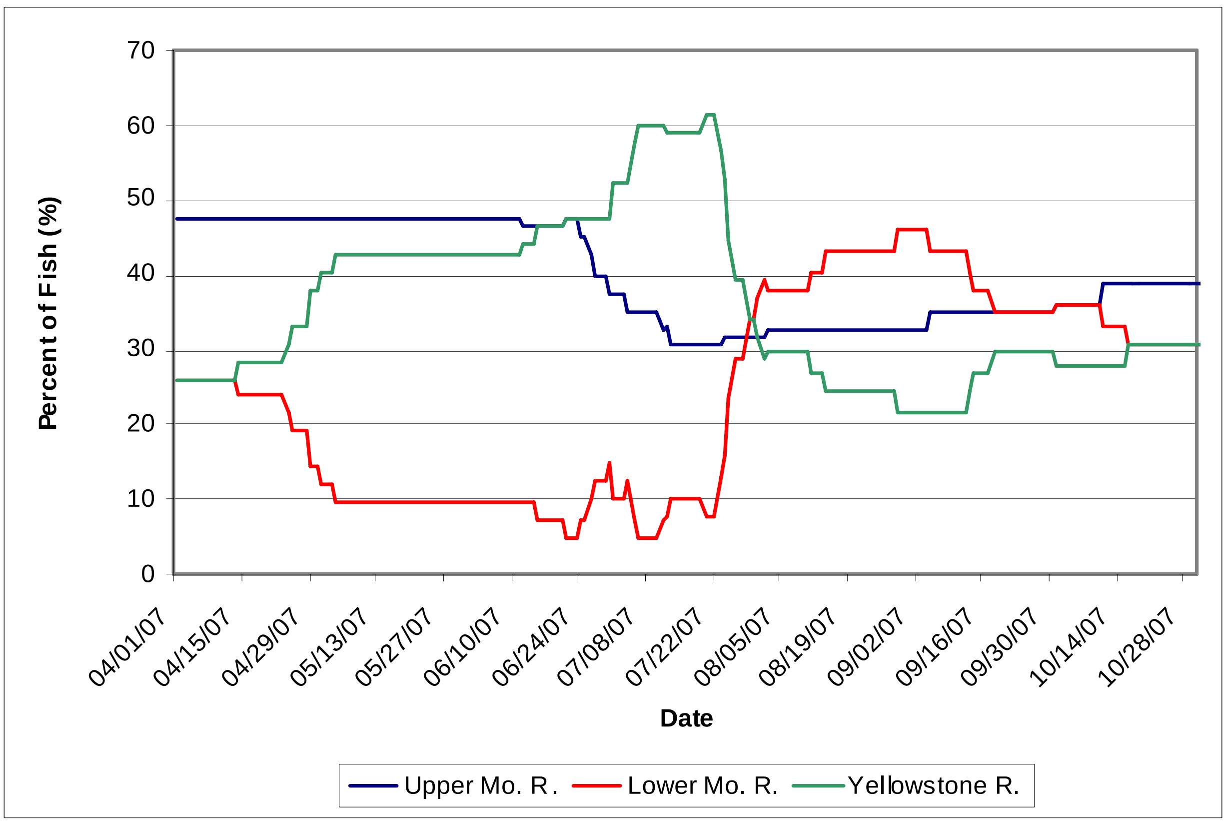


Figure 10. Percent of shovelnose sturgeon relocated in the Missouri River reaches and the Yellowstone River in 2007 by date.

Inter-annual trends in shovelnose sturgeon relocations.- The Missouri River from Wolf Point to Fort Peck Dam was a concentration area in all years (Figure 11). Although use gradually decreased from mid-June through early July, a large number of individuals remained in this reach throughout the tracking season (minimum 34% in 2004, 37% in 2005, 42% in 2006, 31% in 2007). Temporal use of this reach was generally consistent between years. Fish remaining in this reach were implanted in the two upper sampling locations; near Wolf Point and near the Milk River.

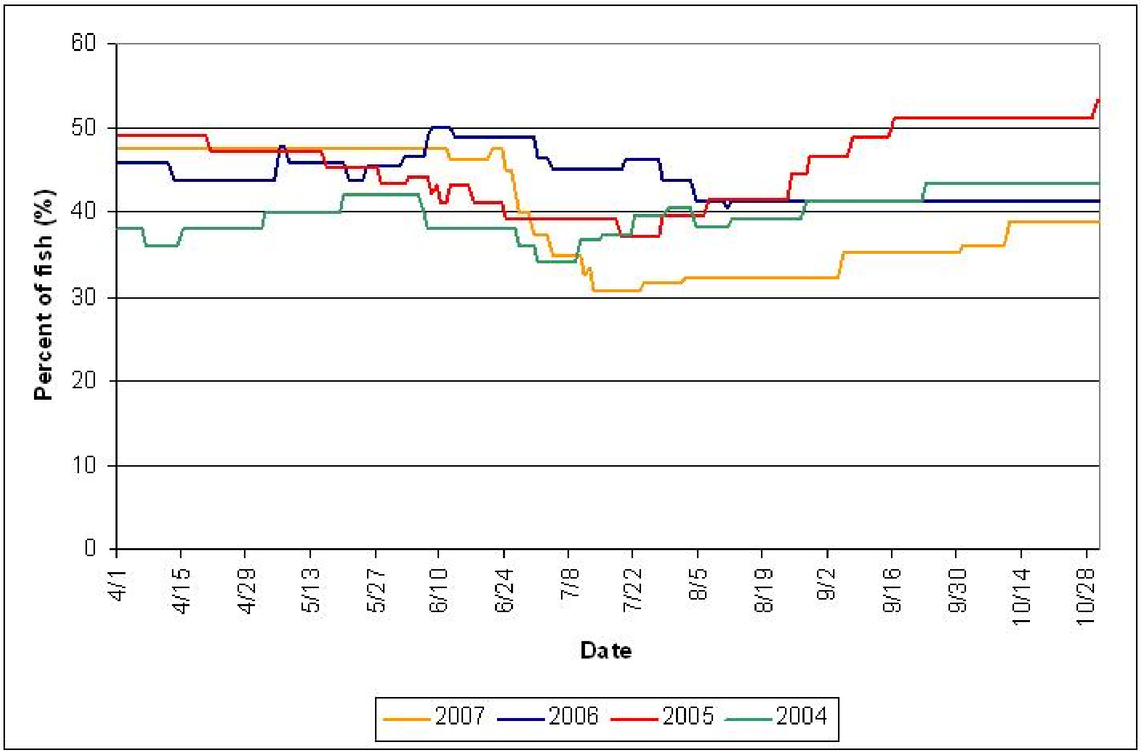


Figure 11. Percent (%) of shovelnose sturgeon relocated in the Missouri River from Fort Peck Dam to Wolf Point from 2004 - 2007 by date.

The Missouri River between Wolf Point and Williston was a movement corridor and reach of river that exhibited variable use during the tracking season (Figure 12). Shovelnose sturgeon use of this segment decreased from early April to late July as individuals emigrated from this reach and migrated into the Yellowstone River. In all years, densities were at their lowest from late May to early June (3%-15%). Densities of shovelnose sturgeon in this reach increased during September as individuals emigrated from the Yellowstone River back into this reach.

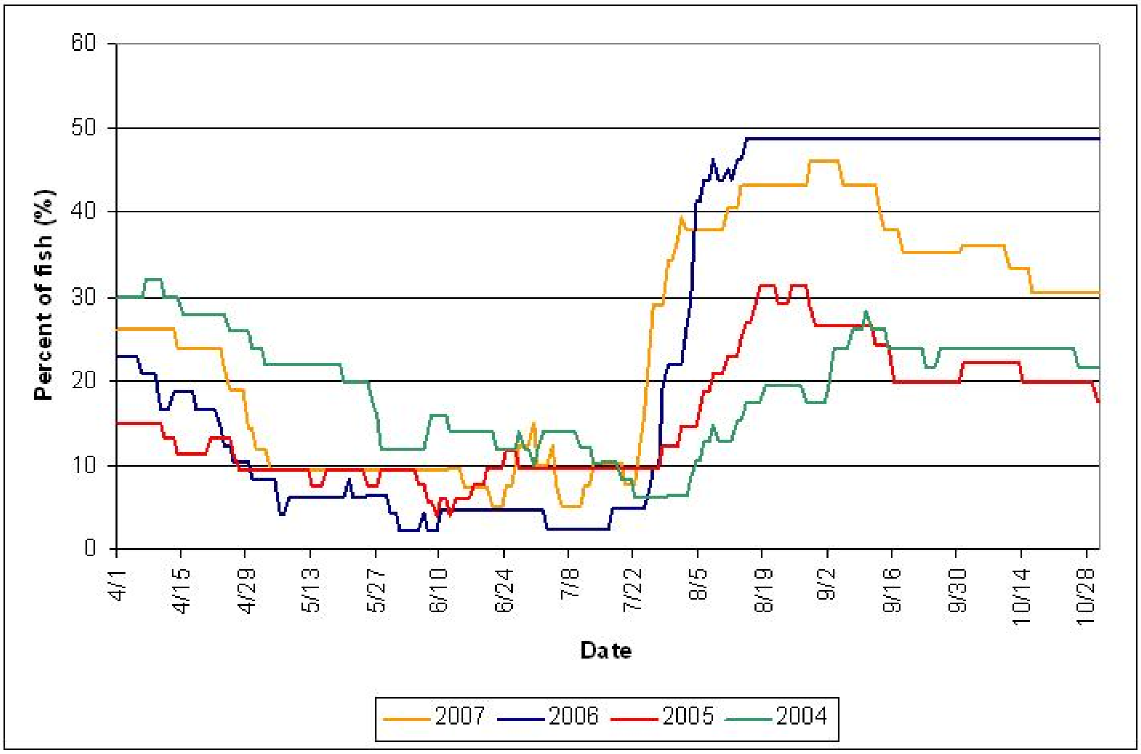


Figure 12. Percent (%) of shovelnose sturgeon relocated in the Missouri River from Wolf Point to Williston from 2004 - 2007 by date.

The Yellowstone River was a concentration area for shovelnose sturgeon, but use of this reach varied seasonally during all years (Figure 13). Use of this reach increased from April through late July (maximum 54% in 2004, 53% in 2005, 53% in 2006, 62% in 2007) and then declined through late September and October as individuals moved into the Missouri River. Some shovelnose sturgeon remained in the Yellowstone River throughout the tracking season in all years.

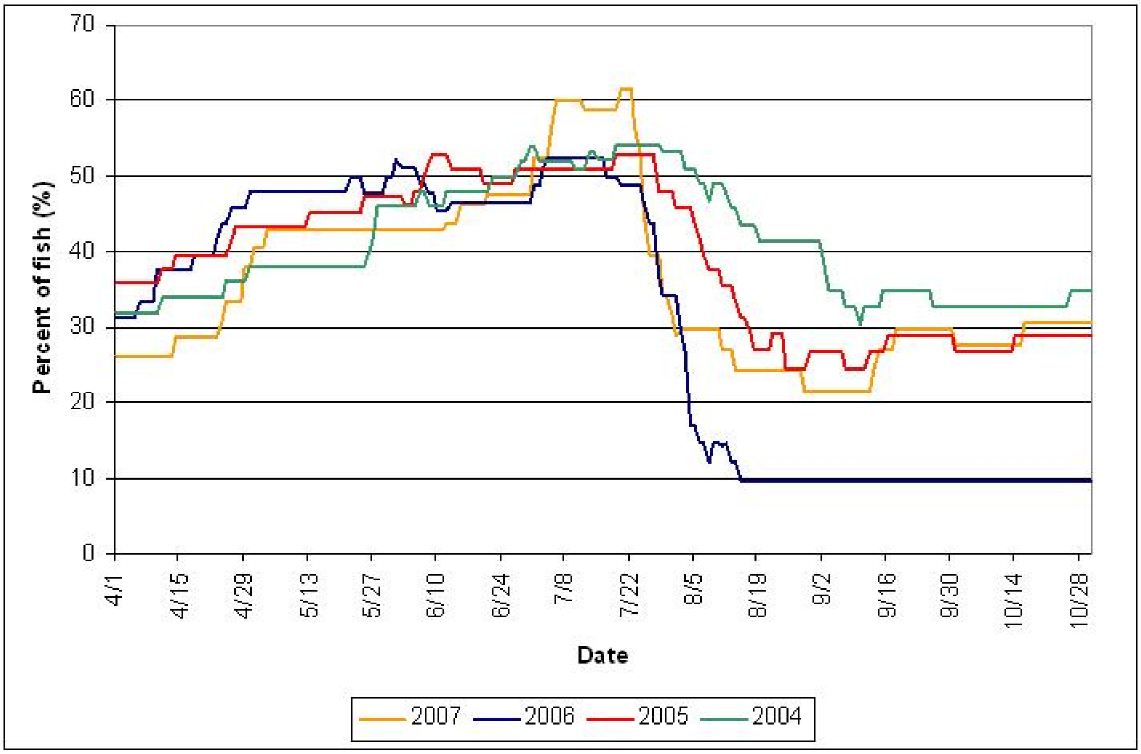


Figure 13. Percent (%) of shovelnose sturgeon relocated in the Yellowstone River from 2004 – 2007 by date.

Paddlefish relocations and movements

The transmitters that were implanted in paddlefish below the confluence in 2001 and 2002 were expiring throughout the 2006 and 2007 tracking seasons. Thus, contacts from ground-based telemetry stations and manual relocations were not frequent enough to determine exact times of fish immigrating or emigrating from particular rivers. However, paddlefish that were implanted in the Wolf Point area of the Missouri River after 2003 provided us with usable data.

Inter-annual trends in paddlefish relocations.-Paddlefish migrated up the Missouri River ATC in mid-April (Figure 14) and reached a maximum by mid-June. Although some paddlefish that were implanted below the confluence over-wintered in the Missouri River in the Wolf Point area, most fish remained in this reach for approximately 12 weeks. Relocations gradually declined through July and August. Migrations of paddlefish into the Missouri River ATC averaged 250 km. Paddlefish remained in the Missouri River ATC through late July in all years (mean date = 30 July).

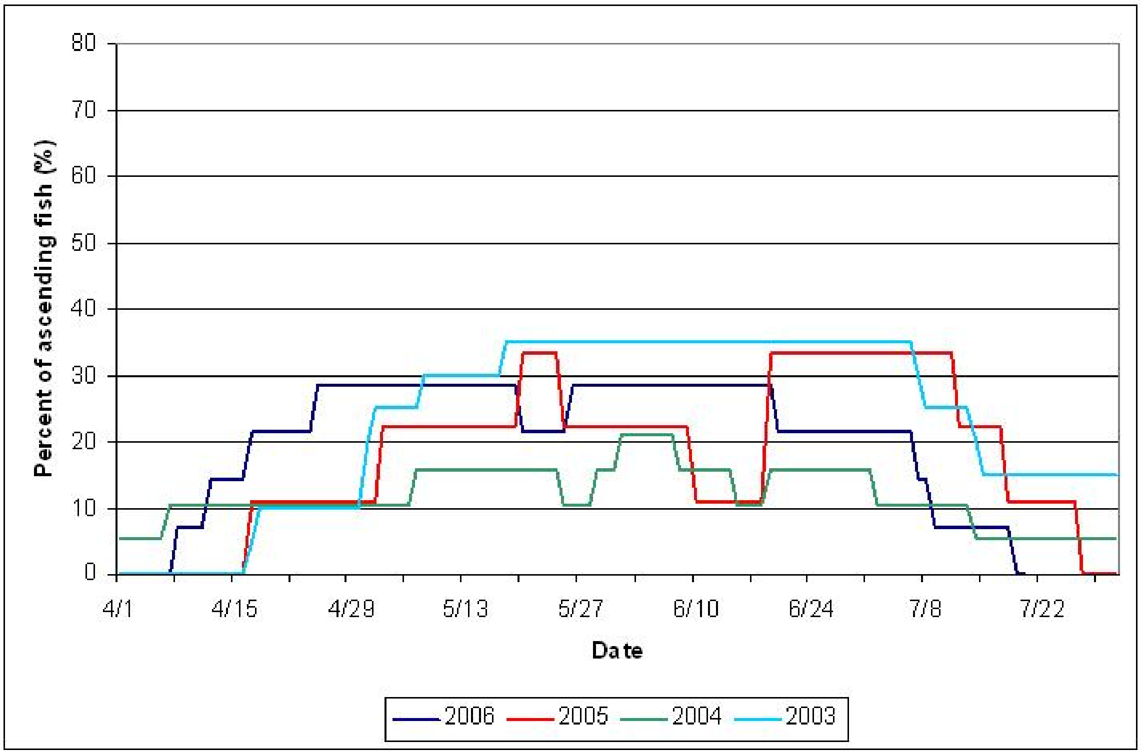


Figure 14. Percent (%) of ascending paddlefish relocated in the Missouri River above the Yellowstone River confluence from 2003-2006 by date.

Paddlefish exhibited seasonal movements in the Milk River in 2004, 2005, and 2007 (Figure 15). No paddlefish entered the Milk River in 2003 or 2006 due to insufficient flows. The maximum number of radio-implanted paddlefish that migrated into the Milk River varied from 2 – 4 individuals among years, but the maximum number always occurred following a large discharge event. The final date that paddlefish were present in the Milk River averaged June 24 among years.

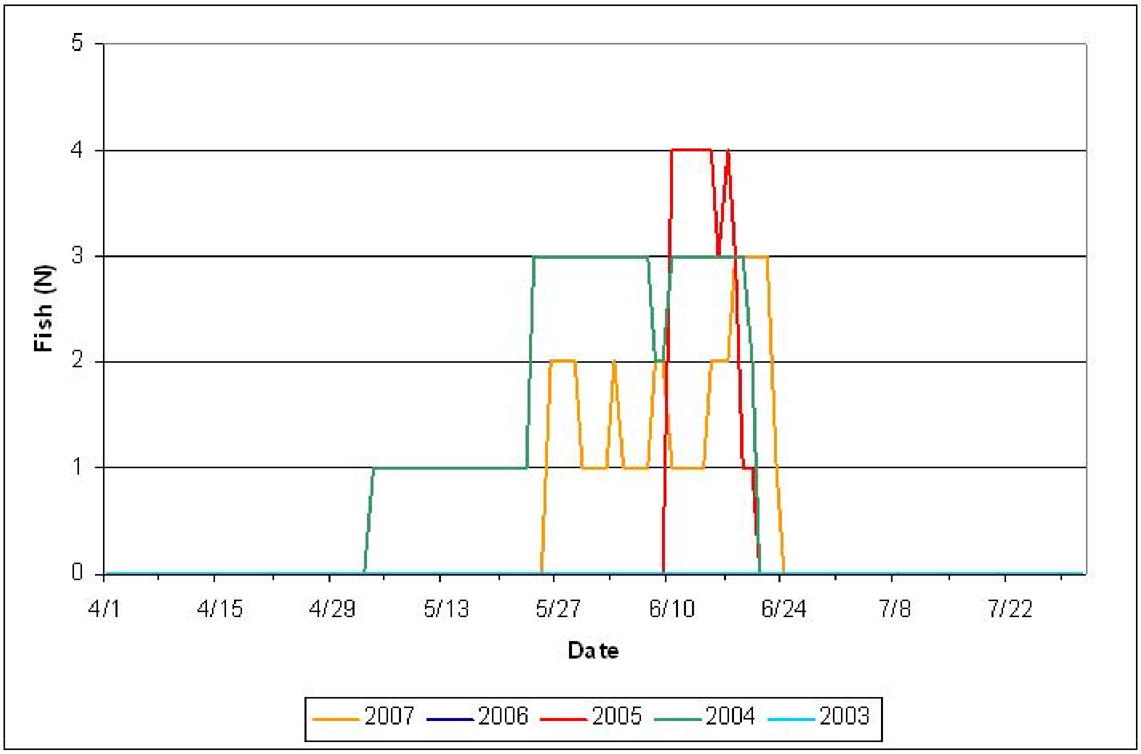


Figure 15. Number of paddlefish relocated in the Milk River in 2003 – 2007. No paddlefish used the Milk River in 2003 or 2006.

With the exception of 2004, the proportion of paddlefish migrating into the Yellowstone River increased between late April and mid-May prior to major discharge events (Figure 16). Initial migrations in mid-April 2004 were terminated as discharge decreased, but resumed as discharge increased in early May. The maximum proportion of all paddlefish that ascended the Yellowstone River at one time was 55% in 2003, 58% in 2004, 78% in 2005, and 72% in 2006. The maximum proportion of paddlefish in the Yellowstone River occurred prior to the date of maximum discharge. Although some paddlefish were relocated at the irrigation diversion structure 114 km up the Yellowstone River, migrations up the Yellowstone River averaged 50 km. Emigration of paddlefish from the Yellowstone River following spawn events was completed by mid-July each year (mean = July 13).

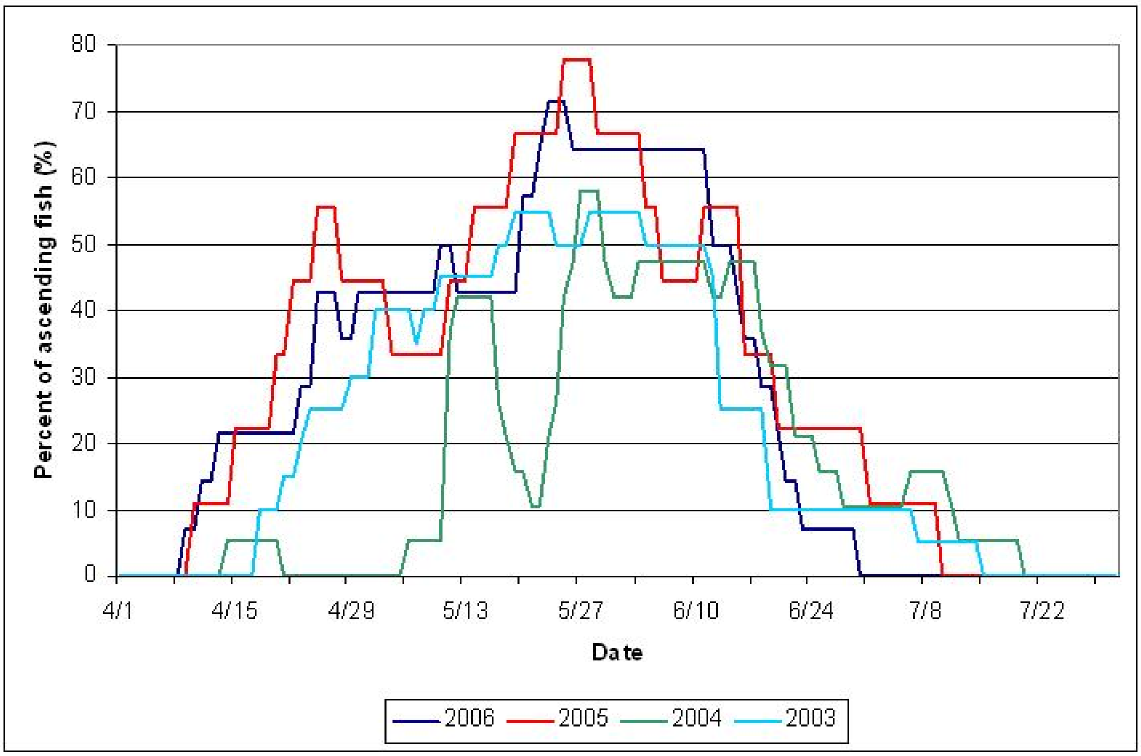


Figure 16. Percentage (%) of ascending paddlefish relocated in the Yellowstone River in 2003 - 2006 by date.

Paddlefish river fidelity: Despite inter annual variation in flows, certain fish selected the same river for their spawning migration (Table 10). Ninety-six percent of paddlefish (N = 23) implanted below the confluence selected the same river for their spawning migration. Only one individual selected the Missouri one year and the Yellowstone two years later. Ninety-two percent of paddlefish implanted in the Missouri River above the confluence (N = 14) returned to the Missouri or Milk rivers in subsequent spawning migrations. Only one fish selected the Yellowstone over the Missouri River one year. Thus, it is unlikely that a flow modification in the Missouri River would result in less fish ascending the Yellowstone River.

Table 10. Repeat spawning migrations of paddlefish implanted below the Yellowstone River confluence and in the Missouri River upstream from the Yellowstone River confluence.

Code	Sex	Implant	2002	2003	2004	2005	2006	2007
Paddlefish implanted below the confluence								
3	U	2001	Yellowstone				Yellowstone	
4	M	2001	Both			Yellowstone		Yellowstone
7	M	2001	Yellowstone		Yellowstone	Yellowstone		
12	M	2001	Yellowstone	Yellowstone		Yellowstone		
13	M	2001	Yellowstone	Yellowstone				
16	M	2001	Yellowstone		Both	Yellowstone		Yellowstone
20	M	2001	Yellowstone		Yellowstone		Yellowstone	
69	M	2001	Yellowstone	Yellowstone	Yellowstone	Yellowstone		
82	M	2001	Yellowstone	Yellowstone		Yellowstone	Yellowstone	
124	M	2002		Yellowstone				Yellowstone
52	M	2003			Yellowstone		Yellowstone	
135	F	2003		Yellowstone			Yellowstone	
5	M	2004			Yellowstone		Yellowstone	
120	M	2004			Yellowstone		Yellowstone	
143	M	2004			Yellowstone		Yellowstone	Yellowstone
146	M	2004			Yellowstone			Yellowstone
21	M	2001	Missouri		Missouri	Both		Missouri
93	M	2001	Both	Missouri	Missouri		Missouri	Milk
119	F	2001	Missouri				Missouri	
147	M	2003		Missouri		Missouri		
123	M	2003			Milk	Milk	Missouri	
148	F	2003		Missouri			Missouri	
105	F	2002		Missouri		Yellowstone		
Paddlefish implanted in the Missouri River above Wolf Point								
115	M	2002			Milk			
118	M	2002		Missouri		Milk		Milk
129	M	2002		Missouri		Missouri	Missouri	
73 *	M	2003			Milk	Dredges	Milk	
123	M	2004				Missouri		Missouri
125	M	2004				Missouri		
126	M	2004				Missouri		
127	M	2004				Milk	Missouri	
130	M	2004				Milk		Milk
133	M	2004				Milk		Milk
135	M	2004				Missouri	Missouri	Missouri
51	M	2005					Missouri	Missouri
109	M	2005					Missouri	Missouri
113	M	2004				Yellowstone	Missouri	Missouri

* Fish was implanted in the dredge cuts

Relocations and movements of pallid sturgeon

Use of the Missouri River ATC by pallid sturgeon occurred during 2007 (Figure 17), but use was minimal. The one individual that was implanted in the tailrace immediately downstream from Fort Peck Dam remained in the Missouri River until early June, then migrated into the Yellowstone River for three weeks, and then migrated back up to the tailrace in the fall.

In general, there was an inverse pattern for pallid sturgeon movements between the Yellowstone River and Missouri River BTC (Figure 17). Pallid sturgeon use of the Missouri River BTC declined though early April as individuals emigrated from this reach into the Yellowstone River. Pallid sturgeon primarily used the Yellowstone River through early July and then emigrated from the Yellowstone River back to the Missouri River below the confluence through the end of the tracking season.

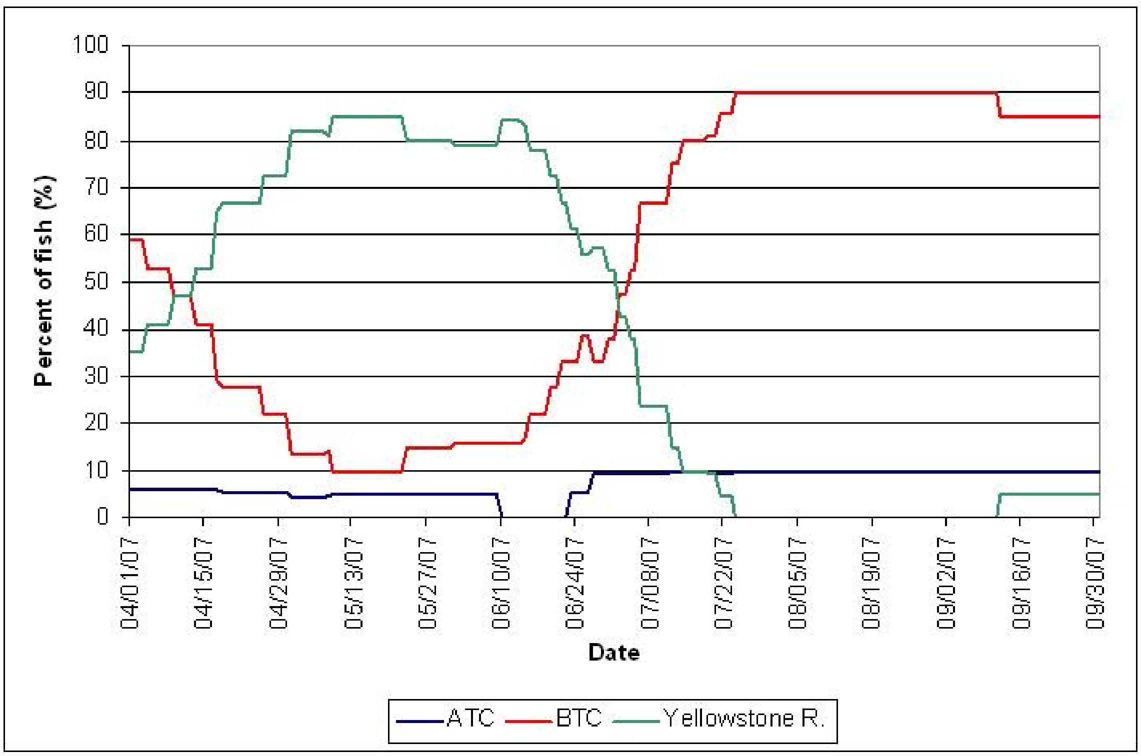


Figure 17. Percent (%) of pallid sturgeon relocated in reaches of the Missouri River and Yellowstone River in 2007.

Inter-annual trends in pallid sturgeon relocations. With the exception of 2004, the Missouri River above the confluence was seldom used (Figure 18). Relocations in this reach primarily consisted of one fish that was implanted in the tailrace area and another that resides in the Culbertson area during autumn, although other fish did occasionally ascend the Missouri River. The individual that was implanted in the tailrace resides in the MRATC until early June and then moves downstream and enters the Yellowstone River for a few weeks, and migrates back up to the tailrace area.

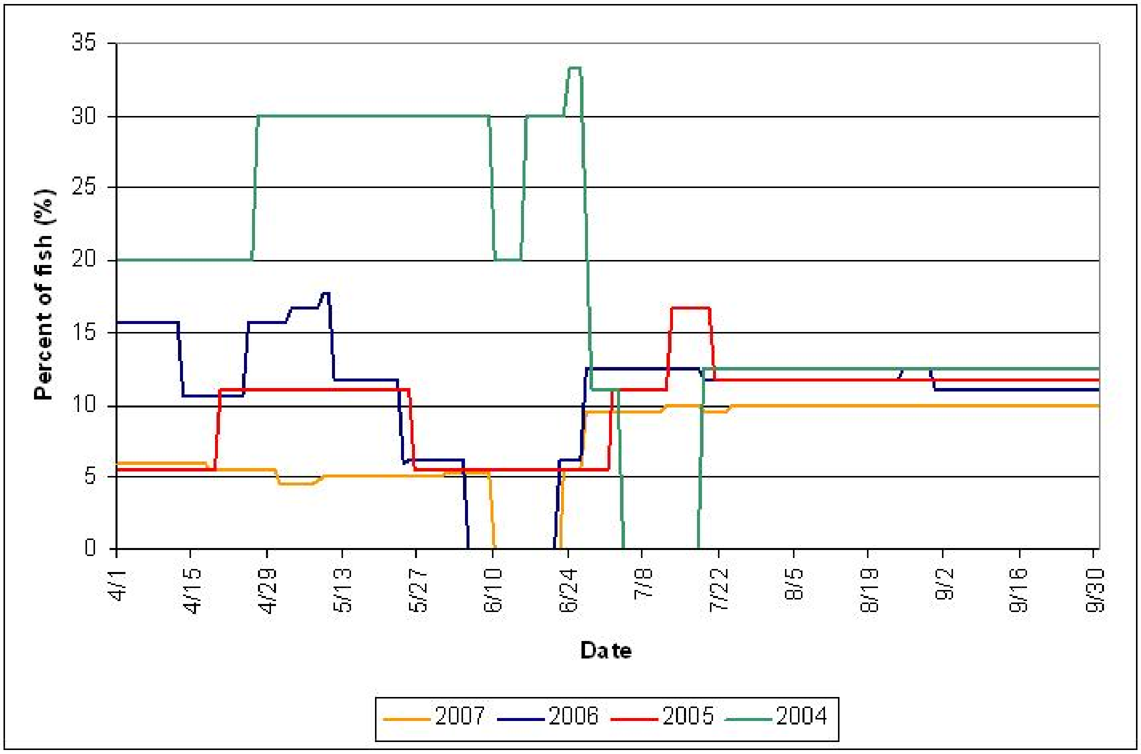


Figure 18. Percent (%) of pallid sturgeon relocated in the Missouri River above the confluence in 2004, 2005, 2006, and 2007 by date.

Pallid sturgeon primarily used the Missouri River BTC for an over-wintering area (Figure 19). There was approximately 10% of fish that remained in this reach for the entire year which were most likely non-ripe males that did not ascend the Yellowstone River

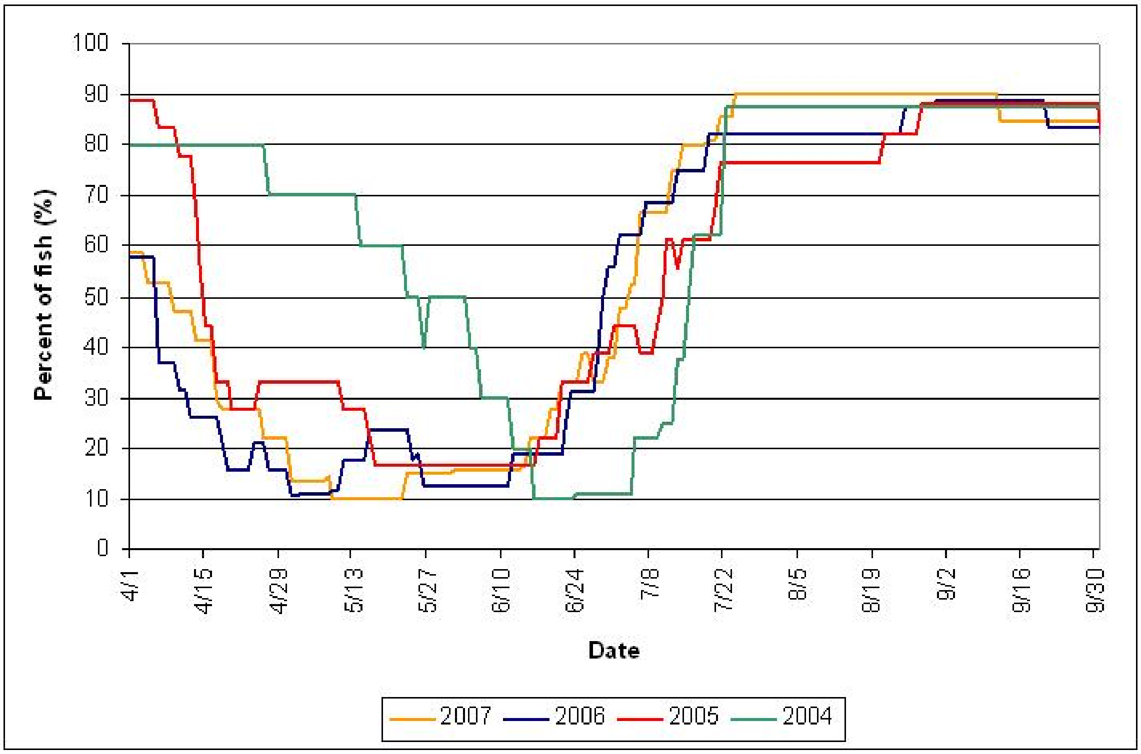


Figure 19. Percent of pallid sturgeon relocated in the Missouri River below the confluence in 2004, 2005, 2006, and 2007 by date.

With the exception of 2004, pallid sturgeon began migrating up the Yellowstone River in early April (Figure 20). Maximum relocations of 78% - 88% were found in mid-June. Fish rapidly emigrated out of the Yellowstone River from late June through early July. The late migration in 2004 was most likely due to very low flows.

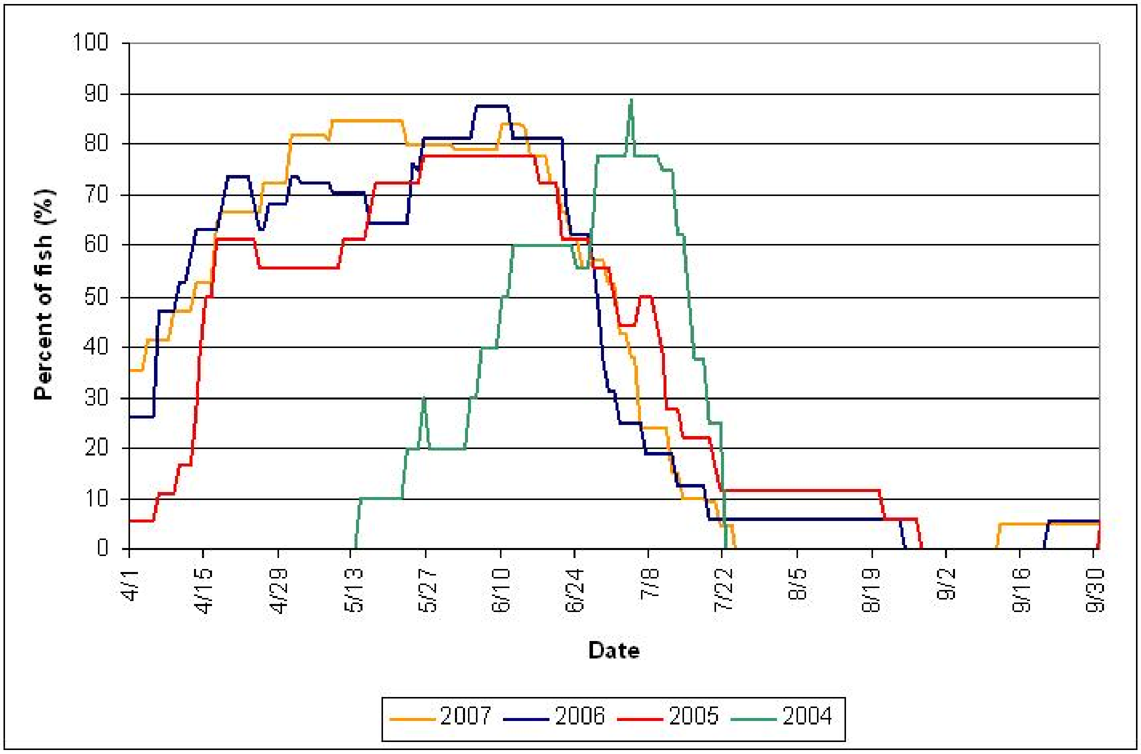


Figure 20. Percent (%) of pallid sturgeon relocated in the Yellowstone River in 2004, 2005, 2006, and 2007 by date.

Transmitter implantation.- Sampling during September 2007 resulted in capturing 15 shovelnose sturgeon and 16 blue suckers suitable for implanting transmitters (Table 11). Shovelnose sturgeon and blue suckers were collected in the Missouri River from the Milk River confluence to the Yellowstone River confluence. A total of five pallid sturgeon were implanted in April during brood stock collection efforts. These fish were captured in the Missouri River below the confluence and lower Yellowstone River.

Table 11. Number, sex ratio (male:female:undetermined), length (mm), and weight (g) for shovelnose sturgeon and blue suckers implanted with transmitters during September 2007 and pallid sturgeon implanted in April 2007.

Species	Number tagged	Sex Ratio	Metric	Mean	Minimum	Maximum
			Length	806	745	915
Shovelnose sturgeon	15	0:15:0	Weight	2482	1550	4350
			Length	720	605	810
Blue sucker	16	3:13:0	Weight	3283	1800	4600
			Length	1484	1398	1570
Pallid sturgeon	5	2:3:0	Weight	21400	15000	30000

Component 3 – Distribution and Abundance of Larval Fish

Larval fishes in 2007 were sampled on 21 sampling events between May 23 and August 2. A total of 2,011 samples were collected, and distributed among the Missouri River site downstream from Fort Peck Dam (252 samples), the spillway channel (168 samples), Milk River (382 samples), Missouri River at Wolf Point (418 samples), Missouri River at Nohly (420 samples), and the Yellowstone River (372 samples). Although the full complement of five replicates and four subsamples per replicate would normally result in a total of 420 samples for the latter four sites listed above, fewer than 420 subsamples were obtained due to environmental conditions. For example, during low flows in the Milk River late in the larval fish sampling season, some replicates were extremely shallow and only one pair of subsamples could only be collected. Similarly, during low flows in the Yellowstone River, water in much of the channel was hardly flowing and the flowing portion of the channel was sampled by one pair of subsamples. Following sampling protocols, the mean volume of water sampled per subsample was 48.4 m^3 at the Missouri River site downstream from Fort Peck Dam (total = 12,195 m^3), 14.9 m^3 in the spillway channel (total = 2,508 m^3), 73.0 m^3 in the Milk River (total = 27,798 m^3), 65.6 m^3 in the Missouri River at Wolf Point (total = 27,405 m^3), 54.2 m^3 in the Missouri River and Nohly (total = 22,762 m^3), and 44.0 m^3 in the Yellowstone River (total = 16,352 m^3).

Relative abundance of larval fishes and eggs. – A total of 8,525 larval fish representing ten families was sampled across all sites during 2007 (Table 12). Catostomidae was the dominant taxon sampled and comprised 60.8% of all larval fishes across sites. Cyprinids (21.7%) and Hiodontidae (9.4%) were the second and third most abundant taxa sampled, respectively. A total of 28 *Scaphirhynchus sp*. larvae (0.3% of the total larvae) and 263 paddlefish larvae (3.1% of the total larvae) were sampled. Seven Acipenseriform larvae could not be definitively distinguished as *Scaphirhynchus sp*. or paddlefish. The number of eggs sampled varied greatly among sites as 57 eggs were sampled in the spillway channel and more than 16,000 eggs were sampled in the Milk River.

Composition of the larval fish assemblage sampled during 2007 varied among sites (Table 12). Seven taxa were identified from the Milk River, Wolf Point, and Nohly; six taxa were identified from the spillway channel and Yellowstone River. The lowest number of taxa (4) was obtained from the site below Fort Peck Dam. Three taxa (Catostomidae, Cyprinidae, Percidae) were sampled at all sites. Hiodontidae (exclusively goldeye *Hiodon alosoides*) was present at all sites with the exception of the site downstream from Fort Peck Dam. Similarly, paddlefish were sampled at all sites except the spillway channel and site below Fort Peck Dam. S*caphirhynchus sp*. were sampled only in the Missouri River at Wolf Point and Nohly, and in the Yellowstone River.

Table 12. Number and frequency (%) of larval fishes by taxon, and numbers of juveniles, adults, and eggs sampled at six sites during 2007.

	Below Fort Peck Dam		Spillway		Milk River		Wolf Point		Nohly		Yellowstone River	
Taxon	N	%	N	%	N	%	N	%	N	%	N	%
Acipenseridae							3	0.2	4	0.5	21	1.2
Catostomidae	66	83.5	216	72.7	2,261	54.1	1,112	76.5	283	36.8	1,248	71.3
Cyprinidae	4	5.1	20	6.7	1,558	37.3	80	5.5	52	6.8	138	7.9
Centrarchidae			50	16.8	2	T	1	T				
Hiodontidae			1	0.3	233	5.6	79	5.4	313	40.8	176	10.1
Ictaluridae									1	0.1		
Percidae	4	5.1	3	1.0	2	T	106	7.3	49	6.4	2	0.1
Polyodontidae					48	1.1	53	3.6	41	5.3	121	6.9
Salmonidae	1	1.3	2	0.7								
Sciaenidae					17	0.4						
Acipenseriform larvae[1]							1	T	1	0.1	5	0.3
Unknown larvae[2]	4	5.1	5	1.7	56	1.3	18	1.2	24	3.1	40	2.3
Total larvae	79		297		4,177		1,453		768		1,751	
Juveniles[3]	1		51		493		8		4		65	
Adults[4]			55		200		5		7		73	
Acipenseriform eggs							2				3	
Other eggs	598		57		16,111		7,096		3,536		11,178	

[1] Larvae that could not definitively be distinguished as paddlefish or sturgeon
[2] Larvae other than Acipenseriform larvae that could not be definitively identified
[3] Juveniles of many species
[4] Adults of many species

Spatial and temporal periodicity and densities of larval Scaphirhynchus sp. and larval paddlefish. – Larval *Scaphirhynchus sp*. were not collected in the Milk River during 2007. However, larval paddlefish were sampled in the Milk River on four of 21 sampling events between June 6 and June 18 (Table 13). The highest density of larval paddlefish occurred on June 11 as mean density reached 5.08 larvae/100 m^3.

Table 13. Total number of larval paddlefish sampled (N), and mean, minimum, and maximum density (number/100 m^3) by date in the Milk River during 2007.

Date	N	Mean	Min.	Max
5/23				
5/29				
5/31				
6/4				
6/6	4	0.30	0	1.01
6/11	39	5.08	0	12.96
6/14	2	0.20	0	0.52
6/18	3	0.34	0	0.64
6/20				
6/25				
6/28				
7/2				
7/5				
7/10				
7/11				
7/16				
7/20				
7/23				
7/26				
7/30				
8/2				

Few larval *Scaphirhynchus sp*. and many larval paddlefish were sampled in the Missouri River at Wolf Point during 2007 (Table 14). Larval *Scaphirhynchus sp*. were sampled on three dates between July 6 and July 25, but mean density was low (≤ 0.19 larvae/100 m^3). A total of 53 larval paddlefish were sampled on 10 of 21 sampling events between June 7 and July 16. Mean density of larval paddlefish was greatest on June 13 (1.5 larvae/100 m^3)

Table 14. Total number of larval *Scaphirhynchus sp*. and paddlefish sampled (N), and mean, minimum, and maximum density (number/100 m^3) by date in the Missouri River at Wolf Point during 2007.

	Scaphirhynchus sp.				Paddlefish			
Date	N	Mean	Min.	Max	N	Mean	Min	Max
5/23								
5/29								
6/1								
6/4								
6/7					1	0.08	0	0.38
6/11					11	0.99	0	2.40
6/13					19	1.50	0.32	4.79
6/18					3	0.25	0	0.46
6/21					3	0.23	0	0.85
6/25					2	0.14	0	0.37
6/27					7	0.72	0	2.66
7/3					1	0.08	0	0.42
7/6	1	0.06	0	0.32	5	0.85	0	3.29
7/9								
7/11								
7/16					1	0.07	0	0.36
7/18	1	0.06	0	0.30				
7/23								
7/25	1	0.19	0	0.94				
7/30								
8/1								

Similar to the Wolf Point site, few larval *Scaphirhynchus sp*. were sampled in the Missouri River at Nohly during 2007; whereas, several paddlefish were sampled at this site (Table 15). Four larval *Scaphirhynchus sp*. were sampled between June 12 and July 17, but density was low (mean ≤ 0.09 larvae/100 m^3). A total of 41 larval paddlefish were sampled at Nohly between June 12 and July 5. The greatest density of larval paddlefish occurred on June 14 and mean density reached 1.76 larvae/100 m^3.

Table 15. Total number of larval *Scaphirhynchus sp*. and paddlefish sampled (N), and mean, minimum (Min.), and maximum (Max.) density (number/100 m^3) by date in the Missouri River at Nohly during 2007. (*Note: The *Scaphirhynchus sp*. sampled on 7/5 was possibly a larval pallid sturgeon originally stocked on July 3 near Grand Champs, near rkm 2808, as part of the pallid sturgeon propagation and augmentation program utilizing larval releases as a stocking strategy).

	Scaphirhynchus sp.				Paddlefish			
Date	N	Mean	Min.	Max	N	Mean	Min.	Max.
5/24								
5/30								
6/1								
6/5								
6/9								
6/12	1	0.09	0	0.43	8	1.04	0	2.93
6/14					14	1.76	0	4.23
6/19					5	0.59	0	2.56
6/21					2	0.29	0	0.75
6/26					1	0.12	0	0.61
6/28					2	0.15	0	0.38
7/2	1	0.07	0	0.36	8	0.61	0	1.71
7/5	1*	0.05	0	0.26	1	0.08	0	0.38
7/10								
7/12								
7/17	1	0.09	0	0.45				
7/19								
7/24								
7/26								
7/31								
8/2								

A total of 21 larval *Scaphirhynchus sp*. and 121 larval paddlefish were sampled in the Yellowstone River during 2007 (Table 16). Larval *Scaphirhynchus sp*. were sampled on seven dates between June 8 and July 2, and densities were greatest on June 8 (mean = 1.48 larvae/100 m^3) and June 14 (mean = 1.43 larvae/100 m^3). Larval paddlefish were present in the drift from the onset of sampling on May 24 through July 2. Mean density of larval paddlefish was greatest on May 30 (2.57 larvae/100 m^3) and June 5 (mean = 5.40 larvae/100 m^3).

Table 16. Total number of larval *Scaphirhynchus sp*. and paddlefish sampled (N), and mean, minimum (Min.), and maximum (Max.) density (number/100 m^3) by date in the Yellowstone River during 2007.

	Scaphirhynchus sp.				Paddlefish			
Date	N	Mean	Min.	Max	N	Mean	Min	Max
5/24					15	1.20	0.33	2.39
5/30					30	2.57	0.45	4.37
6/1					11	0.77	0	3.19
6/5					49	5.40	1.45	12.52
6/8	5	1.48	0	3.85	5	1.51	0	5.69
6/12	3	0.56	0	1.33	2	0.18	0	0.64
6/14	4	1.43	0	3.47	1	0.07	0	0.35
6/19					3	0.49	0	1.07
6/21	1	0.04	0	0.20	2	0.16	0	0.41
6/26	4	0.40	0	1.69	1	0.09	0	0.47
6/28	2	0.15	0	0.39				
7/2	2	0.27	0	0.91	2	0.30	0	0.89
7/5								
7/10								
7/12								
7/17								
7/19								
7/24								
7/26								
7/31								
8/2								

Spatial and temporal periodicity and densities of larval fishes exclusive of Acipenseridae and paddlefish.

The larval fish assemblage sampled in the Missouri River downstream from Fort Peck Dam was dominated by larval catostomids (Figure 21). Densities of catostomids were low through June 14, then peaked on June 18 (mean = 3.54 larvae/100 m^3) when catostomids composed 90% of the total larval fish density. Catostomids exhibited additional increases on June 28 (mean = 1.37 larvae/100 m^3) and July 5 (mean = 1.34 larvae/100 m^3) as this taxon composed 100% of the larval fish assemblage. Cyprinids were present on two dates (June 14, June 20), but densities were low (mean $\leq$ 0.28 larvae/100 m^3). Larval percids were sampled on two dates early in the season (June 4, June 6) at low densities (mean $\leq$ 0.45 larvae/100 m^3). Salmonids were sampled on one date (May 31).

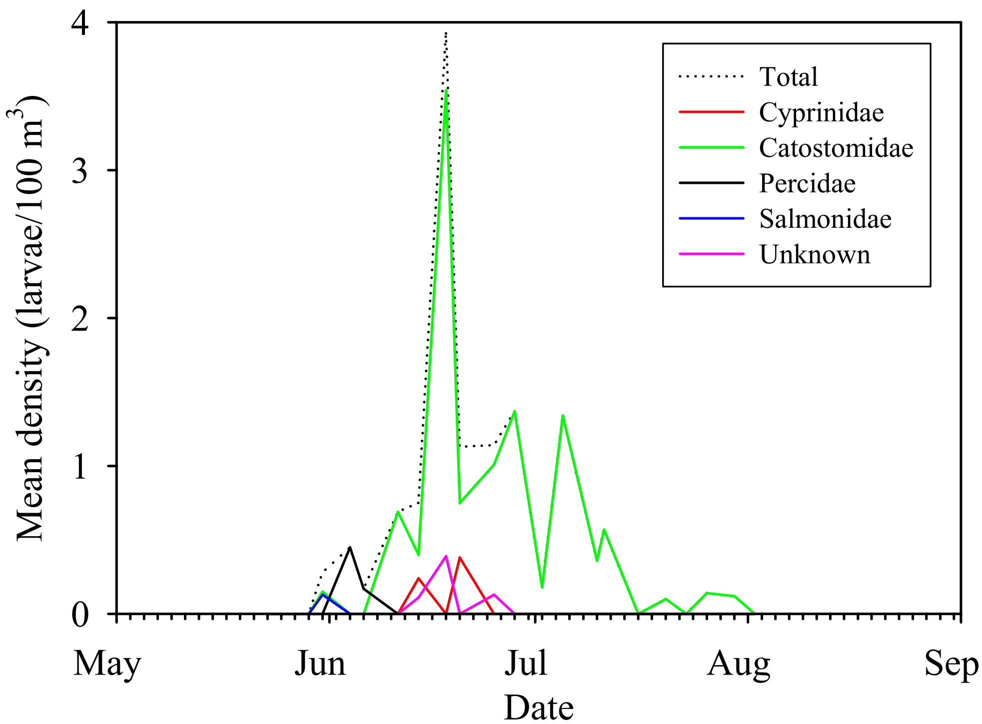


Figure 21. Mean density (number/100 m^3) by date of all larval fishes (Total), Cyprinidae, Catostomidae, Percidae, Salmonidae, and Unknown individuals sampled in the Missouri River below Fort Peck Dam during 2007.

The larval fish assemblage in the spillway channel was comprised of six taxa that exhibited temporal variation in density and periodicity (Figure 22). Initial samples in late-May were comprised of representatives from Salmonidae and Percidae. Densities increased during mid-June as catostomid larvae inititially appeared, but total densities increased substantially on June 28 (mean = 48.68 larvae/100 m^3) and July 5 (mean = 55.88 larvae/100 m^3) as catostomids composed 82% and 89% of the larval fish assemblage on these dates, respectively. Cyprinids were present from May 31 through July 30, but densities were greatest on June 28 (mean = 6.24 larvae/100 m^3). Representatives of Centrarchidae were present between July 2 and July 30, and this taxa exhibited relatively high densities on July 10 (mean = 9.42 larvae/100 m^3) and July 23 (mean = 11.91 larvae/100 m^3).

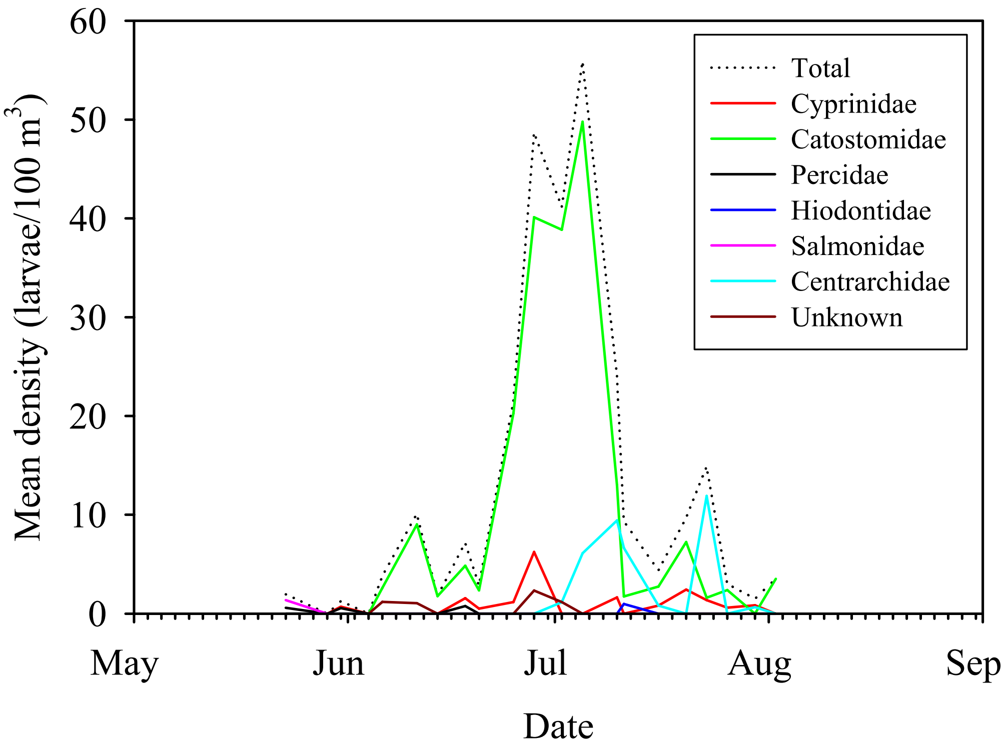


Figure 22. Mean density (number/100 m^3) by date of all larval fishes (Total), Cyprinidae, Catostomidae, Percidae, Hiodontidae, Salmonidae, Centrarchidae, and Unknown individuals sampled in the Fort Peck Dam spillway channel during 2007.

Densities of larval fish in the Milk River exhibited substantial temporal variation during 2007 that were primarily attributed to the temporal periodicity of Catostomidae and Cyprinidae and to a lesser extent other taxa (Figure 23). Densities exhibited an initial increase on June 11 (mean total density = 63.02 larvae/100 m^3) as Catostomidae increased substantially to 56.84 larvae/100 m^3 (90% of the total). Following a decline in densities after the initial peak, total density increased on June 28 as cyprinids increased in abundance (mean density = 65.68 larvae/100 m^3, 69% of the total) and catostomids exhibited a second increase (mean density = 25.67 larvae/100 m^3, 27% of the total). Percids and centrarchids were present on one date (June 11). Freshwater drum (family Sciaenidae) were present between June 11 and July 30, but densities were greatest on July 11 (mean = 0.46 larvae/100 m^3). Goldeye (family Hiodontidae) were present between June 6 and July 20, and densities were greatest on June 11 (mean = 5.54 larvae/100 m^3).

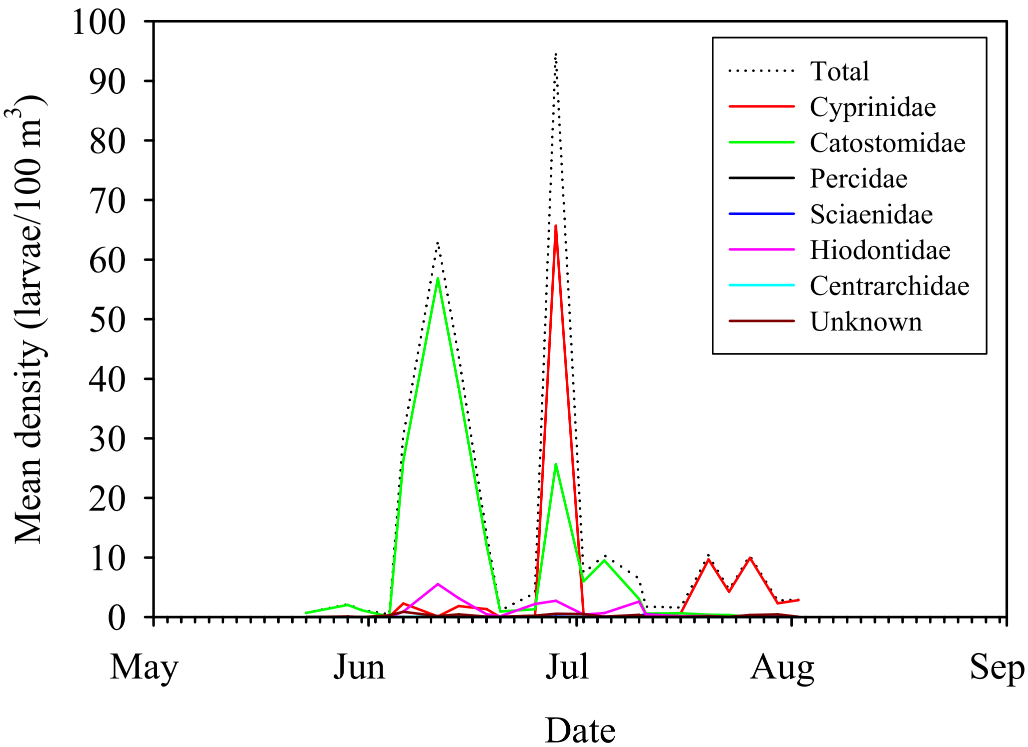


Figure 23. Mean density (number/100 m^3) by date of all larval fishes (Total), Cyprinidae, Catostomidae, Percidae, Sciaenidae, Hiodontidae, Centrarchidae, and Unknown individuals sampled in the Milk River during 2007.

The larval fish assemblage at Wolf Point exhibited temporal variation in taxon composition and density (Figure 24). Larval percids were present in the drift between May 23 and June 13, but peak densities of this taxon occurred on May 29 (mean = 2.59 larvae/100 m^3). In early June, densities of Catostomidae increased substantially to maximum mean of 19.19 larvae/100 m^3 (89% of the total density of larvae). Densities of Catostomidae decreased from this date through the end of the sampling season. Representatives of Cyprinidae were sampled from May 23 through July 30, but densities were greatest on July 6 (2.35 larvae/100 m^3). Goldeye (Family Hiodontidae) were sampled between June 7 and July 3 with greatest densities occurring on June 21 (mean = 1.39 larvae/100 m^3). Representatives of Centrarchidae were sampled on one date (June 13).

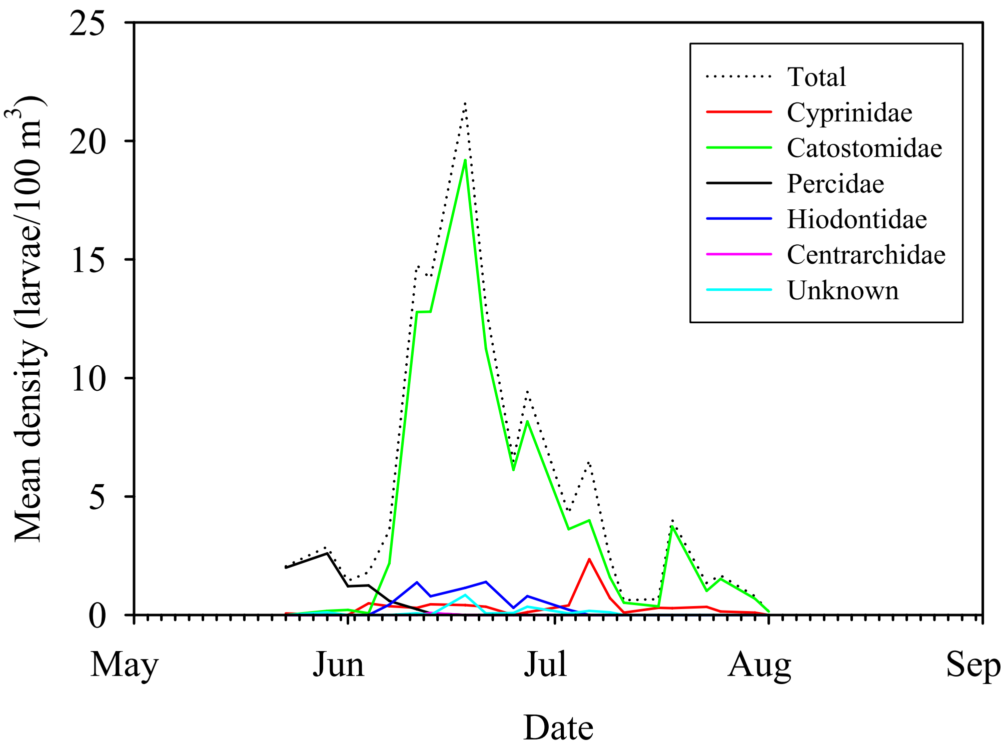


Figure 24. Mean density (number/100 m^3) by date of all larval fishes (Total), Cyprinidae, Catostomidae, Percidae, Hiodontidae, Centrarchidae, and Unknown individuals sampled in the Missouri River at Wolf Point during 2007.

The larval fish assemblage in the Missouri River at Nohly exhibited temporal variations in density that were primarily dependent on the occurrence of goldeye (family Hiodontidae), Catostomidae, and to a lesser extent other taxa (Figure 25). Percids were present in the drift between May 24 and June 14, but exhibited greatest densities on May 30 (mean = 1.74 larvae/100 m^3). As percids declined in abundance, larval goldeye increased substantially on June 14 averaging 13.69 larvae/100 m^3 (72% of the total density). Maintaining their occurrence through later dates, goldeye increased in abundance again on June 28 (mean = 6.59 larvae/100 m^3) as this taxa composed 70% of the total larval density (9.38 larvae/100 m^3). Larval catostomids were present from May 30 through July 31 and attained their greatest density on July 2 (mean = 6.01 larvae/100 m^3). Representatives of Cyprinidae were present throughout the sampling season and exhibited their greatest density on June 9 (1.52 larvae/100 m^3).

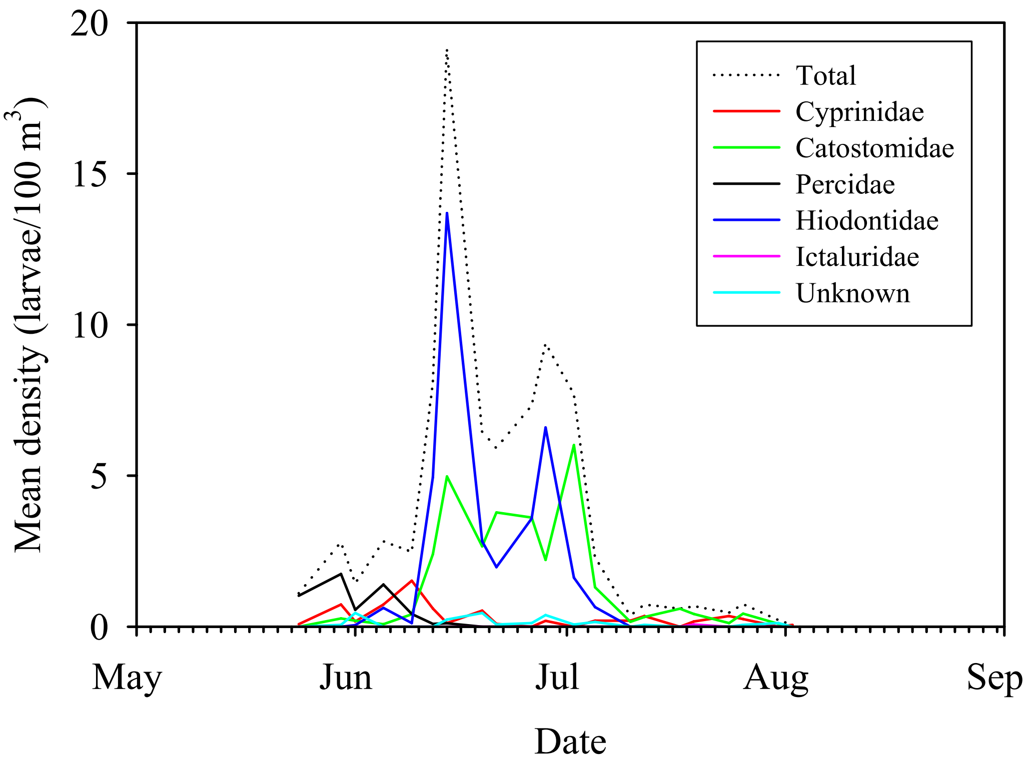


Figure 25. Mean density (number/100 m^3) by date of all larval fishes (Total), Cyprinidae, Catostomidae, Percidae, Hiodontidae, Ictaluridae, and Unknown individuals sampled in the Missouri River at Nohly during 2007.

Exclusive of *Scaphirhynchus sp.* and paddlefish, four taxa (Cyprinidae, Catostomidae, Percidae, and Hiodontidae) were present in the Yellowstone River (Figure 26). Goldeye were sampled from the initiation of sampling on May 24 through July 2, and densities of this taxon were greatest on June 12 (mean = 4.75 larvae/100 m^3). Percids were sampled on one date (June 5). Representatives of Catostomidae exhibited two periods of elevated densities as this taxon initially peaked on June 28 (mean density = 68.9 larvae/100 m^3, 69% of the total larval density) and increased again on July 10 (mean density = 32.02 larvae/100 m^3, 92% of the total larval density). Cyprinids were sampled from June 12 through August 2, but density was greatest on July 5 (mean = 8.44 larvae/100 m^3).

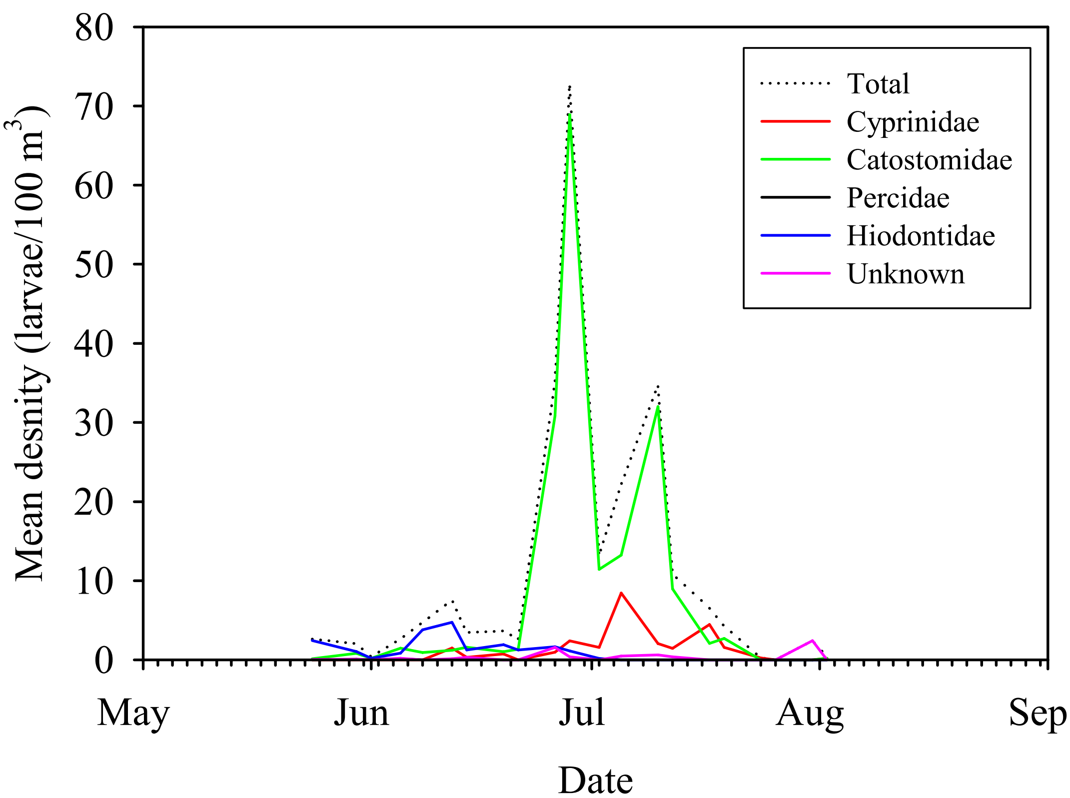


Figure 26. Mean density (number/100 m^3) by date of all larval fishes (Total), Cyprinidae, Catostomidae, Percidae, Hiodontidae, and Unknown individuals sampled in the Yellowstone River during 2007.

Inter-annual trends in larval fish densities

The final analysis of spatial and temporal patterns of larval fish densities will be conducted following completion of the Fort Peck Flow Modification study. However, preliminary trends in larval fish densities for all sites are illustrated below (Figure 27). At the site downstream from Fort Peck Dam, mean densities of larval fishes were relatively similar among all years with the exception of 2005 when densities tended to be greater. Densities of larval fishes in the spillway channel tended to be greater during 2004 and 2005 than other years. Three sites including the Milk River, Missouri River at Wolf Point, and Missouri River near Nohly tended to have similar patterns as densities were high during 2002, decreased sharply in 2003, increased through 2004 (Milk River) or 2005 (Wolf Point, Nohly), decreased in 2006, then increased during 2007. The exception to this pattern occurred at Nohly in 2001 where high densities were accompanied by high variability. In the Yellowstone River, highest densities of larval fishes occurred during 2002 and 2007 (mean > 8 larvae/100 m^3).

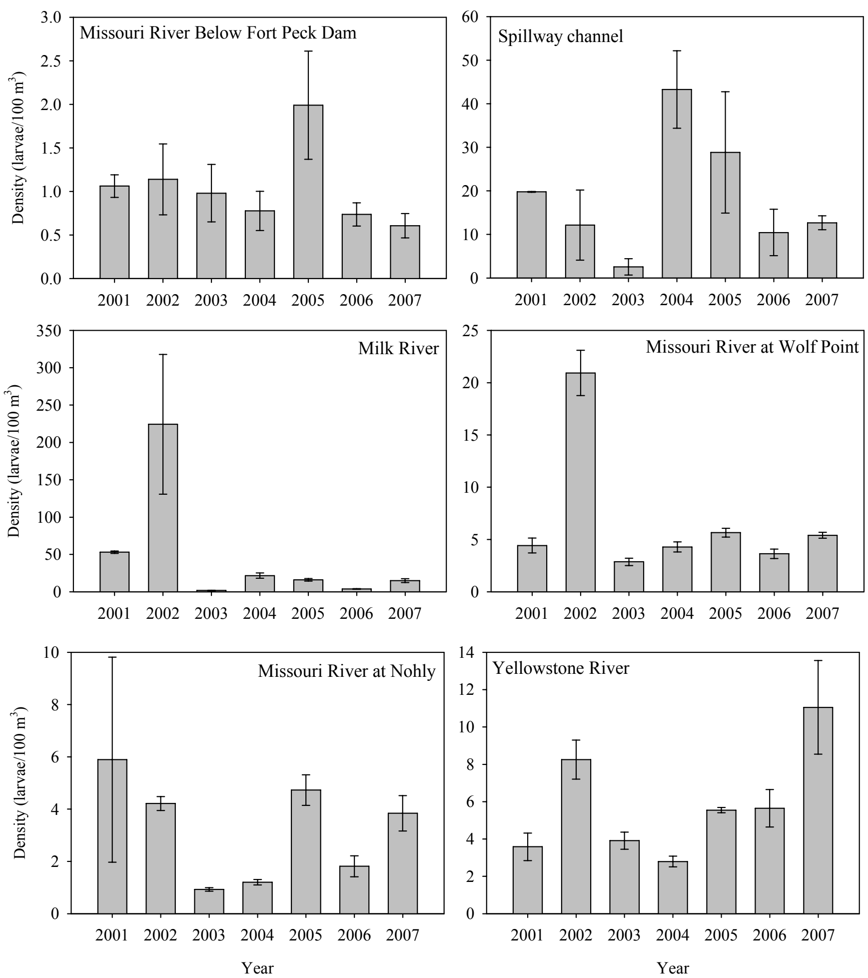


Figure 27. Mean larval density (number/100 m^3, ± one standard error) of all taxa combined except larval *Scaphirhynchus sp*. and paddlefish at six sites between 2001 and 2007. The mean and standard error were calculated by averaging across dates among replicates. Sites were sampled from late May through early August with the exception of 2001 when sampling was terminated in late July.

Component 4 – Reproductive success of shovelnose sturgeon and pallid sturgeon

Young-of-year sturgeon sampling.- Beam trawling for young-of-year sturgeon (*Scaphirhynchus sp*.) was conducted on nine weekly sampling events between early July and early September. The first sampling event was conducted earlier (July 11-12) than previous years to assess relative abundance of young sturgeon present in the system prior to the arrival of pallid sturgeon released as larvae during the 2007 larval drift studies (Braaten et al, in prep.). In this study, about 430,000 larval pallid sturgeon (ages 5-13 days post-hatch) were released on July 9 near Wolf Point in the Missouri River. The drifting larvae had not arrived at the ATC or BTC sampling sites when trawl sampling occurred. Thus, all larvae trawled during the July 11-12 sampling event represented wild-produced sturgeon. Conversely, young-of-year sturgeon sampled after the initial sampling event could have included a combination of wild-produced shovelnose sturgeon and pallid sturgeon and river-released pallid sturgeon resulting from the drift studies.

A total of 504 trawls were conducted across the nine weekly sampling events, and these were partitioned between 376 standard trawls and 128 targeted trawls (Table 17). A total of 126 young-of-year sturgeon were sampled, and these were partitioned among the Missouri River ATC (N = 2), Missouri River BTC (N = 107), and Yellowstone River (N = 17). During the initial July 11-12 sampling event, 15 young-of-year sturgeon were sampled in both the Missouri River BTC and Yellowstone River. These individuals represented wild-spawned young-of-year sturgeon because larvae released during the 2007 larval drift study had not reached the trawling sites by these dates. Young-of-year sturgeon sampled during July 11-12 varied from 38-68 mm in the Yellowstone River and 20-51 mm in the Missouri River BTC. During the July 17-19 sampling event, 33 young-of-year sturgeon were sampled from the Missouri River BTC (19-56 mm) and 1 individual (38 mm) was sampled in the Missouri River ATC. Eleven young-of-year sturgeon were sampled from the Missouri River BTC during July 24-25, and these measured 51-99 mm. During the July 31-August 1 sampling event, 1 young-of-year sturgeon was sampled in the Missouri River ATC (56 mm) and 15 were sampled from the Missouri River BTC (22-108 mm). Only four young-of-year sturgeon measuring 21-67 mm were sampled during August 6-7, and all were captured in the Missouri River BTC. Eight young-of-year sturgeon were collected during the August 14-15 sampling event, and these were partitioned between the Missouri River BTC (7 individuals, 34-96 mm) and Yellowstone River (1 individual, 133 mm). A total of 10 young-of-year sturgeon were sampled on August 21-22 from the Missouri River BTC (62-119 mm). During the August 29-30 sampling event, three young-of-year sturgeon were sampled in the Missouri River BTC (100-119 mm) and one in the Yellowstone River (141 mm). The final sampling event on September 5-6 yielded 9 young-of-year sturgeon, and all were collected in the Missouri River BTC (69-166 mm).

Genetic analyses of young-of-year sturgeon sampled in 2007 indicate that several pallid sturgeon released during the 2007 drift studies were collected during trawling efforts. On July 17-18, four young-of-year pallid sturgeon were sampled in the Missouri River BTC. Three young-of-year pallid sturgeon were sampled on July 31 in the Missouri River BTC. On August 1, one young-of-year pallid sturgeon was sampled in the Missouri River ATC. Lastly, two young-of-year pallid sturgeon were collected on August 21 in the Missouri River BTC. Based on genetic parental assignments, 9 of the 10 young-of-year pallid sturgeon were survivors from larvae originally released at 5 days post-hatch. The one individual collected in the Missouri River ATC was a survivor from larvae originally released at 6 days post-hatch. These results indicate that some larval pallid sturgeon originally released at rkm 2,739 on July 9 survived drifting in the Missouri River, settled from the drift, and survived throughout most of the young-of-year life stage.

Table 17. Summary of trawling effort and catches of young-of-year sturgeon in the Missouri River above the confluence (MOR ATC), below the confluence (MOR BTC) and in the Yellowstone River during 2007.

Site	Sampling protocol	Metric	Jul 11-12	Jul 17-19	Jul 24-25	Jul 31– Aug 1	Aug 6-7	Aug 14-15	Aug 21-22	Aug 29-30	Sep 5-6
MOR ATC	Standard	Sturgeon	0	1	0	1	0	0	0	0	0
		Trawls	12	12	12	12	12	12	12	12	12
		Minutes	47.7	48	46	46	47.8	48	44.3	46	47
	Targeted	Sturgeon		0		0					
		Trawls		2		2					
		Minutes		8		8					
MOR BTC	Standard	Sturgeon	6	18	10	10	2	6	5	3	6
		Trawls	18	18	18	18	18	18	18	18	18
		Minutes	71.5	72	72	71	72	72	71.3	72	71.5
	Targeted	Sturgeon	9	15	1	5	2	1	5	0	3
		Trawls	14	14	14	16	6	8	16	4	16
		Minutes	56	56	55	64	24	32	64.8	16	64
Yellowstone	Standard	Sturgeon	5	0	0	0	0	1	0	1	0
		Trawls	12	12	12	12	12	12	12	12	10
		Minutes	48	43	48	48	47	46.8	46.8	48	39
	Targeted	Sturgeon	10					0		0	
		Trawls	12					2		2	
		Minutes	47.7					8		8	

Component 5 – Assisting in the collection of adult pallid sturgeon for the propagation program.

The Fort Peck Flow Modification Crew participated in pallid sturgeon broodstock collection activities during spring 2007. Broodstock collection activities were not conducted during fall 2007 at the decision of the Upper Basin Work Group due to disease issues associated with returning pallid sturgeon from Gavins Point Dam National Fish Hatchery. Pallid sturgeon sampled during spring 2007 were sexed and staged by hatchery personnel and reproductive physiology experts, and either transported to hatcheries or returned to the river based on sexual state and need. Collection records were submitted to the USFWS Bismarck office for inclusion in the pallid sturgeon database.

Associated activities

A total of 67 hatchery-raised and stocked juvenile pallid sturgeon were sampled in conjunction with netting and trawling activities during 2007 (Table 18). Composition of the catch included six individuals from the 2001 year class, four individuals from the 2003 year class, 29 representatives from the 2005 year class, and 24 juveniles from the 2006 year class. Year class could not be determined from one individual and three others were unmarked. Trammel netting while searching for fish to implant (Component 2) yielded 48 of the fish, while beam trawling for young-of-year sturgeon (Component 4) captured 18 juveniles. One juvenile pallid sturgeon was caught by angling.

Table 18. Juvenile pallid sturgeon sampled as part of the Fort Peck Data Collection Plan activities during 2007. Abbreviations are as follows: (ER = elastomer right, EL = elastomer left, G = green, R = red, Y = yellow, O = orange, U = blue, P = pink, H = horizontal, V = vertical), Lat = latitude, Long = Longitude, YC = year class (obtained from the USFWS juvenile pallid sturgeon PIT tag database). Length and weight are reported in mm and g, respectively. An "*" indicates that the fish was unmarked and genetics were taken.

PIT TAG	ER	EL	Scute	YC	Date	Lat.	Long.	Length	Weight
430E533C5F	VG	VY		2002	7/12/2007	48.02235	-104.09733	413	193
4444052700	VY	HP		2005	7/12/2007	47.94783	-103.95978	302	87
4315556B01	VG	VY		2002	7/18/2007	47.97874	-103.97695	340	220
462409777F	VY			2006	7/18/2007	47.98497	-103.97961	329	102
4310750960	VY			2006	7/18/2007	47.98633	-103.97242	290	75
430E6D357D *			L-2		7/18/2007	47.96628	-103.96425	380	165
430E583027			L-3	2006	7/25/2007	47.95637	-103.92647	285	78
462427726D	VY			2006	7/25/2007	47.97823	-103.97460	389	95
435F61462E	VY	HY	L-2	2005	7/25/2007	47.96836	-103.96583	309	94
46235E792A	VY			2006	8/1/2007	47.95558	-103.92080	335	120
	VY	HO		2005	8/1/2007	47.98570	-103.97807	276	63
43104F204D			R-3	2006	8/1/2007	47.96134	-103.92877	319	95
45373D226A	VY			2006	8/6/2007	48.11055	-103.71279	317	89.5
46250F4123			L-3	2006	8/14/2007	47.95567	-103.92039	287	65
	VY	VR		2006	8/14/2007	48.02816	-104.97691	282	66
	VU	HO		2006	8/14/2007	48.02816	-104.09136	222	35
4532056110	VY			2006	8/15/2007	48.05917	-103.71179	309	93
	VY	VY		2006	8/22/2007	47.95549	-103.92041	234	37
4443685368			R-3/L-2	2006	8/22/2007	47.98587	-103.97791	338	115
4441703667	VY		L-2	2006	9/6/2007	47.96195	-103.89308	291	78
435D5C703E	VG			2002	9/20/2007	47.97294	-103.99055	405	190
47197B6830			R-3	2006	9/20/2007	47.95732	-103.91312	390	172
472E312167			R-3	2006	9/20/2007	47.95732	-103.91312	390	159
4443575B7D			R-3/L-2	2006	9/20/2007	47.97294	-103.99055	375	142
44416B4A77	VG		L-2	2002	10/3/2007	48.11412	-104.51575	483	350
435E210C20	HY			2004	10/3/2007	48.10817	-104.58322	361	136
45315B5B3D	VY			2006	10/3/2007	48.12404	-104.58534	410	206
4623745148	VY			2006	10/3/2007	48.11046	-104.50364	398	190
46252C3E08			L-3	2006	10/3/2007	48.12358	-104.52551	323	97
	VU	HO		2006	10/3/2007	48.10871	-104.58174	262	54
	VU	HO		2006	10/3/2007	48.11836	-104.56692	262	50
	VU	HU		2006	10/3/2007	48.12510	-104.54376	246	41
	VU	HU		2006	10/3/2007	48.11593	-104.57214	257	50
4441730273	VY	HP	L-2	2005	10/3/2007	48.12027	-104.58763	275	70
435D562413	VG			2002	10/4/2007	48.10390	-104.44892	368	158
435F262064	HY			2004	10/4/2007	48.07944	-104.40530	324	99
435D363F4A	HY			2004	10/4/2007	48.10394	-104.44916	351	138
46251B4D1F			L-3	2006	10/4/2007	48.10426	-104.44849	265	57

Table 18. continued.

PIT TAG	ER	EL	Scute	YC	Date	Lat.	Long.	Length	Weight
	VU	HO		2006	10/4/2007	48.10426	-104.44849	163	16
4714701901	VU	HO	L-2	2006	10/4/2007	48.09208	-104.43630	285	67
46272E7B58			R-3	2006	10/4/2007	48.09208	-104.43630	348	110
	VU	HP		2006	10/4/2007	48.07534	-104.39200	247	45
	VU	HO		2006	10/4/2007	48.11800	-104.45936	238	42
4443575E44	VY	HR	L-2	2005	10/4/2007	48.10542	-104.45068	273	52
4713195902	VY	HO	L-2	2005	10/4/2007	48.07944	-104.40530	282	68
471E2B0C12	VY		L-2	2006	10/4/2007	48.10373	-104.44887	324	110
4443241F77	VY	HO	L-2	2005	10/4/2007	48.10342	-104.44898	275	64
4716420C2D	VY	HO	L-2	2005	10/4/2007	48.10394	-104.44916	297	79
4443261E33	VY	HO	L-2	2005	10/4/2007	48.10283	-104.44858	275	69
47155C2E59 *			L-2		10/4/2007	48.10426	-104.44849	305	88
44436E771A	VY	HO	L-2	2005	10/4/2007	48.10373	-104.44887	292	84
47170D372C *			L-2		10/4/2007	48.10371	-104.44826	285	70
	VU	HP		2006	10/15/2007	48.07622	-105.63906	234	37
4443475B11	VU	HP	L-2	2006	10/15/2007	48.07622	-105.63906	268	54
471867281A			R-3	2006	10/15/2007	48.06525	-105.64178	348	112
47145F572F	VY	HO	L-2	2005	10/15/2007	48.05030	-105.64266	291	72
435D562413	VG			2002	10/17/2007	48.10152	-104.44900	367	154
	HY		L-2	2004	10/17/2007	48.10132	-104.44900	310	90
4315305A31	VY	VO	L-2	2006	10/17/2007	48.09100	-104.42867	283	76
	VU	HU		2006	10/17/2007	48.10530	-104.45069	248	42
444355592E	VU	HO	L-2	2006	10/17/2007	48.10132	-104.44854	287	70
44431B2C4E	VU	HO	L-2	2006	10/17/2007	48.09985	-104.44872	268	52
4703292610			R-3	2006	10/17/2007	48.09986	-104.44874	299	80
	VU	HO		2006	10/17/2007	48.10157	-104.44881	240	40
	VU	HU		2006	10/17/2007	48.09992	-104.44874	244	46
4713195902	VY	HO	L-2	2005	10/17/2007	48.10152	-104.44900	280	66
44431D2D06	VY	HP	L-2	2005	10/17/2007	48.11764	-104.45865	266	65

Acknowledgments

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