Fort Peck Flow Modification Biological Data Collection Plan

Summary of 2004 Activities

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Extended Abstract

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

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

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

Under research component 3, extensive radiotracking was conducted between April and October in the lower Yellowstone River and in the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea. A total of 25 individual tracking events were conducted throughout the river systems resulting in a cumulative distance of 10,800 km tracked. We

obtained 799 relocations of blue suckers, 253 relocations of paddlefish, and 1,065 relocations of shovelnose sturgeon via boat. Seven continuous-recording telemetry logging stations logged an additional 480 contacts of implanted fish. Species-specific information on relocation locations and movement patterns are presented. In addition, a total of 241 manual relocations of pallid sturgeon implanted by U. S. Fish and Wildlife Service personnel were obtained. In September 2004, radio transmitters were implanted in an additional 22 shovelnose sturgeon, 20 blue suckers, and 10 paddlefish. These individuals, added to the existing population of implanted fish, will be relocated during the next few years to ascertain discharge- and temperature-related movement patterns and aggregations prior to, during, and after proposed flow changes are implemented.

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

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

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

Introduction

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

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

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

Study Area

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

Methods

Monitoring Component 1 - Water temperature and turbidity.

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

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

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

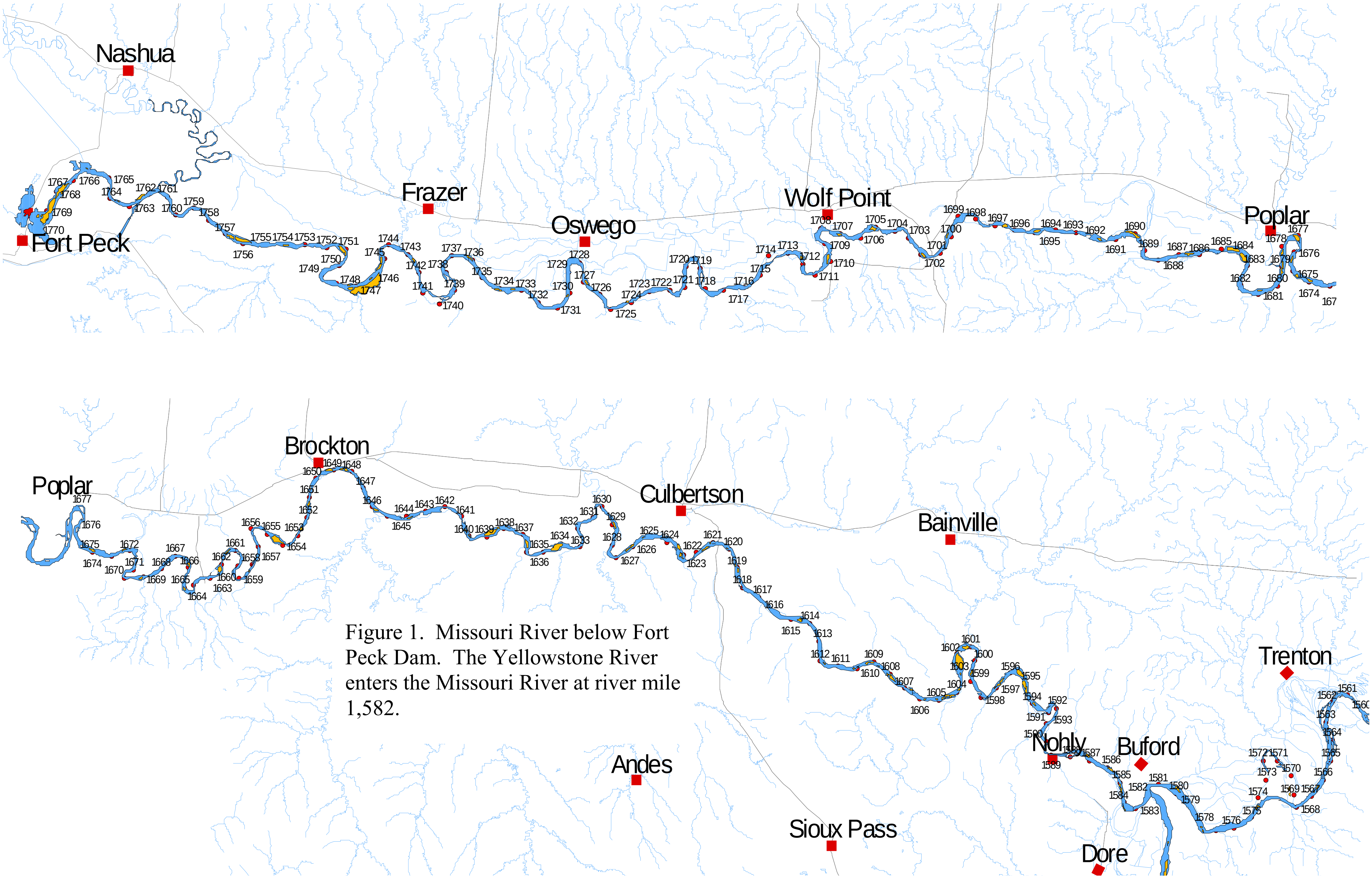


Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Monitoring Component 4 – Larval Fish

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

Specific larval fish sampling protocols varied among sites and were dependent on site characteristics (Table 2). Two to five replicates were collected at the sites, where one replicate was comprised of four subsamples (two subsamples simultaneously collected on the right and left side of the boat at sampling locations near the left and right shorelines). At all sites except the spillway site, the left and right sampling locations corresponded to inside bend and outside bend locations at the mid-point of a river bend. The spillway channel had minimal sinuosity; therefore, samples did not reflect inside and outside bend locations. Only two replicates were

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

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

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

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

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

Monitoring Component 5 – Young-of-year sturgeon

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

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

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

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

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

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

Results and Discussion

Hydrologic conditions

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

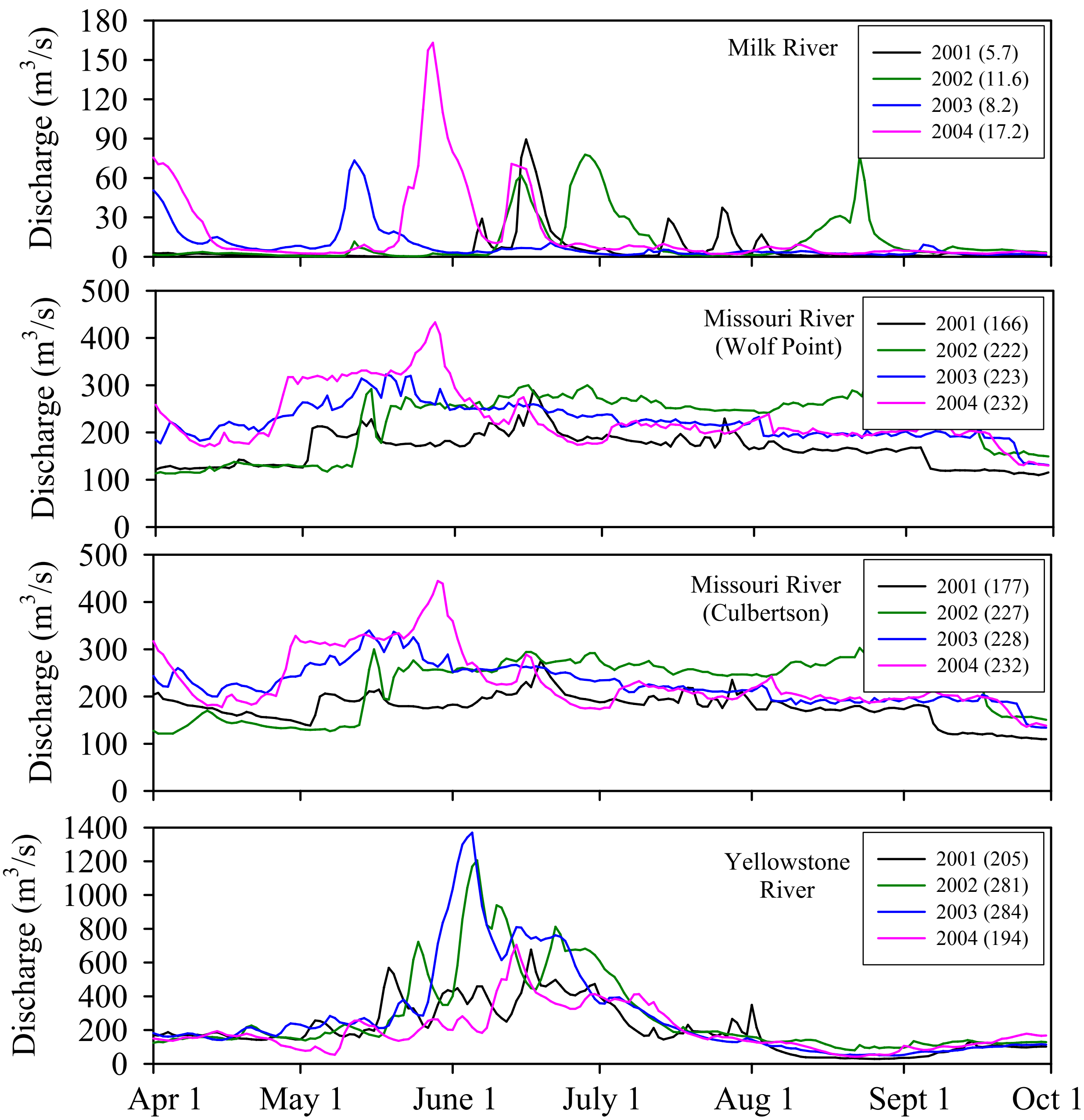


Figure 2. Mean daily discharge in the Milk River, Missouri River at Wolf Point and Culbertson, and in the Yellowstone River during 2001, 2002, 2003, and 2004. Values listed in parentheses represent mean daily discharge (m^3/s) for the specified year between April 1 and September 30. Note the change in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

Monitoring Component 1 - Water temperature and turbidity

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

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

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

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

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

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

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

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

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

Longitudinal water temperatures. Mean daily water temperature differed significantly ($P < 0.0001$) among Missouri River mainstem, tributaries, and off-channel locations during 2004 (Table 7; Figure 3). For mainstem sites, mean daily water temperature was greatest in the Missouri River upstream from Fort Peck Dam (Robinson Bridge, 17.6°C) and significantly lower in the Missouri River below Fort Peck Dam (12.3°C). Thus, hypolimnetic releases from Fort Peck Dam suppressed water temperature by an average of 5.3°C during the common deployment period. However, maximum water temperature was suppressed 10.4°C between Robinson Bridge (maximum = 26.7°C) and below Fort Peck Dam (maximum = 16.3°C). Mean daily water temperature warmed longitudinally from below Fort Peck Dam to the lowermost Nohly site (mean = 15.8°C), but mean daily water temperature at Nohly was significantly less than at the Robinson Bridge site. Thus, thermal impacts of cold hypolimnetic releases from Fort Peck Dam remained evident 174 rm (280 km) downstream from Fort Peck Dam. For off-channel locations, mean daily water temperature was greatest in the Yellowstone River (mean = 17.6°C) and Milk River (17.2°C), but significantly less in the spillway channel (15.8°C). The coefficient of variation (CV) of mean daily water temperatures exceeded 22% for all sites during 2004.

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

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

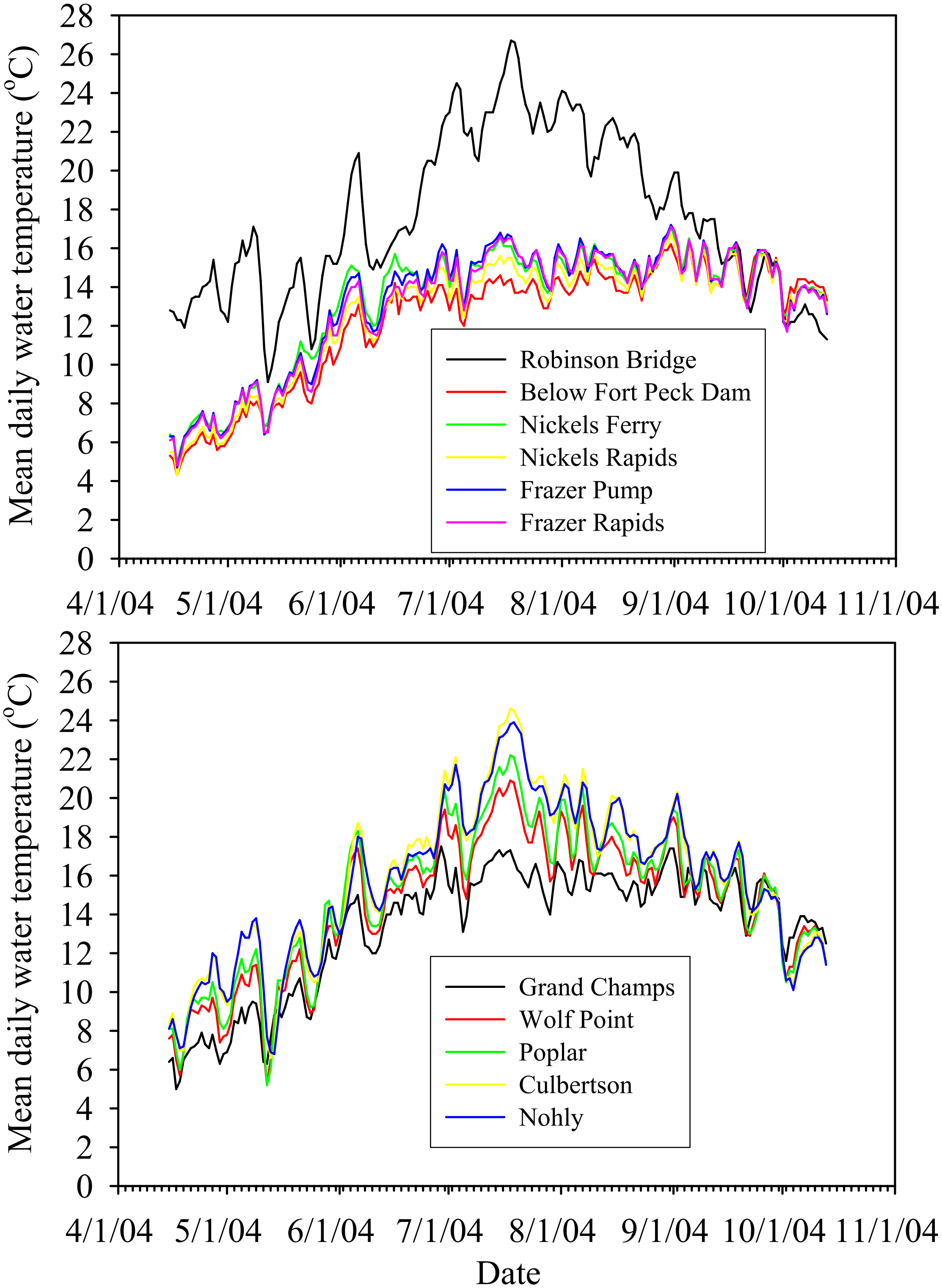


Figure 3. Mean daily water temperature (^{o}C) at 12 sites on the mainstem Missouri River during 2004.

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

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

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

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

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

Table 8. Continued.

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

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

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

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

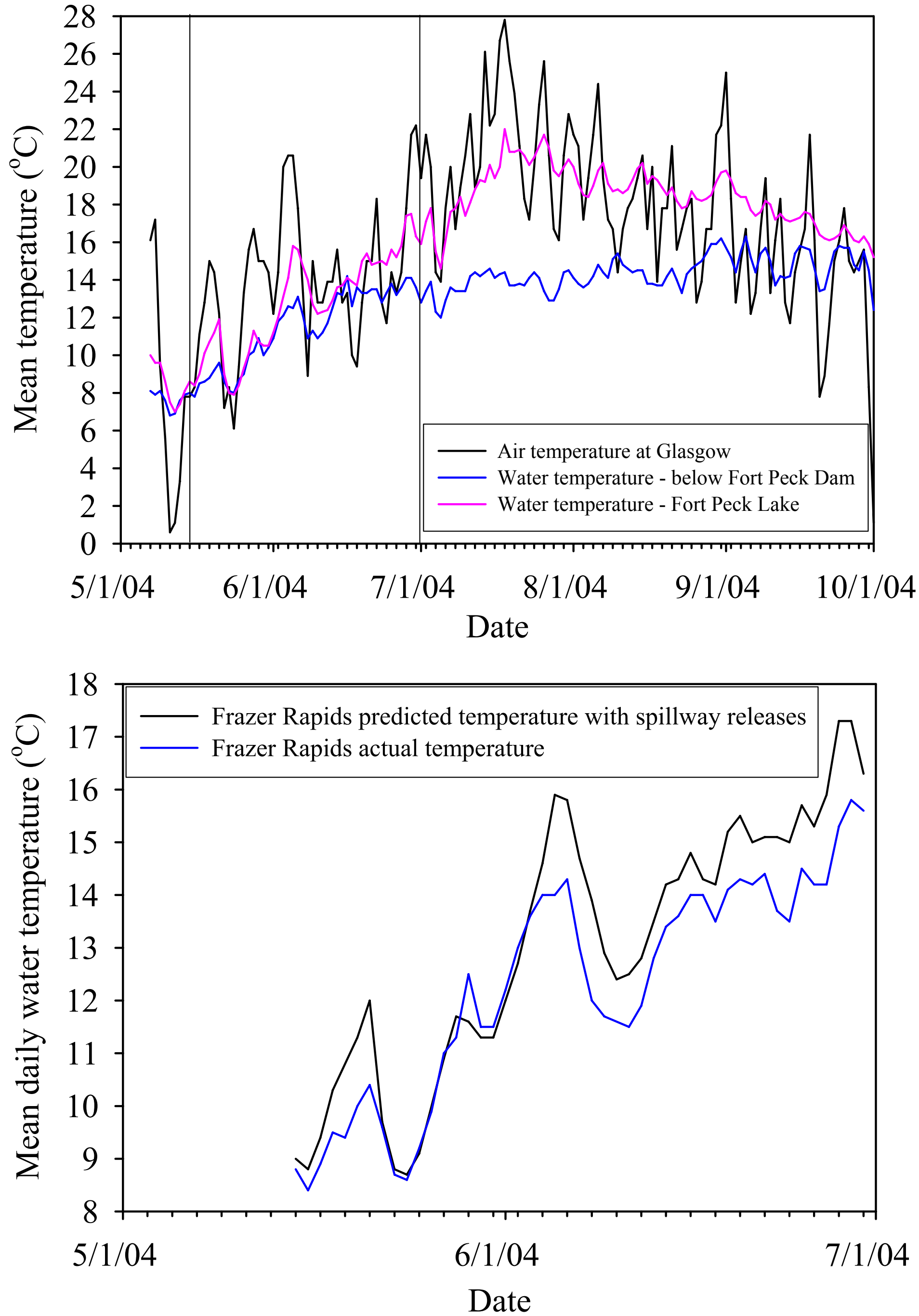


Figure 4. Mean daily temperature regimes during 2004. Top panel: Mean daily air temperature for Glasgow, MT, and mean daily water temperature for Fort Peck Lake and the Missouri River downstream from Fort Peck Dam. The vertical lines delimit dates when the proposed mini-test and full-test are to be conducted when sufficient water levels are available in Fort Peck Lake. Lower Panel: Actual and predicted mean daily water temperature at Frazer Rapids.

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

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

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

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

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

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

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

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

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

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

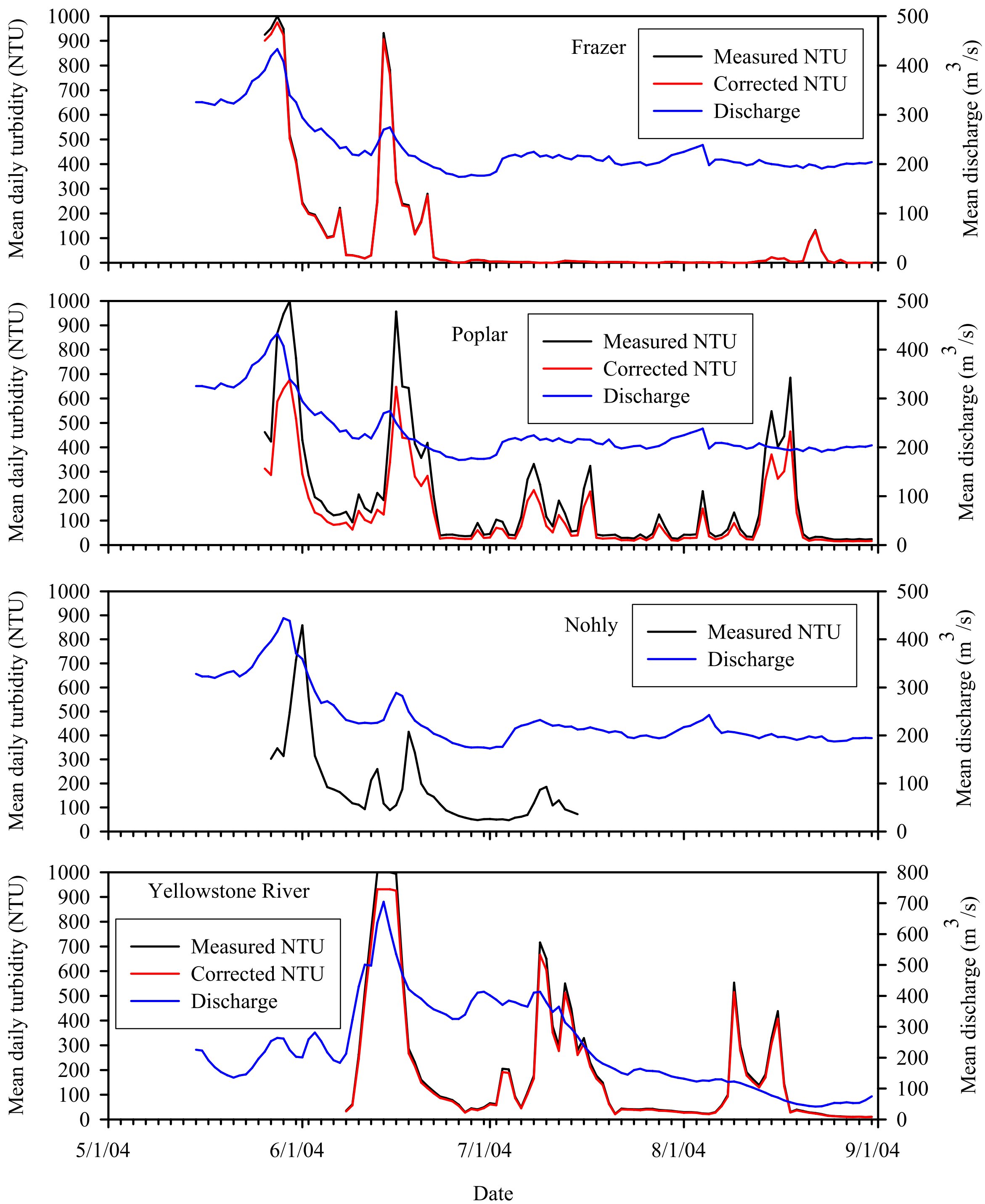


Figure 5. Mean daily turbidity (NTU; solid line) from turbidity loggers and discharge (m^3/s; dotted line) in the Missouri River near Frazer, Poplar, and Nohly, and in the Yellowstone River during 2004.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

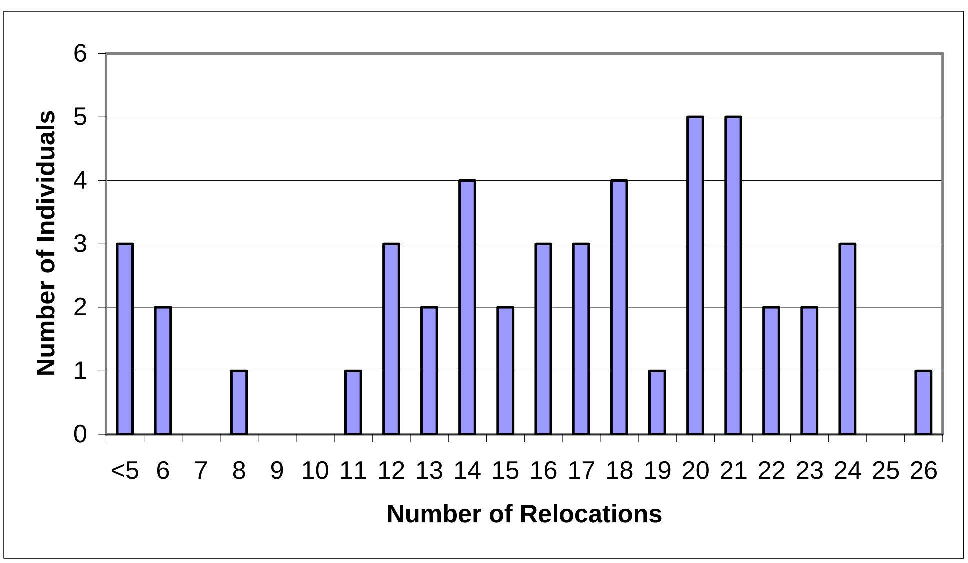


Figure 6. Number of relocations of individual blue suckers in 2004.

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

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

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

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

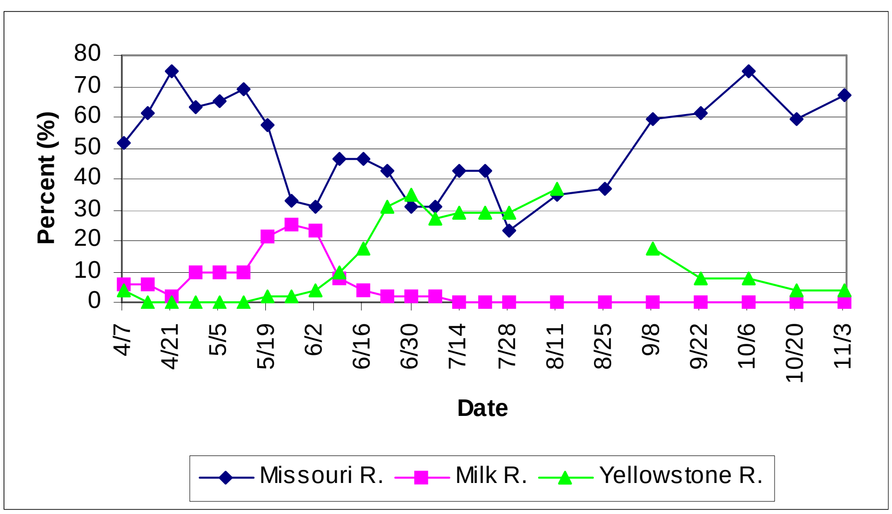


Figure 7. Percent of implanted blue suckers relocated in the Milk, Missouri, and Yellowstone Rivers in 2004 by date. Use of the Milk River was determined from contacts at the Milk River logging station since the Milk River was not manually tracked

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

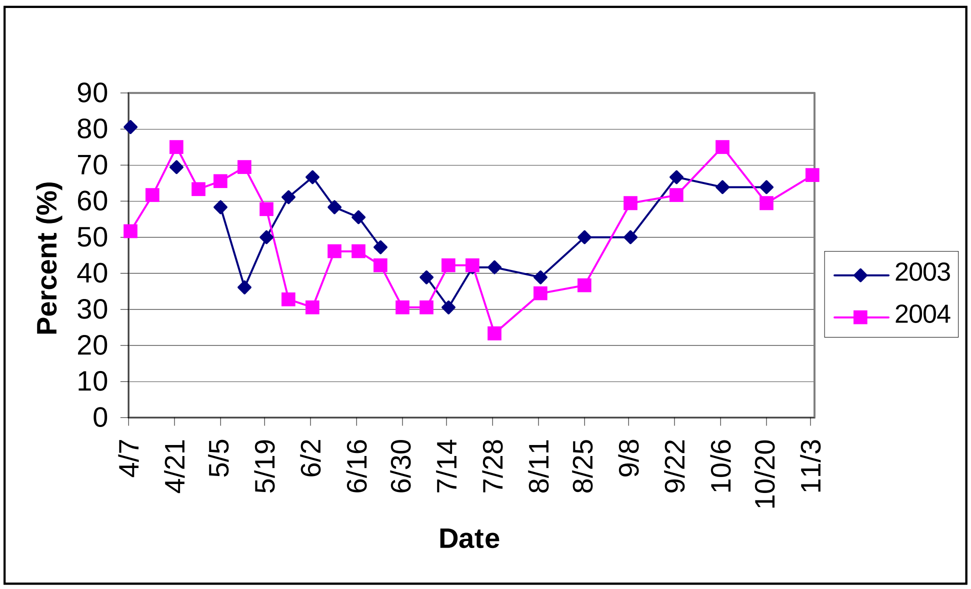


Figure 8. Percent of implanted blue suckers relocated in the Missouri River in 2003 and 2004.

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

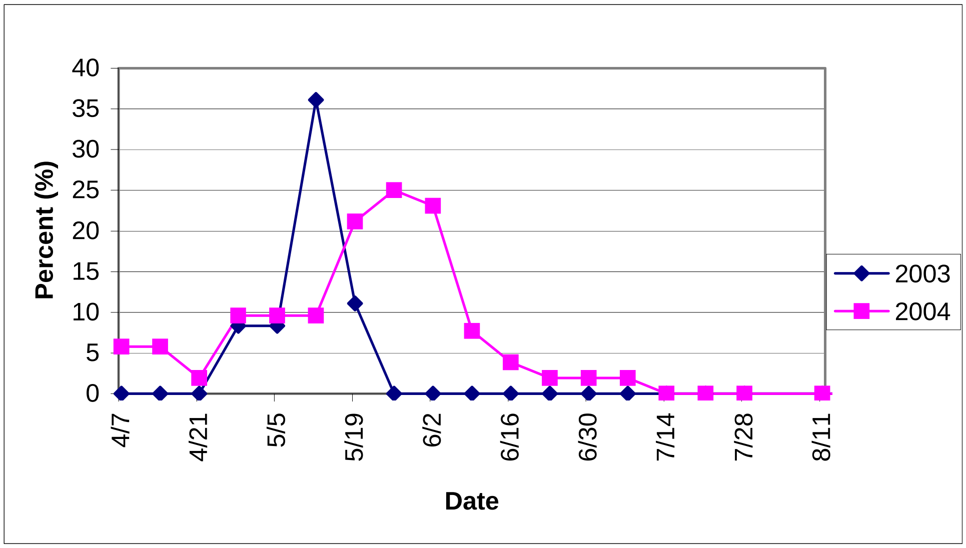


Figure 9. Percent of implanted blue suckers relocated in the Milk River in 2003 and 2004. Use of the Milk River was determined from contacts at the Milk river logging station since the Milk River was not manually tracked.

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

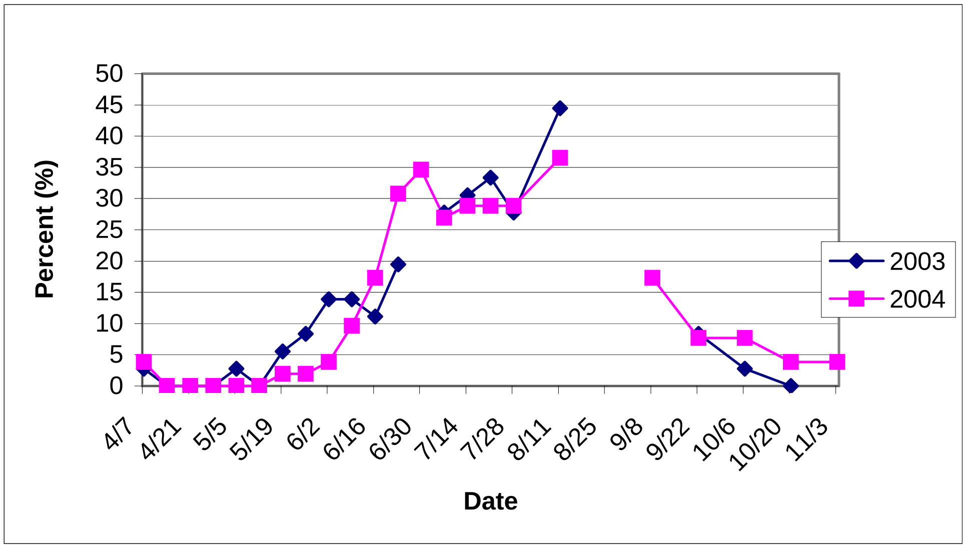


Figure 10. Percent of implanted blue suckers relocated in the Yellowstone River in 2003 and 2004

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

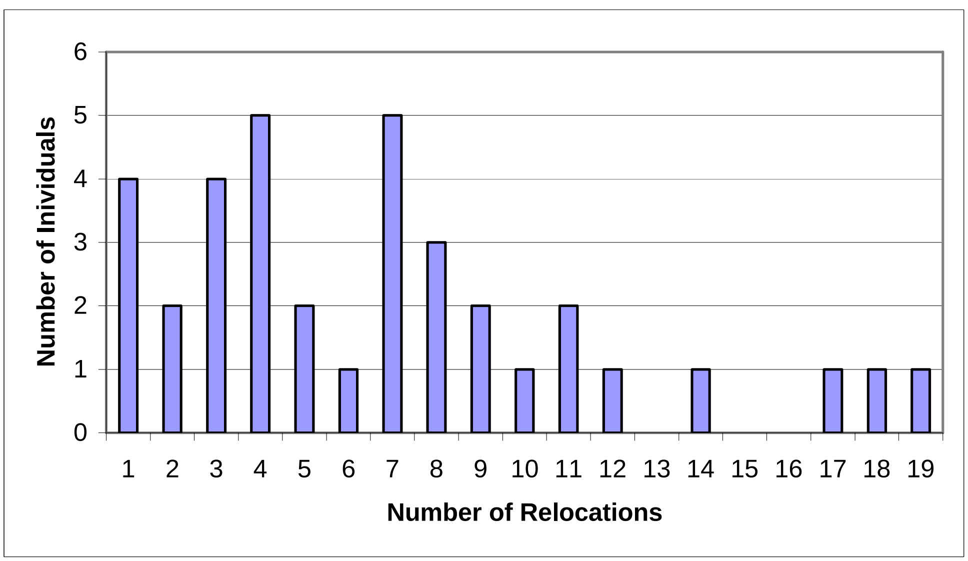


Figure 11. Number of relocations of individual paddlefish in 2004.

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

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

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

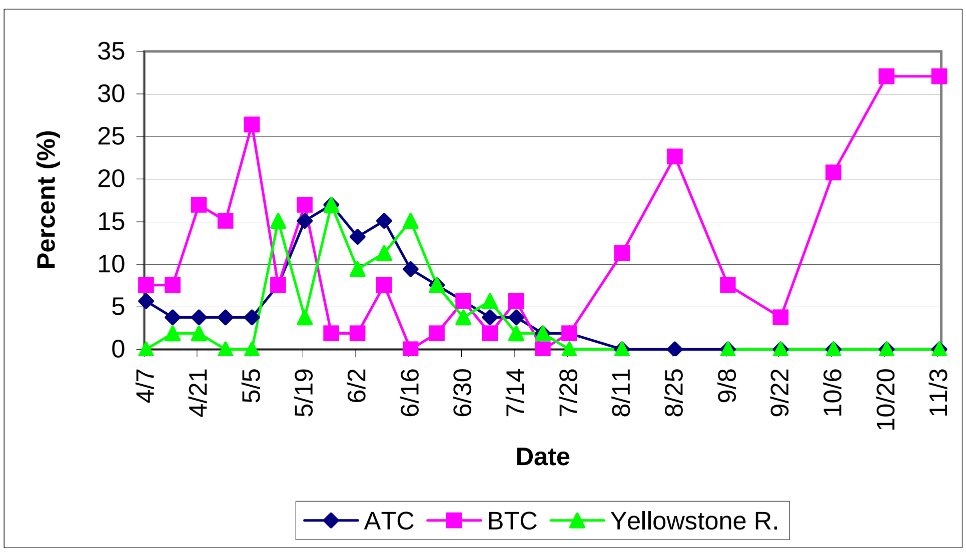


Figure 12. Percentage of implanted paddlefish relocated in reaches of the Missouri River and Yellowstone River during 2004.

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

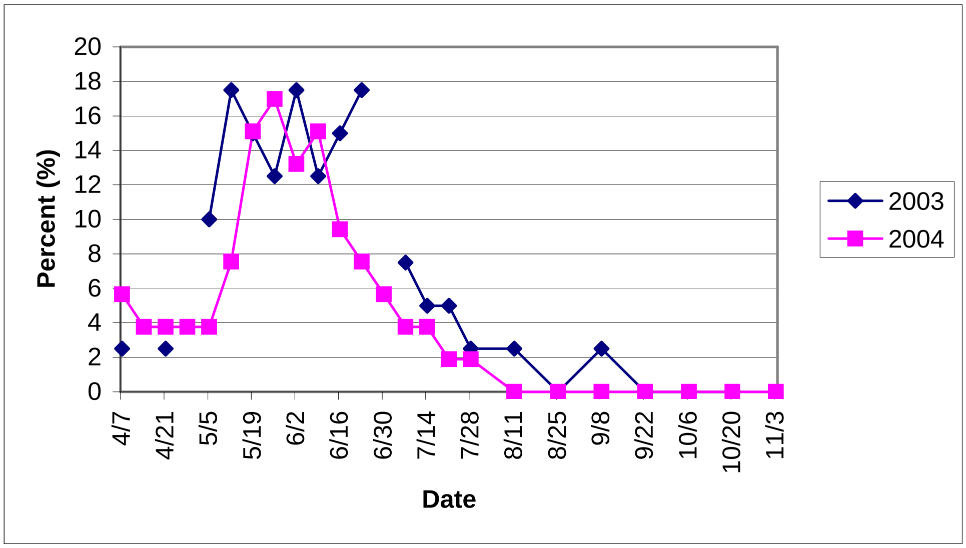


Figure 13. Percent of implanted paddlefish relocated in the Missouri River above the Yellowstone River confluence in 2003 and 2004.

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

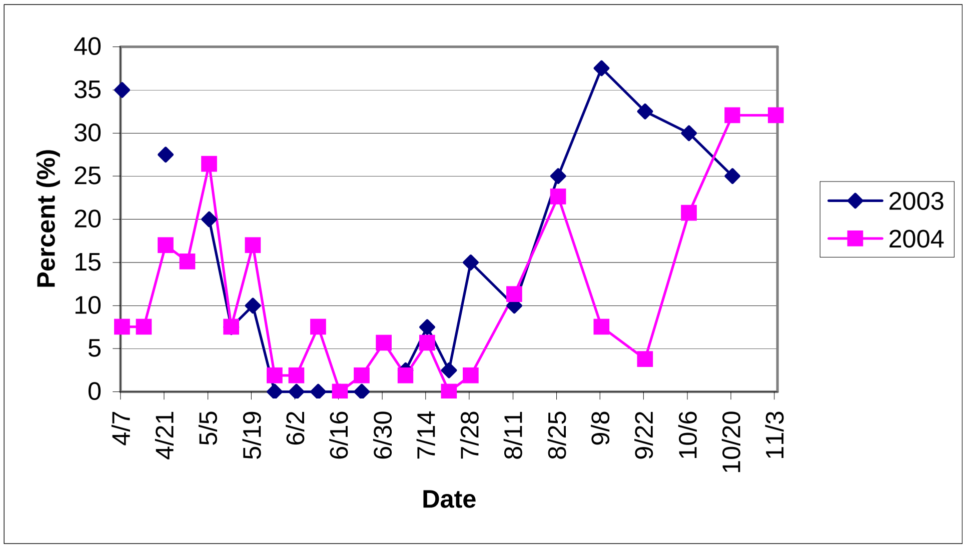


Figure 14. Percent of implanted paddlefish relocated in the Missouri River below the Yellowstone River confluence in 2003 and 2004.

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

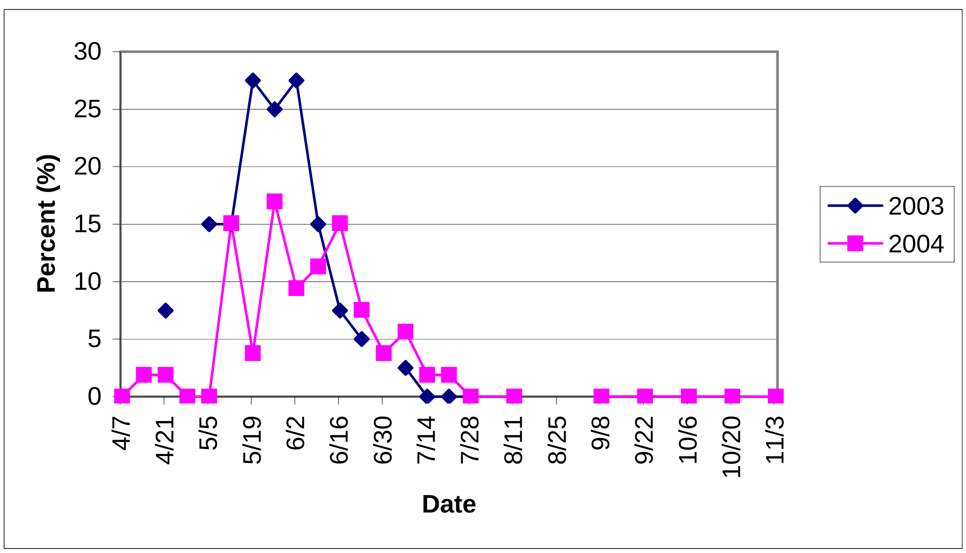


Figure 15. Percent of implanted paddlefish relocated in the Yellowstone River in 2003 and 2004.

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

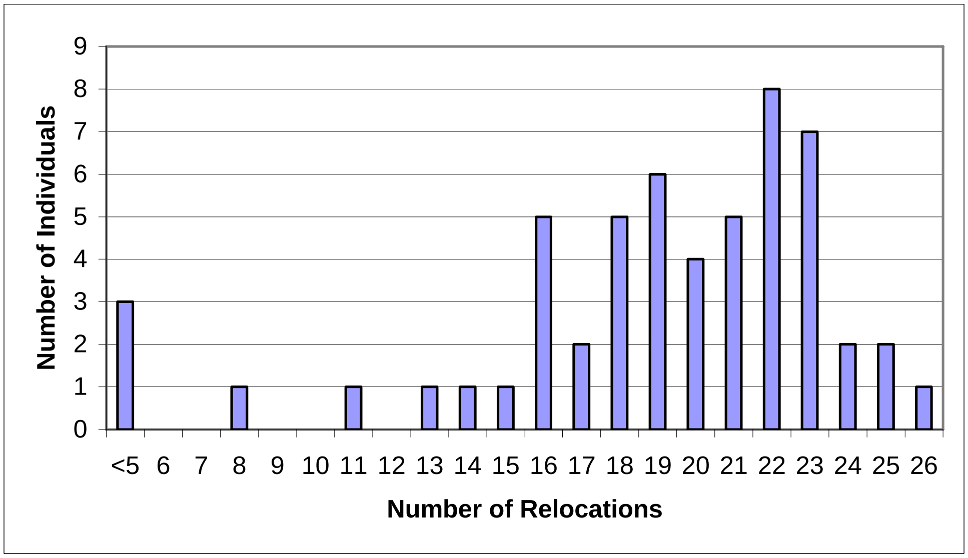


Figure 16. Number of relocations of individual shovelnose sturgeon in 2004.

Use of the Missouri River between Fort Peck Dam and Wolf Point by shovelnose sturgeon was relatively stable from early April through mid-May (Figure 17). Use of this reach declined slightly in mid-May, and varied throughout the remainder of the tracking season. However, a minimum of 25% of the implanted shovelnose sturgeon remained in the study reach for the duration of the season.

The lower Missouri River reach from Wolf Point to the headwaters of Lake Sakakawea is twice as long as the other two reaches. However, this reach exhibited the lowest relative abundance of shovelnose sturgeon (<15% of implanted individuals) during all tracking periods with the exception of one week in early September when 17% of the fish were found in this reach (Figure 17). Less than 10% of implanted individuals were relocated in this reach from June through August.

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

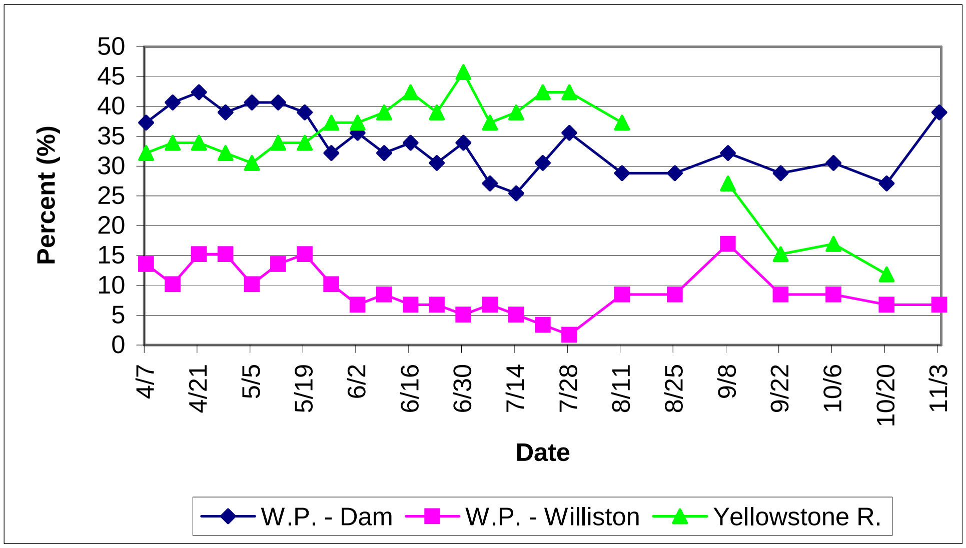


Figure 17. Percent of implanted shovelnose sturgeon relocated in the Missouri River reaches and the Yellowstone River in 2004.

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

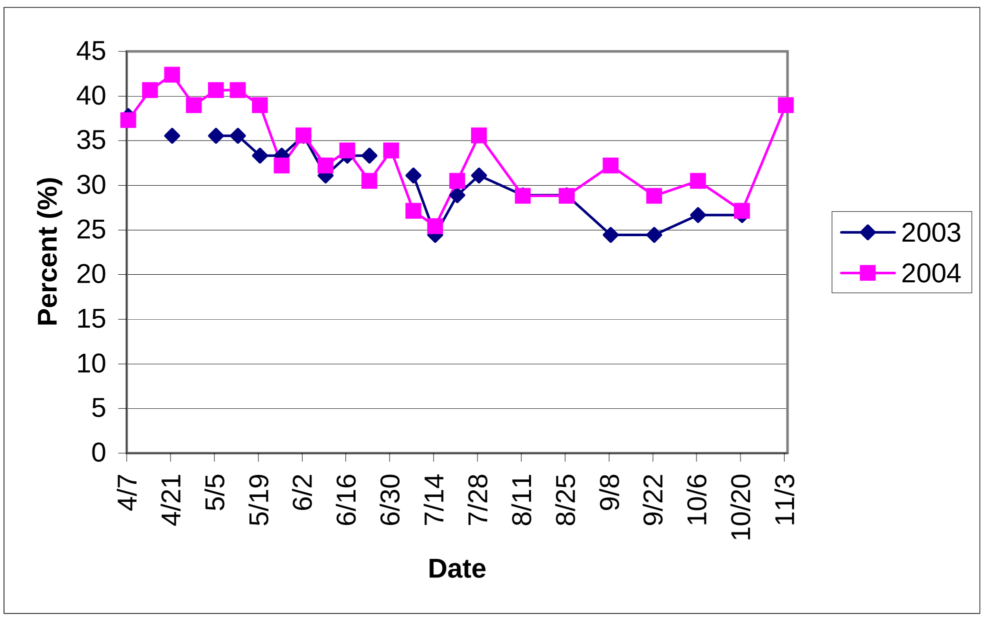


Figure 18. Percent of implanted shovelnose sturgeon relocated in the Missouri River from Wolf Point to Fort Peck Dam in 2003 and 2004.

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

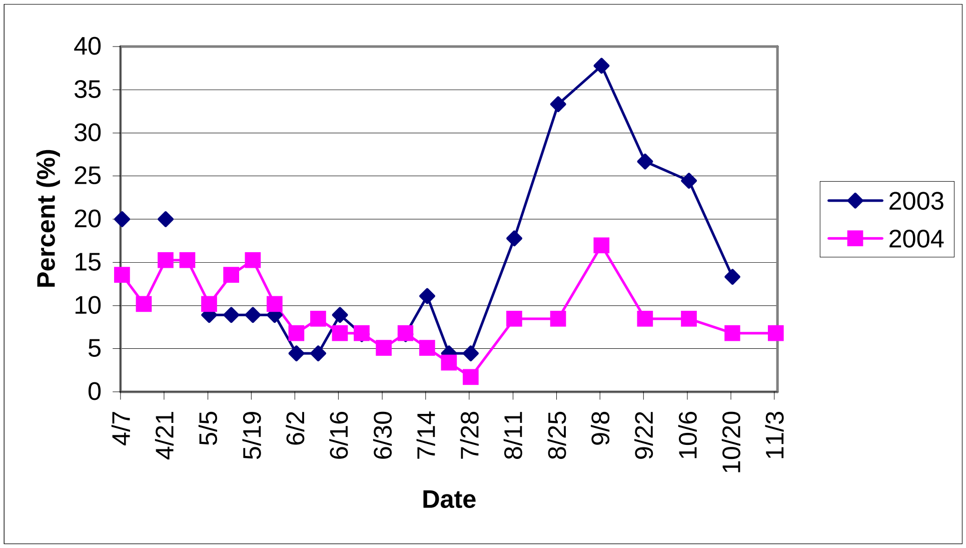


Figure 19. Percent of implanted shovelnose sturgeon relocated in the Missouri River from Wolf Point to Williston in 2003 and 2004.

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

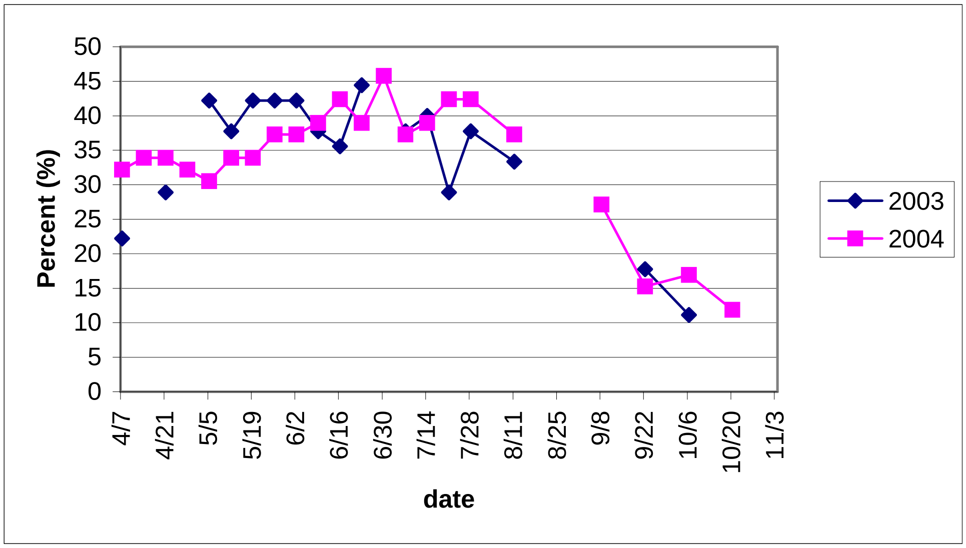


Figure 20. Percent of implanted shovelnose sturgeon relocated in the Yellowstone River in 2003 and 2004.

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

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

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

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

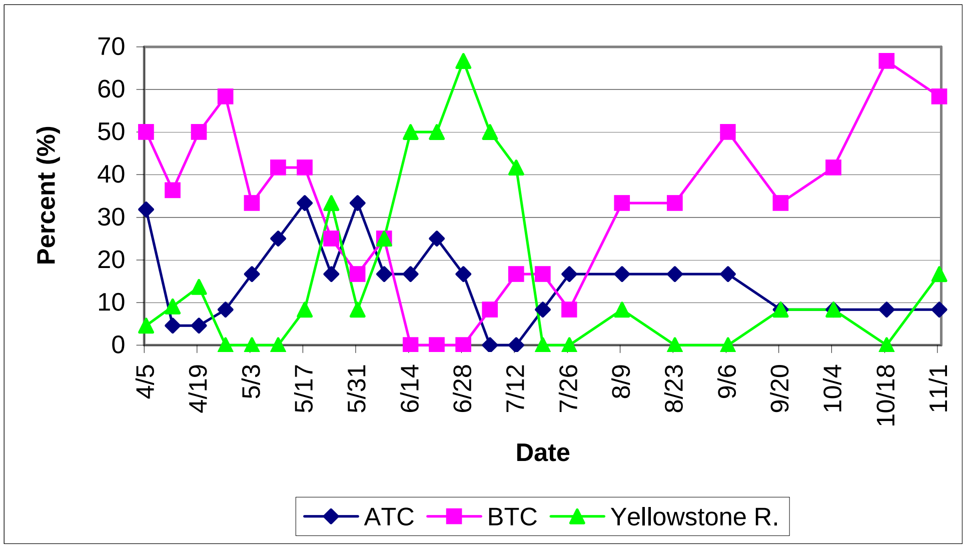


Figure 21. Percent of implanted pallid sturgeon relocated in the reaches of the Missouri River and Yellowstone River in 2004.

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

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

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

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

Monitoring Component 4 – Larval Fish

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

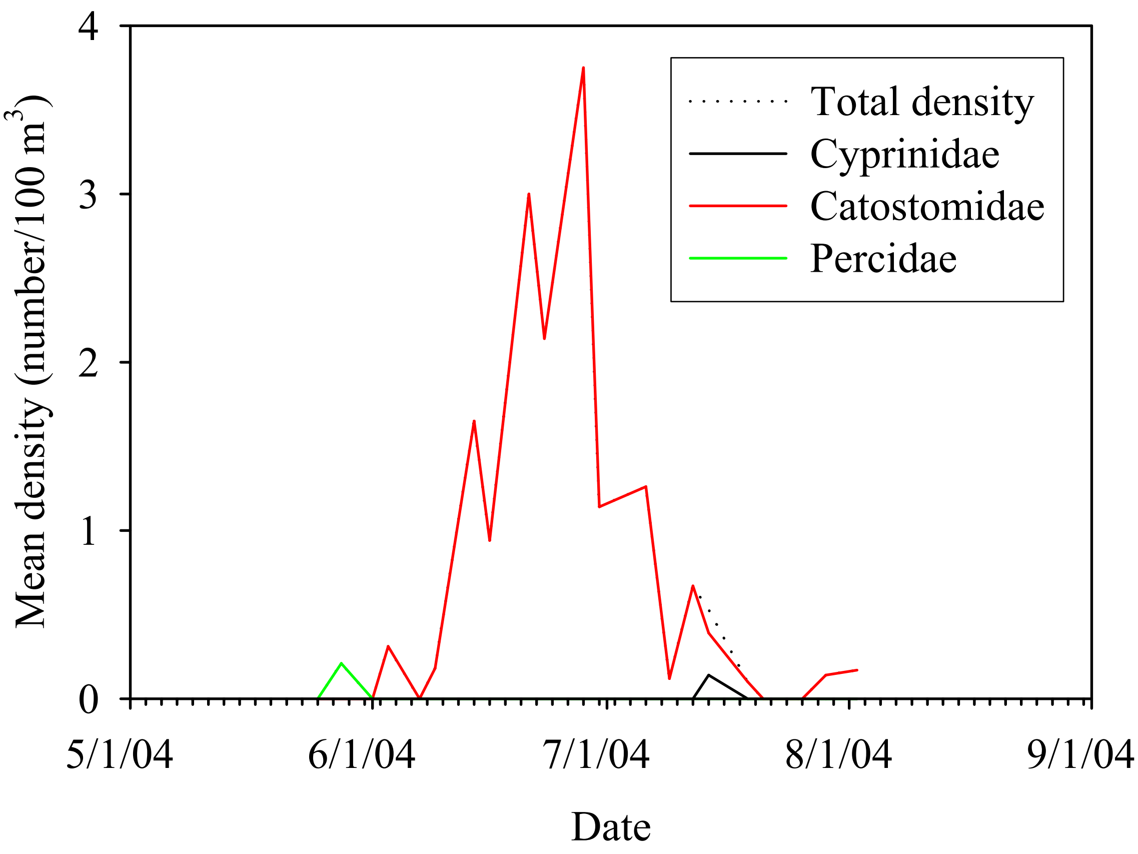


Figure 22. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, and Percidae sampled in the Missouri River at the site downstream from Fort Peck Dam during 2004.

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

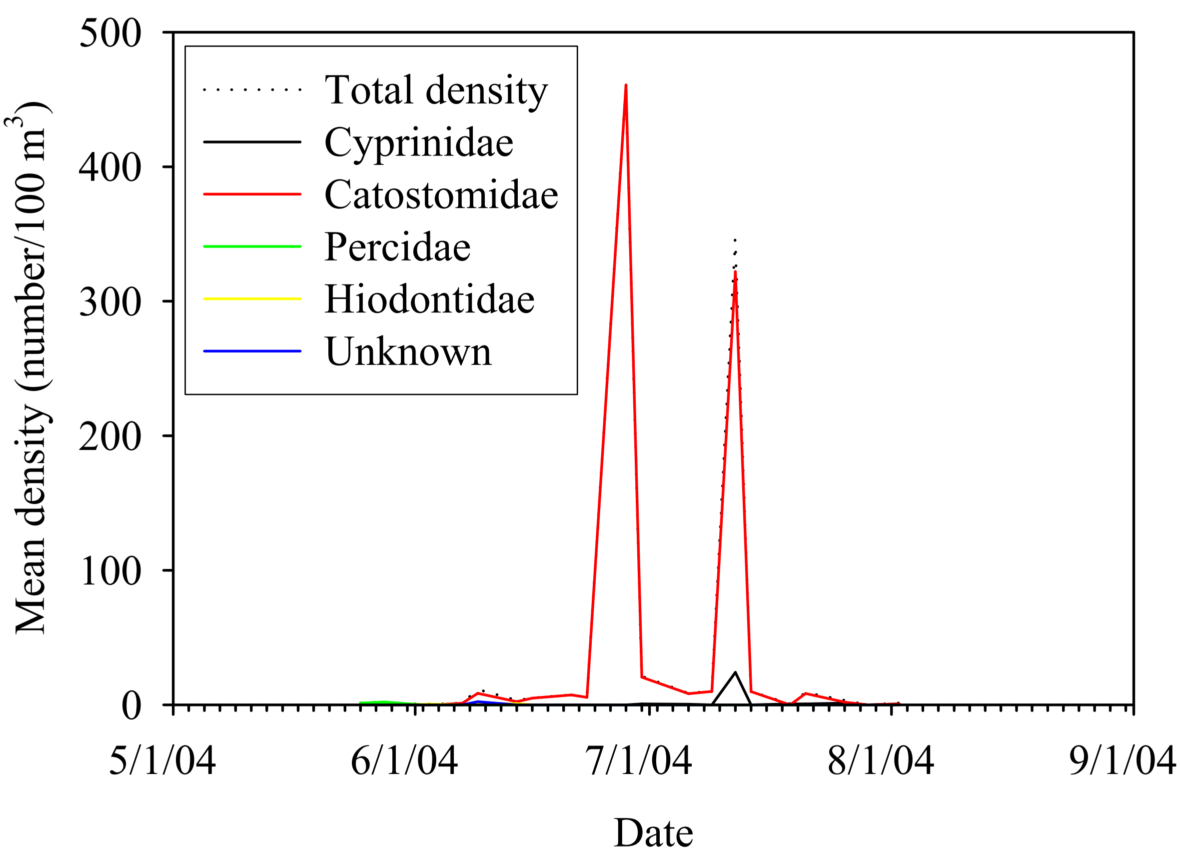


Figure 23. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Hiodontidae, and unknown sampled in the Fort Peck spillway channel during 2004.

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

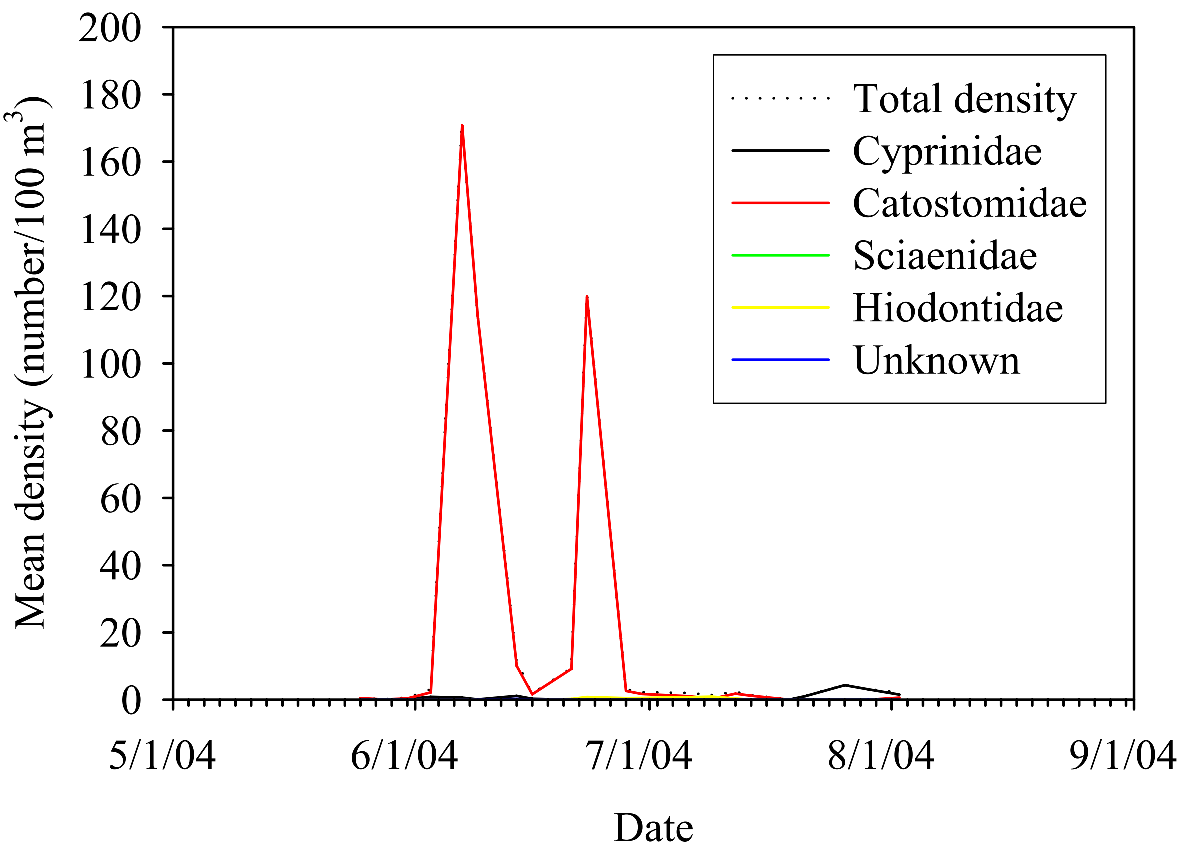


Figure 24. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Sciaenidae, and unknown sampled in the Milk River during 2004.

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

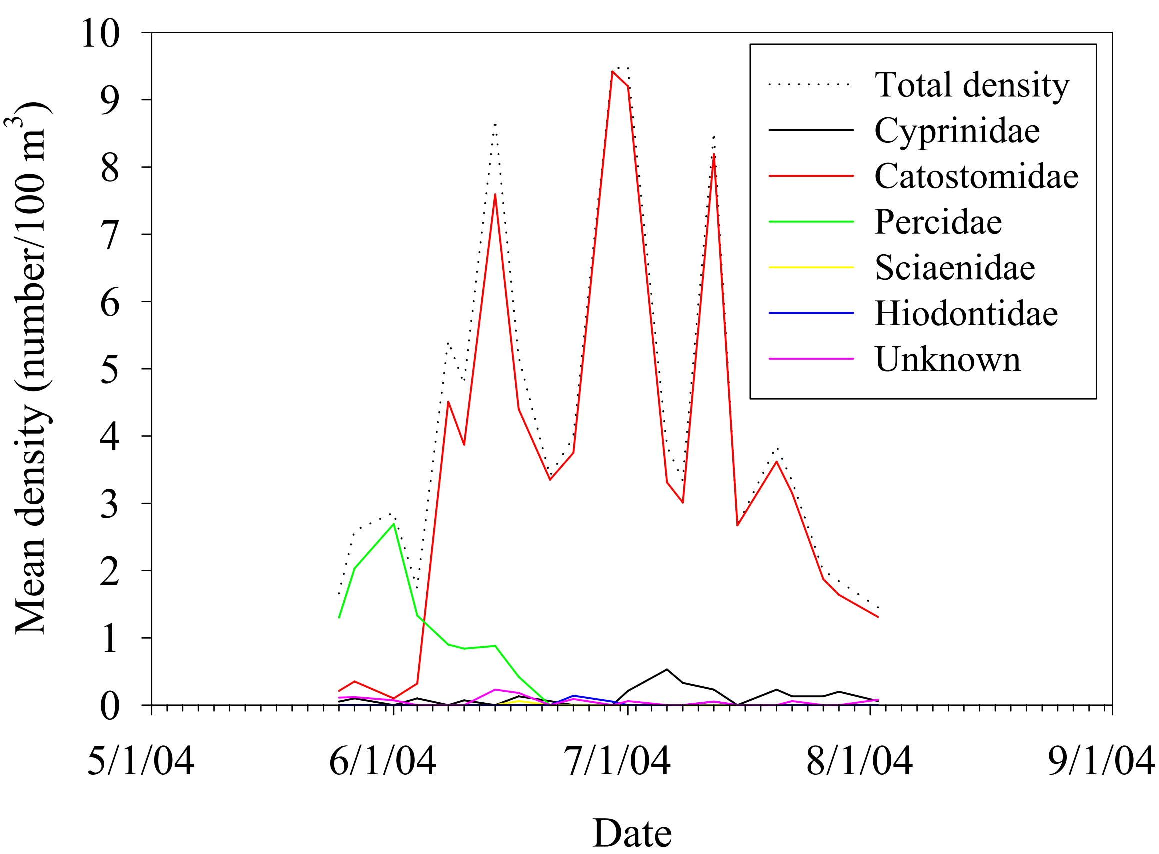


Figure 25. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Sciaenidae, and unknown sampled in the Missouri River at Wolf Point during 2004.

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

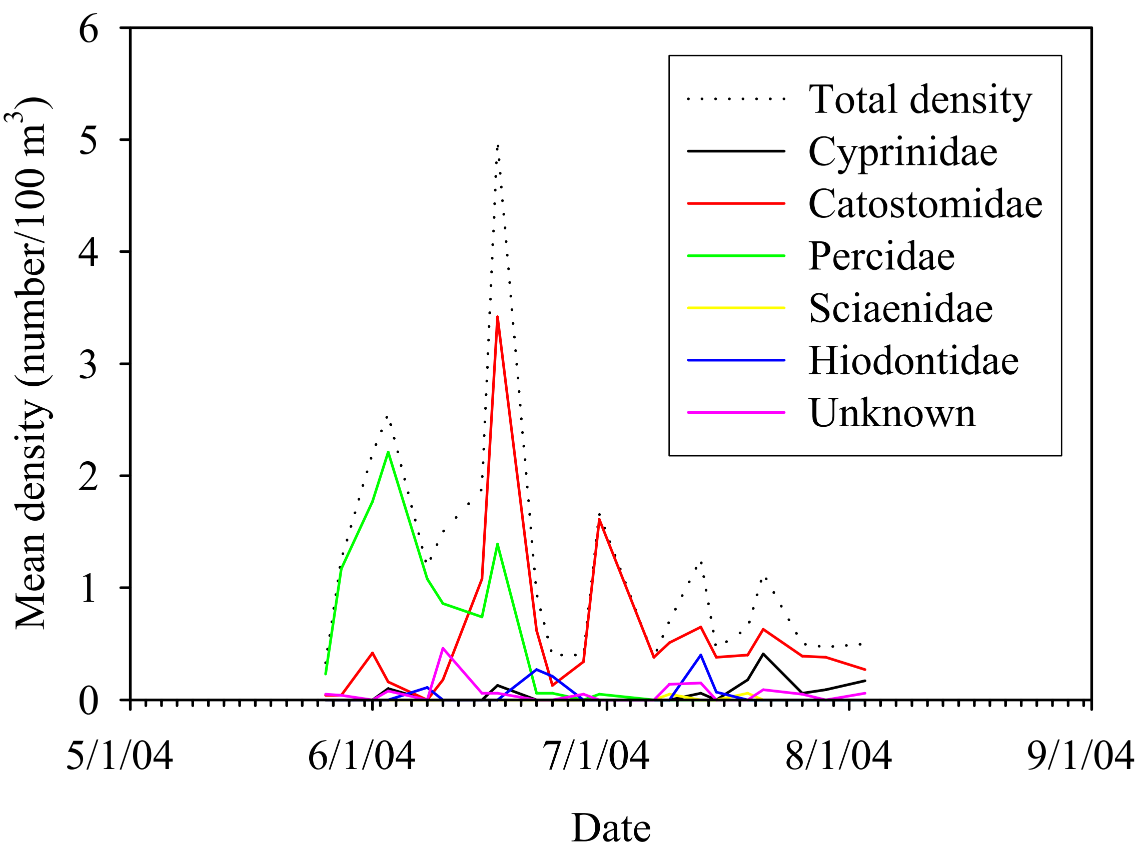


Figure 26. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Sciaenidae, Hiodontidae, and unknown larvae sampled in the Missouri River near Nohly during 2004.

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

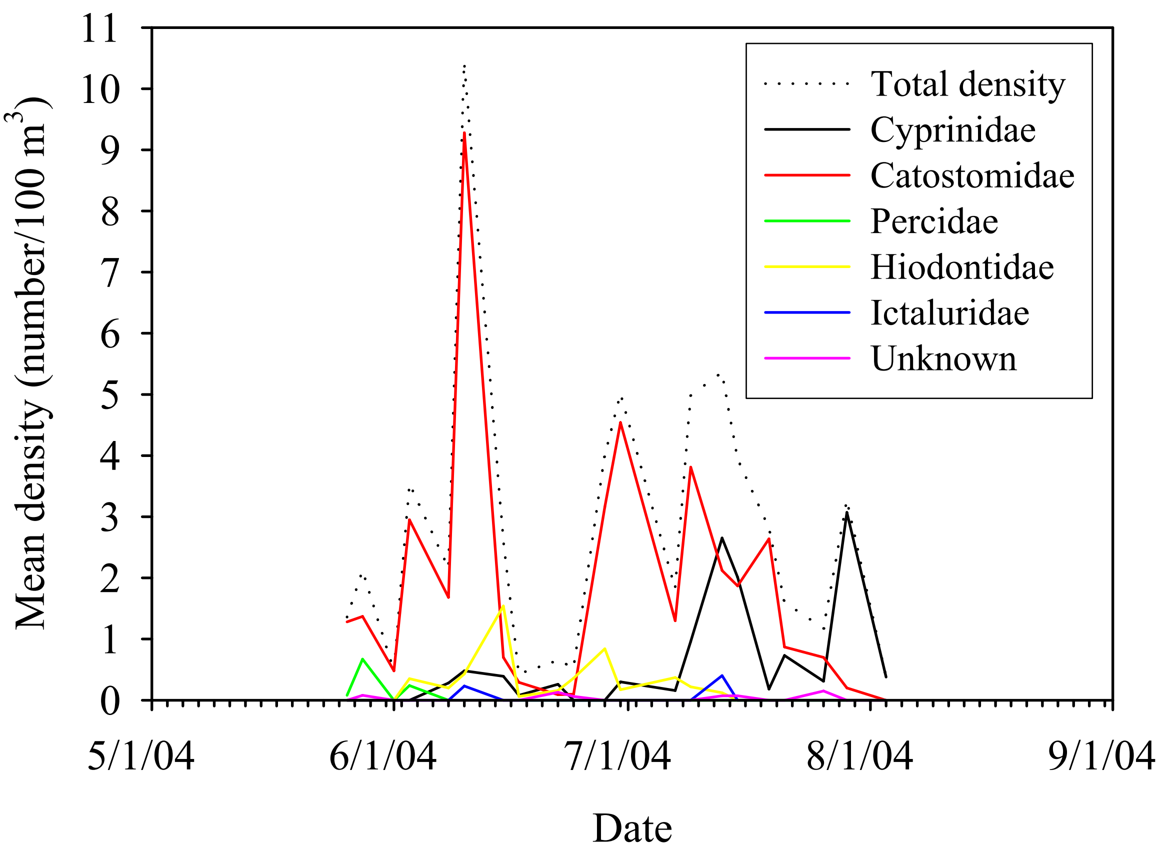


Figure 27. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Ictaluridae, and unknown larvae sampled in the Yellowstone River during 2004.

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

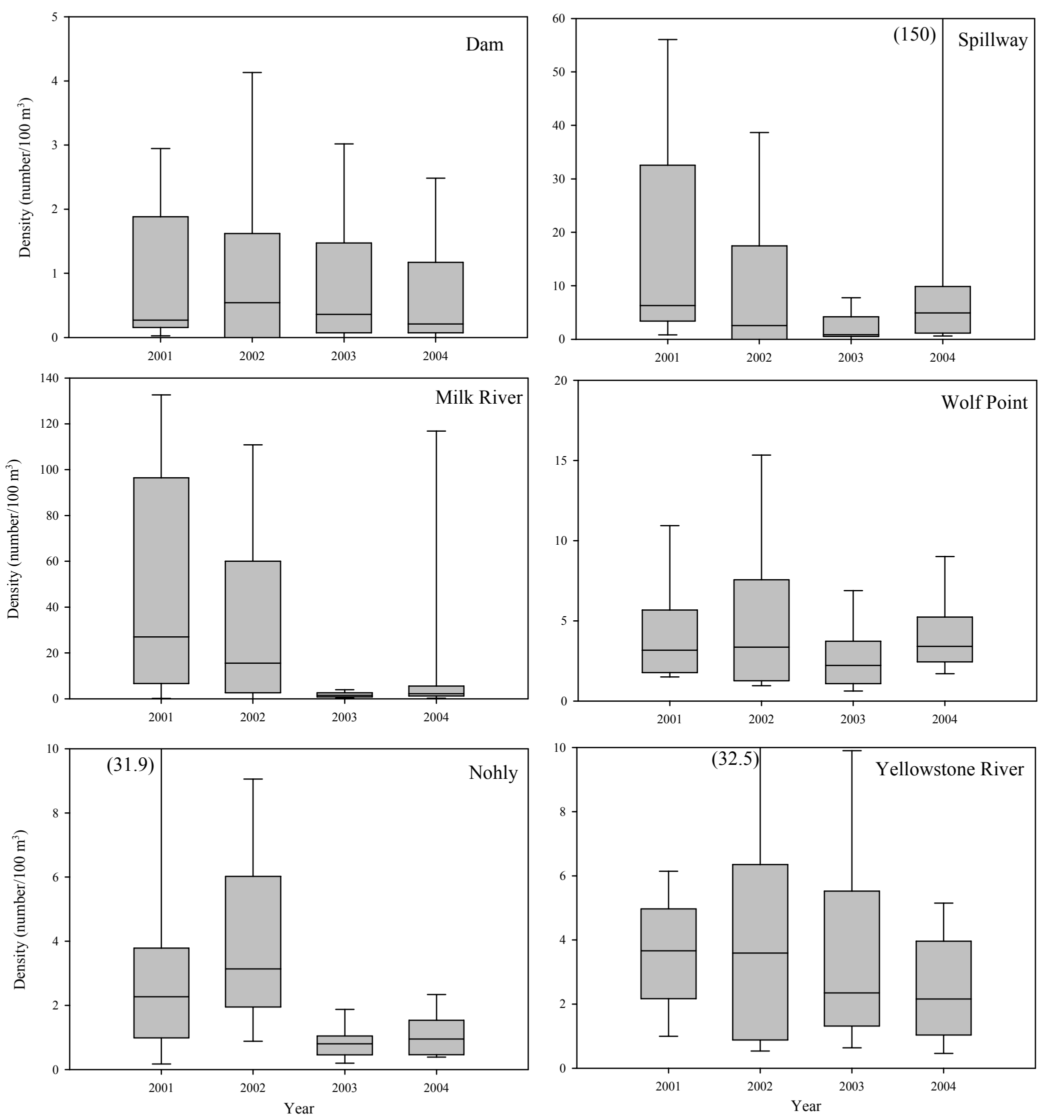


Figure 28. Box and whisker plots of total density (all taxa combined averaged among dates; number/100 m^3) of larval fishes sampled at six sites in 2001, 2002, 2003, and 2004. Boxes delimit the 25^{th} and 75^{th} percentiles of the data, line within the boxes denotes the median, and whiskers delimit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

Monitoring Component 5 – Reproductive success of shovelnose sturgeon and pallid sturgeon.

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

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

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

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

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

In January 2005, species confirmation results for 39 young-of-year sturgeon sampled in 2003 were received from Dr. Darrel Snyder and Sean Seal (Colorado State University; Snyder and Seal 2005). This group of young-of-year sturgeon included the 29 individuals sent to Dr. Heist for genetic testing. The morphometric/meristic results identified one individuals as a highly probable pallid sturgeon, several others as tentative pallid sturgeon, and several others as probable hybrids. Similar to the genetic results, results from Snyder and Seal (2005) suggest that pallid sturgeon reproduction occurred during 2003 and that hybridization is also occurring. Unfortunately, results from the genetics and morphometrics/meristics analyses were somewhat contradictory. For example, the individual confirmed as a pallid sturgeon by genetic testing was identified as a shovelnose sturgeon based on morphometrics/meristic characteristics. Other discrepancies were also noted in species designations. Additional investigations are currently being conducted to address the discrepancies.

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

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

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

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

Acknowledgments

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

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. 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.

Schrey, A. W., and E. J. Heist. 2004. Genetic identification of juvenile sturgeons from the upper Missouri River. Fisheries and Illinois Aquaculture Center, Southern Illinois University, Carbondale.

Snyder, D. E. 2002. Pallid and shovelnose sturgeon larvae – morphological description and identification. Journal of Applied Ichthyology 18: 240-265.

Snyder, D. E., and S. C. Seal. 2005. Identification of sturgeon larvae collected from the Missouri River, Montana and North Dakota, in 2003. Larval Fish Laboratory, Colorado State University, Fort Collins.

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.

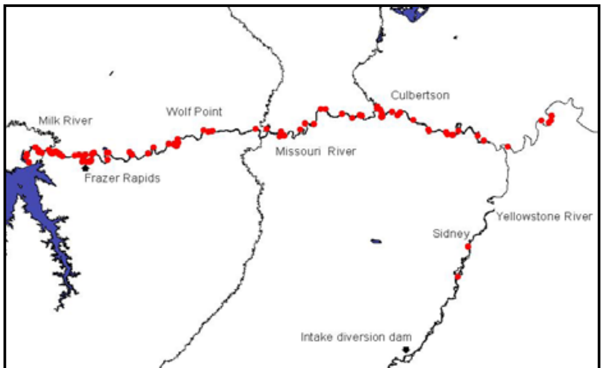
USACE. 2002. Draft environmental assessment, Fort Peck Flow Modification Mini-test. U. S. Army Corps of Engineers, Omaha District.

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

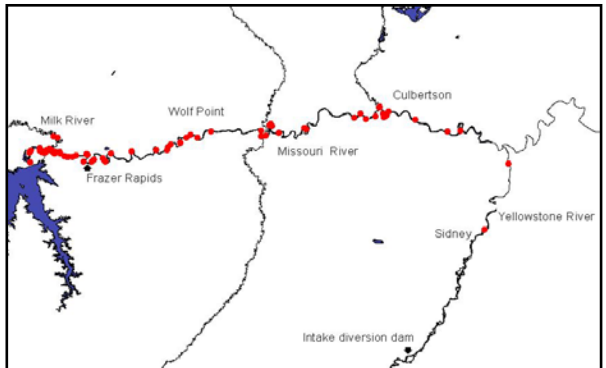
USFWS. 2000. Biological opinion on the operation of the Missouri River main stem reservoir system, operation and maintenance of the Missouri River bank stabilization and navigation project, and operation of the Kansas River reservoir system. U. S. Fish and Wildlife Service, Region 3 (Fort Snelling, Minnesota)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

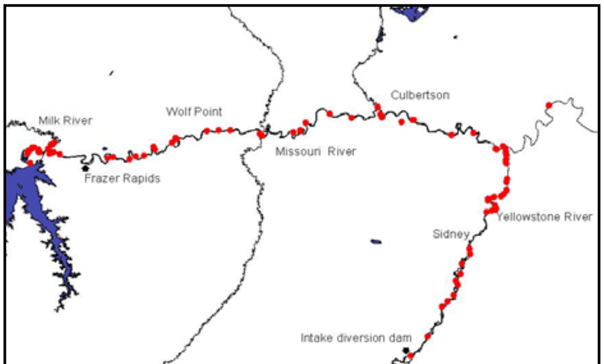
Appendix A. Map extent of blue sucker relocations during 2004.



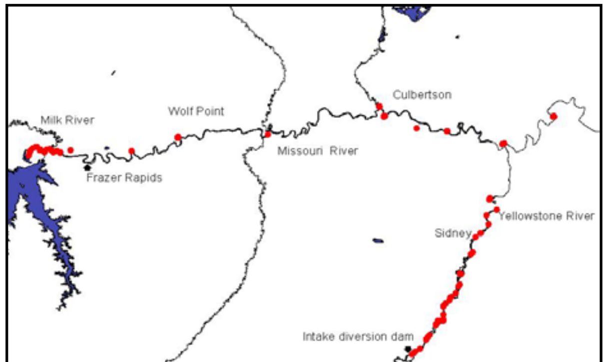
Appendix A.1. Blue sucker relocations in April 2004



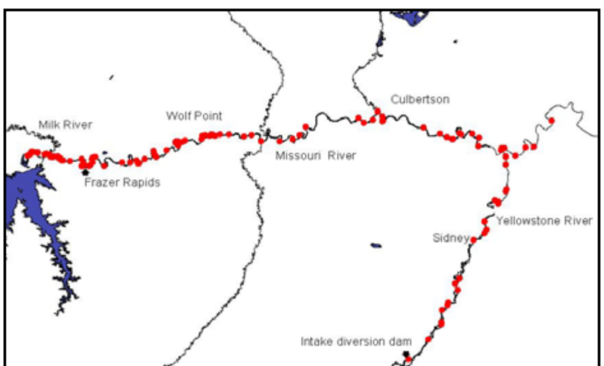
Appendix A.2. Blue sucker relocations in May 2004



Appendix A.3. Blue sucker relocations in June 2004

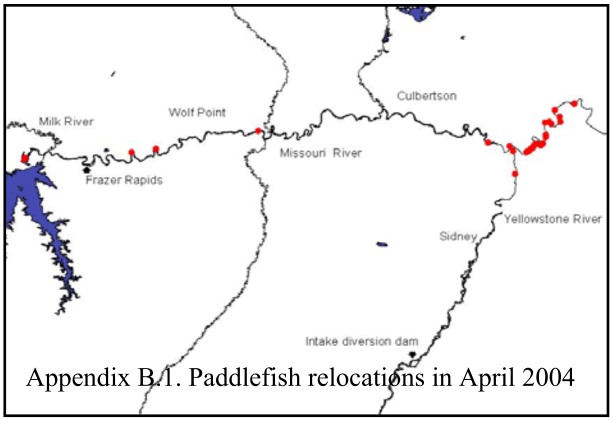


Appendix A.4. Blue sucker relocations in July 2004

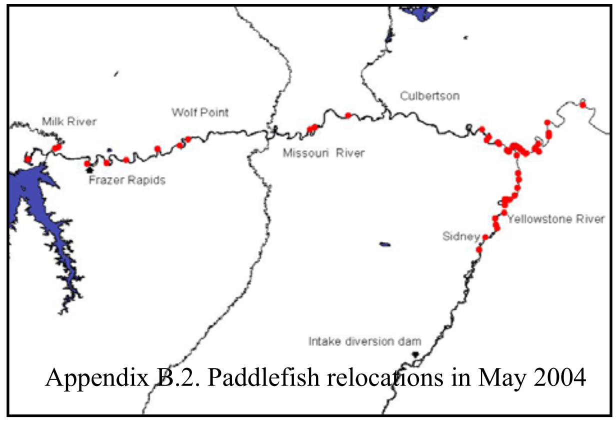


Appendix A.5. Blue sucker relocations in Fall 2004

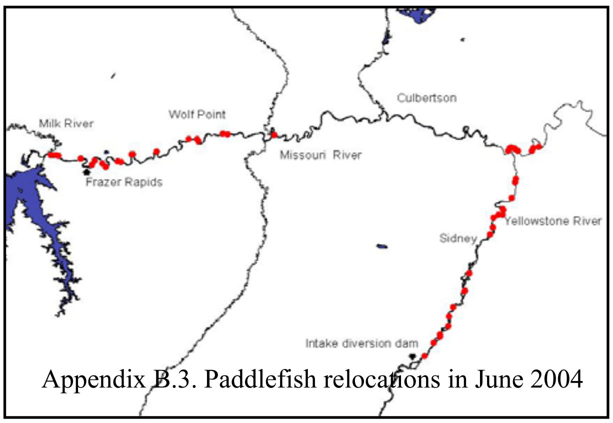
Appendix B. Map extent of paddlefish relocations during 2004.



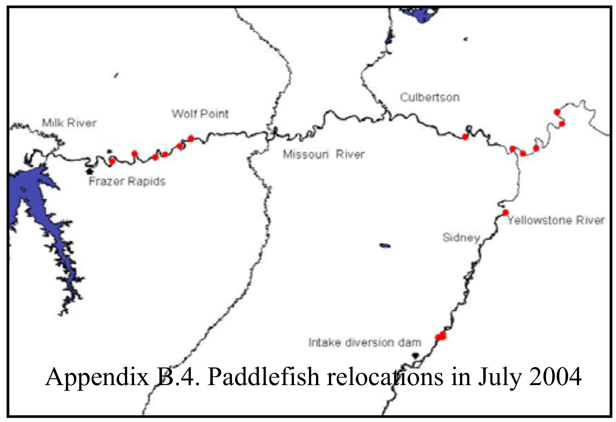
Appendix B.1. Paddlefish relocations in April 2004



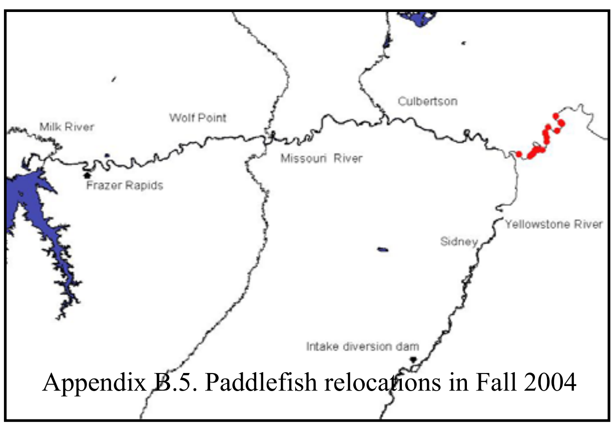
Appendix B.2. Paddlefish relocations in May 2004



Appendix B.3. Paddlefish relocations in June 2004

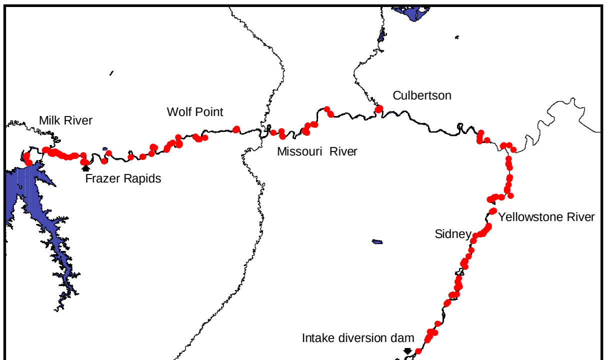


Appendix B.4. Paddlefish relocations in July 2004

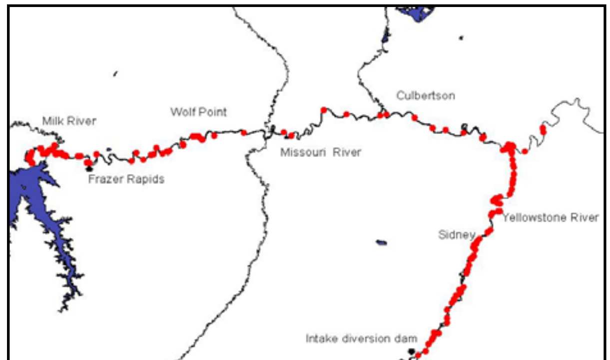


Appendix B.5. Paddlefish relocations in Fall 2004

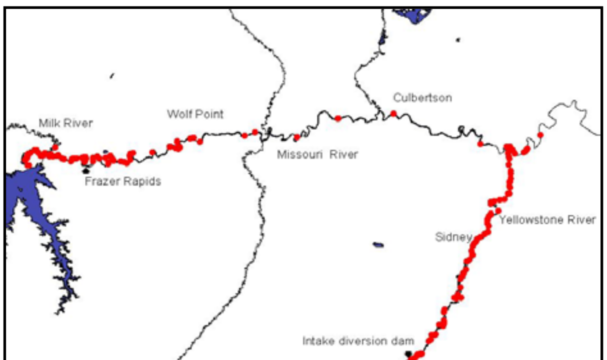
Appendix C. Map extent of shovelnose sturgeon relocations during 2004.



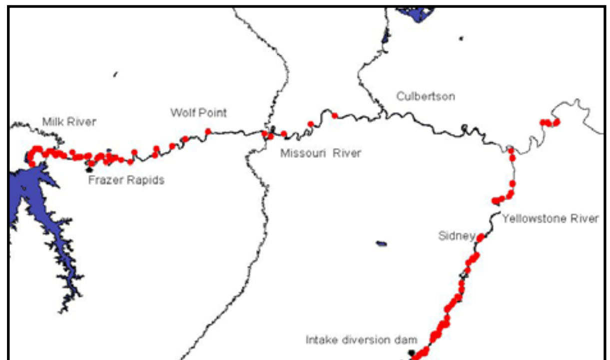
Appendix C.1. Shovelnose sturgeon relocations in April 2004



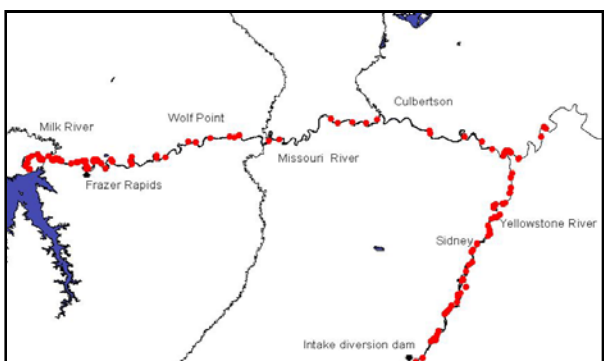
Appendix C.2. Shovelnose sturgeon relocations in May 2004



Appendix C.3. Shovelnose sturgeon relocations in June 2004



Appendix C.4. Shovelnose sturgeon relocations in July 2004



Appendix C.5. Shovelnose sturgeon relocations in Fall 2004