Fort Peck Flow Modification Biological Data Collection Plan

Summary of 2006 Activities

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Extended Abstract

The Missouri River Biological Opinion developed by the U. S. Fish and Wildlife Service formally identified that seasonally atypical discharge and water temperature regimes resulting from operations of Fort Peck Dam have precluded successful spawning and recruitment of pallid sturgeon *Scaphirhynchus albus* in the Missouri River below Fort Peck Dam. In response, the U. S. Army Corps of Engineers (USACE) proposes to modify operations of Fort Peck Dam to enhance environmental conditions for spawning and recruitment of pallid sturgeon. Modified dam operations include releasing warm surface water over the Fort Peck Dam spillway. The Fort Peck Flow Modification Biological Data Collection Plan (hereafter Fort Peck Data Collection Plan) was implemented in 2001 to evaluate the influence of proposed flow and temperature modifications on physical habitat and biological response of pallid sturgeon and other native fishes. Research and monitoring activities conducted during 2006 as part of the multi-year Fort Peck Data Collection were similar to those activities conducted during 2001 – 2005. For 2006, primary research and monitoring activities 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 supported by the USACE, and jointly implemented by the Montana Department of Fish, Wildlife, and Parks and the U. S. Geological Survey - Columbia Environmental Research Center. Similar to 2001 through 2005, proposed flow modifications were not implemented in 2006 due to inadequate precipitation and insufficient reservoir levels.

For research component 1, mean daily water temperature was warmest in the free-flowing Missouri River upstream from Fort Peck Reservoir (Robinson Bridge, mean = 18.2°C), and coolest at the site downstream from Fort Peck Dam (mean = 12.0°C). Thus, hypolimnetic releases from the dam suppressed water temperature by an average of 6.2°C during the common deployment period. However, maximum water temperature was suppressed 11.3°C by hypolimnetic dam releases between the two sites. Water temperatures gradually increased from below Fort Peck Dam downstream to Nohly (most downstream Missouri River site prior to receiving inputs from the Yellowstone River). Although warming occurred, mean (16.7°C) and maximum (24.5°C) water temperatures at Nohly remained 1.5-2.4°C cooler than in the Missouri River upstream from Fort Peck Reservoir. Thus, despite gradual attenuation of the effects of hypolimnetic releases, water temperature remained impacted 290 km downstream from the dam. Turbidity in the Missouri River increased from upstream to downstream sites, and was lowest at the site closest to Fort Peck Dam (i.e., Frazer Rapids), intermediate at Poplar, and highest at Nohly. Turbidity in the Yellowstone River during 2006 tended to be slightly lower than in the Missouri River at Nohly. Temporally, periods of elevated turbidity occurred at all sites and many periods of elevated turbidity were associated with changes in river discharge.

Under research component 2, extensive radio tracking was conducted between April and November in the lower Yellowstone River and in the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea. A total of 24 individual tracking events were conducted throughout the river systems. Totals of 1,022 relocations of shovelnose sturgeon, 995 relocations

of blue suckers, 386 relocations of paddlefish, and 322 relocations of pallid sturgeon were obtained via boat. Seven continuous-recording telemetry-logging stations logged an additional 772 contacts of implanted fish. Species-specific information on relocation locations and movement patterns are presented. In September 2006, radio transmitters were implanted in an additional 21 shovelnose sturgeon, 21 blue suckers, and 4 pallid sturgeon. 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 component 3 resulted in the collection of 2,044 samples between late May and early August. More than 3,700 larvae representative of eight families were sampled from mainstem Missouri River sites, the Milk River, Yellowstone River, and spillway channel. Representatives of Catostomidae (i.e., suckers) were numerically dominant and composed 60.5% of all larvae sampled. The Cyprinidae (i.e., carps and minnows) composed 23.2% of the larvae sampled. Representatives of Percidae (i.e., perches) and Hiodontidae (exclusively goldeye, *Hiodon alosoides*) composed 9.0% and 3.4% of the larvae sampled, respectively. A total of 17 Acipenseridae larvae (0.5% of the total) and 55 Polyodontidae larvae (exclusively paddlefish, 1.5% of the larvae) were identified, but two additional larvae (0.05% of the total) could not be confidently distinguished as *Scaphirhynchus sp*. or paddlefish. Thirteen acipenseriform eggs were sampled in addition to nearly 31,000 eggs from other species. Larval *Scaphirhynchus sp.* were sampled from the Yellowstone River and two sites (Wolf Point, Nohly) in the Missouri River.

Under research component 4, 359 trawls were conducted during 2006 on eight sampling events between July 19 and September 7. Trawls were partitioned among the Missouri River above the Yellowstone River confluence (ATC; 98 trawls), Missouri River below the Yellowstone River confluence (BTC; 168 trawls), and Yellowstone River (93 trawls). Only 13 young-of-year sturgeon were sampled: 1 individual was sampled in the Missouri River upstream from the Yellowstone River confluence, and 12 individuals were sample in the Missouri River downstream from the Yellowstone River confluence. No young-of-year sturgeon were sampled in the Yellowstone River. Genetic analysis of young-of-year sturgeon sampled during 2006 indicated that all fish were shovelnose sturgeon.

As part of research component 5, assistance was provided to catch adult pallid sturgeon during April and October for the propagation and augmentation program. Adults captured were assessed by hatchery personnel and reproductive physiology experts to determine suitability for propagation.

A total of 38 hatchery-raised and stocked juvenile pallid sturgeon were sampled during 2006 field activities. Composition of the catch included three individuals from the 2001 year class, one fish from the 2002 year class, six individuals from the 2003 year class, two individuals from the 2004 year class, and 26 representatives from the 2005 year class.

Introduction

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

The original schedule of events for conducting the flow modifications called for conducting the mini-test during 2001 and conducting the full-test in 2002. However, insufficient water levels in Fort Peck Reservoir during 2001 - 2006 precluded conducting these tests. As a consequence, physical and biological data collected during the initial six years of this study represent baseline conditions under existing dam operations (see Braaten and Fuller 2002, 2003, 2004, 2005, 2006).

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 2006 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 (river mile, RM 1,770) to the headwaters of Lake Sakakawea near rkm 2,471 (RM 1,544.5; Figure 1). The study area also includes the lower 113 rkm (70 RM) of the Yellowstone River (Figure 1). See Gardner and Stewart (1987), White and Bramblett (1993), Tews (1994), Bramblett and White (2001), and Bowen et al. (2003) for a complete description of physical and hydrological characteristics of the study area.

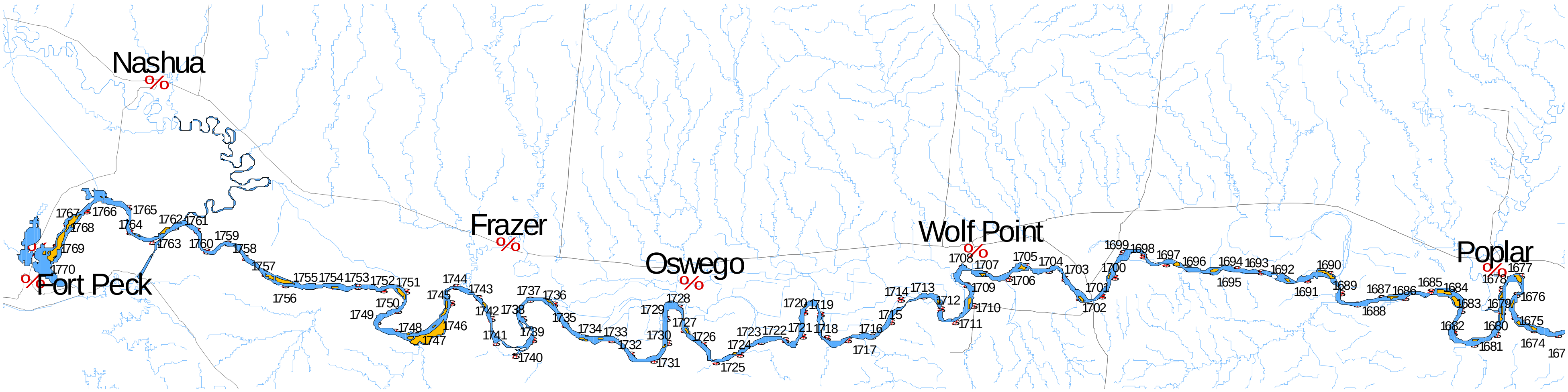
Methods

Monitoring Component 1 - Water temperature and turbidity.

Field measurements of water temperature. Water temperature data were recorded at 18 locations (total of 41 loggers) from early April through late October at sites in the Missouri River, Yellowstone River, tributaries, off-channel areas, and in Fort Peck Reservoir (Table 1). Water temperature data in the free-flowing Missouri River upstream from Fort Peck Reservoir were obtained from the USGS at the Robinson Bridge gage station. Data from all other sites were recorded using water temperature loggers (Optic StowAway, -5^{o}C – +37^{o}C, 4 min response time, accuracy $\pm$ 0.2^{o}C from 0 - 21^{o}C) programmed to record water temperature at 1-hr intervals. Loggers were secured to the north and south bank lines on the river bed at sites in the Missouri River to assess lateral variations in water temperature. An additional logger was stratified in the water column at selected sites to assess vertical variations in water temperature. Expanding on water temperature information collected during 2001-2005, additional loggers were deployed during 2006 in the middle reach of the Yellowstone River (river mile 36) and in the lower reach of the Missouri River near Williston, ND (river mile 1,554; Table 1).

Assessment of water temperature logger precision. Precision of water temperature loggers was assessed prior to and following retrieval from the field. In April 2006, all water temperature loggers (except the USGS logger deployed at Robinson Bridge) were subjected to a series of common water bath treatments to evaluate precision and accuracy among loggers. The water bath treatments were comprised of three temperature ranges (cold, < 10^{o}C, tailwater of Fort Peck Dam; cool, < 20^{o}C, laboratory water bath; warm, > 20^{o}C, laboratory water bath). Following retrieval from the field, water temperature loggers were subjected to a similar series of common water bath treatments. Pre- and post-deployment precision of loggers for each water bath treatment was evaluated with univariate statistics (mean, standard deviation, minimum, maximum, and range) computed over all loggers. The mean, minimum, maximum, and range were screened for precision. If precision was low (e.g., broad range of temperature for an individual water bath trial), logger data were scrutinized to determine which logger(s) was contributing to the extreme values. After identifying and deleting any “suspect” logger(s), univariate statistics were computed again to assess precision.

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



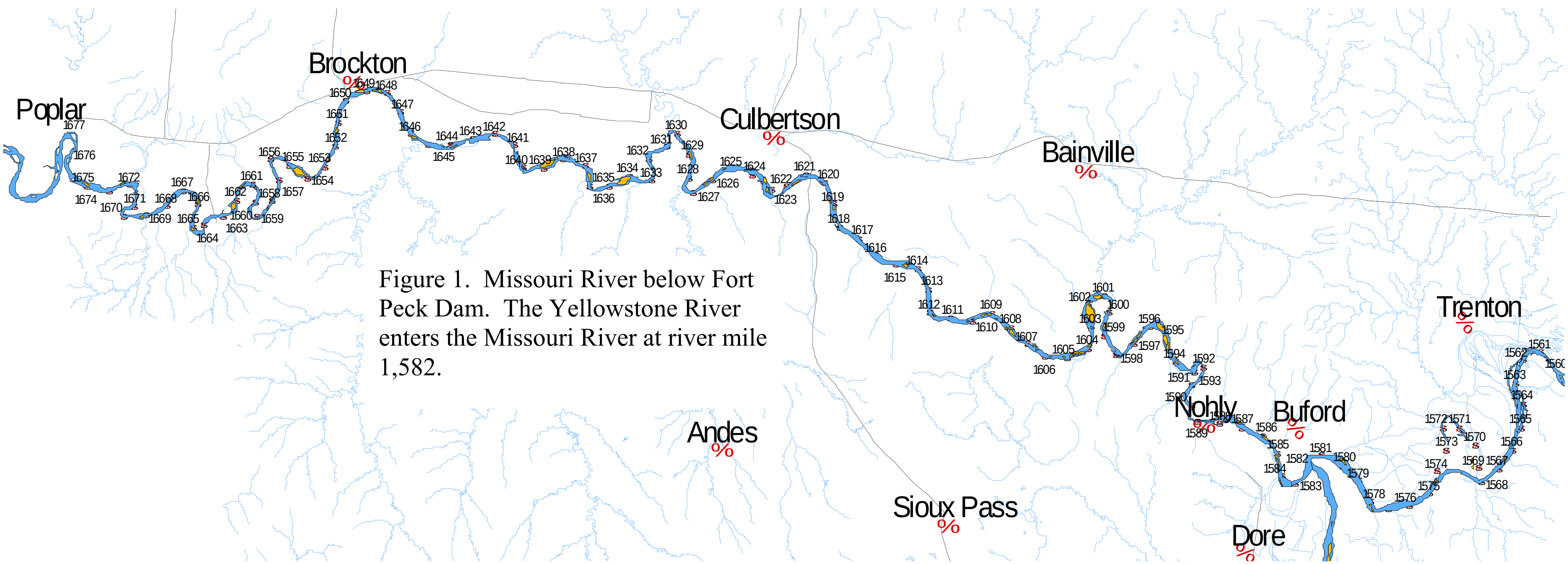


Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

Table 1. Sites, approximate river mile (RM; distance upstream from the Missouri River-Mississippi River confluence or distance upstream in a specified tributary), bank locations (north, south, strat = stratified in the water column), serial numbers, and dates of deployment for water temperature loggers deployed in the Missouri River and adjacent areas during 2006. NR = not recovered at the end of the season.

Site	RM	Bank Location	Latitude	Longitude	Logger serial no.	Deploy date	Retrieval Date
Above Fort Peck Lake	1,920.5	South				4/1/06	10/31/06
Fort Peck Lake					429721	5/15/06	11/2/06
Downstream from	1,765.2	North	48.05568	106.36460	681751	4/10/06	10/26/06
Fort Peck Dam		South	48.06223	106.37865	681711	4/10/06	10/26/06
		Strat	48.06223	106.37865	947703	4/10/06	10/26/06
Spillway			48.03992	106.34102	429724	4/10/06	10/26/06
Milk River	4.0		48.06701	106.30312	429717	4/10/06	10/26/06
Nickels Ferry	1,759.9	North	48.04525	106.28735	947676	4/10/06	10/26/06
		South	48.04451	106.28636	681718	4/10/06	10/26/06
		Strat	48.04525	106.28735	681716	4/10/06	10/26/06
Nickels Rapids	1,757.5	North	48.03437	106.24837	389571	4/10/06	10/26/06
		South	48.03555	106.25475	947720	4/10/06	10/26/06
		Strat	48.03555	106.25475	667855	4/10/06	10/26/06
Frazer Pump	1,751.5	North	48.03097	106.12473	681715	4/10/06	10/26/06
		South	48.03030	106.12677	681696	4/10/06	10/26/06
		Strat	48.03097	106.12473	681686	4/10/06	10/26/06
Frazer Rapids	1,746.0	North	48.00733	106.12962	681740	4/10/06	10/26/06
		South	48.00639	106.12890	681694	4/10/06	10/26/06
		Strat	48.00733	106.12962	681683	4/10/06	10/26/06
Grandchamps	1,741.5	North	48.03546	106.08553	681674	4/10/06	10/26/06
		South	48.03445	106.08241	429723	4/10/06	10/26/06
		Strat	48.03546	106.08553	681687	4/10/06	10/26/06
Wolf Point	1,701.5	North	48.08462	105.51818	681721	4/10/06	NR
		South	48.07929	105.52005	429718	4/10/06	10/24/06
		Strat	48.08462	105.51818	947704	4/10/06	NR
Poplar	1,680	North	48.06680	105.20282	429716	4/11/06	NR
		South	48.06259	105.21549	947733	4/11/06	NR
		Strat	48.06259	105.21549	667869	4/11/06	NR
Poplar River	0.4		48.08376	105.19495	681743	4/11/06	NR
Culbertson	1,620.9	North	48.08782	104.42184	429722	4/11/06	10/24/06
		South	48.09222	104.43961	681707	4/11/06	NR
		Strat	48.09222	104.43961	681745	4/11/06	NR
Nohly	1,591.2	North	48.01907	104.09959	681702	4/11/06	10/24/06
		South	48.01448	104.10711	947695	4/11/06	NR
		Strat	48.01448	104.10711	947698	4/11/06	NR
Yellowstone River	3.5		47.94963	103.96234	681681	4/12/06	10/25/06
	36.0		47.61200	104.18632	681727	4/12/06	10/25/06
Below	1,576.5	North	47.95860	103.90900	947719	4/11/06	NR
Yellowstone River		South	47.95827	103.89805	681706	4/11/06	10/25/06
		Strat	47.95827	103.89805	681720	4/11/06	10/25/06
Highway 85	1,554		48.10740	103.72218	947697	4/11/06	10/25/06

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

A*ssessments of turbidity logger precision and accuracy.* Turbidity loggers were subjected to a series of standard formazin NTU treatments (20 NTU, 200 NTU, 800 NTU) to assess accuracy and precision prior to and following deployment in the field. Each logger was programmed to record 5 - 10 NTU measurements (10 second recording interval) in each NTU treatment.

Monitoring 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 CART tags during 2001 - 2005 was initiated in April 2006. The Missouri River between Fort Peck Dam and the Highway 85 bridge near Williston, N.D. (342 km), and the Yellowstone River from the confluence to Intake Diversion (116 km) were tracked at weekly intervals from April through July, and bi-weekly from August through October. Two radio frequencies (149.760 MHz, 149.620 MHz) were simultaneously monitored during the boat-tracking run using two 4-element Yagi antennae. A hydrophone was used to scan acoustic frequencies (65.6 kHz, 76.8 kHz) in deep areas of the two rivers. The entire study area could be tracked in a 3-day time interval. Several variables (radio/acoustic frequency, fish code, time-of-day, latitude, longitude, river mile, conductivity, habitat type, water temperature, turbidity) were recorded at fish locations.

Stationary telemetry logging stations.- Stationary telemetry logging stations were deployed in April 2006 at seven sites (Milk River, rkm 4.0, RM 2.5; Nickels, rkm 2,828, RM 1,756.5; near Wolf Point, rkm 2,755, RM 1,711; near Culbertson, rkm 2,603, RM 1,616.5; near Fort Buford, rkm 2,533, RM 1583; near Williston, rkm 2,471, RM 1,544.5; Yellowstone River, rkm 1, RM 0.6). 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 2006. Species were sampled using drifted trammel nets. A minimum of 20 suitable-sized individuals of each species was targeted for transmitter implantation. Our goal was to extend flow- and temperature-related movement inferences to all areas of the Missouri River below Fort Peck Dam and Lake Sakakawea. Therefore, species were collected in several areas between rkm 2,850 (RM 1,770) and rkm 2,545 (RM 1,581; Figure 1). The two 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, 149.620 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 1-6 individuals were captured at a sampling location. 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 antenna 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 (342 km) and Yellowstone River (116 km). The reaches for shovelnose sturgeon consisted of the Missouri River from Fort Peck Dam to Wolf Point (112 km), the Missouri River from Wolf Point to the headwaters of Lake Sakakawea (230 km), and the Yellowstone River (116 km). For paddlefish and pallid sturgeon, the reaches consisted of the Missouri River above the confluence of the Yellowstone River (ATC; 302 km), the Missouri River below the confluence of the Yellowstone River (BTC; 40 km), and the Yellowstone River (116 km).

Monitoring Component 3 – Larval Fish Distribution and Abundance

Sampling protocols. Larval fish were sampled two times per week from late May through early August at six sites (Table 2). Similar to 2001 - 2005, 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 2006 sampling events. Abbreviations for net location are as follows: B = bottom, M = mid-water column, S = surface (0.5 - 1.0 m below the surface).

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

Monitoring Component 4 – Young-of-year sturgeon

Sampling for young-of-year sturgeon was conducted with a benthic (beam) trawl between mid-July and early September 2006 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), thus intensive sampling was conducted at this location. The targeted sampling protocol was followed at this site.

Young-of-year sturgeon were processed in the field and laboratory. Total length (mm, excluding the caudal filament) was measured in the field. One of the pectoral fins or fin buds was clipped and placed in alcohol. After fin clipping, the fish was placed in a 5-10% formalin solution.

Table 3. Young-of-year sturgeon sampling sites for 2006. 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 and October 2006. Pallid sturgeon were sexed and staged, and selected individuals were transported to hatcheries.

Results and Discussion

Hydrologic conditions

Flow conditions in the Milk River during 2006 were low in comparison to most others years of this study (Figure 2). Median discharge between April 1 and September 30 was 2.97 m^3/s, and only 2001 had a lower median discharge than 2006. Whereas at least one large discharge pulse occurred in the Milk River during earlier years of the study, a large discharge pulse after May 1 did not occur during 2006.

In the absence of enhanced discharge via spillway releases, median discharge in the Missouri River downstream from Fort Peck Dam during 2006 was 214 m^3/s (Figure 2). This discharge level was exceeded in 2002 and 2003, but lower discharges occurred during 2001, 2004, and 2005. Maximum discharge during 2006 occurred during mid-June; however, dam operations quickly reduced this flow to a lower and more stable discharge pattern.

Median discharge in the Yellowstone River during 2006 (241.7 m^3/s) was the greatest level observed during the six years of this study (Figure 2). Two periods of elevated flow conditions occurred during late-May and mid-June, with the latter peak steadily declining to base flows by early August. Although median discharge from April through September was greatest in 2006, peak discharges were greater in 2002, 2003 and 2005 (Figure 2).

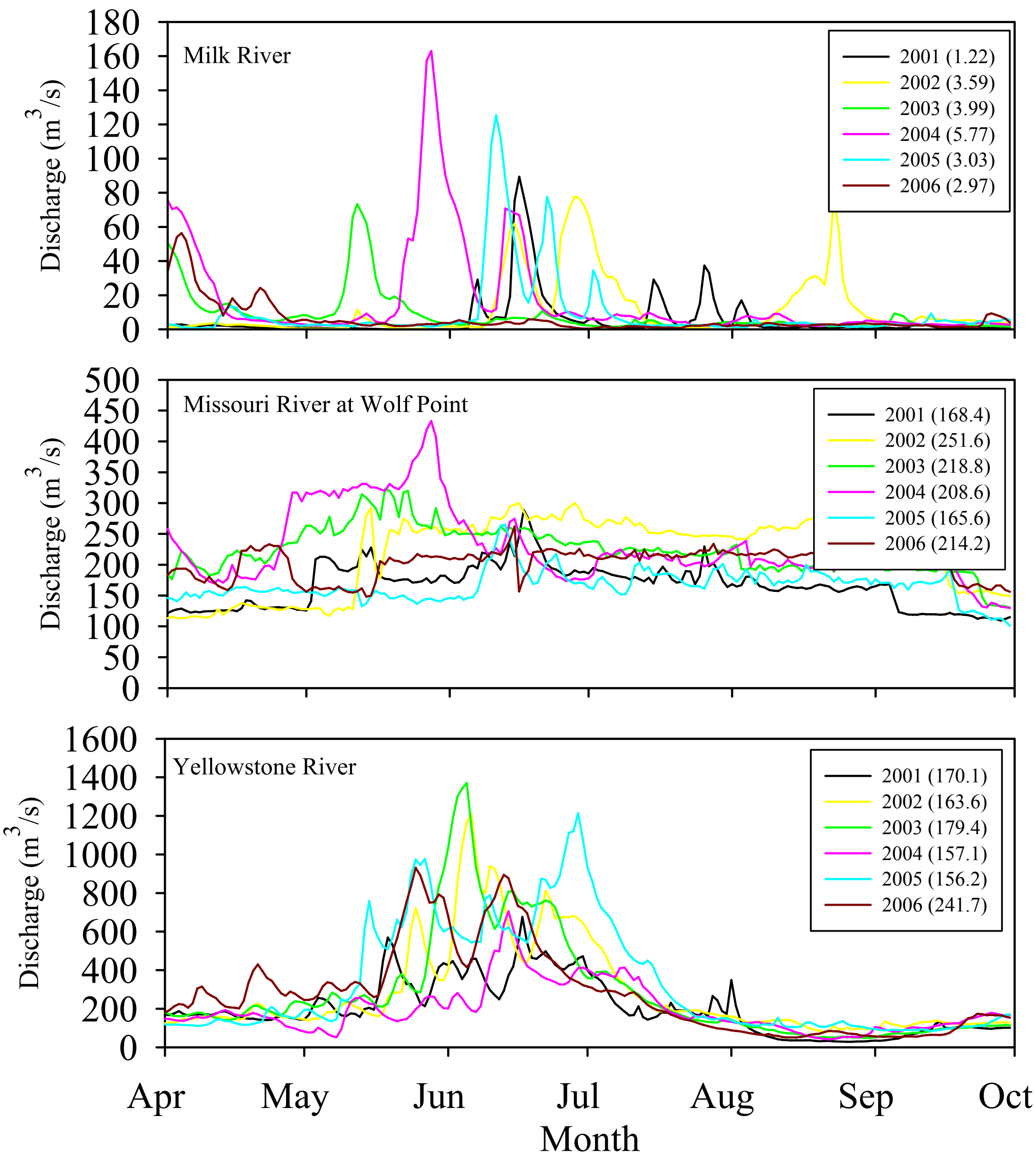


Figure 2. Mean daily discharge in the Milk River (gage 06174500), Missouri River at Wolf Point (gage 06177000), and in the Yellowstone River (gage 06329500) from April 1 through September 30 during 2001 - 2006. Values listed in parentheses represent median daily discharge (m^3/s) for the specified year between April 1 and September 30. Note the change in ordinate values among graphs.

Monitoring Component 1 - Water temperature and turbidity

General comments on water temperature loggers. Data were not recovered from 11 loggers deployed during 2006 (Table 1). All loggers on the mainstem Missouri River at Poplar were not recovered, thus no data were available for this site in 2006. However, at least one logger was recovered from Wolf Point, Culbertson, Nohly, and the Missouri River downstream from the Yellowstone River to characterize water temperature as these sites.

Pre- and post-deployment assessments of water temperature logger precision. Precision of water temperatures prior to deployment in 2006 was good in the cold and cool water bath treatments as evidenced by the narrow range of temperatures recorded in the cold (0.36 – 0.64) and cool treatments (0.39 – 0.49; Table 4). Thus, precision was relatively high for the cold and cool treatments. However, logger precision decreased in the warm treatments as indicated by the broader range of temperatures (1.30 – 1.50) across the five tests. No single logger exhibited consistently higher or lower temperatures than other loggers during the tests suggesting that overall precision of the loggers was lower at the warmer temperatures tested.

Twenty-nine loggers retrieved from the field were scrutinized during post-deployment tests. Initial precision tests indicated that the temperature range was relatively high (1.55 -1.81) for the cold, cool, and warm water bath treatments. Scrutiny of data from individual loggers indicated that one logger (681727, deployed in the Yellowstone River near Sidney) recorded water temperatures that were consistently lower than other loggers in common water bath treatments. Exclusion of this logger from the precision tests significantly improved outputs from the precision tests as indicated by the narrow range of temperatures for the cold treatment (0.44 – 0.51), cool treatment (0.38 – 0.50), and warm treatment (0.87 – 1.44; Table 5). Based on these results, water temperature data recorded by the upper Yellowstone River temperature logger are suspect for the deployment period. Conversely, good post-deployment precision for the other loggers in conjunction with the finding that pre- and post-deployment precision was similar suggests that water temperatures recorded in the field during 2006 accurately represented the thermal regime at deployment sites.

Table 4. Pre-deployment summary statistics for water temperature (^{o}C) comparisons among 41 water temperature loggers in common water bath treatments for 2006. Slight discrepancies in the range (maximum-minimum) occur in the table due to rounding.

Treatment	Sample	Logger mean	Logger minimum	Logger Maximum	Logger range	Logger SD
Cold	1	3.0	2.8	3.1	0.36	0.11
	2	3.1	2.9	3.4	0.49	0.12
	3	3.3	3.1	3.6	0.49	0.13
	4	3.2	2.9	3.4	0.49	0.11
	5	3.4	3.1	3.7	0.64	0.14
Cool	1	19.0	18.7	19.2	0.49	0.10
	2	19.0	18.7	19.1	0.44	0.10
	3	18.9	18.7	19.1	0.39	0.11
	4	18.8	18.6	19.1	0.49	0.10
	5	18.8	18.5	19.0	0.43	0.10
Warm	1	25.6	24.8	26.3	1.47	0.42
	2	25.3	24.5	26.0	1.50	0.40
	3	25.0	24.3	25.6	1.34	0.37
	4	24.8	24.1	25.4	1.30	0.37
	5	24.5	23.8	25.1	1.34	0.38

Table 5. Post-deployment summary statistics for water temperature (^{o}C) comparisons among 29 water temperature loggers in common water bath treatments for 2006. Slight discrepancies in the range (maximum-minimum) occur in the table due to rounding.

Treatment	Sample	Logger mean	Logger minimum	Logger maximum	Logger range	Logger SD
Cold	1	2.7	2.5	2.9	0.47	0.12
	2	2.9	2.6	3.1	0.47	0.12
	3	2.8	2.6	3.1	0.51	0.12
	4	2.7	2.5	2.9	0.44	0.11
Cool	1	19.6	19.3	19.8	0.50	0.12
	2	19.4	19.2	19.7	0.50	0.12
	3	19.3	19.0	19.5	0.50	0.12
	4	19.2	18.9	19.4	0.50	0.11
	5	19.1	18.9	19.2	0.38	0.11
Warm	1	26.7	25.9	27.3	1.44	0.33
	2	25.6	25.0	26.1	1.06	0.28
	3	24.7	24.2	25.2	1.06	0.24
	4	23.9	23.3	24.4	1.05	0.22
	5	23.2	22.8	23.7	0.87	0.18

Lateral and vertical comparisons of water temperature. Mean daily water temperature was compared among north bank, south bank, and stratified locations at 7 sites (Table 6). For all comparisons, mean daily water temperature did not differ significantly between stratified and bottom locations, or between north and south bank locations. These results indicate that water in the mainstem Missouri River was laterally and vertically homeothermal at the locations sampled during 2006.

Table 6. Summary statistics and probability values (P, from ANOVA or t-tests) for comparisons of mean daily water temperature (^oC) among water temperature loggers located on the north bank and south bank, and stratified in the water column during 2006. The letter listed in parentheses designates whether the stratified logger was positioned on the north bank (N) or south bank (S).

Site	Logger location	Number of days	Mean	SD	Minimum	Maximum	P
Below Fort Peck Dam	North	200	12.2	3.3	3.8	15.9	0.24
	South		11.8	3.4	3.2	15.6	
	Stratified(S)		11.7	3.4	3.1	15.5	
Nickels Ferry	North	200	12.7	3.1	4.8	16.6	0.58
	South		12.5	3.3	3.8	16.3	
	Stratified(N)		12.9	3.1	4.8	16.6	
Nickels Rapids	South	200	12.4	3.3	3.7	16.1	0.92
	Stratified(S)		12.4	3.2	3.8	16.0	
Frazer Pump	North	200	13.0	3.4	4.1	17.2	0.77
	South		13.0	3.4	3.9	17.1	
	Stratified(N)		13.2	3.3	4.3	17.3	
Frazer Rapids	North	200	12.9	3.3	4.0	17.0	0.43
	South		13.3	3.5	4.0	17.8	
	Stratified(N)		12.9	3.4	4.1	17.1	
Grandchamps	North	200	13.2	3.4	4.1	17.6	0.99
	South		13.1	3.5	3.8	17.9	
	Stratified(N)		13.2	3.4	4.1	17.6	
Below Yellowstone River	South	198	17.4	5.7	4.9	25.7	0.81
	Stratified(S)		17.5	5.7	4.9	25.8	

Longitudinal water temperatures. Mean daily water temperature differed significantly ($P < 0.0001$) among sites during the common deployment period during 2006 (Table 7; Figure 3). Mean daily water temperature was warmest in the free-flowing Missouri River upstream from Fort Peck Reservoir (Robinson Bridge, mean = 18.2°C), and coolest at the site downstream from Fort Peck Dam (mean = 12.0°C). Thus, hypolimnetic releases from the dam suppressed water temperature by an average of 6.2°C during the common deployment period. However, maximum water temperature was suppressed 11.3°C by dam releases between the Robinson Bridge site and the site below the dam. Water temperatures gradually increased from below Fort Peck Dam downstream to Nohly (most downstream Missouri River site prior to receiving inputs from the Yellowstone River). Although warming occurred, mean (16.7°C) and maximum (24.5°C) water temperatures at Nohly remained 1.5-2.4°C cooler than in the Missouri River upstream from Fort Peck Reservoir. Thus, despite gradual attenuation of the effects of hypolimnetic releases, water temperature remained impacted 290 km downstream from the dam.

Listed under reasonable and prudent alternatives in the Missouri River Biological Opionion (USFWS 2000), spillway releases from Fort Peck Dam are targeted to enhance water temperature to a minimum of 18.0°C at Frazer Rapids. Mean daily water temperature did not achieve 18.0°C at Frazer Rapids during 2006 in the absence of spillway releases. The maximum water temperature achieved at Frazer Rapids during 2006 was 17.3°C (July 11).

Table 7. Mean daily water temperature (°C) summary statistics (mean, minimum, maximum, standard deviation, SD; coefficient of variation, CV) for Missouri River mainstem locations and off-channel locations in 2006. Summary statistics for all sites except Fort Peck Reservoir were calculated for common deployment dates (4/12 – 10/24, N = 196 days) to standardize comparisons among all loggers. Inclusive dates for Fort Peck Reservoir spanned 5/15 – 10/24 (N = 163 days). Mainstem Missouri River sites are listed from upstream to downstream. See Figure 3 for a graphical representation of mean daily water temperatures.

Location	Site	Mean	Minimum	Maximum	SD	CV
Missouri River mainstem	Robinson Bridge	18.2	8.0	26.9	5.4	29.6
	Fort Peck Reservoir	17.7	9.8	24.5	4.1	23.3
	Below Fort Peck Dam	12.0	3.7	15.6	3.3	27.2
	Nickels Rapids	12.5	3.8	16.0	3.2	25.6
	Nickel Ferry	12.8	4.5	16.5	3.1	24.1
	Frazer Pump	13.1	4.1	17.2	3.3	24.9
	Frazer Rapids	13.1	4.0	17.3	3.3	25.1
	Grandchamps	13.3	4.0	17.7	3.3	25.2
	Wolf Point	14.6	4.4	20.7	4.4	30.2
	Culbertson	16.2	4.7	23.7	5.2	32.1
	Nohly	16.7	4.4	24.5	5.5	33.3
	Below Yellowstone	17.5	4.9	25.7	5.6	32.2
	Highway 85	17.5	5.1	25.8	5.6	32.1
Off-channel or tributary	Spillway	16.0	4.9	22.8	4.4	27.6
	Milk River	17.4	4.2	25.7	5.5	31.5
	Yellowstone River	17.5	4.0	25.9	5.7	32.4

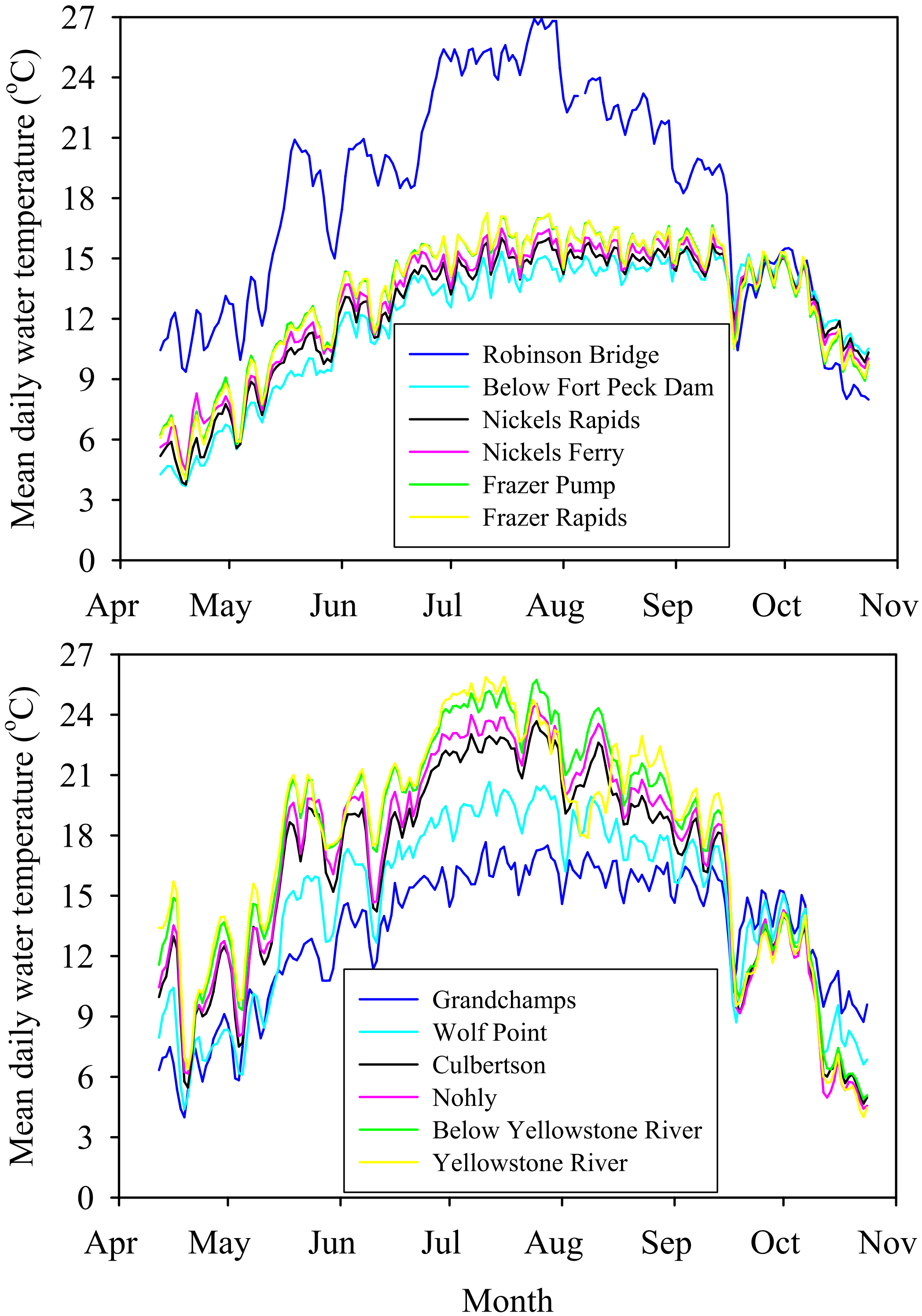


Figure 3. Mean daily water temperature (^{o}C) at 12 sites on the mainstem Missouri River, tributaries, and off-channel sites during 2006.

Inter-annual comparisons of mean daily water temperature within sites. Mean daily water temperature was compared among years for 16 sites, and temperature differed significantly at all sites with the exception of the Yellowstone River and Missouri River below the Yellowstone River confluence (Table 8). Excluding the Poplar site (for which data were not obtained in 2006), 2006 represented the year with the warmest mean daily water temperatures for 11 sites and the second warmest year for four sites. Water temperature from the Milk River in 2005 was not included because the data set was not complete (data collection terminated in mid-September 2005).

Table 8. Summary statistics (mean, ^oC; minimum, maximum, standard deviation, SD; coefficient of variation, CV; ANOVA probability value, P) for comparisons of mean daily water temperature among 2001 - 2006 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	P
Missouri River above Fort Peck Lake (Robinson Bridge)	2001	20.1	10.3	25.8	3.7	18.4	< 0.0001
	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	
Fort Peck Lake	2003	19.0	8.4	23.6	3.8	20.2	< 0.0001
	2004	16.4	7.9	22.0	3.6	22.3	
	2006	19.1	9.8	24.5	3.9	20.2	
Below Fort Peck Dam	2001	13.0	8.2	15.2	1.5	11.6	< 0.0001
	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	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	
Spillway	2001	18.4	10.7	23.8	3.0	16.6	< 0.0001
	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	
Milk River	2001	19.1	9.9	26.2	3.8	19.6	< 0.0001
	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	
Nickels Ferry	2001	13.4	8.3	18.4	1.8	13.6	< 0.0001
	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	
Nickels Rapids	2001	13.5	8.5	16.6	1.7	12.5	< 0.0001
	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	
Frazer Pump	2001	13.9	8.5	17.0	1.8	13.2	< 0.0001
	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	
Frazer Rapids	2001	13.8	8.3	17.3	1.8	13.3	< 0.0001
	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	
Grandchamps	2001	14.4	8.5	18.1	2.0	14.1	< 0.0001
	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	
Wolf Point	2001	16.5	9.4	22.7	3.1	18.7	< 0.0001
	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	
Poplar	2001	16.8	9.9	21.2	2.8	16.8	0.0056
	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	
Culbertson	2001	17.9	9.7	24.0	3.5	19.3	0.0023
	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	
Nohly	2001	18.9	11.4	25.3	3.8	20.0	< 0.0001
	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	
Yellowstone River	2001	19.3	10.7	26.6	4.2	21.7	0.0964
	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	
Below Yellowstone River	2001	19.4	9.8	26.0	4.1	20.9	0.1340
	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	
Highway 85 (Williston, ND)	2006	19.9	10.5	25.8	4.0	19.9	

Pre- and post-deployment accuracy of turbidity loggers. Turbidity accuracy varied among turbidity loggers during the pre- and post-deployment tests. During pre-deployment tests, recorded turbidity varied from 24.4 - 34.9 NTU for the 20 NTU standard, 177.1 – 235.4 NTU for the 200 NTU standard, and 739.6 – 1000 NTU for the 800 NTU standard (Table 9). Due to the lack of accuracy, an attempt was made to calibrate the loggers to the standard NTU values; however, calibrations were met with limited success. For example, calibrating a logger to one NTU standard would increase logger accuracy at NTU values near the standard, but not necessarily improve accuracy at other NTU standards. This situation was similar to laboratory and factory attempts to calibrate the loggers in earlier years – improvement might be gained at one standard, but not necessarily through the entire range of NTU. Following deployment in the field, post-deployment tests indicated decreased accuracy (increased drift) from NTU standards (Table 9); however, the logger deployed in the Yellowstone River exhibited minimal drift during deployment. Based on these considerations, turbidity measurements and daily patterns obtained during 2006 should be viewed as relative rather than absolute.

Table 9. Pre- and post-deployment turbidity assessments for 2006 of turbidity loggers subjected to common formazin NTU treatments. Values listed under each turbidity logger are the means of five turbidity measurements recorded during the trials. The maximum range of measurable turbidity for the loggers is 1000 NTU.

Formazin NTU	Deployment test	Frazer	Poplar	Nohly	Yellowstone
20	Pre	24.4	30.1	34.9	27.3
	Post	40.0	35.1	57.3	32.7
200	Pre	177.1	200.0	235.4	200.2
	Post	212.3	220.3	252.1	199.5
800	Pre	739.6	1000	1000	902.6
	Post	949.6	1000	1000	900.3

Field turbidity measurements. Hourly field measurements of turbidity recorded by the loggers varied greatly during the deployment period among and within sites. At the Frazer logger, at least one hourly measurement of 1000 NTU (maximum value measured by the loggers) was recorded on 7 dates between July 13 and July 21. At Poplar, an hourly measurement of 1000 NTU was recorded on eight dates between June 1 and July 20. In addition, the Poplar logger also recorded several measurements of 0 NTU between June 6 and July 30. These values likely reflect mechanical or electrical problems in the logger. All measurements of 0 NTU were excluded from the data set. Measured turbidities at Nohly exceeded 1000 NTU on one date (August 28), and 0 NTU was recorded periodically on three dates between June 6 and August 2. These measurements were excluded from the analysis. In the Yellowstone River, at least one hourly measurement of 1000 NTU was recorded on 12 dates between May 25 and July 29. Because the loggers did not record turbidity exceeding 1000 NTU and due to the fact that measurements of 0 NTU occurred, estimates of mean daily turbidity for specific dates were conservative and precluded quantitative statistical comparisons of spatial and temporal trends. Therefore, only general trends in turbidity are reported.

Turbidity in the Missouri River and Yellowstone River exhibited spatial and temporal variability. Spatially, turbidity in the Missouri River increased from upstream to downstream as median turbidity during the deployment period was lowest at Frazer, intermediate at Poplar, and highest at Nohly (Table 10). Turbidity in the Yellowstone River during 2006 tended to be slightly lower than in the Missouri River at Nohly. Temporally, periods of elevated turbidity occurred at all sites and many periods of elevated turbidity were associated with changes in river discharge. For example, periods of increasing and decreasing turbidity at Nohly typically coincided with increased and decreased flow events in the Missouri River (Figure 4). Most periods of elevated turbidity in the Yellowstone River were also associated with changing flow conditions. However, periods of elevated turbidity also occurred in the absence of major flow changes as observed at Poplar during early June and in the Yellowstone River during late July (Figure 4).

Table 10. Turbidity (nephelometric turbidity units; NTU) summary statistics for loggers deployed in the Missouri River at Frazer, Poplar and Nohly, and in the Yellowstone River during 2006.

Site	Maximum	75% quartile	Median	25% quartile	Minimum	Number of days
Frazer	964	62.1	19.2	11.6	0.3	100
Poplar	1000	133.0	38.9	22.6	0.4	98
Nohly	392	109.8	78.2	67.1	22.0	100
Yellowstone River	1000	303.4	58.3	26.3	13.6	100

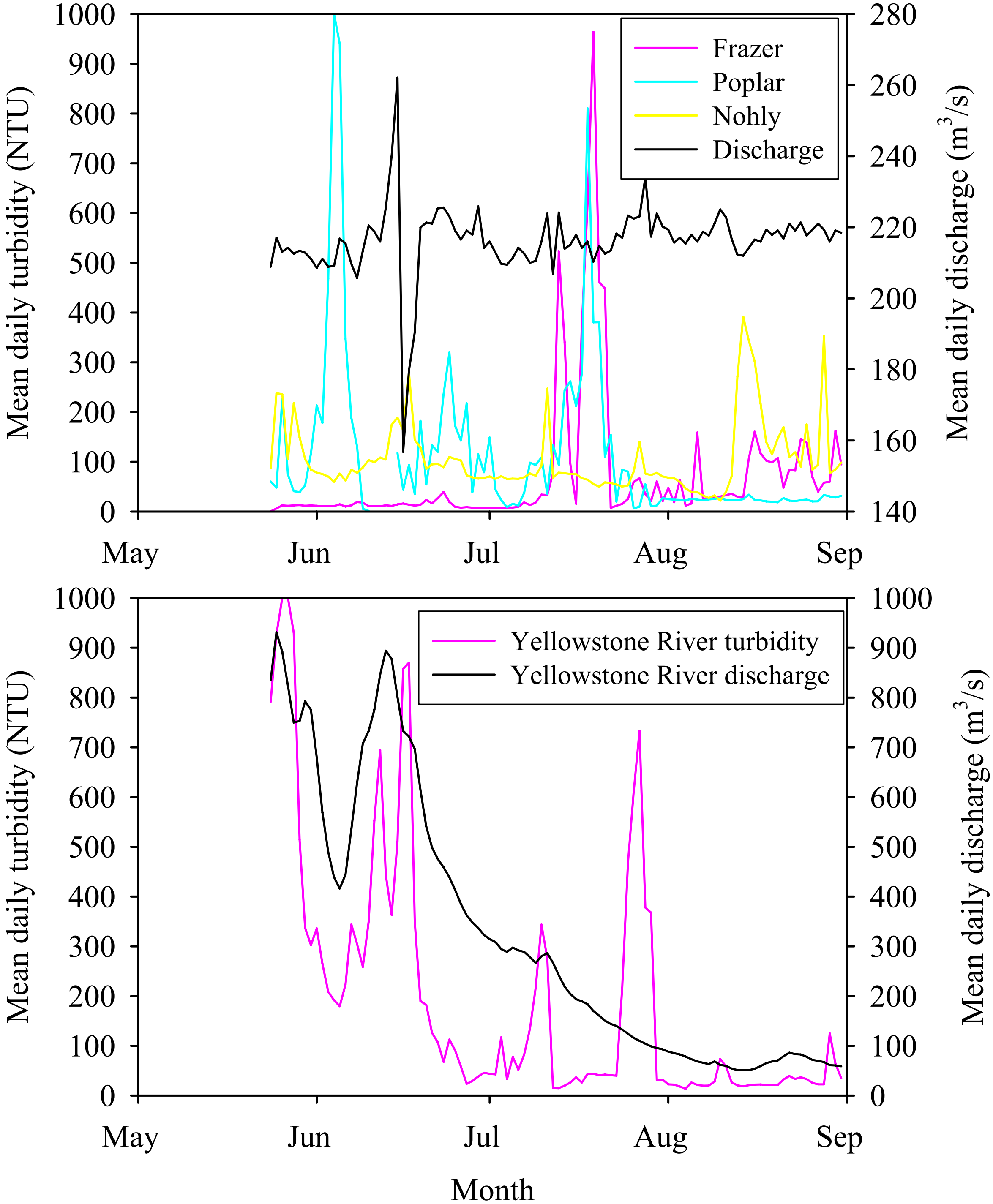


Figure 4. Mean daily turbidity (NTU) from turbidity loggers and discharge in the Missouri River near Frazer, Poplar, and Nohly, and in the Yellowstone River during 2006.

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

Extensive radio tracking was conducted between April and November in the lower Yellowstone River and in the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea. A total of 24 individual tracking events were conducted throughout the river systems. We obtained 1,022 relocations of shovelnose sturgeon, 995 relocations of blue suckers, 386 relocations of paddlefish, and 322 relocations of pallid sturgeon via boat.

The seven continuous-recording logging stations deployed during 2006 contributed additional movement and relocation information that augmented the manual tracking data set (Table 11). The logging stations recorded 131 contacts of 0-23 individual shovelnose sturgeon, 450 contacts for 0-32 individual blue suckers, 114 contacts of 0-19 individual paddlefish, and 80 contacts of 0-16 individual pallid sturgeon. The logging station located at the mouth of the Yellowstone River recorded the highest number of contacts and individuals for shovelnose sturgeon, paddlefish, and pallid sturgeon. Blue suckers were most frequent at the Nickels stations, below the Milk River.

Table 11. Number of contacts and number of individual fish recorded by eight logging stations for shovelnose sturgeon, blue sucker, paddlefish, and pallid sturgeon during 2006.

	Shovelnose sturgeon		Blue sucker		Paddlefish		Pallid sturgeon	
Logging Station	Contacts	Individ. fish	Contacts	Individ. fish	Contacts	Individ. fish	Contacts	Individ. Fish
Milk River	0	0	35	11	1	1	0	0
Nickels	33	9	178	32	0	0	1	1
Wolf Point	7	4	40	26	24	7	1	1
Culbertson	14	10	62	32	17	13	4	1
Ft. Buford	17	12	70	32	18	12	6	4
Williston	0	0	0	0	3	2	3	2
Yellowstone	60	23	65	31	51	19	65	16

Shovelnose sturgeon-.Fifty-two shovelnose sturgeon had active transmitters at the onset of the 2006 season. Fifty of these fish were manually relocated for a total of 1,022 relocations during the tracking season. A ground-based telemetry station in the Powder River (maintained by M. Jaeger, MTFWP) contacted one individual. The remaining shovelnose sturgeon was not relocated in 2006. The last relocation in 2005 was above Glendive in the Yellowstone River, out of the study area.

Relocations in the Missouri River above Wolf Point remained relatively consistent (40%-50%) throughout the year (Figure 5). Little immigration and emigration occurred in this reach, and most movements were just to and from the lower Missouri River. Sixteen-shovelnose sturgeon remained in this reach for the entire tracking season. All of these fish were implanted in areas within 20 kilometers of the dam.

The lower Missouri River reach from Wolf Point to Williston (which is near 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 5). There is little spawning that takes place in this reach due to the lack of gravel. This stretch of river has consistently been used as a movement corridor and an over-wintering area. A maximum of 48% of the fish was found during mid-September as shovelnose sturgeon emigrated out of the Yellowstone River.

Approximately 32% of shovelnose sturgeon over-wintered in the Yellowstone River in 2005-2006. Individuals steadily migrated into the Yellowstone River in April from the Missouri River between Wolf Point and Williston (Figure 5). The number of fish present in the Yellowstone River remained relatively constant from May through July (47% - 53%). During the first two weeks in August, the number of fish in the Yellowstone River declined to less than 10%, most likely due to low flows and high temperatures. There was no movement of shovelnose sturgeon between reaches after mid-August 2006.

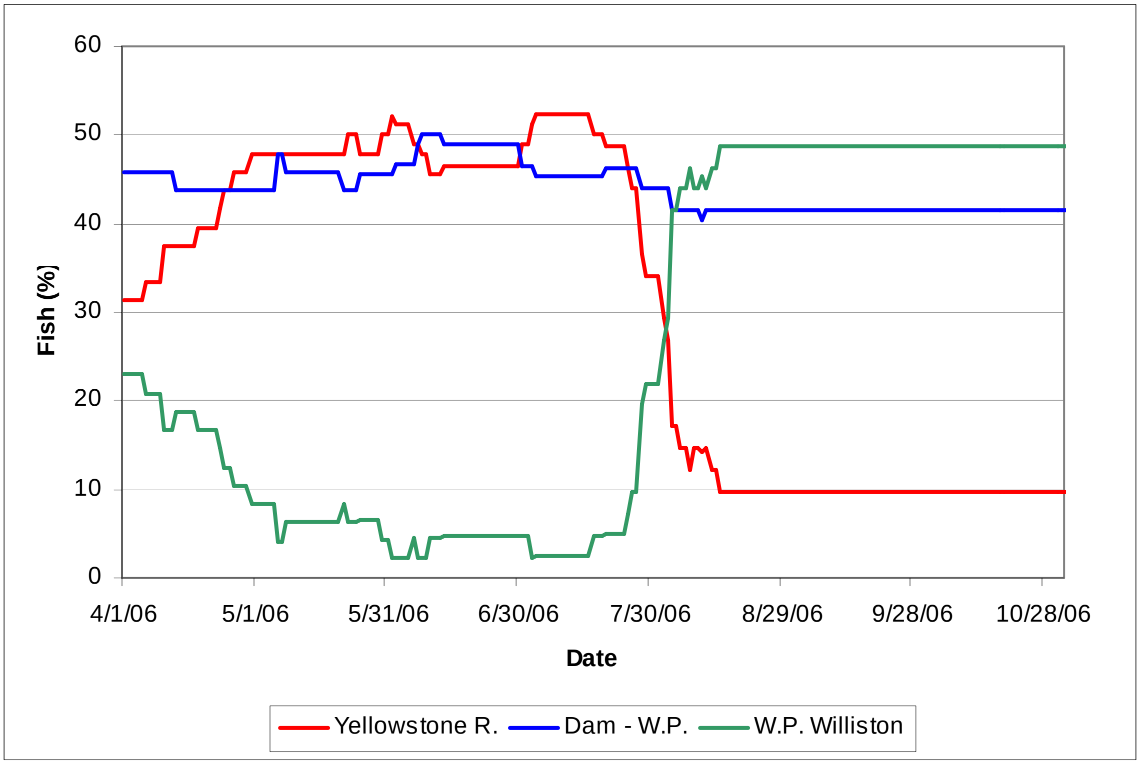


Figure 5. Percent of shovelnose sturgeon in the Missouri River reaches and the Yellowstone River in 2006 by date.

Blue sucker-.There were a total of 56 blue suckers that had active transmitters at the onset of the 2006 tracking season. Fifty-three of these fish were relocated for a total of 995 relocations in 2006. The remaining three individuals were last relocated in the fall 2005 below the confluence and presumably moved out of the study area into Lake Sakakawea.

The distribution and relative abundance of blue suckers varied among rivers through time (Figure 6). Through mid-May, blue suckers primarily used (>95% of relocations) the Missouri River between Fort Peck Dam and Williston, and most were relocated upstream from Wolf Point. The percentage of blue suckers relocated in this reach declined from 95% to 40% from mid-May to the end of June, and remained stable through mid-August. During the remainder of the tracking season, blue sucker relative abundance steadily increased as blue suckers emigrated out of the Yellowstone River and began migrating back up the Missouri River to areas they had previously been occupied earlier in the spring.

Blue suckers did enter the Milk River in 2006; however, most forays were of short duration (1-3 days) as evidenced by ground stations. Only one individual passed the ground station at Glasgow (R.M. 52) and resided in the Milk River for almost two months. Milk River discharge was very low in 2006 (Figure 2).

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 from April to mid-May (<5% of individuals), consistently increased through June, remained high (55-60% of individuals) through early August, and then declined through the remainder of the tracking season.

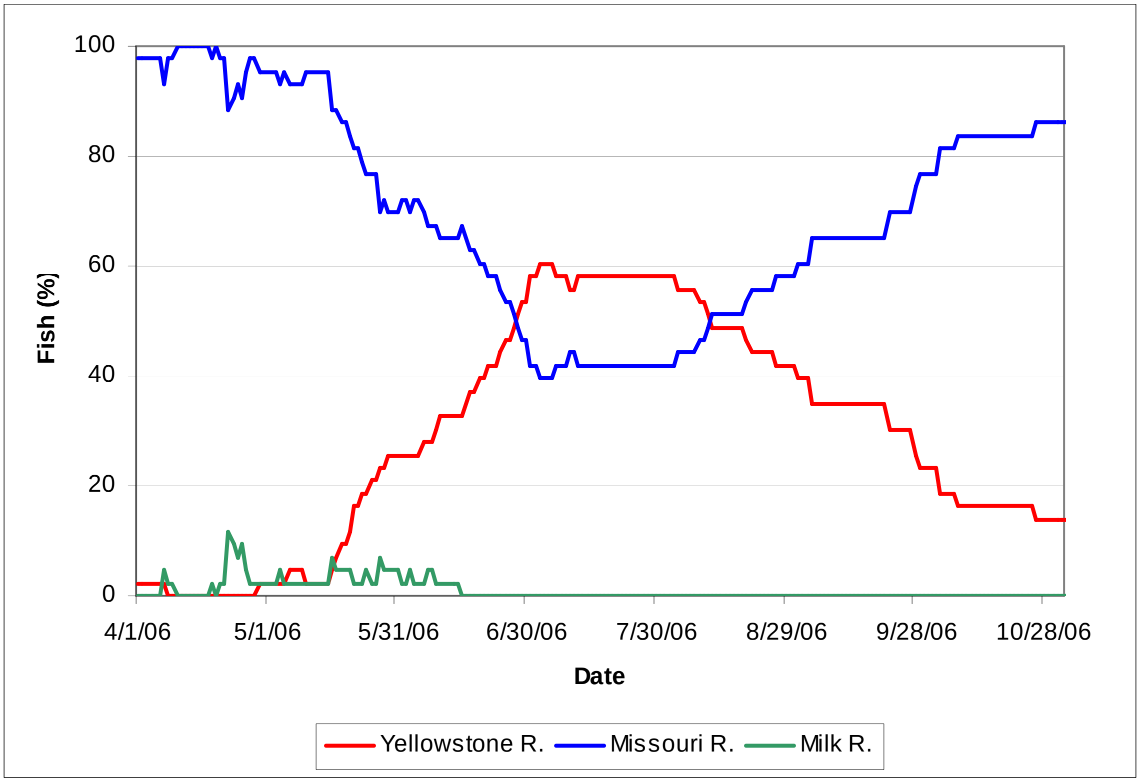


Figure 6. Percent of blue sucker in the Missouri River, Milk River, and the Yellowstone River in 2006 by date.

Paddlefish.-Thirty-nine paddlefish were relocated for a total of 386 relocations in 2006. Paddlefish exhibited distinct use patterns of Missouri River reaches and the Yellowstone River in 2006 (Figure 7). Relative abundance of paddlefish in the Missouri River above the confluence of the Yellowstone River (ATC) increased through April to 40%. Relocations fluctuated and reached a maximum of 44% in mid-June. Then paddlefish steadily emigrated out of this reach through late July. No telemetered paddlefish entered the Milk River in 2006.

Relative abundance of paddlefish in the Missouri River below the Yellowstone River confluence (BTC) followed distinct seasonal patterns (Figure 7). All paddlefish that were implanted BTC were relocated there at the onset of tracking in early April. Use of this reach declined as paddlefish began making their spawning migrations up the Missouri and Yellowstone rivers (min. 7%). Use of this reach steadily increased from mid-June through late July as paddlefish returned from their spawning migrations (maximum 93%).

Temporal use of the Yellowstone River by paddlefish occurred during a 2.5 month period (Figure 7). Relative abundance increased through April, reached a maximum of 66% in late May, then declined through June. No fish were relocated in the Yellowstone River after June 23. Consistent with previous years, approximately one-third and two-thirds of paddlefish implanted below the confluence ascended the Missouri River and Yellowstone River, respectively.

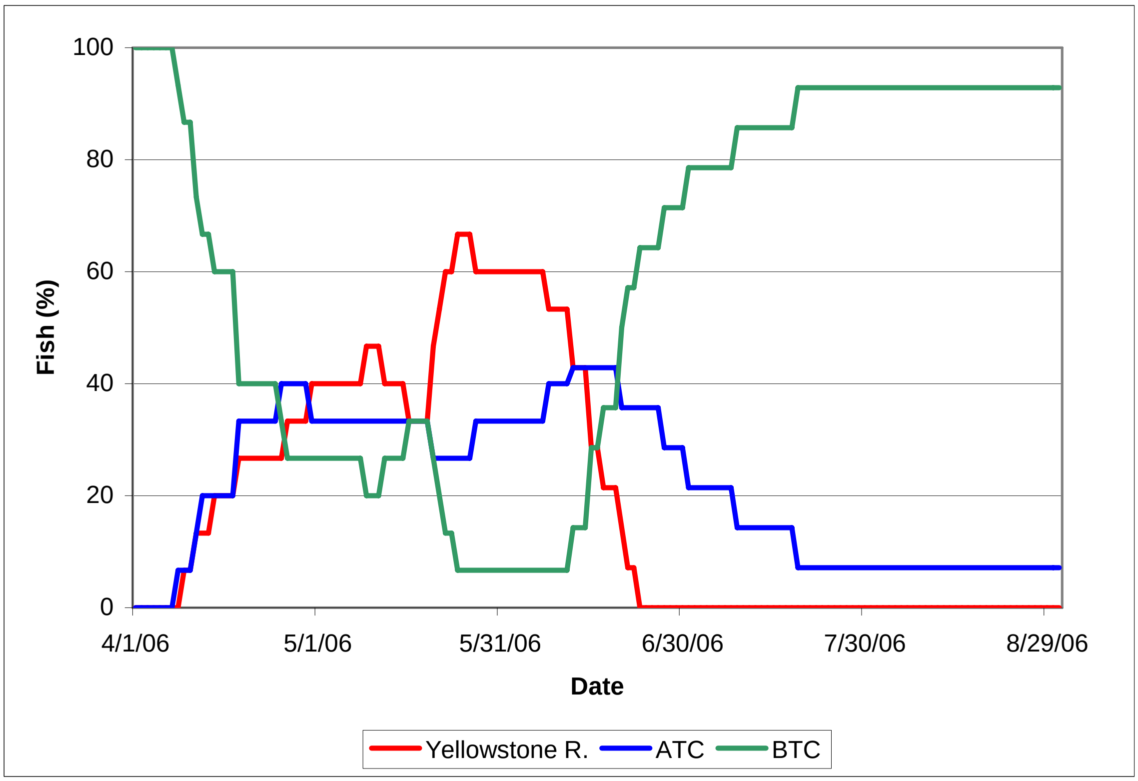


Figure 7. Percent of ascending paddlefish in the Missouri River above the confluence and the Yellowstone River in 2006 by date

Pallid sturgeon.-Eighteen pallid sturgeon were relocated for a total of 322 relocations in 2006. Two fish were taken to the hatchery and used in the propagation program in the spring.

Use of the Missouri River ATC by pallid sturgeon occurred during 2006 (Figure 8), but was minimal. The two fish that were implanted in the Missouri River above the confluence of the Yellowstone River remained there until late May and early June, then emigrated out of the Missouri River and into the Yellowstone River.

In general, there was inverse use pattern for pallid sturgeon between the Yellowstone River and Missouri River BTC (Figure 8). Pallid sturgeon use of the Missouri River BTC declined from early April through mid-May as individuals migrated 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 from early-July through the end of the tracking season.

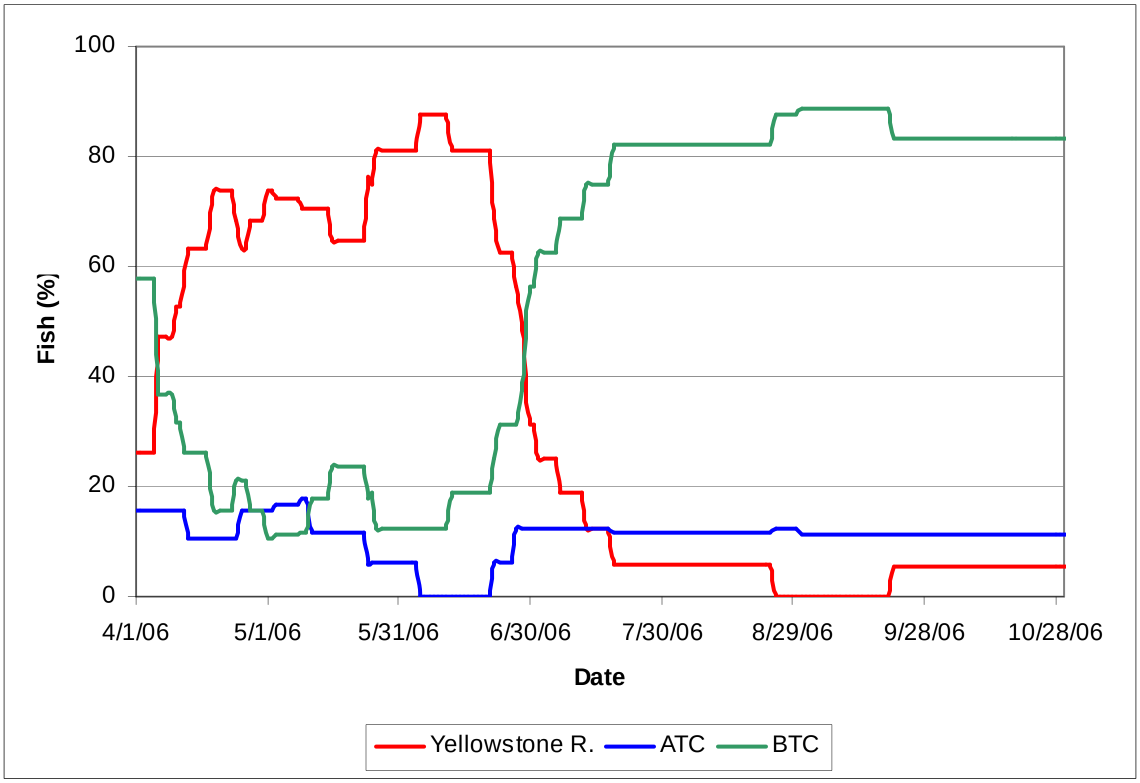


Figure 8. Percent of pallid sturgeon in the Missouri River ATC, Missouri River BTC, and Yellowstone River by date during 2006.

Transmitter implantation.-A total of 41 fish partitioned among 18 shovelnose sturgeon, 19 blue suckers, and four pallid sturgeon were implanted with radio transmitters during 2006 (Table 12). Shovelnose sturgeon and blue suckers implanted with transmitters were captured from several areas of the Missouri River between the Milk River confluence area and the Yellowstone River confluence. Three pallid sturgeon were sampled from the Missouri River BTC, and one individual was sampled in the Yellowstone River.

Table 12. Number, sex ratio (male:female:undetermined), length (mm), and weight (g) for shovelnose sturgeon, blue suckers, and pallid sturgeon implanted with transmitters during September and October 2006.

Species	Number tagged	Sex Ratio	Metric	Mean	Minimum	Maximum
			Length	792	704	887
Shovelnose sturgeon	18	3:14:1	Weight	2260	1500	4300
			Length	736	705	793
Blue sucker	19	7:11:1	Weight	3509	2900	4400
			Length	1476	1347	1585
Pallid sturgeon	4*	2:1:1	Weight	18000	13500	22000

* Includes one non-gravid female implanted in April 2006.

Monitoring Component 3 – Distribution and Abundance of Larval Fish

Larval fishes during 2006 were sampled on 21 individual sampling events between May 23 and August 3. The sampling regime resulted in a total of 2,044 larval fish samples partitioned among the Missouri River downstream from Fort Peck Dam (252 samples), spillway channel (168 samples), Milk River (368 samples), Missouri River at Wolf Point (420 samples) and Nohly (418 samples), and in the Yellowstone River (418 samples). Mean volume of water sampled per subsample was 60.3 m^3 at the site downstream from Fort Peck Dam (total volume = 15,199 m^3), 21.8 m^3 in the spillway channel (total volume = 3,656 m^3), 87.0 m^3 in the Milk River (total volume = 32,040 m^3), 72.7 m^3 in the Missouri River at Wolf Point (total volume = 30,531 m^3), 64.1 m^3 in the Missouri River at Nohly (total volume = 26,806 m^3), and 37.2 m^3 in the Yellowstone River (total volume = 15,536 m^3).

Relative abundance of larval fishes and eggs. A total of 3,752 larvae representing eight families were sampled across all sites during 2006 (Table 13). Representatives of Catostomidae (i.e., suckers) were numerically dominant and composed 60.5% of all larvae sampled. The Cyprinidae (i.e., carps and minnows) composed 23.2% of the larvae sampled. Representatives of Percidae (i.e., perches) and Hiodontidae (exclusively goldeye, *Hiodon alosoides*) composed 9.0% and 3.4% of the larvae sampled, respectively. A total of 17 Acipenseridae larvae (0.5% of the total) and 55 Polyodontidae larvae (exclusively paddlefish, 1.5% of the larvae) were identified, but two additional larvae (0.05% of the total) could not be confidently distinguished as *Scaphirhynchus sp*. or paddlefish. Thirteen acipenseriform eggs were sampled in addition to nearly 31,000 eggs from other species.

Composition of the larval fish assemblage sampled during 2006 varied among sites. Six taxonomic families were identified from larvae sampled in the Yellowstone River, and the Missouri River at Wolf Point and Nohly (Table 13). The Milk River, spillway channel, and

Missouri River site downstream from Fort Peck Dam yielded 4, 3, and 2 families, respectively. Representatives of Catostomidae and Cyprinidae were sampled from all sites. Percidae were found in the spillway channel, Milk River, Wolf Point, and Nohly. Freshwater drum (family Sciaenidae) occurred in the Milk River, at Nohly, and in the Yellowstone River. Larval acipenserids were sampled at three sites (Missouri River at Wolf Point and Nohly, Yellowstone River). Paddlefish occurred only at Wolf Point and in the Yellowstone River.

Table 13. Number (N) and frequency (%) of larval fishes, and numbers of juveniles, adults, and eggs sampled at six sites during 2006.

	Below Fort Peck Dam		Spillway		Milk River		Wolf Point		Nohly		Yellowstone River	
Taxon	N	%	N	%	N	%	N	%	N	%	N	%
Acipenseridae							4	0.4	1	0.3	12	1.5
Catostomidae	107	92.2	284	87.9	498	42.7	747	72.7	181	53.9	452	57.5
Cyprinidae	7	6.0	32	9.9	627	53.8	50	4.9	28	8.3	126	16.1
Hiodontidae									1	0.3	127	16.2
Percidae			5	1.5	2	0.2	214	20.8	115	34.2		
Polyodontidae							1	0.1			54	6.9
Salmonidae							1	0.1				
Sciaenidae					25	2.1			1	0.3	2	0.3
Unknown-sturgeon/paddlefish											2	0.3
Unknown-other	2	1.7	2	0.6	13	1.1	11	1.1	9	2.7	9	1.1
Total larvae	116		323		1165		1028		336		784	
Juveniles	2		208		1450		2		1		3	
Adults			4		73				1		2	
Sturgeon/ paddlefish eggs					6				2		5	
Misc. eggs	3900		19		804		8377		2918		14739	

Spatial and temporal periodicity and densities of larval Scaphirhynchus sp. and larval paddlefish. Only four larval sturgeon were sampled in the Missouri River at Wolf Point during 2006 (Table 14). Individual larval sturgeon were sampled on July 3, July 10, July 12 and July 17, and maximum densities were less than 0.40 larvae/100 m^3. Only one larval paddlefish was sampled at Wolf Point during 2006, and this individual was sampled on June 26 (Table 14).

Table 14. Total number sampled (N), median density (number/100 m^3), minimum density (min.), and maximum density (max.) of larval sturgeon (*Scaphirhynchus* sp.) and larval paddlefish by date in the Missouri River at Wolf Point during 2006.

	Scaphirhynchus sp.				Paddlefish			
Date	N	Median	Min.	Max.	N	Median	Min.	Max.
5/24								
5/30								
6/1								
6/05								
6/08								
6/12								
6/14								
6/19								
6/21								
6/26					1	0	0	0.32
6/28								
7/3	1	0	0	0.31				
7/06								
7/10	1	0	0	0.38				
7/12	1	0	0	0.29				
7/17	1	0	0	0.25				
7/21								
7/24								
7/26								
7/31								
8/02								

Larval fish sampling in the Missouri River at Nohly during 2006 yielded only one larval sturgeon. This individual was collected on July 11, and density was low (median = 0, maximum = 0.34 larvae/100 m^3). No larval paddlefish were collected at Nohly during 2006.

A total of 12 larval sturgeon were sampled in the Yellowstone River during 2006. Larval sturgeon first occurred in the drift on June 6 (Table 15). Collections were devoid of larval sturgeon for the next two weeks, but several larvae were sampled between June 22 and July 11. Median densities were low, and never exceeded 0.53 larvae/100 m^3.

Larval paddlefish in the Yellowstone River were initially sampled on May 31, and remained present in the drift through June 27 (Table 15). The greatest density of larval paddlefish occurred on June 6 (median = 4.39 larvae/100 m^3). Numbers of larval paddlefish declined through June 20, then increased on June 22 and June 27 as densities increased to 0.31 larvae/100 m^3.

Table 15. Total number sampled (N), median density (number/100 m^3), minimum density (min.), and maximum density (max.) of larval sturgeon (*Scaphirhynchus* sp.) and larval paddlefish by date in the Yellowstone River during 2006.

	Scaphirhynchus sp.				Paddlefish			
Date	N	Median	Min.	Max.	N	Median	Min.	Max.
5/23								
5/31					1	0	0	0.88
6/2					4	0	0	3.82
6/6	1	0	0	2.57	29	4.39	0.44	9.95
6/8					6	0.53	0	1.21
6/13								
6/15					1	0	0	0.50
6/20					1	0	0	0.22
6/22	2	0	0	0.83	8	0.31	0	2.29
6/27	7	0.53	0	1.49	4	0.31	0	0.74
6/29	1	0	0	0.37				
7/3								
7/5								
7/11	1	0	0	1.89				
7/13								
7/18								
7/20								
7/25								
7/27								
8/1								
8/3								

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

Larval catostomids and cyprinids were the only two taxa sampled in the Missouri River at the site downstream from Fort Peck Dam (Figure 9). Catostomids were initially collected on June 5, and densities increased to maximum levels (mean = 2.78 larvae/100 m^3) on June 29. Following brief periods of reduced densities, elevated densities of Catostomidae also occurred on July 13 (mean = 1.05 larvae/100 m^3) and July 24 (mean = 0.79 larvae/100 m^3). Larval cyprinids initially occurred on June 15 (mean density = 0.43 larvae/100 m^3) as larval common carp composed 100% of the cyprinids sampled. Larval cyprinids were represented at this site through August 3, but densities were low (< 0.23 larvae/100 m^3).

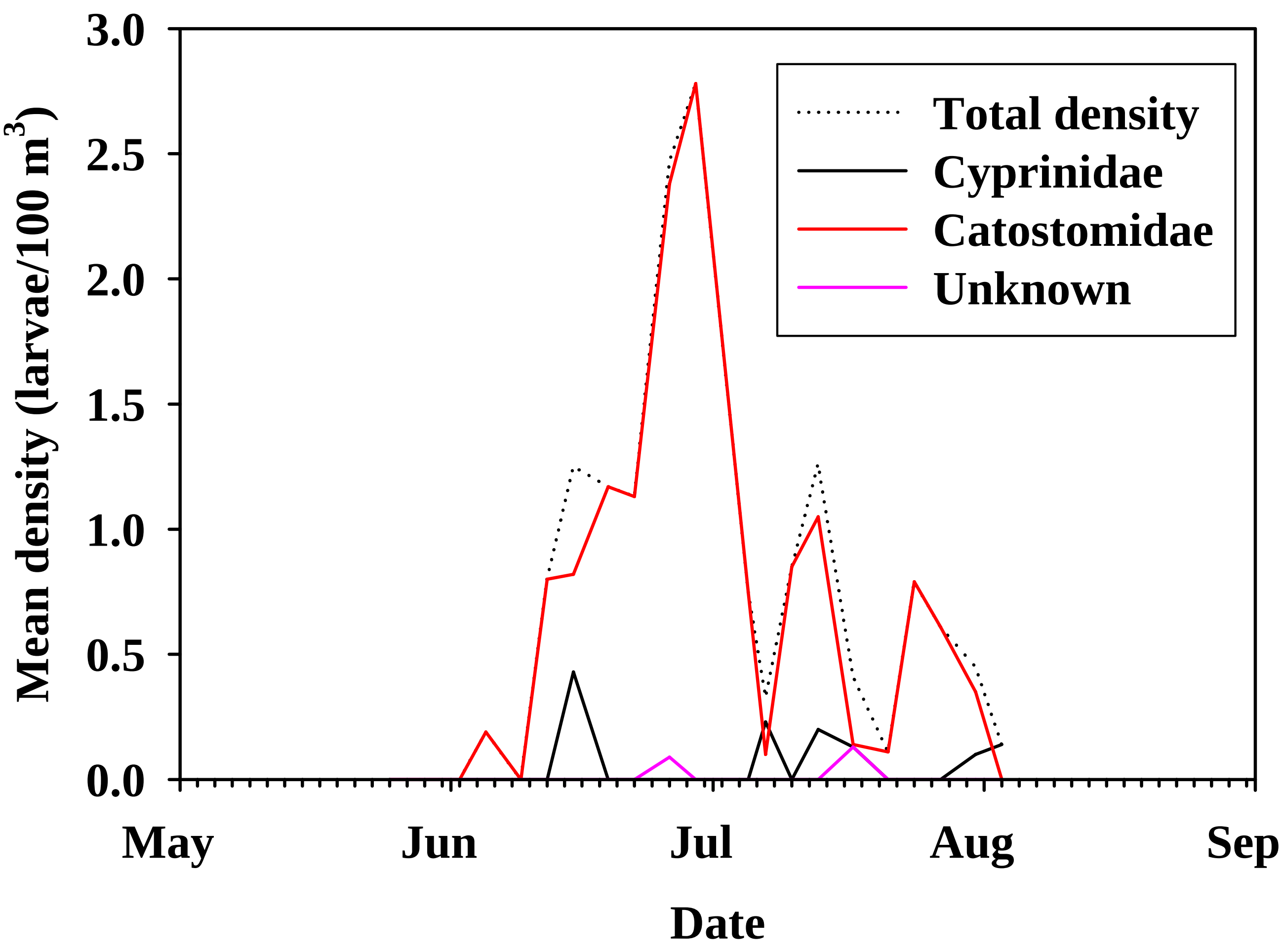


Figure 9. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, and unknown sampled in the Missouri River at the site downstream from Fort Peck Dam during 2006.

Three taxa of larval fishes were identified from the spillway channel during 2006 (Figure 10). Larval percids were sampled between May 25 and June 15, but at low densities (≤ 1.47 larvae/100 m^3). Catostomids exhibited three periods of elevated densities as mean density was 21.7, 86.4, and 38.6 larvae/100 m^3 on June 15, June 29, and July 17, respectively. Larval cyprinids were sampled from June 15 through August 3, but densities were highest (mean = 3.70 larvae/100 m^3) on July 31.

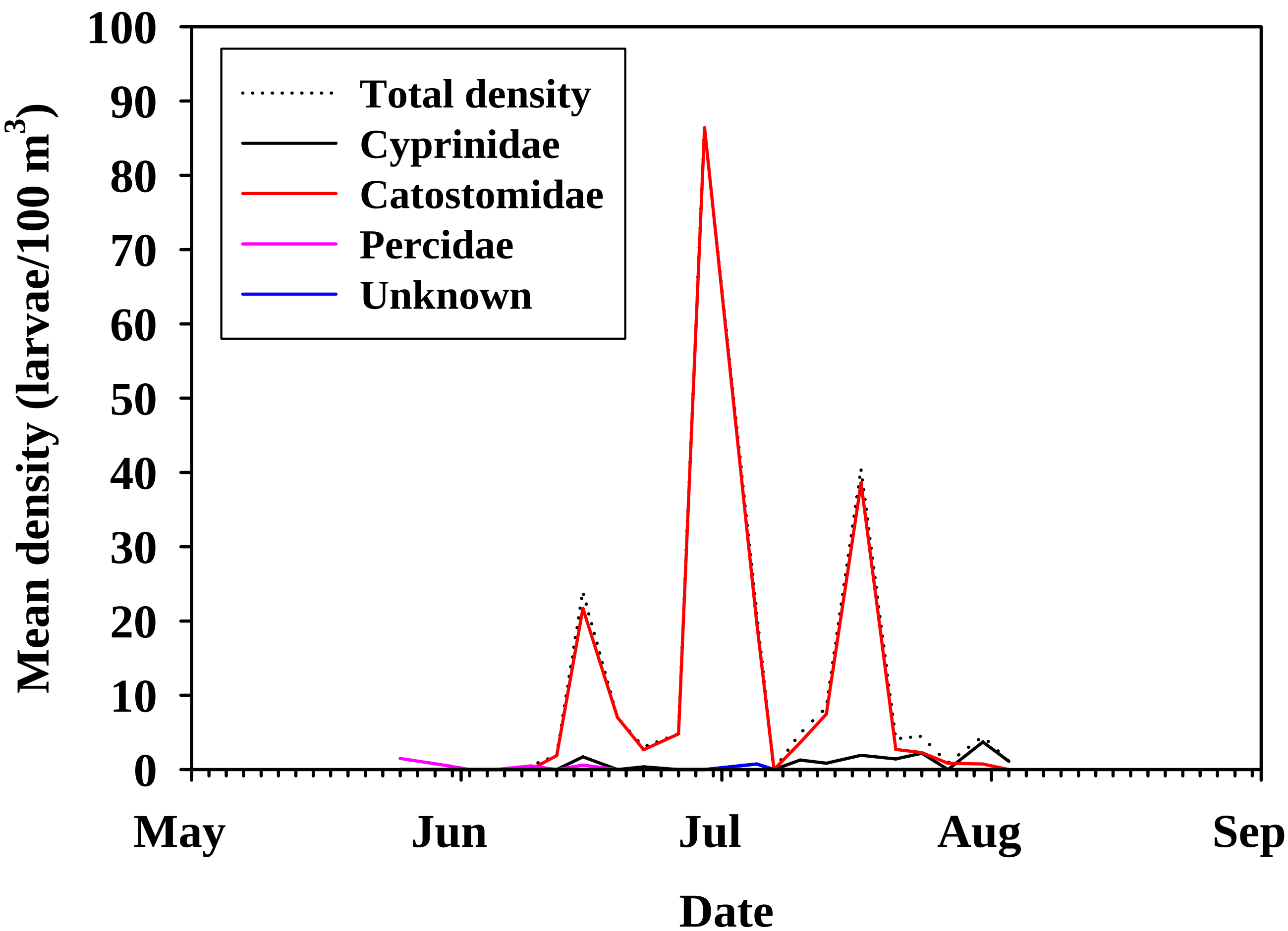


Figure 10. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, and unknown sampled in the Fort Peck spillway channel during 2006.

In the Milk River, four larval fish taxa were identified from samples collected between May 25 and August 3 (Figure 11). Total density of larval fishes in the community was low (≤ 2.21 larvae/100 m^3) through June 29. Density increased substantially on July 5 (mean = 19.9 larvae/100 m^3) as cyprinids and catostomids composed 59% and 41% of the catch, respectively. After July 5, total density of larval fishes declined. Low densities of larval percids (≤ 0.06 larvae/100 m^3) were sampled in the Milk River on two dates (June 26, July 7). Larval freshwater drum (family Sciaenidae) were sampled on 9 of 15 dates between June 5 and July 24, but densities were low (mean < 0.50 larvae/100 m^3).

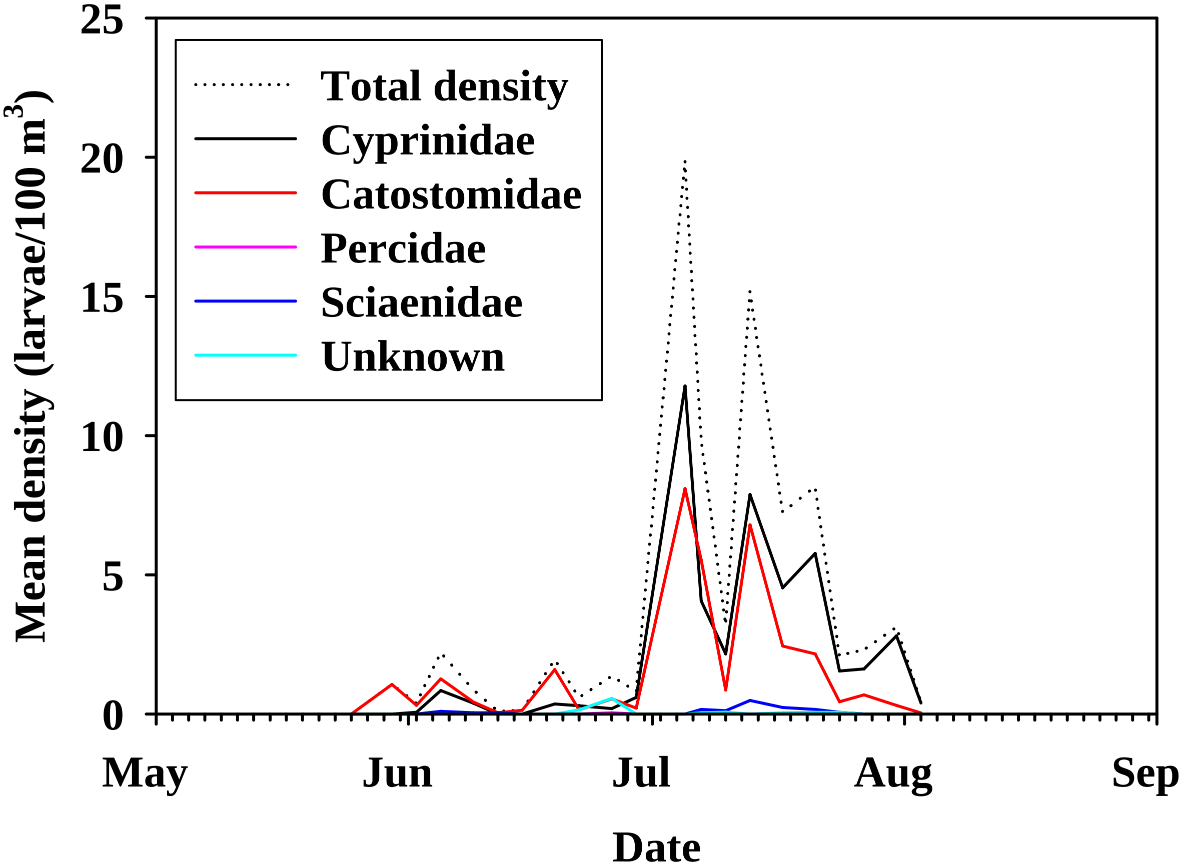


Figure 11. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Sciaenidae, and unknown sampled in the Milk River during 2006.

Taxonomic composition and densities of larval fishes exhibited substantial temporal variation at the Missouri River site near Wolf Point (Figure 12). Larval percids were sampled in the drift between May 24 and June 14, and maximum density occurred on June 1 (mean = 7.4 larvae/100 m^3). Following peak densities of percids, total density increased to a maximum of 8.43 larvae/100 m^3 on June 21 as catostomids comprised 97% of the community. Cyprinids were represented in the larval fish community on 15 of 21 dates during 2006 and achieved highest densities on June 26 (0.56 larvae/100 m^3).

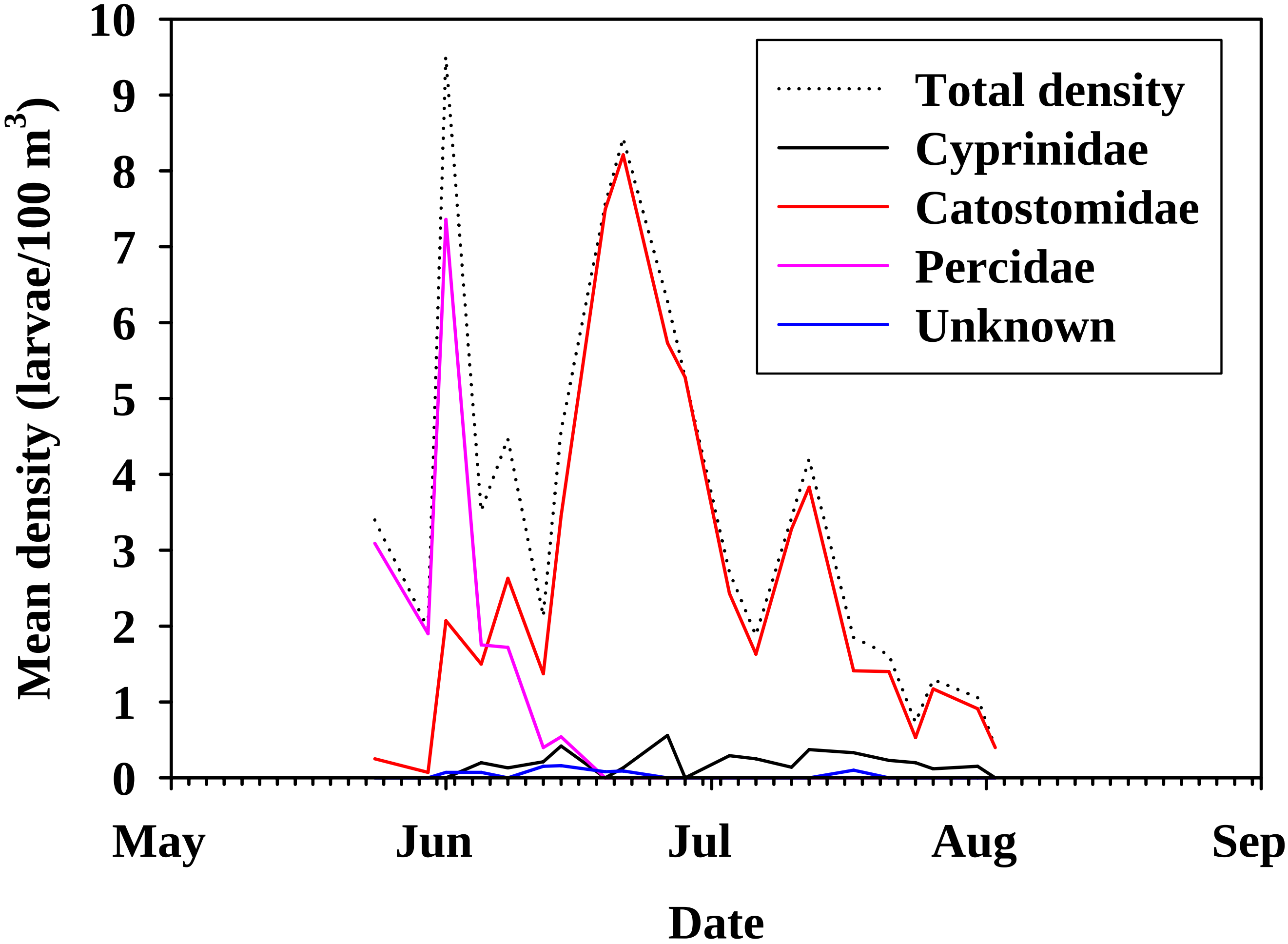


Figure 12. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, and unknown sampled in the Missouri River at Wolf Point during 2006.

Taxonomic periodicity and patterns of larval fish abundance in the Missouri River at Nohly (Figure 13) were similar to those in the Missouri River at Wolf Point. Percids were present at Nohly between May 23 and June 15, but densities were greatest on May 23 (mean = 6.62 larvae/100 m^3) when this taxon composed 89% of total density. Total densities of larval fish peaked on June 15 (mean = 9.05 larvae/100 m^3) when larval catostomids composed 85% of the larval fish sampled. Cyprinids were intermittently sampled during the collection period at low densities ($\leq$ 0.62 larvae/100 m^3). Larval freshwater drum (Sciaenidae) and goldeyes (Hiodontidae) occurred in the drift on one day as these taxa were collected on July 3 and May 23, respectively.

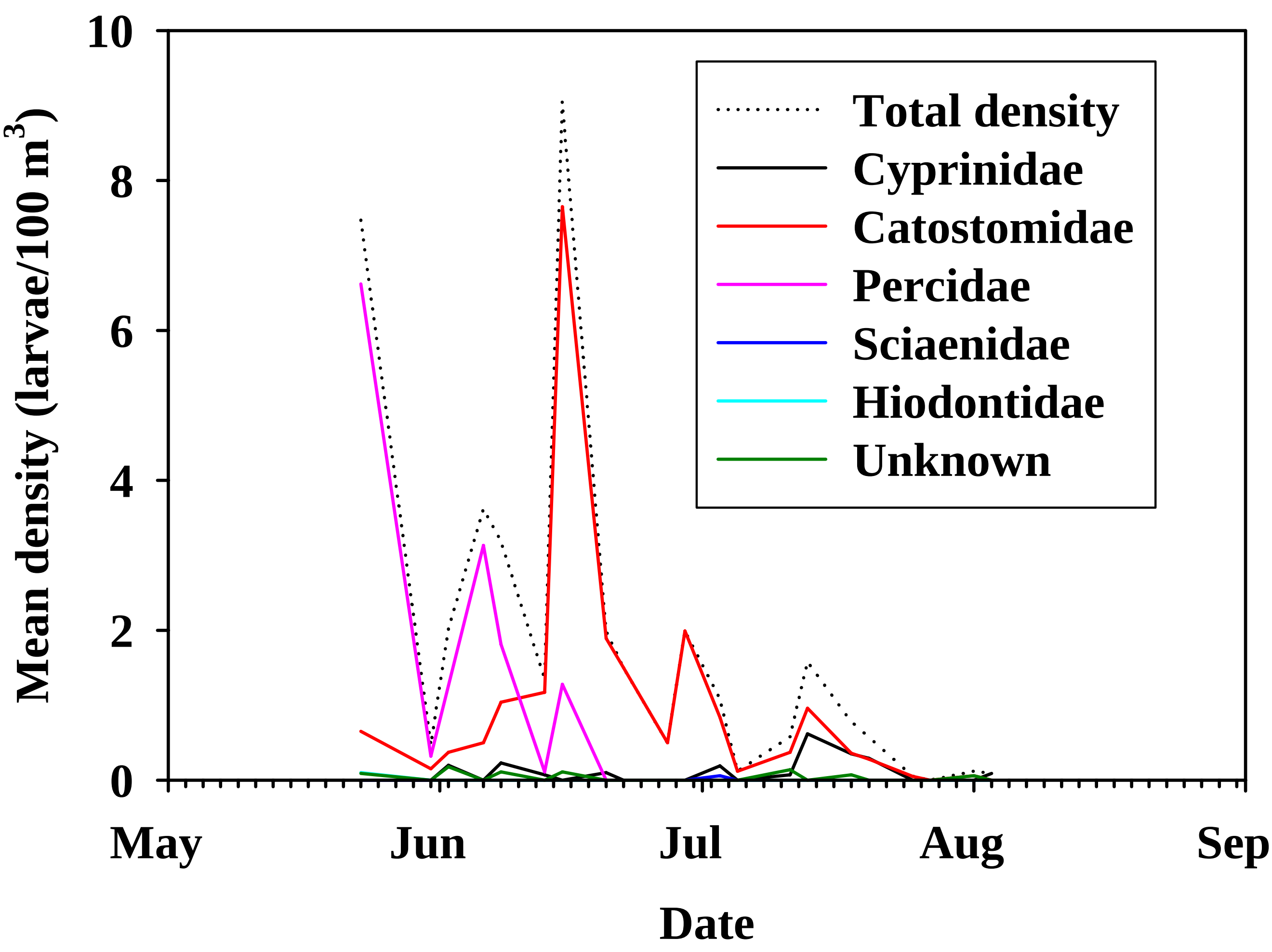


Figure 13. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Sciaenidae, Hiodontidae, and unknown larvae sampled in the Missouri River near Nohly during 2006.

The larval fish community sampled in the Yellowstone River during 2006 included representatives of Cyprinidae, Catostomidae, Sciaenidae, and Hiodontidae (Figure 14). Total densities were high (mean = 14.61 larvae/100 m^3) on the initial sampling date of May 23 as goldeyes composed 59% of the larvae sampled. Total densities declined following this initial sampling date, but increased substantially on July 3 (mean = 22.83 larvae/100 m^3) as catostomids increased in abundance (86% of all larvae). A third period of elevated densities occurred on July 18 (mean = 16.38 larvae/100 m^3) as this peak was comprised predominantly of larval cyprinids (61% of the community). Larval freshwater drum were sampled only on June 8 (mean density = 0.22 larvae/100 m^3).

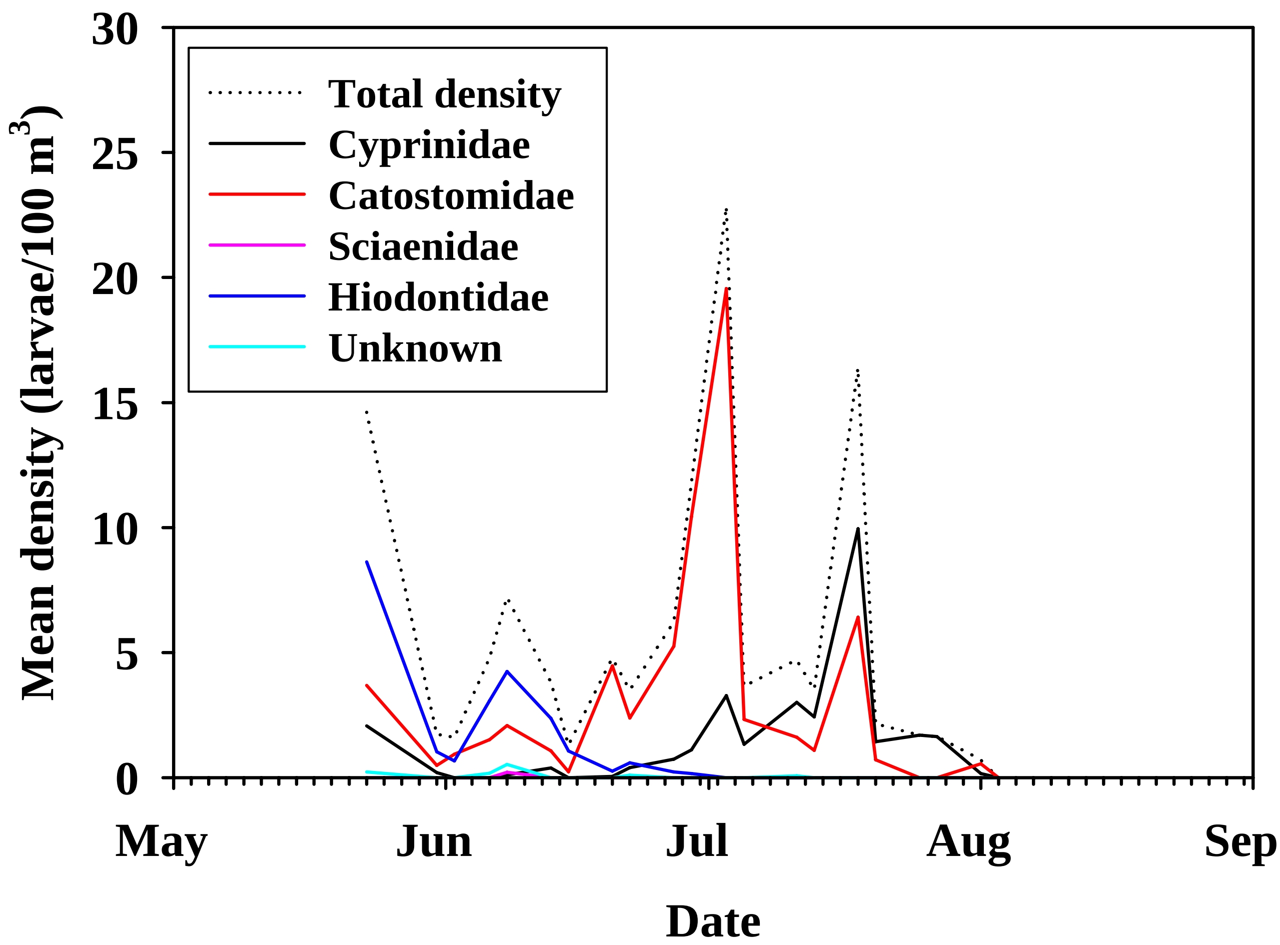


Figure 14. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Sciaenidae, Hiodontidae, and unknown larvae sampled in the Yellowstone River during 2006.

Inter-annual trends in larval fish densities

The final analyses 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 among sites and years are illustrated below (Figure 15). For example, mean densities of larval fish in the Milk River and Missouri River at Wolf Point exhibit a similar pattern as densities were moderate in 2001, increased greatly during 2002, declined in 2003, slightly increased during 2004 and 2005, then declined in 2006. A similar pattern was noted in the Missouri River at Nohly with the exception of elevated densities during 2001 when this site exhibited extreme variability. Densities of larval fish in the Missouri River downstream from Fort Peck Dam have been relatively stable among years, with an exception during 2005 when densities were slightly elevated.

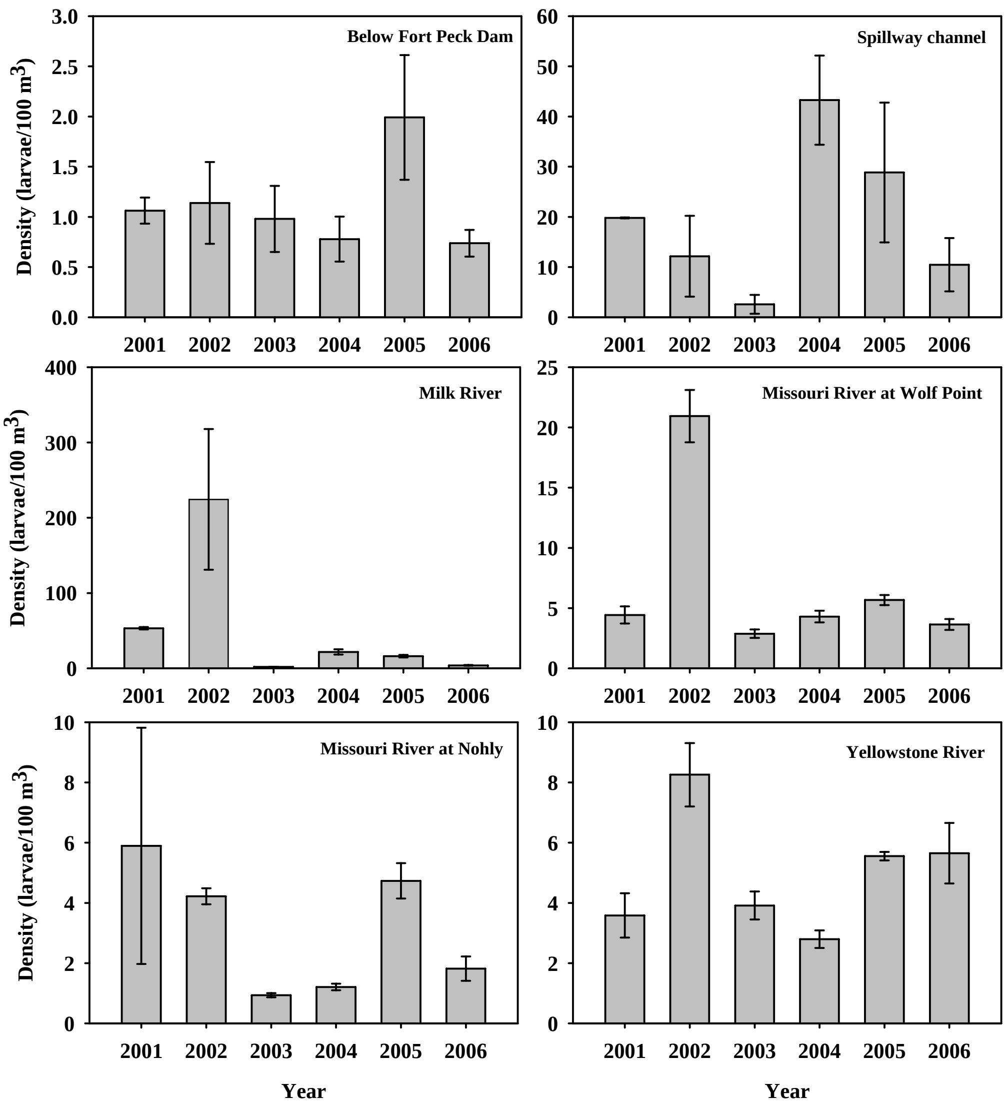


Figure 15. Mean density (all taxa combined averaged across sampling dates among replicates; number/100 m^3) of larval fishes sampled at six sites between 2001 and 2006. Errors bars delimit one standard error. Inclusive data span from late May through early August with the exception of 2001 when sampling was terminated in late July.

Monitoring Component 4 – Reproductive success of shovelnose sturgeon and pallid sturgeon.

Young-of-year sturgeon sampling.- A total of 333 standard trawls and 26 targeted trawls were conducted during 2006 on eight sampling events between July 19 and September 7 (Table 16). Recall, targeted trawls were conducted in the same location as a standard trawl only if a young-of-year sturgeon was sampled in the preceding standard trawl. Trawls were partitioned among the Missouri River ATC (N = 98), Missouri River BTC (N = 168), and Yellowstone River (N = 93).

Thirteen young-of-year sturgeon were sampled among dates and sites (Table 16). Only one young-of-year sturgeon was sampled in the Missouri River ATC and this collection occurred on July 27 (length = 30 mm). No young-of-year sturgeon were sampled in the Yellowstone River. Young-of-year sturgeon were collected from the Missouri River BTC on July 19 (lengths = 49 mm, 63 mm), July 26 (length = 57 mm), August 2 (length = 89 mm), August 15 (lengths = 43, 69, 93, 98 mm), August 23 (lengths = 26 mm, 107 mm, 112 mm), and August 29 (length = 116 mm). Genetic analysis of young-of-year sturgeon sampled during 2006 indicated that all individuals were shovelnose sturgeon (P. HeHaan, USFWS AFTC, personal communication).

Table 16. Summary of trawling effort and catches of young-of-year sturgeon in the Missouri River ATC, Missouri River BTC, and in the Yellowstone River during 2006.

			Date 2006							
Site	Sampling protocol	Metric	Jul 19-20	July 26-27	Aug 2 -3	Aug 8-9	Aug 14-15	Aug 22-23	Aug. 29-30	Sept. 6-7
Missouri River ATC	Standard	Sturgeon sampled	0	1	0	0	0	0	0	0
		Number of trawls	12	12	12	12	12	12	12	12
		Total minutes	48	49.25	47.75	48	48	48	48	48
	Targeted	Sturgeon sampled		0						
		Number of trawls		2						
		Total minutes		8						
Missouri River BTC	Standard	Sturgeon sampled	2	1	1	0	2	3	1	0
		Number of trawls	18	18	18	18	18	18	18	18
		Total minutes	72	72	72	72	71.25	72	72.25	72.75
	Targeted	Sturgeon sampled	0	0	0		2	0	0	
		Number of trawls	4	2	2		8	6	2	
		Total minutes	16	8	8		32	24	8	
Yellowstone River	Standard	Sturgeon sampled	0	0	0	0	0	0	0	0
		Number of trawls	12	12	12	12	9	12	12	12
		Total minutes	47	48	48	48	34	46.5	47	47.1
	Targeted	Sturgeon sampled								
		Number of trawls								
		Total minutes								

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

The Fort Peck Flow Modification Crew participated in brood stock collection activities during April and October 2006. Selected adult pallid sturgeon were transported to state and federal hatcheries. Collection records were submitted to the USFWS Bismarck Office for inclusion in the pallid sturgeon database.

Associated activities.

A total of 38 hatchery-raised and stocked juvenile pallid sturgeon were sampled in conjunction with netting activities during 2006 (Table 17). Composition of the catch included three individuals from the 2001 year class, one fish from the 2002 year class, six individuals from the 2003 year class, two individuals from the 2004 year class, and 26 representatives from the 2005 year class. Two individuals (160 mm collected July 19; 244 mm collected September 13) were not physically marked at time-of-capture, but genetic analysis indicated that these individuals were progeny of adult pallid sturgeon spawned in the hatcheries (P. DeHaan, USFWS, personal communication). Thus, the year class could be determined. Information from the juveniles was sent to the USFWS for inclusion in the pallid sturgeon database.

Table 17. Juvenile pallid sturgeon sampled as part of the Fort Peck Data Collection Plan activities during 2006. Abbreviations are as follows: Elastomere (G = green, R = red, Y = yellow, O = orange, 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.

Date	PIT	N/R	Elastomer Right		Elastomer Left		CWT	Scute	Length	Weight	Lat.	Long.	YC
			H/V	Color	H/V	Color							
05/23/06	44417A0230	N	V	G					410	115	48.01653	-104.10372	2001
06/13/06	4444133363	N	V	G	V	Y	Y		387	170	48.00117	-104.05548	2001
06/27/06	43155B0638	N	V	G	V	Y	Y		410	195	48.02763	-104.09165	2001
07/19/06	None								160	14	48.11870	-103.70773	2005*
07/19/06	None		V	Y	H	Y	Y		226	38	47.98594	-103.97381	2005
07/19/06	435E2A460F	R	V	R	V	Y			412	205	47.96357	-103.87850	2002
08/09/06	None		V	Y	H	O			207	26	48.02366	-104.09531	2005
08/09/06	435F503E03	R	H	Y					346	118	47.99946	-104.93700	2003
08/23/06	4441666667	N	V	Y	H	Y			255	48	47.98602	-103.97386	2005
08/29/06	4625507676	N	V	Y					359	118	47.98613	-103.97430	2005
08/29/06	453479772A	N	V	Y					317	92	48.02310	-104.09629	2005
08/29/06	None		V	Y	H	O			228	32	48.03167	-104.09142	2005
08/29/06	435F79403B	N	V	Y	H	Y	Y		283	64	47.94726	-103.95980	2005
09/07/06	None		V	Y	H	Y	Y		260	55	47.98613	-103.97490	2005
09/07/06	None		V	Y	H	O	Y		221	35	47.98613	-103.97490	2005
09/07/06	4360017522	R	V	G					365	156	47.98621	-103.97523	2003
09/07/06	None		V	Y	H	Y	Y		269	58	47.98661	-103.97125	2005
09/07/06	44420A723D	N	H	Y					325	106	47.98572	-103.97682	2003
09/07/06	430E625E7E	N	V	R	V	Y			459	301	47.97680	-103.98730	2004
09/13/06	None		V	Y	H	Y			251	52	47.98618	-103.97544	2005
09/13/06	4310393161	N							244	43	47.98618	-103.97544	2003*
09/13/06	None		V	Y	H	Y			240	43	47.98627	-103.97330	2005
09/13/06	None		V	Y	H	Y			253	49	47.95763	-103.90496	2005
09/13/06	None		V	Y	H	O	Y		230	38	47.98573	-103.97520	2005
09/19/06	4624696460	R						L-3	273	64	48.09536	-105.50797	2005
09/19/06	4463760B0A	R	V	Y					337	115	48.09501	-105.50680	2005
09/25/06	46240B425C	R	V	Y					339	111	48.07787	-104.39766	2005
09/25/06	43105F1565	N	H	Y					286	76	48.05187	-104.29373	2003
09/26/06	4625037860	R						L-3	257	49	48.10937	-104.50802	2005
09/26/06	46253D1138	R						L-3	265	55	48.11968	-104.56368	2005
09/26/06	None		V	G	V	O			270	60	48.12228	-104.62712	2004
09/26/06	None		V	Y	V	O			249	46	48.11180	-104.50069	2005
09/26/06	None		V	Y	V	O			267	50	48.11814	-104.62329	2005
09/28/06	None		V	Y	H	Y	Y		286	67	47.98615	-103.96444	2005
09/28/06	None		V	Y	H	R			290	75	47.98615	-103.96444	2005
10/03/06	4531014F64	R	V	Y					351	105	48.09068	-105.48165	2005
10/11/06	435F79403B	R	V	Y	H	Y	Y		287	64	47.98579	-103.97501	2005
11/01/06	44235C0E4D	R	V	R	V	Y			486		48.02130	-103.79329	2003

* Year class determined from genetic analysis

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References

Bowen, Z. H., K. D. Bovee, and T. J. Waddle. 2003. Effects of flow regulation on shallow-water habitat dynamics and floodplain connectivity. Transactions of the American Fisheries Society 132:809-823.

Braaten, P. J., and D. B. Fuller. 2006. Fort Peck Flow Modification Biological Data Collection Plan – Summary of 2005 Activities. Report prepared for the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Fort Peck.

Braaten, P. J., and D. B. Fuller. 2005. Fort Peck Flow Modification Biological Data Collection Plan – Summary of 2004 Activities. Report prepared for the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Fort Peck.

Braaten, P. J., and D. B. Fuller. 2004. Fort Peck Flow Modification Biological Data Collection Plan – Summary of 2003 Activities. Report prepared for the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Fort Peck.

Braaten, P. J., and D. B. Fuller. 2003. Fort Peck Flow Modification Biological Data Collection Plan – Summary of 2002 Activities. Report prepared for the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Fort Peck.

Braaten, P. J., and D. B. Fuller. 2002. Fort Peck Flow Modification Biological Data Collection Plan – Summary of 2001 Activities. Report prepared for the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Fort Peck.

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

Gardner, W. M., and P. A. Stewart. 1987. The fishery of the lower Missouri River, Montana. Project FW-2-R, Job 1-b. Final report. Montana Department of Fish, Wildlife, and Parks, Helena.

Ross, M. J., and C. F. Kleiner. 1982. Shielded-needle technique for surgically implanting radio-frequency transmitters in fish. Progressive Fish-Culturist 44:41-43.

Sappington, L., D. Dieterman, and D. Galat. 1998. 1998 Standard operating procedures to evaluate population structure and habitat use of benthic fishes along the Missouri and lower Yellowstone Rivers. Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri, Columbia.

Tews, A. 1994. Pallid sturgeon and shovelnose sturgeon in the Missouri River from Fort Peck Dam to Lake Sakakawea and in the Yellowstone River from Intake to its mouth. Final Report submitted to the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Helena.

USACE. 2002. Draft environmental assessment, Fort Peck Flow Modification Mini-test. U. S. Army Corps of Engineers, Omaha District.

USACE. 2004. Final environmental assessment, Fort Peck Flow Modification Mini-test. U. S. Army Corps of Engineers, Omaha District.

USFWS. 2000. Biological opinion on the operation of the Missouri River main stem reservoir system, operation and maintenance of the Missouri River bank stabilization and navigation project, and operation of the Kansas River reservoir system. U. S. Fish and Wildlife Service, Region 3 (Fort Snelling, Minnesota) and Region 6 (Denver, Colorado).

White, R. G., and R. G. Bramblett. 1993. The Yellowstone River: Its fish and fisheries. Pages 396-414 *in* L. W. Hesse, C. B. Stalnaker, N. G. Benson, and J. R. Zuboy, editors. Restoration planning for rivers of the Mississippi River ecosystem. Biological Report 19, National Biological Survey, Washington, D.C.