Fort Peck Flow Modification Biological Data Collection Plan

Summary of 2005 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 2005 as part of the multi-year Fort Peck Data Collection were similar to those activities conducted during 2001 – 2004. For 2005, primary research and monitoring activities included: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements and relocating adult pallid sturgeon, paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus* in the Missouri River between Fort Peck Dam and Lake Sakakawea, and in the lower Yellowstone River, 3) quantifying larval fish distribution and abundance, 4) quantifying the reproductive success of shovelnose sturgeon and pallid sturgeon based on captures of young-of-year sturgeon, and 5) assisting in the collection of adult pallid sturgeon for the propagation program. The Fort Peck Data Collection Plan is supported by the USACE, and jointly implemented by the Montana Department of Fish, Wildlife, and Parks and the U. S. Geological Survey - Columbia Environmental Research Center.

Similar to 2001 through 2004, proposed flow modifications were not implemented in 2005 due to inadequate precipitation and insufficient reservoir levels. For component 1, water temperatures between mid-April and mid-October averaged 17.6^{o}C in the free-flowing Missouri River upstream from Fort Peck Reservoir and 12.4^{o}C downstream from Fort Peck Dam. Thus, hypolimnetic releases from the dam thermally suppressed water temperatures by an average of 5.4^{o}C during the study period. Despite gradual increases in temperature as water flowed downstream from the dam, mean water temperature at Nohly (290 km downstream; just upstream from the Yellowstone River confluence) remained 0.7^{o}C cooler than water temperatures upstream from Fort Peck Reservoir indicating continued affects of hypolimnetic releases. Water temperature at Frazer Rapids – a target location for enhancing water temperature to 18.0^{o}C via spillway releases – exceeded 18.0^{o}C on only two dates during 2005 in the absence of spillway releases. Turbidity during late-May through August increased from upstream to downstream sites below Fort Peck Dam, but was higher in the Yellowstone River than Missouri River. Periods of elevated turbidity were associated with increasing discharge in both rivers.

Under research component 2, extensive radio-tracking was conducted between April and November in the lower Yellowstone River and in the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea. A total of 26 individual tracking events was conducted throughout the river systems resulting in a cumulative distance of 11,437 km tracked. We obtained 960 relocations of blue suckers, 389 relocations of paddlefish, and 1,047 relocations of shovelnose sturgeon via boat. Eight continuous-recording telemetry logging stations logged an additional 864 contacts of implanted fish. Species-specific information on locations and movement patterns were ascertained. In addition, a total of 345 manual relocations of pallid

sturgeon implanted by USFWS personnel were obtained. In September 2005, radio transmitters were implanted in an additional 21 shovelnose sturgeon, 21 blue suckers, 7 paddlefish, and 1 pallid sturgeon. These individuals, in conjunction with 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.

For research component 3, larval fishes were sampled two times per week between late May and early August at three sites on the mainstem Missouri River (below Fort Peck Dam, Wolf Point, Nohly), two tributaries (Milk River, Yellowstone River), and the Fort Peck spillway channel. The sampling regime resulted in 2,073 larval fish samples. Representatives of Catostomidae (i.e., suckers) were numerically dominant and composed 59.6% of all larval fish sampled. The Cyprinidae (i.e., carps and minnows) composed 23.7% of the larvae sampled. Hiodontidae (exclusively goldeye, *Hiodon alosoides*), Sciaenidae (exclusively freshwater drum, *Aplodinotus grunniens*) and Percidae (i.e., perches) composed 6.2%, 4.7%, and 4.1% the larvae sampled, respectively. A total of 12 Acipenseridae larvae (0.1% of the total) and 59 Polyondontidae larvae (exclusively paddlefish, 0.7% of the larvae) were identified, but an additional 15 larvae (0.2% of the total) could not be confidently distinguished as *Scaphirhynchus sp*. or paddlefish. Six acipenseriform eggs were sampled in addition to nearly 30,000 eggs from other species.

Under research component 4, trawling was conducted between July 19 and September 7 at four sites in the Missouri River upstream from the Yellowstone River confluence (ATC), four sites in the Missouri River downstream from the Yellowstone River confluence (BTC), and four sites in the Yellowstone River. A total of 535 trawls were conducted on eight sampling events. Trawling efforts resulted in a total of 178 young-of-year sturgeon. Eleven young-of-year sturgeon were sampled from the Missouri River ATC, 155 young-of-year sturgeon were sampled from the Missouri River BTC, and 12 young-of-year were collected sampled from the Yellowstone River. Tissue samples from all young-of-year sturgeon were collected. Genetic analyses are being conducted to differentiate the young-of-year individuals as pallid sturgeon or shovelnose sturgeon.

For component 5, personnel from MTFWP and USGS assisted in the pallid sturgeon broodstock and propagation program by capturing pallid sturgeon in the Missouri River and Yellowstone River. Sampling was conducted during April and October. Pallid sturgeon sampled were provided to hatchery personnel and reproductive physiology experts to determine sex and reproductive stage.

As part of sampling associated with the research components, 44 juvenile pallid sturgeon were sampled during 2005. Three individuals did not carry any identifying marks (e.g., PIT tags, elastomere, coded-wire tags) indicative of hatchery-raised progeny. It was suspected that these individuals were surviving progeny from the larval pallid sturgeon drift study conducted in 2004. Therefore, fin clips for genetic analyses were obtained from these individuals. Genetic analyses from one individual positively identified this fish as progeny from the 2004 larval drift study. Tissue samples from the other two individuals are currently being analyzed, and it is highly likely that these individuals will also represent progeny from the drift study.

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 during the initial five years of this study represent baseline conditions under existing dam operations (see Braaten and Fuller 2002, 2003, 2004, 2005).

The Fort Peck Flow Modification Biological Data Collection Plan (hereafter referred to as the Fort Peck Data Collection Plan) is a multi-component research and monitoring program designed to examine the influence of proposed flow modifications from Fort Peck Dam on physical habitat and biological response of pallid sturgeon and other native fishes. Similar to previous years, primary research activities of the multi-year Fort Peck Data Collection Plan during 2005 included: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements and relocating adult pallid sturgeon, paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus* in the Missouri River between Fort Peck Dam and Lake Sakakawea, and in the lower Yellowstone River, 3) quantifying larval fish distribution and abundance, 4) quantifying the reproductive success of shovelnose sturgeon and pallid sturgeon based on captures of young-of-year sturgeon, and 5) assisting in the collection of adult pallid sturgeon for the propagation program. The Fort Peck Data Collection Plan is funded by the USACE, and jointly implemented by the Montana Department of Fish, Wildlife, and Parks (MTFWP) and the U. S. Geological Survey Columbia Environmental Research Center – Fort Peck Project Office.

Study Area

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

Methods

Monitoring Component 1 - Water temperature and turbidity.

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 most 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. 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 2005, 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 two temperature ranges (cold, < $10^{o}C$, tailwater of Fort Peck Dam; 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 (cold, < $10^{o}C$, outdoor water; 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.

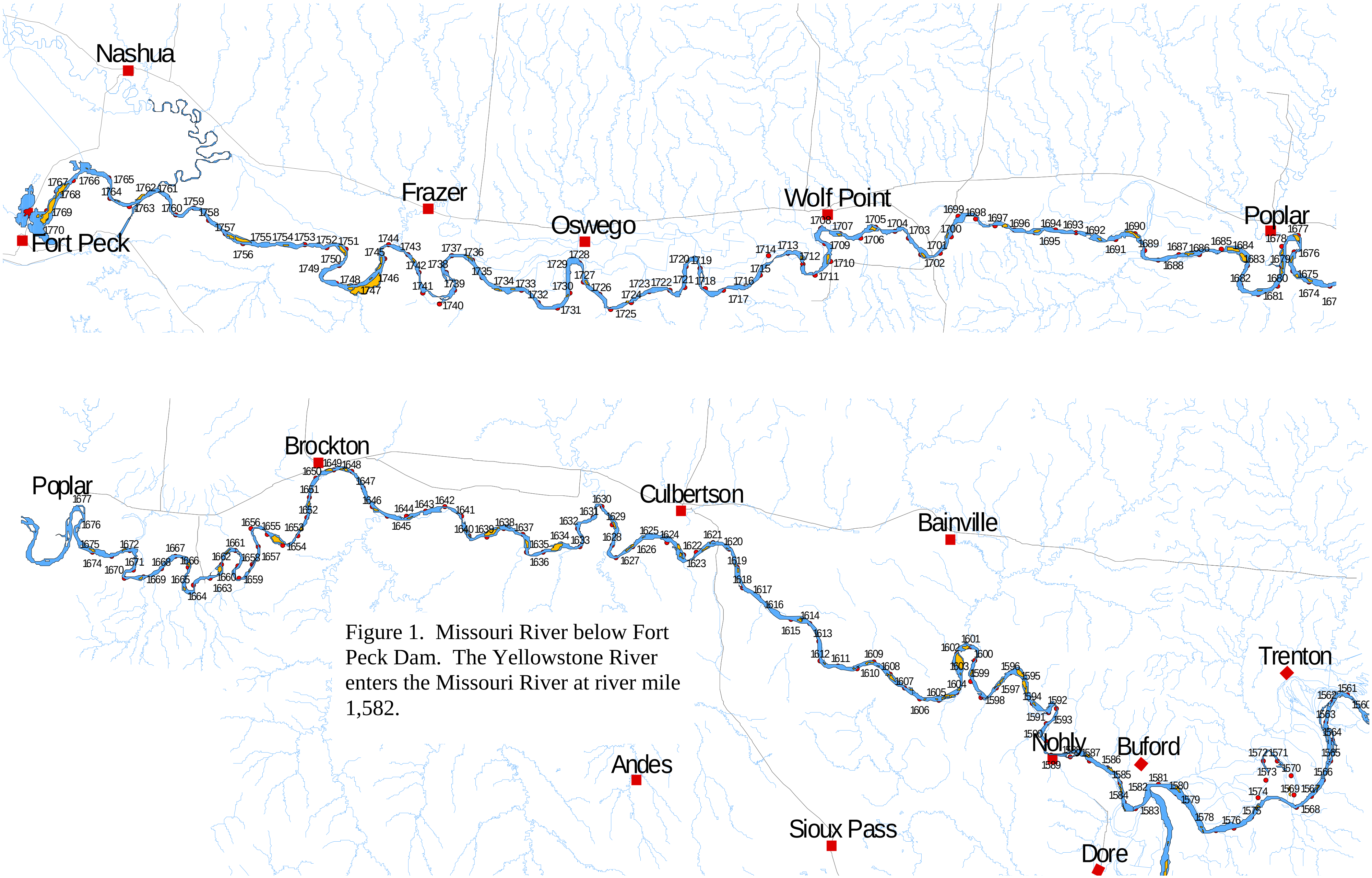


Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

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 2005. NR = not recovered at the end of the season, ND = logger recovered but data would not download.

Site	RM	Bank location	Latitude	Longitude	Logger serial no.	Deploy date	Retrieval Date
Above Fort Peck Lake	1,920.5	South				3/29/05	10/25/05
Fort Peck Lake			48.00938	106.36760	389546	4/12/05	NR
Downstream from Fort Peck Dam	1,765.2	North	48.05561	106.36462	681470	4/12/05	10/17/05
		South	48.06224	106.37871	389571	4/12/15	10/17/05
		Strat	48.06224	106.37871	429715	4/12/05	10/17/05
Spillway			48.03998	106.34099	389575	4/12/05	10/17/05
Milk River	4.0		48.06701	106.30312	681745	4/12/05	10/17/05
Nickels Ferry	1,759.9	North	48.04578	106.28652	681727	4/12/05	10/17/05
		South	48.04509	106.28536	681718	4/12/05	10/17/05
		Strat	48.04578	106.28652	667855	4/12/05	10/17/05
Nickels Rapids	1,757.5	North	48.03531	106.25084	681715	4/12/05	10/17/05
		South	48.03551	106.25475	429720	4/12/05	10/17/05
		Strat	48.03551	106.25475	429713	4/12/05	10/17/05
Frazer Pump	1,751.5	North	48.03093	106.12480	389497	4/12/05	10/21/05
		South	48.03026	106.12668	681706	4/12/05	10/21/05
		Strat	48.03093	106.12480	429709	4/12/05	10/21/05
Frazer Rapids	1,746.0	North	48.00730	106.12961	681716	4/12/05	10/21/05
		South	48.00644	106.12894	429719	4/12/05	10/21/05
		Strat	48.00644	106.12894	429696	4/12/05	10/21/05
Grandchamps	1,741.5	North	48.03541	106.08562	407323	4/12/05	10/21/05
		South	48.03449	106.08234	667869	4/12/05	10/21/05
		Strat	48.03541	106.08562	681751	4/12/05	10/21/05
Wolf Point	1,701.5	North	48.06982	105.53049	429711	4/13/05	10/19/05
		South	48.08152	105.51843	429723	4/13/05	10/19/05
		Strat	48.08152	105.51843	681731	4/13/05	10/19/05
Poplar	1,680	North	48.06678	105.20394	667824	4/13/05	NR
		South	48.06260	105.21553	429717	4/13/05	10/19/05
		Strat	48.06678	105.20394	389563	4/13/05	10/19/05
Poplar River	0.4		48.08378	105.19498	681730	4/13/05	NR
Culbertson	1,620.9	North	48.08769	104.42165	681723	4/13/05	NR
		South	48.09226	104.43986	389572	4/13/05	ND
		Strat	48.09226	104.43986	389490	4/13/05	10/19/05
Nohly	1,591.2	North	48.02082	104.09798	681707	4/13/05	10/19/05
		South	48.01449	104.10710	429697	4/13/05	10/19/05
		Strat	48.01449	104.10710	389504	4/13/05	ND
Yellowstone River	3.5				389493	4/20/05	10/24/05
Below Yellowstone River	1,576.5	North	47.95927	103.90653	681743	4/14/05	10/19/05
		South	48.95876	103.89597	389574	4/14/05	10/19/05
		Strat	48.95876	103.89597	429712	4/14/05	10/19/05

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 $\pm$ 2%). Turbidity loggers were deployed in the Missouri River near Frazer Rapids (rkm 2,811; RM 1,746), near Poplar (rkm 2,708; RM 1,682) and near Nohly (rkm 2,558; RM 1589), and in the Yellowstone River 0.81 km (0.5 miles) upstream from the confluence.

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

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

Manual tracking of implanted fish.- Manual tracking by boat of fish implanted with combination acoustic/radio transmitters (CART) tags in 2002, 2003, and 2004 was initiated in March 2005. 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 was tracked over a 3-day time interval. Several variables (radio/acoustic frequency, fish code, latitude, longitude, river mile, conductivity, water temperature, turbidity, time-of-day) were recorded at fish locations. Aerial tracking was conducted on May 7 and July 29 above Intake and June 25 around the headwaters of Sakakawea with a Lotek SRX-400 receiver in conjunction with a single 4-element Yagi antennae. Aerial tracking was conducted to search for implanted fish that presumably moved out of the study area.

Stationary telemetry logging stations.- Stationary telemetry logging stations were deployed in April 2005 at eight 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 Brockton, rkm 2,658, RM 1,651; near Culbertson, rkm 2,603, RM 1,616.5; near Fort Buford, rkm 2,533, RM 1583; near Williston, rkm 2,471, RM 1,544.5; Yellowstone River, rkm 1, RM 0.6). The logging stations at Nickels, Wolf Point, 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 in the Milk River, at Culbertson, Fort Buford, Williston, and in the Yellowstone River were placed on shore with two 4-elemnet Yagi 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 2005. 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, > 5 year 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 released immediately after the surgery.

Analyses of telemetry data.-A complete analysis of telemetry data will be conducted after completion of the study; however, summary analyses were conducted to report and illustrate trends. Spatial and temporal use of the Missouri River, Yellowstone River, and Milk River were quantified using 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). Comparisons were conducted among the 2003, 2004 and 2005 tracking seasons. During these years, additional ground based telemetry stations were deployed at various reach breaks. This provided information of when individuals immigrated or emigrated out of a particular reach. These data were used for percent relocations within that reach. These data were not available in prior years; therefore, overall percentages were lower in 2003.

Monitoring Component 3 – Larval Fish Distribution and Abundance

Sampling protocols. Larval fish were sampled two times per week from late May through early August at six sites (Table 2). Similar to 2001 - 2004, sites on the mainstem Missouri River were located just downstream from Fort Peck Dam, near Wolf Point, and near Nohly. Sites located off the mainstem Missouri River included the spillway channel, the Milk River, and the Yellowstone River. Larval fish at all sites were sampled with 0.5-m-diameter nets (750 µm mesh) fitted with a General Oceanics Model 2030R velocity meter.

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

Table 2. Larval fish sampling locations, number of replicates, samples, and net locations for 2005 sampling events. Abbreviations for net location are as follows: B = bottom, M = mid-water column, S = surface (0.5 - 1.0 m below the surface).

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

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

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

Monitoring Component 4 – Young-of-year sturgeon

Sampling for young-of-year sturgeon was conducted with a benthic (beam) trawl between mid-July and early September 2005 in the Missouri River above the Yellowstone River confluence (i.e., ATC), Missouri River below the Yellowstone River confluence (i.e., BTC), and in the Yellowstone River. Four replicate sampling locations were established at each site (Table 3) where each replicate was comprised of an inside bend, outside bend, and channel crossover habitat complex (IOCX) associated with a river bend. A dual sampling protocol was followed to quantify young-of-year sturgeon. Standard sampling consisted of conducting a single trawl in each habitat type within the IOCX. If a young-of-year sturgeon was collected in the standard trawl, two additional "targeted trawls" were conducted in the exact same location. If young-of-year sturgeon were sampled in either of the two targeted trawls, two additional targeted trawls were conducted. This process was repeated up to a maximum of eight targeted trawls. Targeted sampling was conducted to obtain information on aggregations. An exception to the IOCX sampling protocol was followed at replicate 1 in the Missouri River BTC where nine standard trawl subsamples were used to characterize this location. This location produced several young-of-year sturgeon in previous years (Braaten and Fuller 2002, 2003, 2004, 2005), thus intensive sampling was conducted at this location. The targeted sampling protocol was followed at this site.

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

Table 3. Young-of-year sturgeon sampling sites for 2005. ATC = above the Yellowstone River confluence, BTC = below the Yellowstone River confluence. River km sites denotes distance upstream from the mouth.

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

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

For this component, crews assisted the USFWS in capturing adult pallid sturgeon for the hatchery propagation program. Crews were involved in sampling the Missouri River and Yellowstone River during April and October 2005. Pallid sturgeon were sexed and staged, and selected individuals were transported to hatcheries.

Results and Discussion

Hydrologic conditions

Mean daily discharge in the Milk River during 2005 averaged 9.3 m^3/s between April 1 and September 30 (Figure 2). Two major peaks in discharge occurred during this time period (early June, peak = 125 m^3/s; late-June, peak = 78 m^3/s), and a smaller third peak occurred during early July. Across years, mean discharge in the Milk River during 2005 was less than 2002 and 2004, but greater than 2001 and 2003.

Discharge in the Missouri River during 2005 was relatively constant from April 1 to early June, then increased to maximums of 264 m^3/s in early June and 217 m^3/s in late June (Figure 2). Increased discharge during these two periods resulted from Milk River inflows. Between April 1 and September 30, 2005, discharge in the Missouri River at Wolf Point averaged 166 m^3/s – similar to mean daily discharge during 2001. However, mean discharge in 2005 was less than that recorded during 2002, 2003, and 2004.

In the Yellowstone River, mean daily discharge averaged 333 m^3/s between April 1 and September 30, 2005 (Figure 2). Elevated flow conditions persisted for nearly a 2-month time period between mid-May and early July when four peak discharge events occurred. Maximum discharge occurred in late June (1214 m^3/s). Across years, mean daily discharge during 2005 was greater than other years.

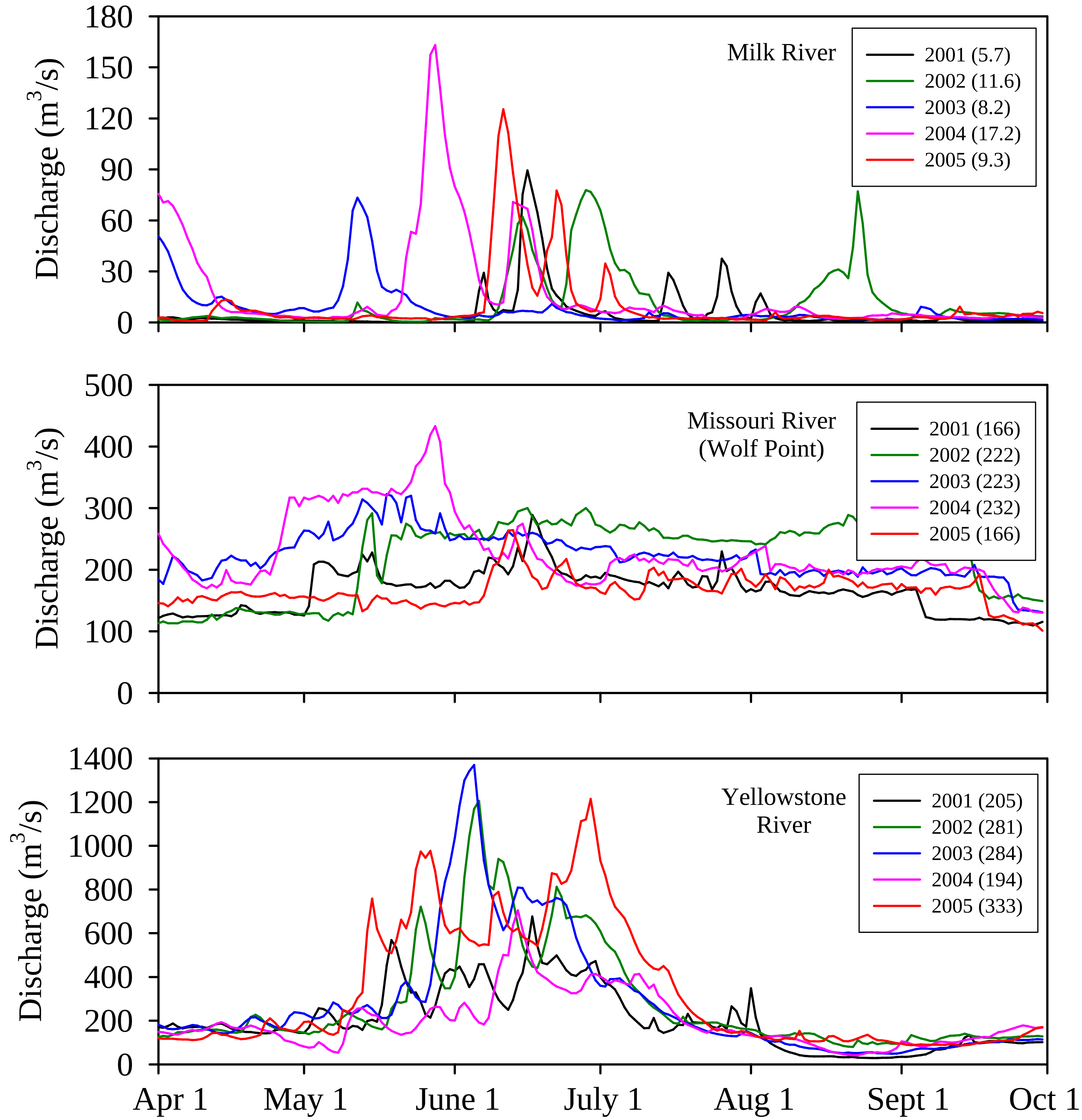


Figure 2. Mean daily discharge in the Milk River (gage 06174500), Missouri River at Wolf Point (gage 06177000), and in the Yellowstone River (gage 06329500) during 2001 - 2005. Values listed in parentheses represent mean daily discharge (m^3/s) for the specified year between April 1 and September 30. Note the change in ordinate values among graphs.

Monitoring Component 1 - Water temperature and turbidity

General comments on water temperature loggers. Data were not obtained from six of the 39 loggers deployed during 2005 (Table 1). Loggers were not recovered from Fort Peck Lake, Poplar north bank, Poplar River, and Culbertson north bank. Two additional loggers (Culbertson south bank, Nohly stratified) were recovered at the end of the season, but the data would not download. For example, the stratified Nohly logger was chewed by a beaver which allowed water to enter the logger causing internal logger damage. However, with the exception of Fort Peck Lake and Poplar River, additional loggers deployed at the sites provided water temperature information for at least one bank of the river.

Pre- and post-deployment assessments of water temperature logger precision. Precision of water temperature loggers prior to deployment varied slightly between the cold and water treatments (Table 4). At cold temperatures in the tailwaters of Fort Peck Dam, logger range was 0.9 – 1.4 at mean water temperatures between 4.7 – 4.9^{o}C. However, the range decreased to 0.3 – 0.5^{o}C when the water temperature loggers were subjected to warm trials between 22.9 and 23.7^{o}C Table 4). Thus, precision tended to be greater at warm than cold water temperatures.

For the post-deployment tests, loggers exhibited high variability (broad temperature range) during the cold water bath treatments as range varied from 1.0 to 4.0 (Table 5). Although some of this variability may be associated with logger imprecision, it is also likely that lack of homeothermal water temperature conditions in the outdoor water bath contributed to the high variability. For example, following the transfer of the water bath from the laboratory to cold condition outdoors, it is likely that the water did not cool consistently throughout the water bath. Under cool (10-20^{o}C) temperature treatments, the loggers exhibited relatively good precision as evidenced by the moderate water temperature range (0.6 – 0.8^{o}C; Table 5). At warm water temperature treatments (> 20^{o}C), precision was not quite as good as cool treatments as the range of water temperature for the individuals trials varied between 0.8 and 1.0^{o}C. However, after two hours of being in the warm water temperature bath (trial 1, 2), the range appeared to stabilize at 0.8 during subsequent trials separated by 1-hr. Based on this result, a prolonged period of water temperature bath exposure to laboratory (or constant) air conditions is necessary to achieve homeothermal water temperatures in the water bath.

The pre- and post-deployment precision tests suggest some "drift" or changes in precision following field deployment. For example, the pre-deployment tests indicated a narrow range (0.3-0.5^{o}C) for the warm treatments; whereas, the range was higher during the warm post-deployment tests (i.e., 0.8^{o}C, excluding the initial two warm trials). However, it is unlikely that slight changes in precision and accuracy during field deployment would have a significant impact on water temperatures recorded during field deployment. In addition, the loggers have an accuracy $\pm$ 0.2^{o}C. Based on these results, water temperatures recorded by the loggers during 2005 likely reflected accurate thermal conditions at the deployment sites. However, based on the pre- and post-deployment tests, there is likely some error at extremely cold temperatures (< 10^{o}C).

Table 4. Pre-deployment summary statistics for water temperature (^{o}C) comparisons among 39 water temperature loggers in common water bath treatments for 2005. 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	4.7	4.2	5.2	1.0	0.26
	2	4.9	4.4	5.5	1.1	0.30
	3	4.7	4.3	5.2	0.9	0.23
	4	4.7	4.2	5.6	1.4	0.31
	5	4.9	4.4	5.6	1.2	0.29
Warm	1	23.7	23.5	23.9	0.4	0.12
	2	23.6	23.3	23.7	0.4	0.13
	3	23.3	23.0	23.5	0.5	0.12
	4	23.1	22.8	23.3	0.5	0.12
	5	22.9	22.7	23.0	0.3	0.12

Table 5. Post-deployment summary statistics for water temperature (^{o}C) comparisons among 35 water temperature loggers in common water bath treatments for 2005. 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	6.2	3.9	7.9	4.0	1.0
	2	3.2	2.1	4.1	2.0	0.48
	3	5.0	4.0	6.7	2.6	0.63
	4	6.8	6.2	7.7	1.5	0.36
	5	8.8	8.4	9.4	1.0	0.27
Cool	1	19.2	18.8	19.5	0.8	0.15
	2	18.8	18.4	19.2	0.8	0.16
	3	18.5	18.1	18.7	0.6	0.14
	4	18.3	17.8	18.6	0.8	0.16
	5	18.1	17.6	18.4	0.8	0.14
Warm	1	25.6	25.1	26.1	1.0	0.19
	2	24.2	23.7	24.7	1.0	0.19
	3	23.1	22.7	23.5	0.8	0.17
	4	22.1	21.7	22.5	0.8	0.17
	5	21.3	20.9	21.7	0.8	0.17

Lateral and vertical comparisons of water temperature. Mean daily water temperature was compared among north bank, south bank, and stratified locations at 11 sites (Table 6). At all sites, mean daily water temperature did not differ significantly between stratified and bottom bank locations. These results indicate that water in the mainstem Missouri River was homeothermal, and that thermal stratification was not evident. Significant differences in mean daily water temperature between north and south bank locations occurred only at the site downstream from Fort Peck Dam where water temperature was greater on the north bank than south bank of the river. However, mean water temperatures only differed by 1.0^{o}C. Although the specific reason(s) for the lateral difference is unknown, it is likely that the proximity of the north bank temperature logger to the dredge cut (off-channel lake) located on the north bank of the river exhibited and influence on water temperature at this site. For example, during normal hydropeaking operations, warmer water from the dredge cut flows into the river as dam releases are reduced. If warmer water from the dredge cut is incompletely mixed with cooler river water during the initial few km downstream, the water temperatures would be slightly elevated on the north bank of the river.

Although water temperatures did not differ significantly between north and south bank locations, slight differences in water temperature were evident between bank locations periodically during the deployment period (Figures 3, 4). Water temperature on the north bank of the river at Nickels Ferry, Nickels Rapids, and Frazer Pump were elevated in comparison to the south bank during June and briefly during early July. However, this pattern was not evident at sites further downstream including Frazer Rapids and Wolf Point (Figure 3, 4). Elevated water temperatures on the north bank of the river were primarily attributed to increased discharges of warm water from the Milk River (confluence on the north river bank), and incomplete lateral mixing. For example, at the Nickels Ferry site (closest site downstream from the Milk River), north bank water temperatures increased when discharge from the Milk River increased (Figure 5). Differences in temperature between the north and south banks diminished as water mixed while flowing to sites further downstream. Lateral mixing was complete by the time water reached the Frazer Rapids site as evidenced by nearly identical temperature on the north and south banks at this site and Wolf Point.

Table 6. Summary statistics and probability values (P, from ANOVA or t-tests) for comparisons of mean daily water temperature (°C) among water temperature loggers located on the north bank and south bank, and stratified in the water column during 2005. 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) or south bank (S).

Site	Logger location	Number of days	Mean	SD	Minimum	Maximum	P
Below Fort Peck Dam	North	189	12.7[a]	3.0	5.0	17.2	0.003
	South	183	11.7[b]	3.2	5.2	16.9	
	Stratified(S)	183	11.8[b]	3.2	5.3	17.0	
Nickels Ferry	North	189	13.1[a]	3.3	5.0	21.5	0.12
	South		12.6[a]	3.1	4.9	17.2	
	Stratified(N)		13.3[a]	3.4	5.1	21.7	
Nickels Rapids	North	189	12.6[a]	3.0	5.1	18.8	0.61
	South		12.4[a]	3.1	4.5	16.9	
	Stratified(S)		12.8[a]	3.1	4.8	17.2	
Frazer Pump	North	193	13.3[a]	3.2	4.6	19.1	0.86
	South		13.2[a]	3.1	4.7	17.6	
	Stratified(N)		13.3[a]	3.3	4.6	19.2	
Frazer Rapids	North	193	13.2[a]	3.2	5.0	18.7	0.78
	South		13.4[a]	3.3	4.6	18.4	
	Stratified(S)		13.3[a]	3.2	4.4	18.4	
Grandchamps	South	193	13.6[a]	3.3	4.6	18.7	0.93
	Stratified(N)		13.6[a]	3.3	4.7	19.1	
Wolf Point	North	190	15.2[a]	4.1	4.0	22.5	0.82
	South		15.0[a]	4.1	3.9	22.2	
	Stratified(S)		14.9[a]	4.1	3.8	22.2	
Poplar	South	190	15.6[a]	4.4	4.0	23.9	0.78
	Stratified(N)		15.7[a]	4.4	4.0	24.0	
Culbertson	South	85	16.4[a]	4.3	6.5	23.5	0.97
	Stratified(S)		16.4[a]	4.3	6.4	23.4	
Nohly	North	190	16.7[a]	5.2	4.5	25.6	0.85
	South		16.6[a]	5.2	4.3	25.6	
Below Yellowstone	North	189	17.1[a]	5.2	4.9	25.5	0.99
River	South		17.1[a]	5.3	4.9	25.5	
	Stratified(S)		17.1[a]	5.3	5.0	25.4	

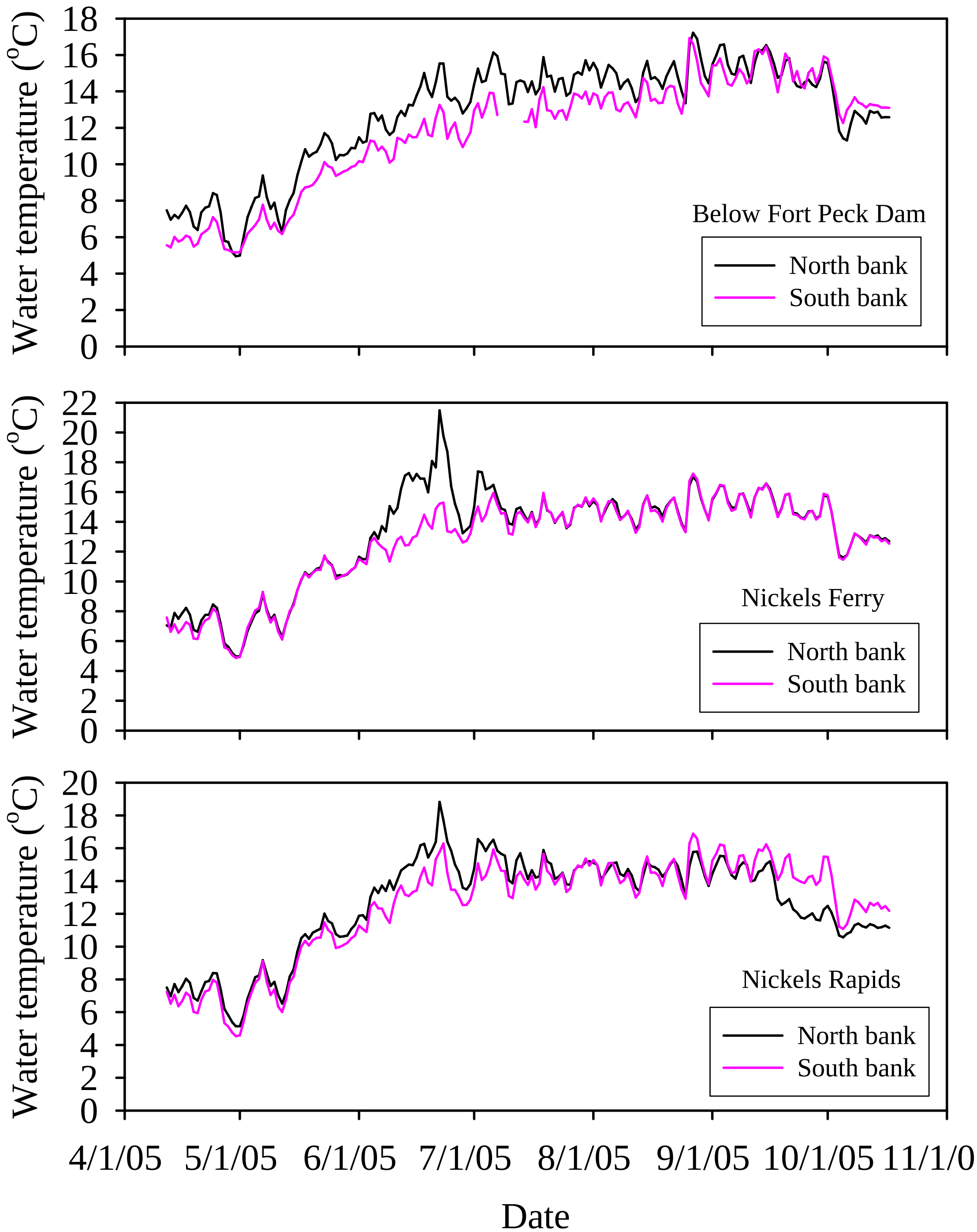


Figure 3. Mean daily water temperature on opposite river banks of the Missouri River at sites located downstream from Fort Peck Dam (top panel), Nickels Ferry (middle panel), Nickels Rapids (lower panel) during 2005.

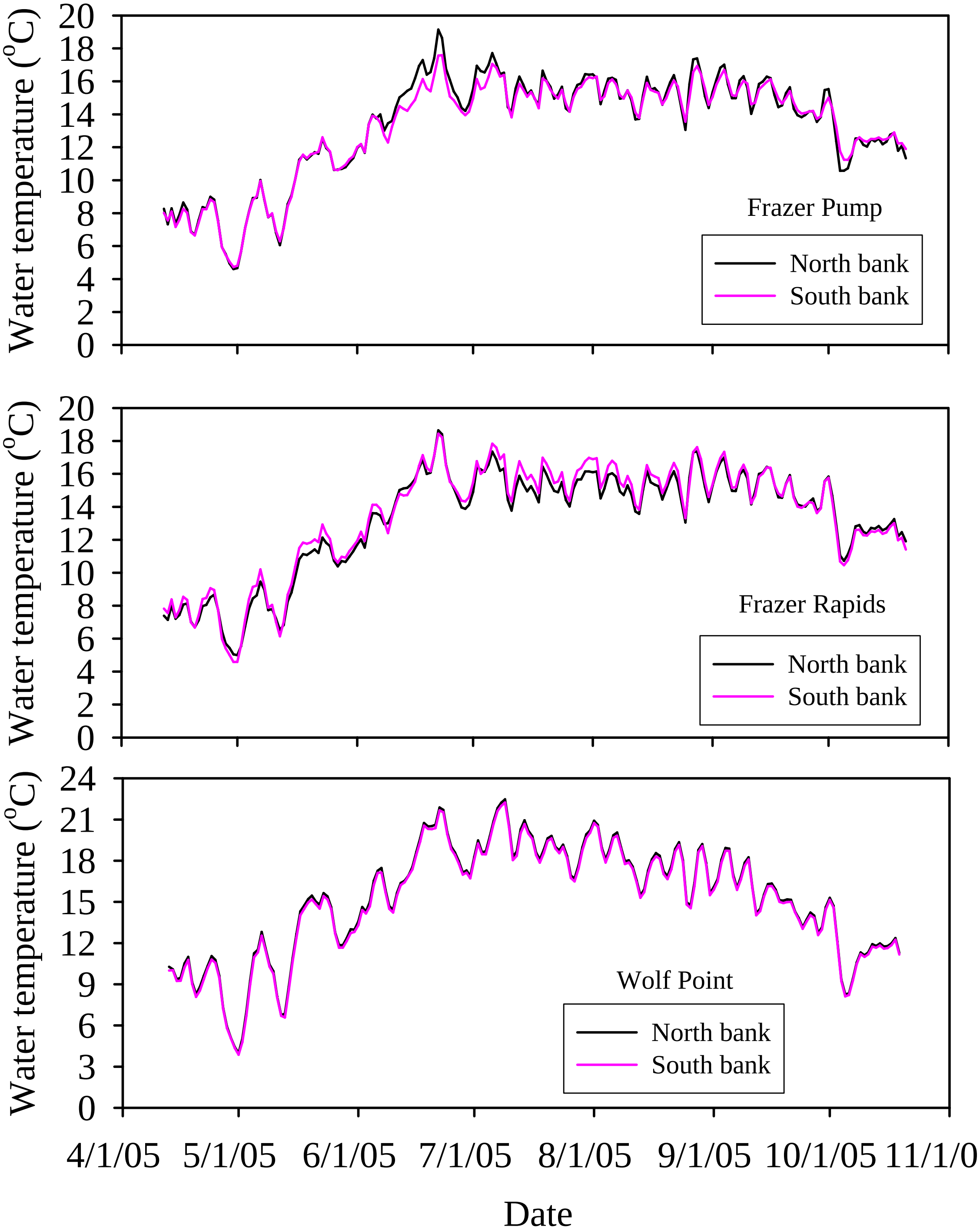


Figure 4. Mean daily water temperature on opposite river banks of the Missouri River at sites located near Frazer Pump (top panel), Frazer Rapids (middle panel), and Wolf Point (lower panel) during 2005.

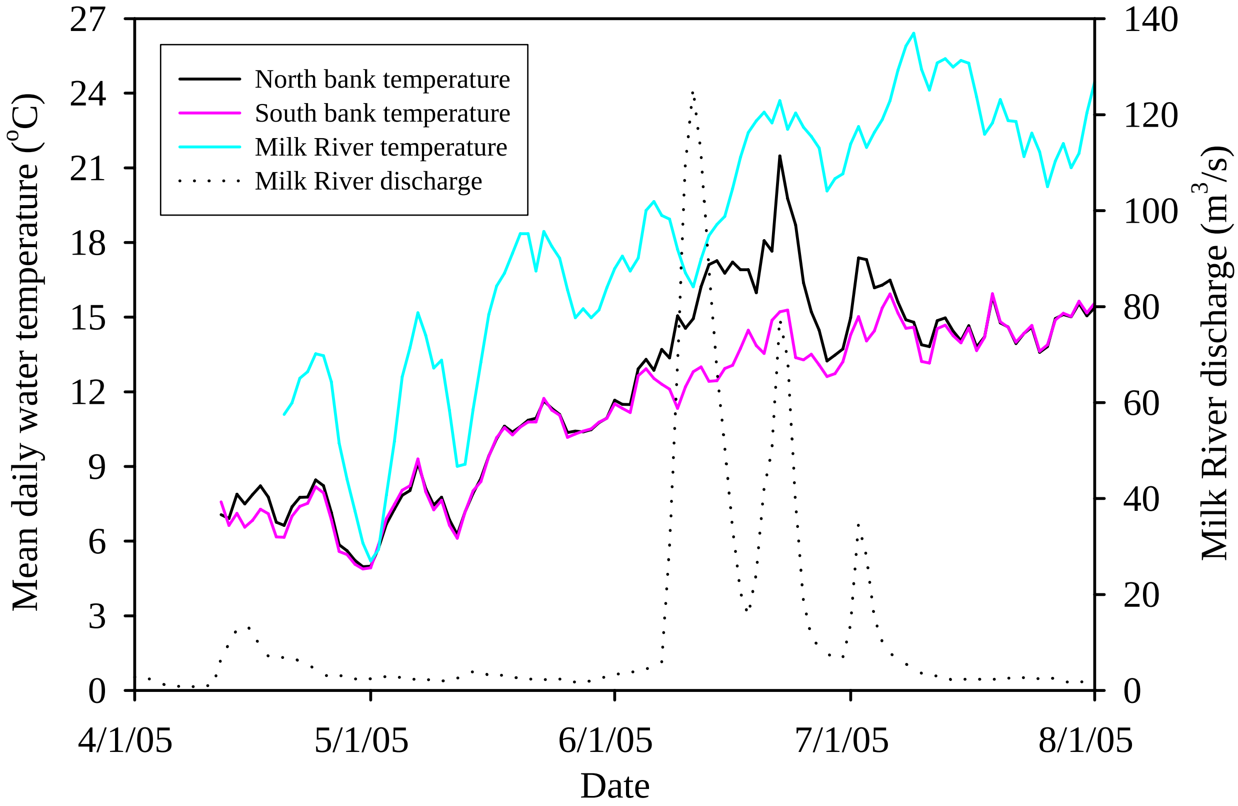


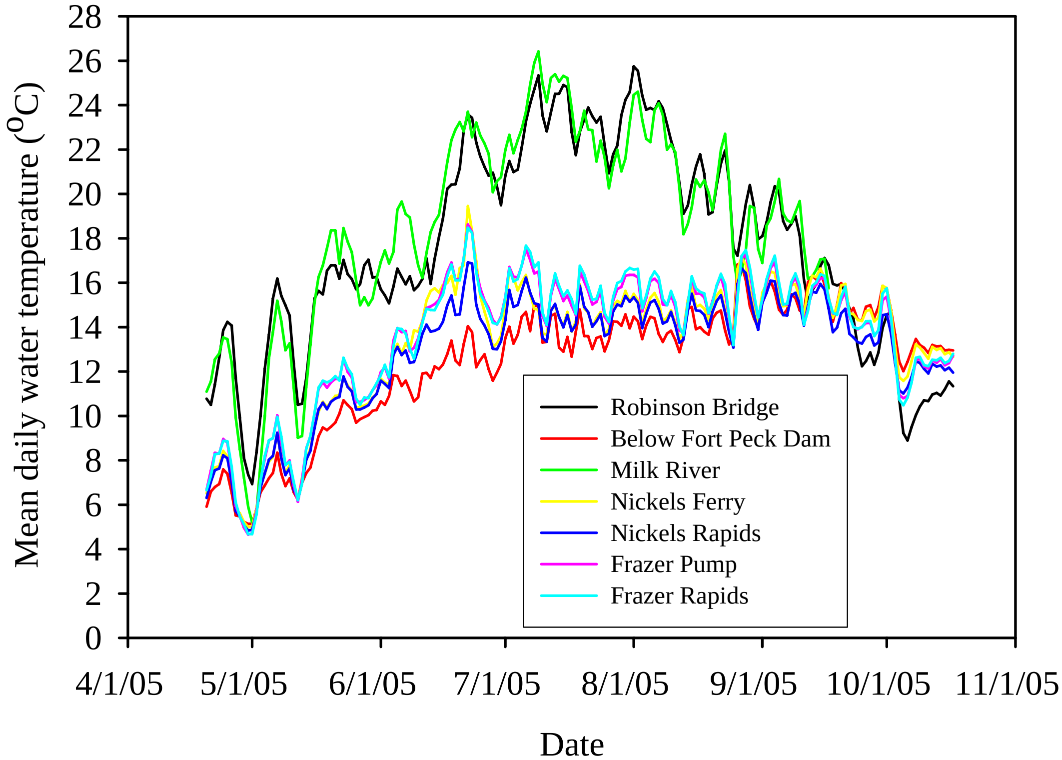
Figure 5. Mean daily water temperature on opposite river banks of the Missouri River at Nickels Ferry (downstream from the Milk River) as influenced by discharge and temperature inputs from the Milk River during 2005.

Longitudinal water temperatures. Mean daily water temperature differed significantly among sites during the common deployment period during 2005 (Table 7; Figure 6). The trend indicated that mean daily water temperature was greatest in the Missouri River upstream from Fort Peck Dam, Missouri River downstream from the Yellowstone River, and in the Yellowstone River, but these sites were not significantly different from Nohly and Culbertson. Water temperatures were significantly cooler downstream from Fort Peck Dam and at Nickels Rapids. Across the common deployment period, hypolimnetic releases from Fort Peck Dam reduced temperatures by an average of 5.2^{o}C from riverine conditions upstream from the reservoir. However, maximum temperature was reduced by 8.9^{o}C. Despite gradual increases in temperature as water flowed downstream from the dam, mean water temperature at Nohly (just upstream from the Yellowstone River confluence) remained 0.7^{o}C cooler than water temperatures upstream from Fort Peck reservoir. Thus, thermal impacts of the dam were maintained more than 300 km downstream. Patterns in the variability of mean daily water temperature generally mimicked those of mean daily water temperature as the coefficient of variation was greatest in the Yellowstone River and Missouri River at Nohly, Culbertson, and below the Yellowstone River confluence. Variability was least at the sites closer in proximity to Fort Peck Dam.

Listed under reasonable and prudent alternatives in the Missouri River Biological Opionion (USFWS 2000), spillway releases from Fort Peck Dam are targeted to enhance water temperature to a minimum of 18.0^{o}C at Frazer Rapids. During 2005, a mean daily water temperature maximum of 18.5^{o}C occurred at Frazer Rapids on June 22 (Table 7) and 18.2^{o}C occurred on June 23. Achievement of water temperatures in excess of 18.0^{o}C on these two dates resulted from warm inputs of water from the Milk River when this system exhibited high discharges during late June (Figure 2). Aside from these two dates, mean daily water temperature did not reach 18.0^{o}C at Frazer Rapids.

Table 7. Mean daily water temperature (^{o}C) summary statistics (mean, minimum, maximum, standard deviation, SD; coefficient of variation, CV) for Missouri River mainstem locations and off-channel locations in 2005. Summary statistics for all sites except the Milk River were calculated for common deployment dates (4/20 – 10/17, N = 181 days) to standardize comparisons among all loggers. Inclusive dates for the Milk River spanned 4/20 – 9/17 (N = 151 days), and the Milk River was not included in the ANOVA. Means with the same superscript are not significantly different (P > 0.05). Mainstem Missouri River sites are listed from upstream to downstream. See Figure 6 for a graphical representation of mean daily water temperatures.

Location	Site	Mean	Minimum	Maximum	SD	CV
Missouri River mainstem	Robinson Bridge	17.6^{a}	6.9	25.7	4.6	26.3
	Below Fort Peck Dam	12.4^{l}	5.1	16.8	2.9	23.3
	Nickels Rapids	$12.8^{i,j,k,l}$	4.8	16.9	2.9	22.3
	Nickel Ferry	$13.3^{h,i,j,k}$	5.0	19.5	3.1	23.0
	Frazer Pump	$13.5^{h,i,j}$	4.7	18.6	3.1	22.7
	Frazer Rapids	$13.6^{h,i}$	4.7	18.5	3.1	22.9
	Grandchamps	13.8^{h}	4.7	18.9	3.2	23.2
	Wolf Point	15.3^{g}	3.9	22.3	4.0	26.4
	Poplar	$15.9^{e,f,g}$	4.0	24.0	4.4	27.3
	Culbertson	$16.7^{a,b,c,d,e}$	4.2	25.5	5.0	29.7
	Nohly	$16.9^{a,b,c,d}$	4.4	25.6	5.1	30.3
	Below Yellowstone	$17.3^{a,b,c}$	4.9	25.5	5.2	30.3
Off-channel or tributary	Spillway	$16.2^{d,e,f}$	5.0	22.3	3.8	23.4
	Milk River	18.7	5.2	26.4	4.6	24.5
	Yellowstone River	$17.6^{a,b}$	5.1	25.6	5.4	30.7



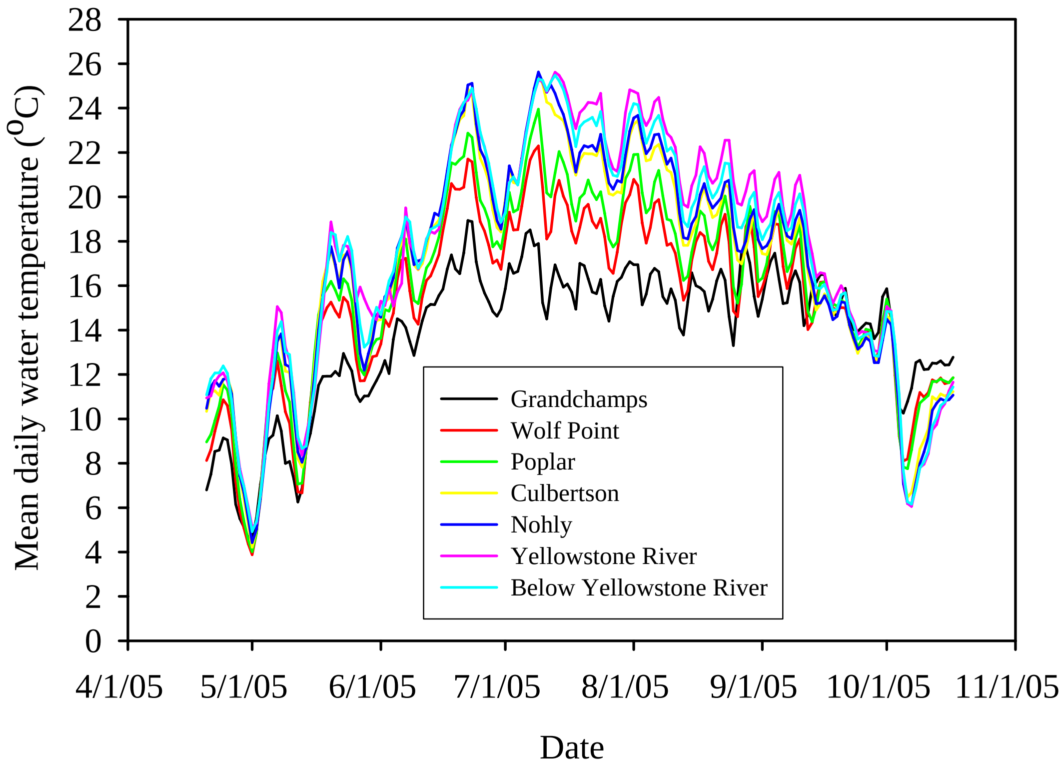


Figure 6. Mean daily water temperature (°C) at 14 sites on the mainstem Missouri River, tributaries, and off-channel sites during 2005.

Inter-annual comparisons of mean daily water temperature within sites. Mean daily water temperature was compared among years for 17 sites, and temperature differed significantly at all sites with the exception of the Yellowstone River and Missouri River below the Yellowstone River confluence (Table 8). In the Missouri River upstream from Fort Peck Lake, water temperature during 2001 was significantly warmer than other years except 2003. Water temperature tended to be highest during 2004 and 2005 for mainstem Missouri River sites downstream from Fort Peck Dam (below Fort Peck Dam, Nickels Ferry, Nickels Rapids, Frazer Pump, Frazer Rapids). Warmest water temperatures occurred during 2005 and 2001 at Wolf Point and Poplar, and 2005, 2003, and 2001 at Culbertson and Nohly. In the Milk River, mean daily water temperature was greatest during 2003.

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 - 2005 at mainstem Missouri River sites and off-channel sites. Common dates for all years are 5/17 – 10/9 (N = 146 days) with the exception of Fort Peck Lake (5/17 – 8/29) and Milk River (5/17 – 9/17, N = 124 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	0.0076
	2002	18.7^{bcd}	9.2	26.7	4.2	22.5	
	2003	19.3^{ab}	11.4	25.2	4.0	20.5	
	2004	18.7^{bcd}	10.8	26.7	3.9	20.9	
	2005	19.0^{bc}	8.9	25.7	3.9	20.7	
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	16.3	1.8	13.5	
	2005	13.4^{ab}	9.1	16.8	1.8	13.2	
Spillway	2001	18.4^{a}	10.7	23.8	3.0	16.6	< 0.0001
	2002	15.7^{d}	8.6	20.0	2.7	16.9	
	2003	16.9^{bc}	11.5	22.5	3.0	17.9	
	2004	17.0^{bc}	9.7	21.4	2.8	16.3	
	2005	17.6^{b}	8.3	22.3	2.8	15.7	
Milk River	2001	20.0^{bcd}	12.0	26.2	3.3	16.5	< 0.0001
	2002	20.1^{bc}	13.0	26.9	3.5	17.2	
	2003	21.8^{a}	11.7	27.4	3.5	16.2	
	2004	19.2^{d}	11.6	27.4	3.4	17.5	
	2005	20.3^{b}	15.0	26.4	2.9	14.2	
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	
	2005	14.4^{a}	10.2	19.5	1.8	12.2	
Nickels Rapids	2001	13.5^{b}	8.5	16.6	1.7	12.5	< 0.0001
	2002	12.9^{c}	6.7	16.1	2.2	16.9	
	2003	12.8^{c}	8.1	15.9	1.6	12.3	
	2004	13.8^{ab}	8.6	16.7	1.7	12.6	
	2005	13.9^{a}	10.3	16.9	1.6	11.4	
Frazer Pump	2001	13.9^{b}	8.5	17.0	1.8	13.2	< 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	
	2005	14.7^{a}	10.6	18.6	1.8	12.0	
Frazer Rapids	2001	13.8^{c}	8.3	17.3	1.8	13.3	< 0.0001
	2002	13.1^{d}	7.1	17.1	2.3	17.2	
	2003	12.9^{d}	8.1	15.7	1.5	11.8	
	2004	14.3^{b}	8.6	17.1	1.9	13.0	
	2005	14.8^{a}	10.5	18.5	1.8	12.3	
Grandchamps	2001	14.4^{b}	8.5	18.1	20.	14.1	< 0.0001
	2002	13.5^{c}	7.5	17.3	2.3	16.9	
	2003	13.6^{c}	8.3	17.4	1.8	13.4	

Table 8 continued.

Site	Year	Mean	Minimum	Maximum	SD	CV	P
Grandchamps	2004	14.6[ab]	8.6	17.5	2.0	13.3	
	2005	15.1[a]	10.3	18.9	1.9	12.6	
Wolf Point	2001	16.5[ab]	9.4	22.7	3.1	18.7	< 0.0001
	2002	15.0[d]	9.3	19.4	2.8	18.8	
	2003	15.6[cd]	9.0	21.2	2.9	18.4	
	2004	15.8[bc]	8.9	20.9	2.6	16.2	
	2005	16.7[a]	8.1	22.3	2.9	17.1	
Poplar	2001	16.8[ab]	9.9	21.2	2.8	16.8	0.0056
	2003	16.3[bc]	9.4	22.3	3.2	19.9	
	2004	16.3[bc]	9.2	22.2	2.8	17.2	
	2005	17.4[a]	7.8	24.0	3.2	18.5	
Poplar River	2001	19.4[a]	10.2	25.9	3.9	19.9	0.0009
	2004	17.9[b]	9.8	25.3	3.5	19.4	
Culbertson	2001	17.9[ab]	9.7	24.0	3.5	19.3	0.0121
	2002	17.0[d]	8.3	23.9	3.9	23.0	
	2003	17.9[abc]	10.4	24.7	4.0	22.5	
	2004	17.2[bcd]	10.5	24.6	3.3	19.4	
	2005	18.3[a]	6.5	25.5	3.9	21.3	
Nohly	2001	18.9[a]	11.4	25.3	3.8	20.0	0.0005
	2002	17.5[cd]	7.7	25.4	4.3	24.6	
	2003	18.2[abc]	10.2	25.0	4.2	23.0	
	2004	17.1[d]	10.1	23.9	3.2	18.7	
	2005	18.6[ab]	6.1	25.6	4.1	22.0	
Yellowstone River	2001	19.3[a]	10.7	26.6	4.2	21.7	0.0986
	2002	19.3[a]	8.4	27.9	4.8	24.7	
	2003	20.1[a]	11.1	27.2	4.7	23.1	
	2004	18.7[a]	11.1	26.3	3.4	18.3	
	2005	19.4[a]	6.1	25.6	4.3	22.1	
Below Yellowstone River	2001	19.4[a]	9.8	26.0	4.1	20.9	0.645
	2002	18.8[a]	8.2	27.3	4.5	24.2	
	2003	18.9[a]	10.6	27.8	4.4	23.2	
	2005	19.1[a]	6.2	25.5	4.1	21.8	

General comments on turbidity loggers. Three of the four turbidity loggers deployed during 2005 functioned properly throughout the duration of the deployment period. The logger deployed at Nohly exhibited episodic (minutes to hours) power-loss or late probe turn-on times on eleven dates between July 18 and August 30. However, these occurrences did significantly influence the data collected. For example, despite episodic power-loss or late probe turn-on times, 24 hourly measurements of turbidity were recorded on all dates except August 27 – 30 when 18 to 23 measurements were obtained.

Pre- and post-deployment accuracy of turbidity loggers. Accuracy of the Frazer turbidity logger relative to formazin NTU treatments was high during pre- and post-deployment tests. With the exception of the pre-deployment test at 20 NTU, measurements from the Frazer logger deviated from 1.9% less to 4.6% greater than formazin NTU (Table 9). The turbidity logger deployed at Poplar tended to record turbidity values that were at least 25% to 45% higher than formazin treatments. The Nohly turbidity logger recorded turbidity values that were at least 15.7% to 33.5% higher than formazin NTU. Turbidity measurements obtained from the Yellowstone River logger were zero to 13.5% higher than formazin NTU. Thus, accuracy was relatively high for the Frazer and Yellowstone loggers, but lower for the Poplar and Nohly loggers. There was little indication of accuracy "drift" between pre- and post-deployment for the Frazer and Yellowstone loggers, but some indication of drift for the Poplar and Nohly loggers as the deviation from formazin NTU tended to be slightly higher for post-deployment tests. Across pre- and post-deployment formazin treatments, measured turbidity values averaged 3.4% higher (Frazer logger), 33.5% higher (Poplar logger), 25% higher (Nohly logger), and 7.5% higher (Yellowstone logger). Based on these deviations, a correction factor of 0.966, 0.675, 0.75, and 0.925 for the respective loggers can be applied to field measurements to more accurately depict field turbidity conditions.

Table 9. Pre- and post-deployment turbidity assessments for 2005 of turbidity loggers subjected to common formazin NTU treatments. Values listed under each turbidity logger are the means of 5 (pre-deployment) and 10 (post-deployment) turbidity measurements. The maximum range of measurable turbidity for the loggers is 1000 NTU.

Formazin NTU	Deployment test	Frazer	Poplar	Nohly	Yellowstone
20	Pre	22.4	27.9	25.4	22.3
	Post	20.5	29.0	26.7	22.1
200	Pre	199.7	256.6	231.4	200.8
	Post	196.3	276.5	248.3	205.6
800	Pre	837.1	1000	1000	855.5
	Post	825.4	1000	1000	908.2

Field turbidity measurements. Hourly field measurements of turbidity recorded by the loggers varied greatly during the deployment period among and within sites. At the Frazer logger, measurements of 1000 NTU (maximum value measured by the logger) were recorded on 17 dates between June 6 and August 3. At Poplar, 1000 NTU was recorded on 26 dates between June 8 and August 16. Measured turbidities at Nohly exceeded 1000 NTU on 22 dates between June 10 and July 16. In the Yellowstone River, 1000 NTU was recorded on 19 dates between June 11 and August 20. Because the turbidity loggers did not record turbidity exceeding 1000

NTU, estimates of mean daily turbidity for specific dates were conservative and precluded quantitative statistical comparisons of spatial and temporal trends. Therefore, only general trends in turbidity are reported.

Turbidity in the Missouri River and Yellowstone River exhibited substantial spatial and temporal variation. Spatially, turbidity in the Missouri River increased from upstream to downstream as median turbidity during the deployment period was lowest at Frazer, intermediate at Poplar, and highest at Nohly (Table 10). Turbidity in the Yellowstone River tended to be higher than in the Missouri River. Temporally, episodic periods of elevated turbidity occurred at all sites and many of these periods were associated with changes in river discharge. For example, rapidly increasing and decreasing turbidity during June and early July was associated with rapidly increasing and decreasing discharge levels, respectively (Figure 7). Periods of elevated turbidity at Frazer and Poplar also occurred during early and mid-August as discharge moderately fluctuated. In the Yellowstone River, a sharp increase in turbidity occurred during mid-August in the absence of significant discharge fluctuations.

Table 10. Turbidity summary statistics for turbidity loggers in the Missouri River at Frazer, Poplar, and Nohly, and in the Yellowstone River during 2005. 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 measurement error determined from pre- and post-deployment accuracy tests.

Site	Metric	Maximum	75% quartile	Median	25% quartile	Minimum	Number of days
Frazer	Measured NTU	1000	154.4	39.3	8.2	0.4	96
	Corrected NTU	966	149.2	38.0	7.9	0.4	
Poplar	Measured NTU	1000	421.0	64.6	34.9	0	99
	Corrected NTU	675	284.1	43.6	23.6	0	
Nohly	Measured NTU	1000	392.7	116.1	66.1	39.7	99
	Corrected NTU	750	294.5	87.0	49.5	29.8	
Yellowstone River	Measured NTU	1000	459.4	161.6	41.6	23.9	83
	Corrected NTU	925	425.0	149.4	38.5	22.1	

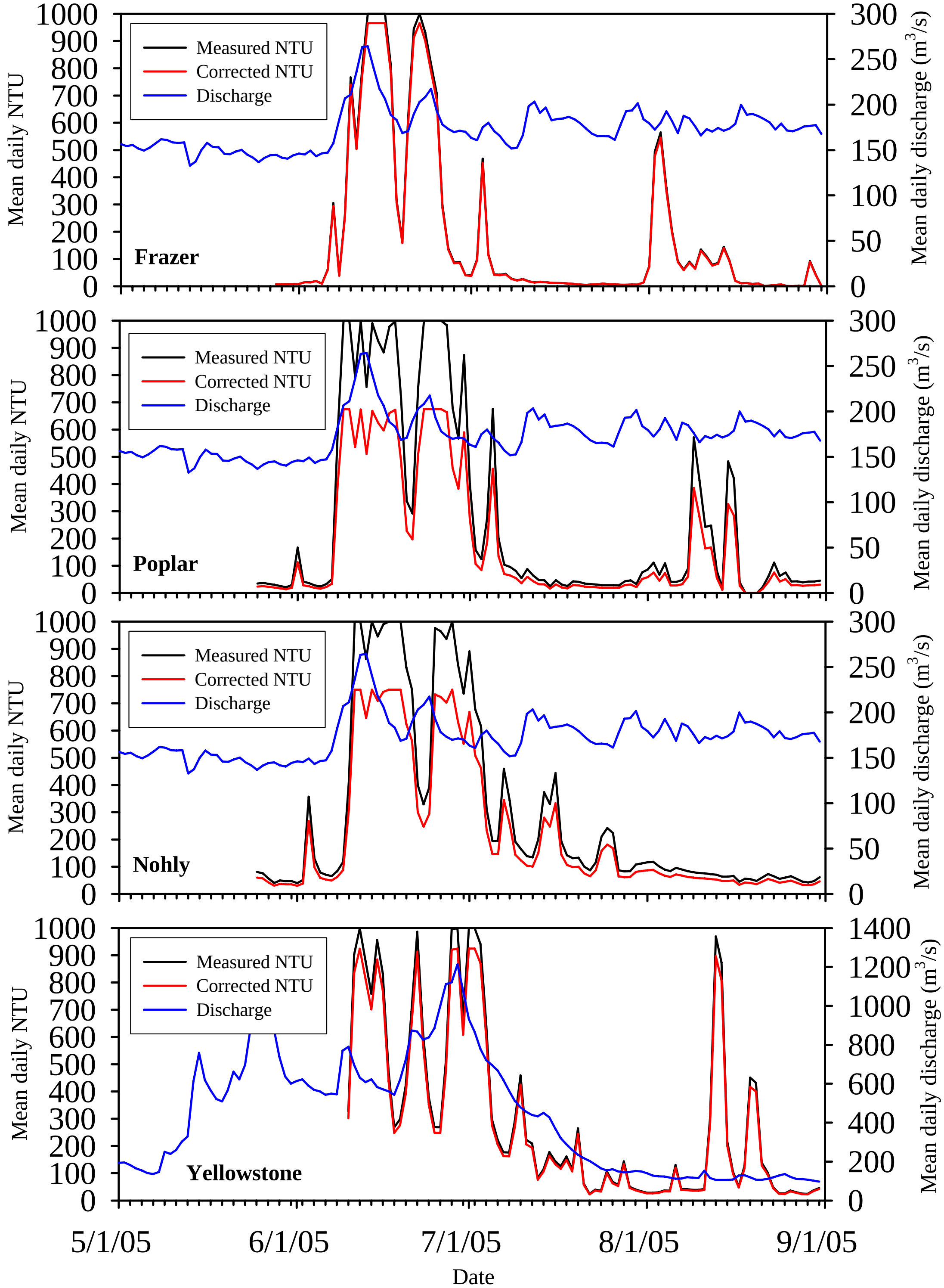


Figure 7. Mean daily turbidity (NTU) from turbidity loggers and discharge in the Missouri River near Frazer, Poplar, and Nohly, and in the Yellowstone River during 2005.

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

***Manual relocations and ground station contacts*.-** At the onset of manual tracking in April 2005, there were 52 blue suckers (21 males, 25 female, 6 unknown), 57 shovelnose sturgeon (14 males, 35 females, 8 unknown), 64 paddlefish (40 males, 17 females, 7 unknown), and 19 pallid sturgeon (15 males, 3 female, 1 unknown) implanted with CART tags throughout the study area. We conducted 26 tracking events between April and November, and cumulatively searched 11,437 km of riverine habitat in the Missouri River and Yellowstone River (Table 11). Twenty-four tracking events covered the entire study area; whereas, two tracking events covered only selected reaches. We obtained 960 relocations of blue suckers, 1047 relocations of shovelnose sturgeon, and 389 relocations of paddlefish. We also obtained 345 relocations of pallid sturgeon implanted by the USFWS and MTFWP.

Table 11. Dates, river reaches, total river kilometers tracked by boat, and numbers of relocations obtained for blue suckers, paddlefish, shovelnose sturgeon, and pallid sturgeon during 2005.

Tracking Dates	Reaches tracked	Total km	Blue sucker	Paddlefish	Pallid sturgeon	Shovelnose sturgeon
3/28–4/3	All	457.6	51	21	17	48
4/4–4/10	All	457.6	46	21	13	50
4/11–4/17	All	457.6	46	20	13	46
4/18–4/24	All	457.6	43	16	17	47
4/25–5/1	All	457.6	44	19	14	48
5/2–5/8	All	457.6	43	14	15	50
5/9–5/15	All	457.6	29	17	15	50
5/16– /22	All	457.6	39	15	18	48
5/23–5/29	All	457.6	44	15	15	50
5/30–6/5	All	457.6	45	15	16	49
6/6–6/12	All	457.6	41	13	12	47
6/13–6/19	All	457.6	37	9	15	48
6/20–6/26	All	457.6	43	12	13	46
6/27–7/3	All	457.6	41	11	15	37
7/4–7/10	All	457.6	32	9	10	40
7/11–7/17	All	457.6	33	6	12	42
7/18–7/24	All	457.6	30	6	14	44
7/25–7/31	All	457.6	29	9	11	42
8/8–8/14	All	457.6	27	14	12	35
8/22–8/28	All	457.6	31	18	11	34
9/5–9/11	All	457.6	32	21	12	29
9/29–9/25	All	457.6	32	19	15	29
10/3–10/9	All	457.6	34	21	14	26
10/17–10/23	All	457.6	31	19	12	30
10/31–11/6	Missouri River above Wolf Point	112	23	2	1	13
11/14-11/20	Missouri River	342.4	34	27	13	19
Totals	26	11436.8	960	389	345	1047

The eight continuous-recording logging stations deployed during 2005 contributed additional movement and relocation information that augmented the manual tracking data set (Table 12). The logging stations recorded 386 contacts for 0-37 individual blue suckers, 212 contacts of 5-26 individual paddlefish, 149 contacts of 0-20 individual shovelnose sturgeon, and 117 contacts of 0-15 individual pallid sturgeon. The Culbertson logging station recorded the highest number of contacts for blue suckers. The logging station above the mouth of the Yellowstone had the highest number of contacts for pallid sturgeon, shovelnose sturgeon, and paddlefish although the largest number of individual paddlefish was recorded at the Williston station.

Table 12. Number of contacts and number of individual fish recorded by eight logging stations for blue suckers, paddlefish, pallid sturgeon, and shovelnose sturgeon during 2005.

	Paddlefish		Pallid sturgeon		Shovelnose sturgeon		Blue sucker	
Logging Station	Contacts	Individ. fish	Contacts	Individ. fish	Contacts	Individ. fish	Contacts	Individ. fish
Milk River	12	5	0	0	2	2	40	13
Nickels	17	5	0	0	38	13	54	19
Wolf Point	42	9	3	2	23	10	45	23
Brockton	14	10	8	2	9	6	39	25
Culbertson	23	13	12	3	19	12	82	37
Ft. Buford	14	10	8	3	11	9	50	31
Williston	40	26	2	2	0	0	0	0
Yellowstone	50	18	84	15	47	20	76	36

Blue sucker relocations and movements.

All of the 52 blue suckers implanted with transmitters were relocated during 2005. Two of the transmitters expired early in the season and were not used in the analyses; transmitters from the remaining 50 blue suckers provided usable data for most of the season.

The distribution and relative abundance of blue suckers varied among rivers through time (Figure 8). During April and May, blue suckers primarily used (86-96% 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 35% and 64% from June to early September, then increased during late-September. The increased relative abundance of blue suckers in the reach during late-September was due to movements of blue suckers out of the Yellowstone River when discharge was low and water temperature was high.

The occurrence of blue suckers in the Milk River (Figure 8) was dependant on discharge conditions in the Milk River. Fish entered the Milk River (N = 10) as indicated by our ground based telemetry station during a large pulse of water in early June (Figure 2). The residence time of blue suckers in the Milk River spanned only a 2-week time period as evidenced by ground station information and was directly related to the decrease in flow. Ground stations indicated that 20 % 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 8). Relative abundance of blue suckers in the Yellowstone River was low from early April to late May (<5% of relocations), consistently increased through June, remained high (50-65% of relocations) through early September, then declined during mid-September and early October to one individual.

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 June 6, 2005 through July 30, 2005 (N = 15) and passed downstream over the dam from July 31, 2005 through October 5, 2005 (N = 15). This information was based on a telemetry logging station positioned at Intake Diversion Dam (M. Jaeger, MTFWP).

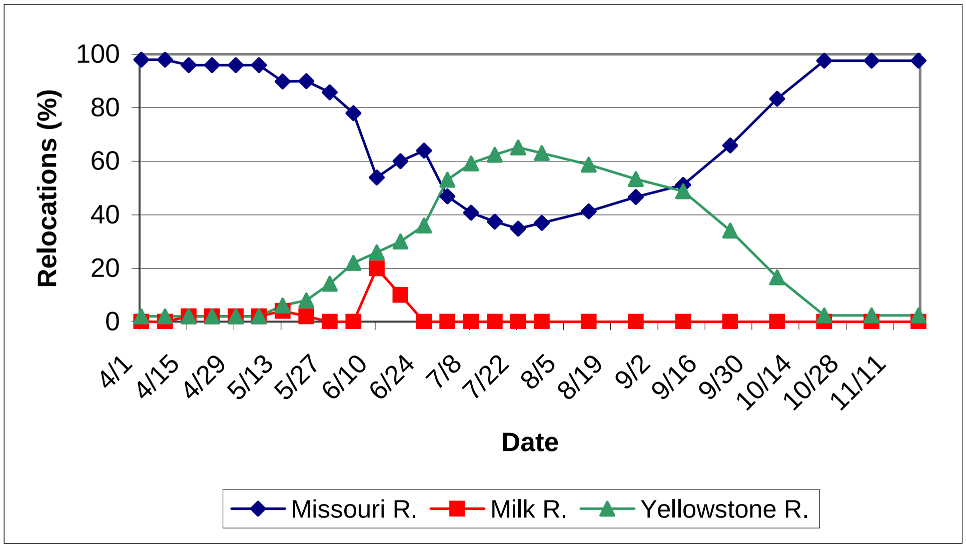


Figure 8. Percent blue suckers relocated in the Milk, Missouri, and Yellowstone Rivers in 2005 by date.

Inter-annual trends in blue sucker relocations.-The Missouri River was a concentration area for blue suckers during 2003, 2004, and 2005 but use of this reach varied during the year (Figure 9). 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 late August and early September. However, several individuals remained in the Missouri River for the entire year (minimum 30% in 2003, minimum 47% in 2004, minimum 35% in 2005). Although similar immigration and emigration dynamics among rivers occurred during these three years, the timing of movement dynamics varied slightly between years. These differences are likely attributed to differences in the dates that the Milk River had suitable water conditions, and the subsequent influence of Milk River hydrologic conditions on immigration and emigration dynamics (see below).

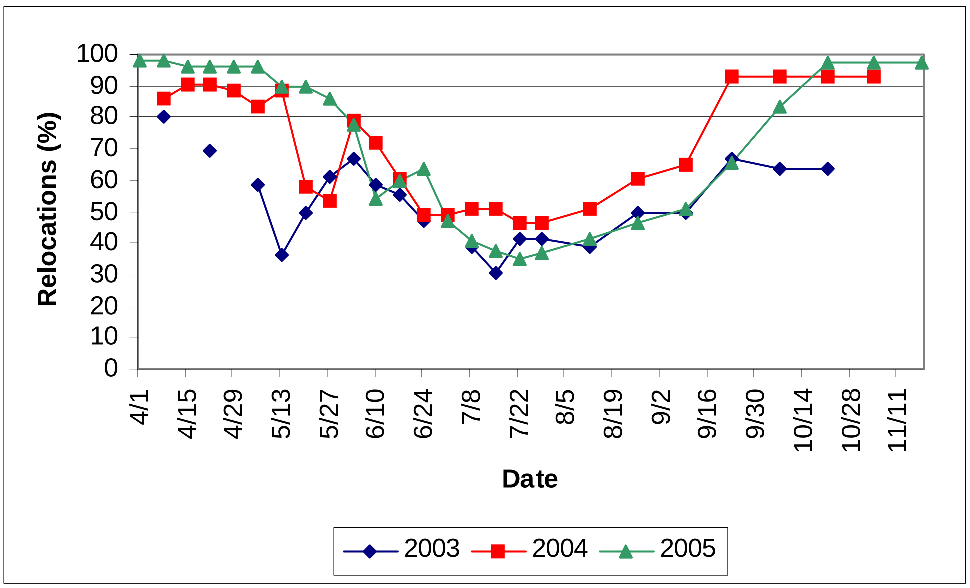


Figure 9. Percent blue suckers relocated in the Missouri River in 2003, 2004, and 2005 by date.

Blue suckers exhibited limited seasonal use of the Milk River in 2003, 2004, and 2005 (Figure 10). Individuals migrated up the Milk River in early May 2003, late May 2004, and early June 2005 during an increase in the hydrograph (maximum 37% in 2003, maximum 38% in 2004, maximum 20% in 2005; see Figure 2 for Milk River hydrographs). When discharge declined, blue suckers moved out of the Milk River and re-entered the Missouri River. There were no relocations of blue suckers in the Milk River later than early July in 2003, 2004, or 2005. Although the Milk River was used in all years, temporal use of this river was not consistent among years as use varied slightly according to temporal variations in Milk River discharge.

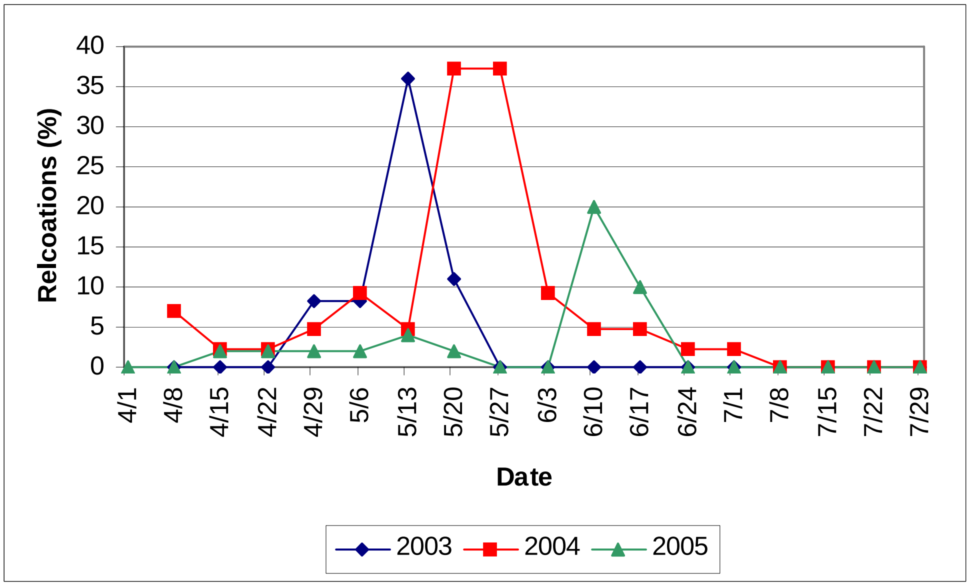


Figure 10. Percent of implanted blue suckers relocated in the Milk River in 2003, 2004, and 2005 by date.

The Yellowstone River was rarely used during April and early May by blue suckers in 2003, 2004, and 2005 (Figure 11). Use of the Yellowstone River rapidly increased in early June as fish exited the Missouri River. Blue sucker use of the Yellowstone River remained high (maximum 45% in 2003, maximum 52% in 2004, maximum 65% in 2005) through early September. Use of the Yellowstone River was low after mid-October (< 10%) in all years. Temporal use of the Yellowstone River was very consistent among years. Thus, these results suggest that use patterns of the Yellowstone River by blue suckers are fairly similar among 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.

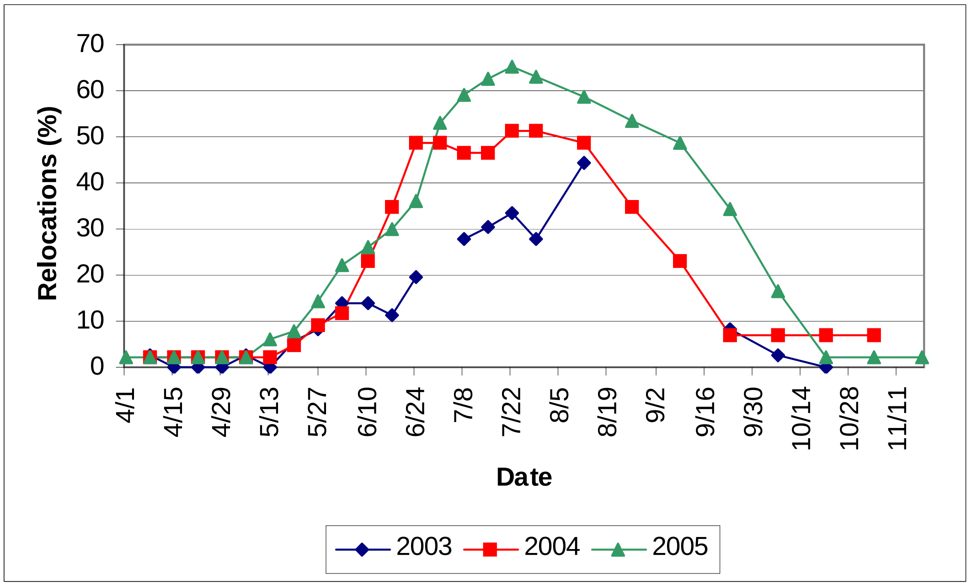


Figure 11. Percent of blue suckers relocated in the Yellowstone River in 2003, 2004, and 2005 by date.

Shovelnose sturgeon relocations and movements.

Fifty-six of 57 radio-tagged shovelnose sturgeon in the study area during 2005 were relocated. Fifty-five of these fish provided usable information for most of the tracking season.

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 12). Use of this reach declined from mid-May through early August; however, a minimum of 31% of the shovelnose sturgeon remained in the study reach for the duration of the season. Use of this reach of the Missouri River increased in September.

The lower Missouri River reach from Wolf Point to the headwaters of Lake Sakakawea is twice as long as the other two reaches. However, this reach exhibited the lowest relative abundance of shovelnose sturgeon (Figure 12). Less than 10% of implanted individuals were relocated in this reach from mid-April through August. A maximum of 32% was found during late September as shovelnose sturgeon emigrated out of the Yellowstone River.

The percentage of shovelnose sturgeon relocations in the Yellowstone River steadily increased from early April (36%) through late July (58%; Figure 12). Use of this reach declined in August to 38% of relocations, then it remained stable until the end of the tracking season.

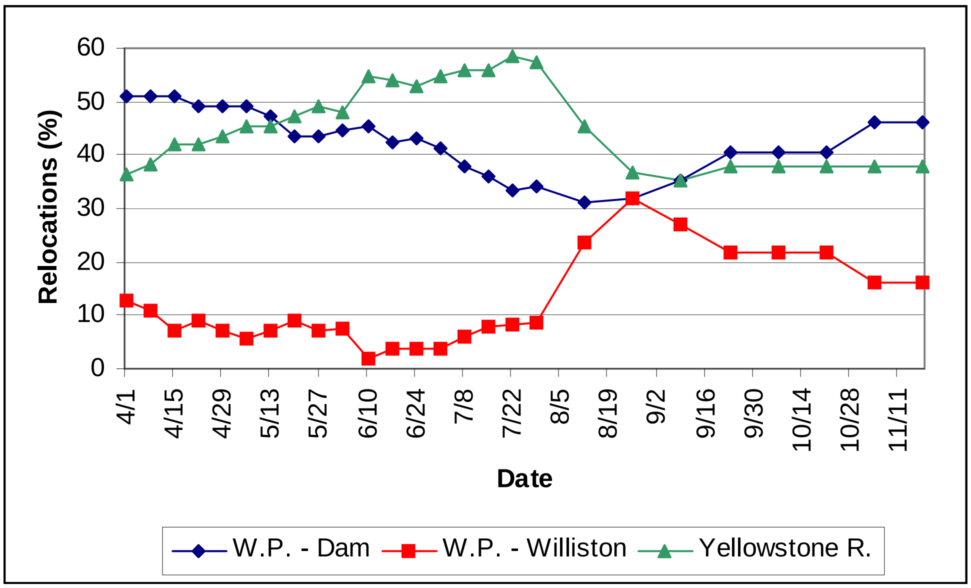


Figure 12. Percent of shovelnose sturgeon relocated in the Missouri River reaches and the Yellowstone River in 2005 by date.

Inter-annual trends in shovelnose sturgeon relocations.- The Missouri River from Wolf Point to Fort Peck Dam was a concentration area during 2003, 2004 and 2005 (Figure 13). Although use gradually decreased from mid-April through early July (2004) or mid-August (2005), a large number of individuals remained in this reach throughout the tracking season (minimum 31% in 2004 and 2005). Temporal use of this reach was generally consistent among years.

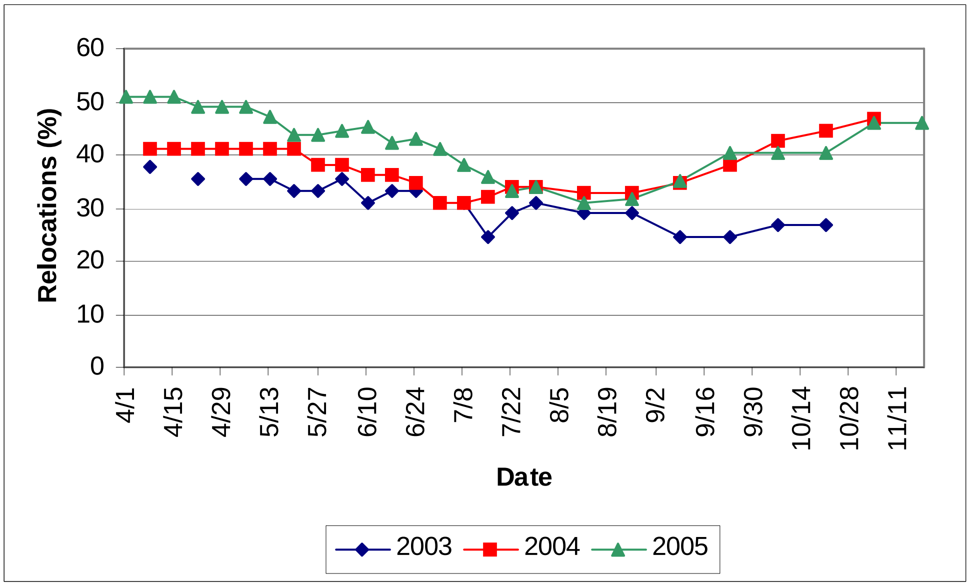


Figure 13. Percent of shovelnose sturgeon relocated in the Missouri River from Wolf Point to Fort Peck Dam in 2003, 2004, and 2005 by date.

The Missouri River reach between Wolf Point and Williston was primarily a movement corridor during the tracking season for individuals moving between the upper reaches of the Missouri River and the Yellowstone River (Figure 14). Although shovelnose sturgeon were present in this reach during April and May, densities declined through June (< 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 among years.

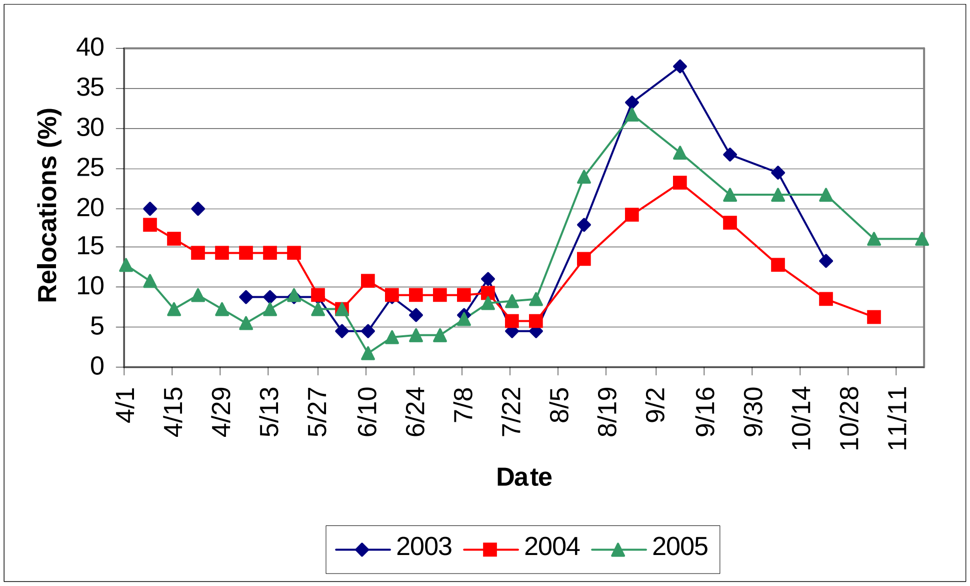


Figure 14. Percent of shovelnose sturgeon relocated in the Missouri River from Wolf Point to Williston in 2003, 2004, and 2005 by date.

The Yellowstone River was a concentration area for shovelnose sturgeon, but use of this reach varied during the year (Figure 15). Use of this reach increased from April through late July (maximum 58% in 2004 and 2005), and 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. In general, temporal use of the Yellowstone River was consistent among years.

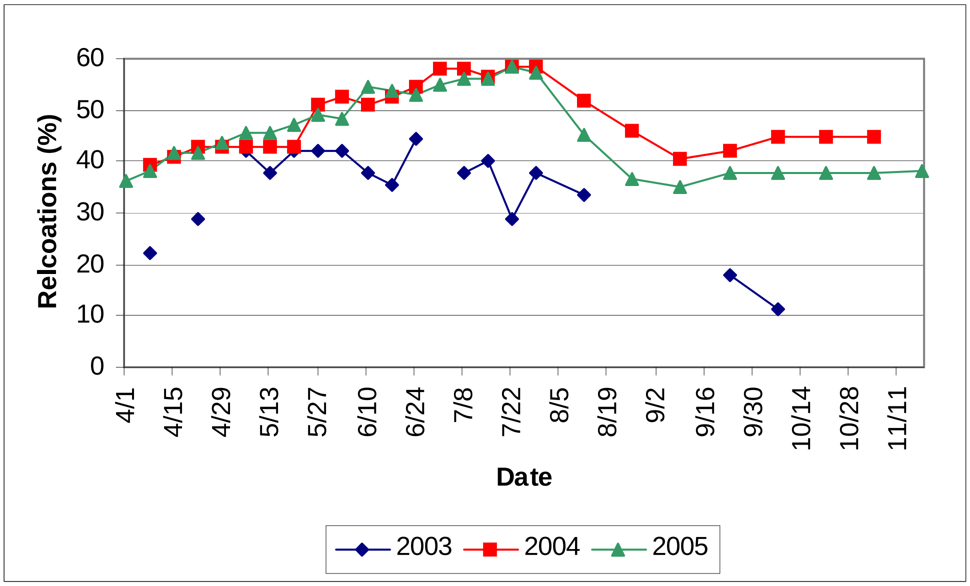


Figure 15. Percent of shovelnose sturgeon relocated in the Yellowstone River in 2003, 2004, and 2005 by date.

Paddlefish relocations and movements.- Forty-two of the 64 paddlefish implanted with CART tags were relocated during 2005. Two were harvested and the other 22 are assumed to have spent the season in Lake Sakakawea. These 22 fish were not used for the "below the confluence" reach percentages since they were not in the riverine areas of the Missouri River. They were included in the denominator when percent of fish per reach was calculated to possibly address what proportion of the adult population makes a spawning migration from year-to-year.

Paddlefish exhibited distinct use patterns of Missouri River reaches and the Yellowstone River in 2005 (Figure 16). Relative abundance of paddlefish in the Missouri River above the confluence of the Yellowstone River (ATC) was initially high in April (16%) due to 10 individuals that were implanted near Wolf Point during fall 2004. Relocations gradually increased to 20% as fish from below the confluence migrated up to this reach. In addition, five paddlefish entered the Milk River for two weeks based on ground station information. These five fish were included in the ATC relocations for this time frame. Paddlefish steadily exited the Missouri River ATC from mid-June to late August. Some paddlefish reentered this reach in the fall where they then over-wintered.

Relative abundance of paddlefish in the Missouri River below the Yellowstone River confluence (BTC) followed distinct seasonal patterns (Figure 16). The percentage of relocations in this reach decreased through mid-June to 0%, and remained low (<10%) through June and July as most paddlefish had ascended either the Missouri River ATC or the Yellowstone River. Use of this reach steadily increased from August through early November (maximum 36%).

Temporal use of the Yellowstone River by paddlefish occurred during a 3.5 month period (Figure 16). Relative abundance was low in April, increased in May, then declined through late June and July. No fish were relocated in the Yellowstone River after July. About 10% of the implanted paddlefish moved up the Yellowstone River.

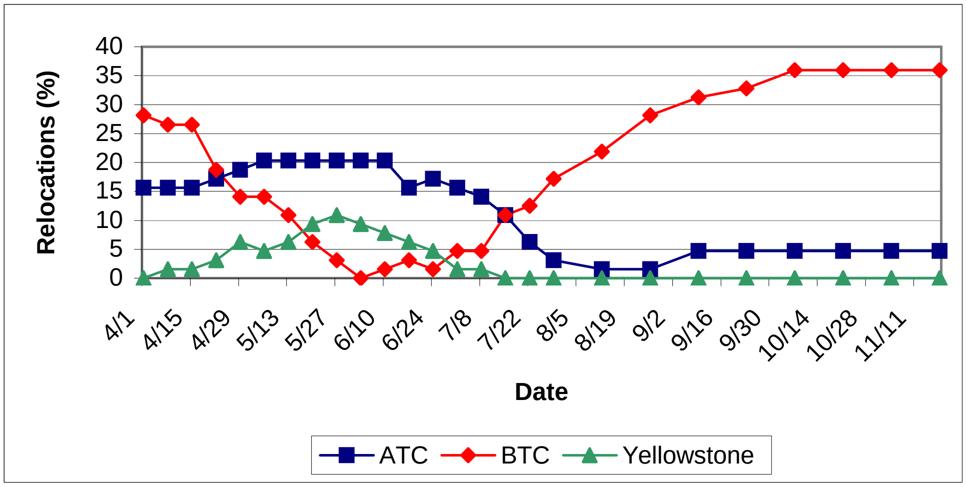


Figure 16. Percent of all implanted paddlefish relocated in reaches of the Missouri River and Yellowstone River during 2005.

Since 13 of these paddlefish were implanted in the Missouri River upstream from the Yellowstone River confluence, there may be some bias in movements and river use related to site fidelity. The following information is based off only the paddlefish that were implanted below the confluence. Focusing only on paddlefish that ascended above the confluence of the Missouri and Yellowstone rivers (N=16 in 2002, N=20 in 2003, N=19 in 2004, N=9 in 2005), trends were rather consistent from year to year even though flows were not (Figure 17). For example, 58 - 70% of the migrating paddlefish (among year mean = 65%) ascended the Yellowstone River. Comparatively, 22 – 37% (among year mean = 30%) of the paddlefish ascended the Missouri River ATC. Thus, about one-third of the Lake Sakakawea population of paddlefish ascends the Missouri River and two-thirds ascends the Yellowstone River each year.

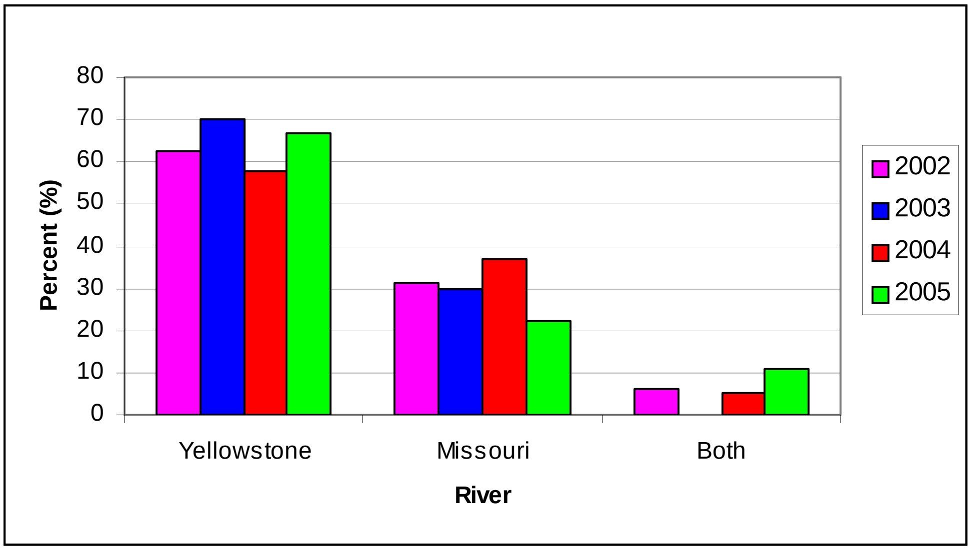


Figure 17. Percent of individual paddlefish that ascended the Yellowstone River, Missouri River or both from 2002 – 2005.

Inter-annual trends in paddlefish relocations.-Paddlefish migrated up the Missouri River ATC during late April 2003, early May 2004 and mid-April 2005 (Figure 18). Although some paddlefish that were implanted below the confluence over-wintered in the Missouri River in the Wolf Point area, most fish remained in this reach for approximately 12 weeks. Relocations gradually declined through July and August. Temporal use of this reach was consistent among years.

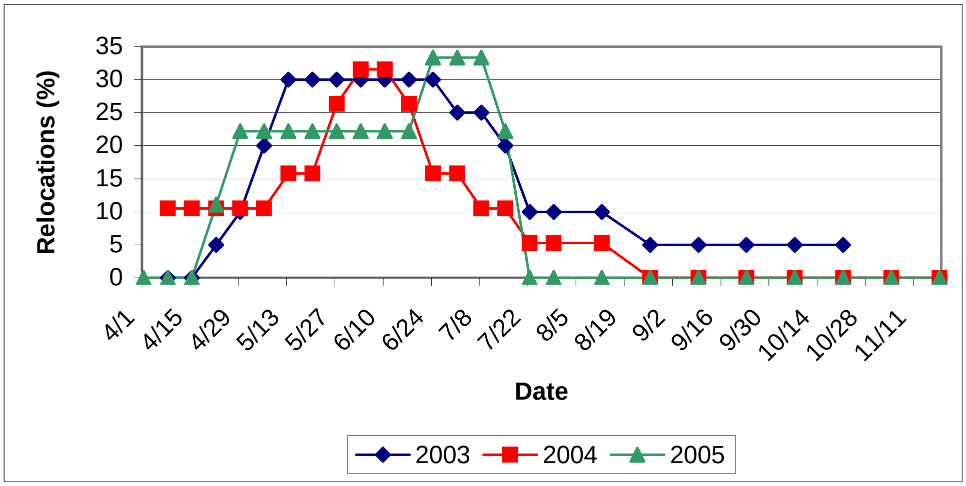


Figure 18. Percent of ascending paddlefish relocated in the Missouri River above the Yellowstone River confluence in 2003, 2004, and 2005 by date.

Paddlefish exhibited seasonal use of the Missouri River reach BTC corresponding to migration patterns (Figure 19). 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 generally consistent among years.

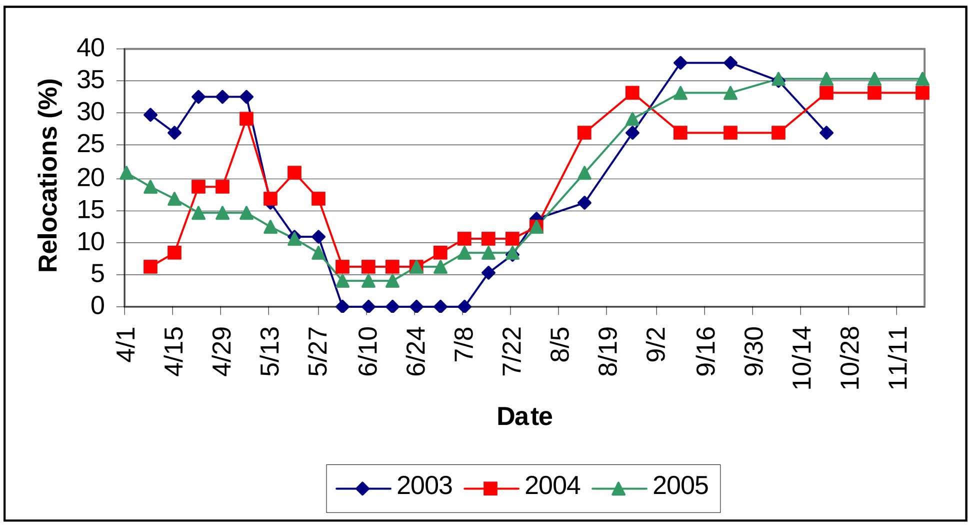


Figure 19. Percent of paddlefish relocated in the Missouri River below the Yellowstone River confluence (BTC) during 2003, 2004, and 2005.

Similar to the Missouri River BTC, the Yellowstone River was used seasonally by implanted paddlefish in relation to spawning movements (Figure 20). Paddlefish ascended the Yellowstone River in late April 2003, early in May 2004 and mid-April 2005. Paddlefish remained in the Yellowstone River for approximately 7-9 weeks. Relocations declined through out most of June and July. No paddlefish were found in the Yellowstone River after late July in all years. Similar to other species and river reaches, temporal use of the Yellowstone River by paddlefish was consistent among years.

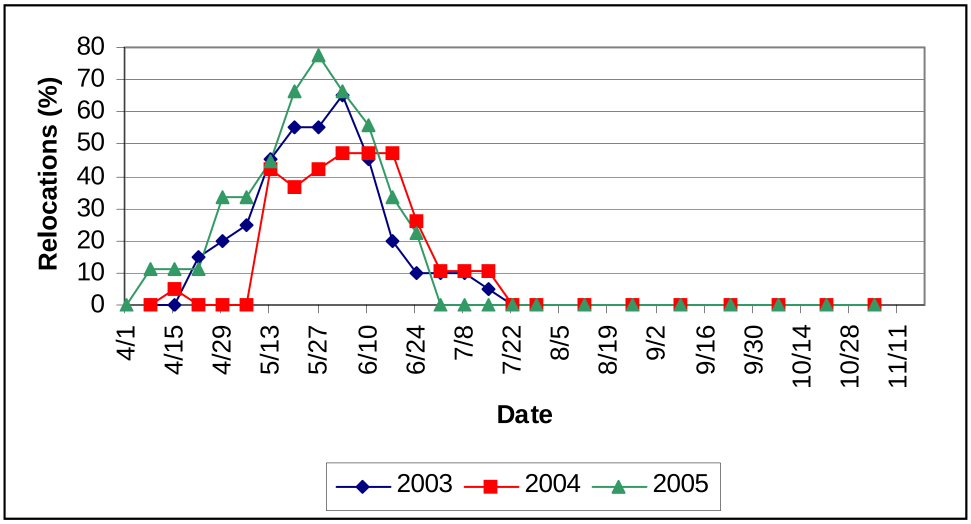


Figure 20. Percentage of ascending paddlefish relocated in the Yellowstone River in 2003, 2004, and 2005 by date.

Pallid Sturgeon.- Seventeen of the nineteen pallid sturgeon were relocated in 2005. The remaining two individuals were last relocated near the headwaters of Lake Sakakawea in October 2004.

Use of the Missouri River ATC by pallid sturgeon occurred during 2005, but use was minimal (Figure 21). The one individual that was implanted in the tailrace immediately downstream from Fort Peck Dam remained in the Missouri River above the confluence for the entire year. One individual migrated up the Missouri River to the Frazer area (r.m. 1736). This fish made a similar migration in 2003.

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 declined from early April through mid-May as individuals migrated from this reach into the Yellowstone River. Pallid sturgeon primarily used the Yellowstone River through early July and then emigrated from the Yellowstone River back to the Missouri River below the confluence from early-July through the end of the tracking season.

Telemetered adult pallid sturgeon exhibited the capability to migrate long distances. For the population of implanted pallid sturgeon, 2005 represented the first year that a telemetered pallid sturgeon was relocated at the Intake Diversion Structure on the Yellowstone River (rkm 115, rm 72). The furthest upstream migration on the Missouri River during 2005 was 247 rkm (154.5 rm) in the Frazer area.

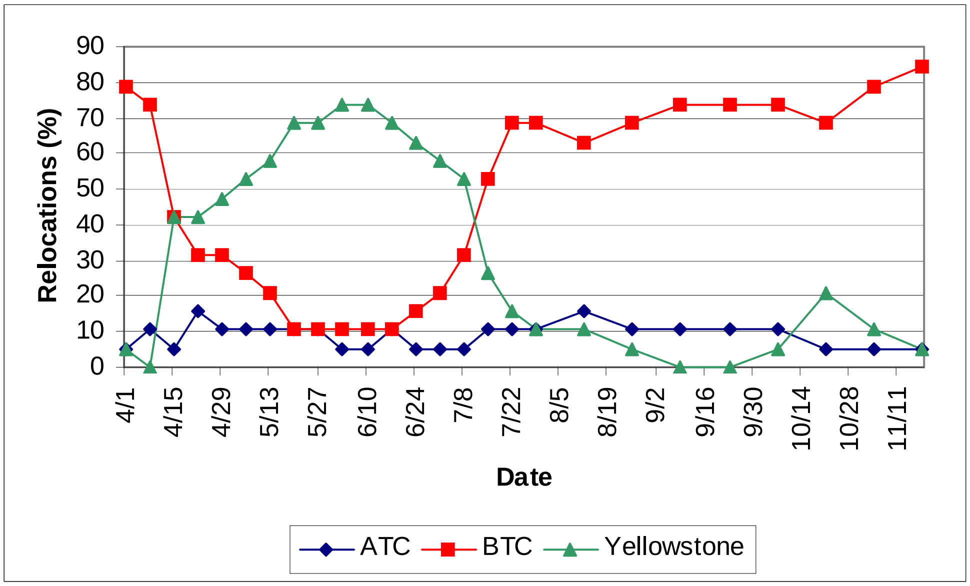


Figure 21. Percent of pallid sturgeon relocated in the reaches of the Missouri River and Yellowstone River in 2005.

Inter-annual trends in pallid sturgeon relocations.- Use of the Missouri River ATC by pallid sturgeon has been relatively inconsistent among years (Figure 22). In 2003, a maximum of 25% of the relocated pallid sturgeon were in the reach during late-April. Greatest use of the Missouri River ATC occurred during 2004 when maximums of 36% and 30% of the relocated individuals were in the reach during early April and mid-May, respectively. In 2005, a maximum of 16% of the relocated pallid sturgeon were relocated ATC during late-April and mid-August.

Use of the Missouri River BTC and Yellowstone River by pallid sturgeon reflected movement patterns that were relatively consistent among years within reaches; however, there were slight variations in the timing of movements among years (Figures 23, 24). For example, pallid sturgeon primarily used the Missouri River BTC during early April, then moved into the Yellowstone River during late April and early May. Use of the Yellowstone River increased and was maximized through early July when the percentage of relocations in the Missouri River BTC was lowest. By mid- to late-July, the majority of the pallid sturgeon migrated from the Yellowstone River back to the Missouri River BTC contributing to the increased proportion of implanted pallid sturgeon in the BTC reach. Slight variations in the timing of movements among years may be related to environmental conditions (e.g., discharge, temperature), and the subsequent influence of these variables as stimuli for movements.

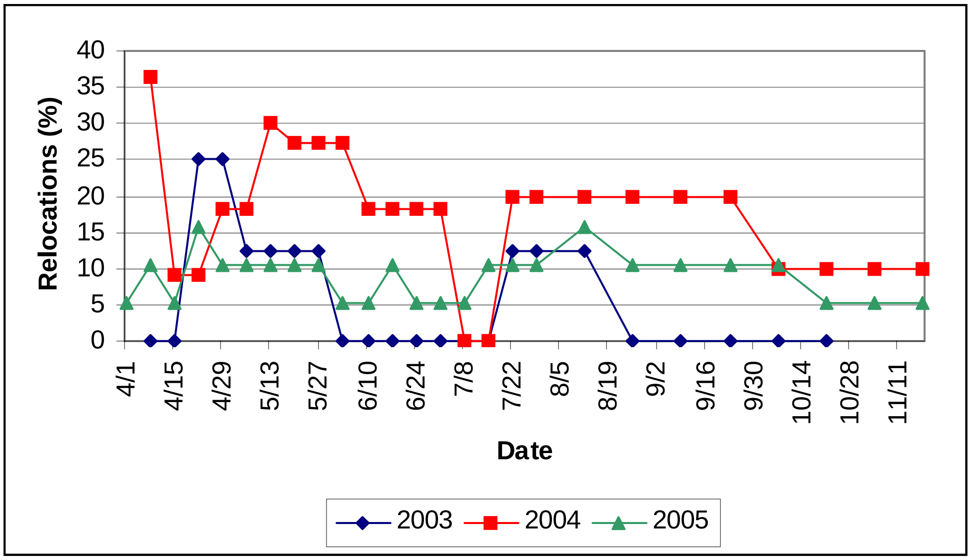


Figure 22. Percent of pallid sturgeon relocated in the Missouri River above the confluence in 2003, 2004, and 2005 by date.

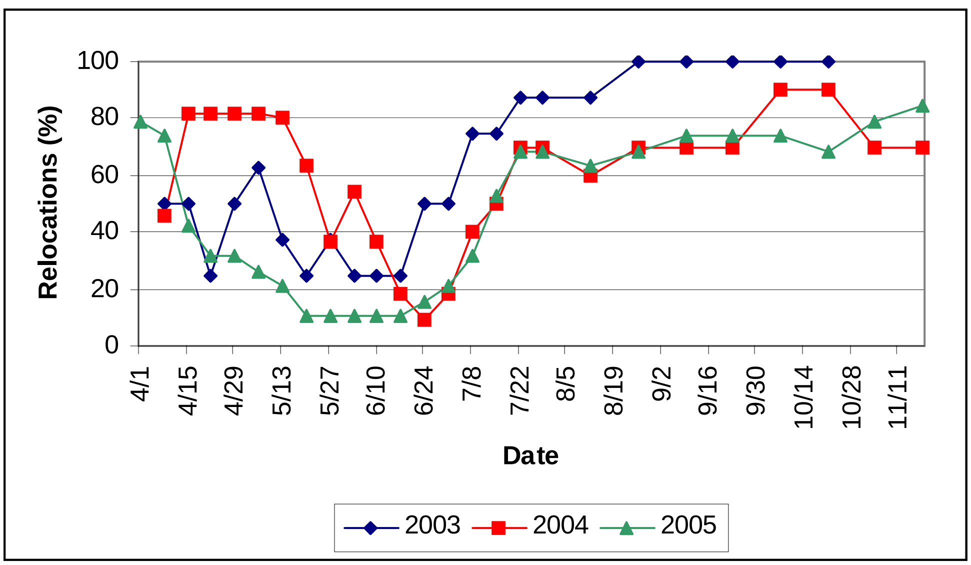


Figure 23. Percent of pallid sturgeon relocated in the Missouri River below the confluence in 2003, 2004, and 2005 by date.

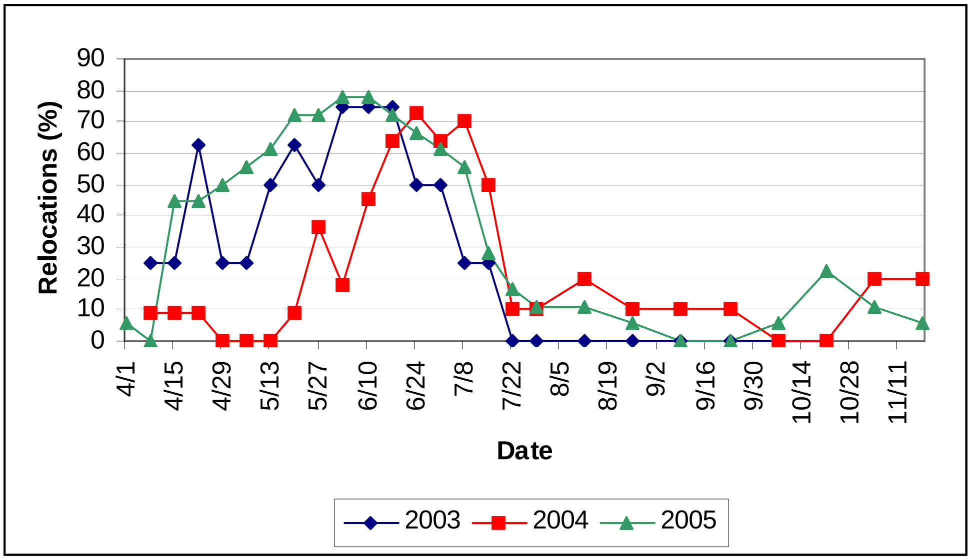


Figure 24. Percent of pallid sturgeon relocated in the Yellowstone River in 2003, 2004, and 2005 by date.

Transmitter implantation.- Sampling during September 2005 resulted in capturing 21 shovelnose sturgeon, 21 blue suckers, 7 paddlefish, and 1 pallid sturgeon suitable for implanting CART tags (Table 13). Shovelnose sturgeon and blue suckers were collected in the Missouri River from the Milk River confluence to the Yellowstone River confluence. Sampling efforts for paddlefish were restricted to the upper reach of the Missouri River below Fort Peck Dam. A concentration of paddlefish was found in the Missouri River near Wolf Point (rkm 2763, rm 1716), and seven individuals were implanted at this site. One female pallid sturgeon containing black eggs was also captured and implanted with a transmitter at a site just upstream from Wolf Point.

Table 13. Number, sex ratio (male:female:undetermined), length (mm), and weight (g) for shovelnose sturgeon, blue suckers, paddlefish, and pallid sturgeon implanted with transmitters during September 2005.

Species	Number tagged	Sex Ratio	Metric	Mean	Minimum	Maximum
			Length	798 mm	728 mm	910 mm
Shovelnose sturgeon	21	7:12:2	Weight	2289 gm	1650 gm	3850 gm
			Length	721 mm	632 mm	771 mm
Blue sucker	21	6:15:0	Weight	3235 gm	1950 gm	5100 gm
			Length	1132 mm	1000 mm	1262 mm
Paddlefish	7	3:4:0	Weight	24 kg	14 kg	40 kg
			Length	1520 mm		
Pallid sturgeon	1	0:1:0	Weight	24 kg		

Monitoring Component 3 – Distribution and Abundance of Larval Fish

Larval fishes during 2005 were sampled on 21 individual sampling events between May 23 and August 3. The sampling regime resulted in a total of 2,073 larval fish samples partitioned among sites downstream from Fort Peck Dam (252 samples), spillway channel (167 samples), Milk River (394 samples), Missouri River at Wolf Point (420 samples) and Nohly (420 samples), and in the Yellowstone River (420 samples). Mean volume of water sampled per subsample was 60.2 m^3 at the site downstream from Fort Peck Dam (total volume = 15,174 m^3), 20.5 m^3 in the spillway channel (total volume = 3,431 m^3), 67.0 m^3 in the Milk River (total volume = 26,402 m^3), 84.5 m^3 in the Missouri River at Wolf Point (total volume = 35,490 m^3), 65.6 m^3 in the Missouri River at Nohly (total volume = 27,570 m^3), and 51.8 m^3 in the Yellowstone River (total volume = 21,766.5 m^3).

Relative abundance of larval fishes and eggs. A total of 8,757 larvae representing nine families were sampled across all sites during 2005 (Table 14). Representatives of Catostomidae (i.e., suckers) were numerically dominant and composed 59.6% of all larval fish sampled. The Cyprinidae (i.e., carps and minnows) composed 23.7% of the larvae sampled. Hiodontidae (exclusively goldeye, *Hiodon alosoides*), Sciaenidae (exclusively freshwater drum, *Aplodinotus grunniens*) and Percidae (i.e., perches) composed 6.2%, 4.7%, and 4.1% the larvae sampled, respectively. A total of 12 Acipenseridae larvae (0.1% of the total) and 59 Polyondontidae larvae (exclusively paddlefish, 0.7% of the larvae) were identified, but an additional 15 larvae (0.2% of the total) could not be confidently distinguished as *Scaphirhynchus sp*. or paddlefish. Six acipenseriform eggs were sampled in addition to nearly 30,000 eggs from other species.

Composition of the larval fish assemblage sampled during 2005 varied among sites. Seven families of larval fish were sampled from the Missouri River at Wolf Point and from the Yellowstone River (Table 14). Six families were sampled from the Milk River and Missouri River at Nohly, and four families were sampled from the spillway channel. The site downstream from Fort Peck Dam yielded only three families of larval fish. Representatives of Catostomidae and Cyprinidae were most ubiquitous as these taxa were sampled at all sites. Representatives of Percidae were sampled at all sites except at the site downstream from Fort Peck Dam. Larval goldeye were sampled at four sites, but were not found in the spillway channel or below Fort Peck Dam. Larval freshwater drum were sampled from the spillway channel, Milk River, and Missouri River at Wolf Point and Nohly; however, freshwater drum were absent from collections in the Yellowstone River and the site downstream from Fort Peck Dam. Larval paddlefish were positively identified from collections in the Milk River, Yellowstone River, and Missouri River at Wolf Point and Nohly. *Scaphirhynchus sp.* were identified exclusively from collections at Wolf Point and in the Yellowstone River.

Table 14. Number (N) and frequency (%) of larval fishes, and numbers of juveniles, adults, and eggs sampled at six sites during 2005. T = less than 0.1%.

	Below Fort Peck Dam		Spillway		Milk River		Wolf Point		Nohly		Yellowstone River	
Taxon	N	%	N	%	N	%	N	%	N	%	N	%
Acipenseridae							6	0.3			6	0.5
Catostomidae	355	99.2	783	87.8	1261	39.7	1676	78.6	365	37.4	775	63.5
Centrarchidae											2	0.2
Cyprinidae	2	0.6	34	3.8	1383	43.5	159	7.5	239	24.5	256	21.0
Hiodontidae					217	6.8	21	1.0	184	18.8	125	10.2
Percidae			55	6.2	3	0.1	171	8.0	124	12.7	6	0.5
Polyodontidae					17	0.5	4	0.2	6	0.6	32	2.6
Salmonidae	1	0.3										
Sciaenidae			18	2.0	284	8.9	81	3.8	26	2.7		
Unknown-sturgeon/paddlefish							4	0.2	1	0.1	10	0.8
Unknown-other			2	0.2	13	0.4	9	0.4	32	3.3	9	0.7
Total larvae	358		892		3178		2131		977		1221	
Juveniles			8		141		3		15		20	
Adults												
Sturgeon/ paddlefish eggs							1				5	
Misc. eggs	1619		48		7554		10727		3577		6422	

Spatial and temporal periodicity and densities of larval Scaphirhynchus sp. and larval paddlefish. Temporal periodicity and densities of larval sturgeon and paddlefish varied among sites. In the Milk River, no larval sturgeon were sampled during 2005. Larval paddlefish were sampled on two dates in the Milk River at median densities of 1.87 larvae/100m^3 (June 20) and 0.73 larvae/100 m^3 (June 22; Table 15).

Table 15. Total number of paddlefish sampled (N), median density (median; number/100 m^3), minimum density, and maximum density of larval paddlefish by date in the Milk River during 2005.

Date	N	Median	Minimum	Maximum
5/23/05				
5/27/05				
5/31/05				
6/2/05				
6/6/05				
6/9/05				
6/13/05				
6/15/05				
6/20/05	12	1.87	0.62	4.63
6/22/05	5	0.73	0	1.31
6/27/05				
6/29/05				
7/05/05				
7/7/05				
7/11/05				
7/13/05				
7/18/05				
7/20/05				
7/25/05				
7/27/05				
8/3/05				

Larval sturgeon in the Missouri River at Wolf Point were initially sampled on July 5, and were present in the drift on three other dates (July 18, 21, 29) through the termination of sampling on August 3 (Table 16). Median densities were low on all dates, and maximum densities varied between 0.29 larvae/100 m^3 and 0.32 larvae/100 m^3). Larval paddlefish were sampled from the drift on only one date (June 23) when median density was 0.30 larvae/100 m^3. In addition to these individuals, unidentifiable sturgeon/paddlefish larvae were sampled at Wolf Point on July 5 (3 individuals) and July 8 (1 individual). Although unknown, timing of appearance of these larvae suggests that these individual were sturgeon larvae.

Table 16. Total number sampled (N), median density (number/100 m^3), minimum density (min.), and maximum density (max.) of larval sturgeon (*Scaphirhynchus* sp.) and larval paddlefish by date in the Missouri River at Wolf Point during 2005.

	Scaphirhynchus sp.				Paddlefish			
Date	N	Median	Min.	Max.	N	Median	Min.	Max.
5/23								
5/25								
5/31								
6/03								
6/06								
6/08								
6/13								
6/16								
6/20								
6/23					4	0.30	0	0.31
6/27								
6/30								
7/05	2	0	0	0.30				
7/08								
7/11								
7/14								
7/18	2	0	0	0.32				
7/21	1	0	0	0.29				
7/25								
7/29	1	0	0	0.30				
8/01								

No larval sturgeon were sampled from the Missouri River at Nohly. Six larval paddlefish were sampled between June 21 and July 8 (Table 17); however, median density was low and maximum density varied from 0.41 larvae/100m^3 to 1.81 larvae/100m^3.

Table 17. Total number sampled (N), median density (number/100 m^3), minimum density (min.), and maximum density (max.) of larval sturgeon (*Scaphirhynchus* sp.) and larval paddlefish by date in the Missouri River at Nohly during 2005.

	Scaphirhynchus sp.				Paddlefish			
Date	N	Median	Min.	Max.	N	Median	Min.	Max.
5/24								
5/26								
6/01								
6/03								
6/07								
6/09								
6/14								
6/16								
6/21					1	0	0	0.41
6/23								
6/28					1	0	0	1.81
6/30					1	0	0	0.75
7/06								
7/08					3	0	0	0.91
7/12								
7/14								
7/19								
7/21								
7/26								
7/28								
8/01								

In the Yellowstone River, larval sturgeon were sampled on several dates between June 7 and August 1 (Table 18). Median densities were low, and maximum varied from 0.39 larvae/100 m^3 to 1.01 larvae/100 m^3. Paddlefish larvae were sampled in the Yellowstone River on six dates between June 3 and June 21, and median densities varied from 0 to 0.66 larvae/100 m3. In addition to identifiable larvae, ten unidentifiable larvae were sampled June 21 (1 individual), July 6 (5 individuals), and July 8 (4 individuals). Although unknown, it is possible that the nine larvae sampled on July 6 and July 8 were sturgeon larvae based on the finding that the occurrence of known larval paddlefish was completed by June 21.

Table 18. Total number sampled (N), median density (number/100 m^3), minimum density (min.), and maximum density (max.) of larval sturgeon (*Scaphirhynchus* sp.) and larval paddlefish by date in the Yellowstone River during 2005.

	Scaphirhynchus sp.				Paddlefish			
Date	N	Median	Min.	Max.	N	Median	Min.	Max.
5/24								
5/26								
6/01								
6/03					4	0	0	0.77
6/07	1	0	0	0.66	8	0.6	0	2.16
6/09					7	0.66	0.32	1.68
6/14					7	0.34	0	2.57
6/16	1	0	0	0.39	1	0	0	0.42
6/21	1	0	0	0.52	5	0.42	0	0.75
6/23								
6/28								
6/30								
7/06								
7/08	1	0	0	0.68				
7/12								
7/14								
7/19								
7/21	1	0	0	0.94				
7/26								
7/28								
8/01	1	0	0	1.01				

Spatial and temporal periodicity and densities of larval fishes exclusive of Acipenseridae and Polyodontidae. Mean densities of larval fish at the site downstream from Fort Peck Dam were low (< 3 larvae/100 m^3) throughout the sampling season with the exception of June 29 when mean density increased to 28 larvae/100 m^3 (Figure 25). On this date, Catostomidae composed 99.5% of the density. Larval cyprinids were present at low densities (mean = 0.13 larvae/100 m^3) on two dates (June 29, July 7) and were represented exclusively by common carp *Cyprinus carpio* larvae. Larval salmonids were present only on May 23 at low densities (mean = 0.11 larvae/100 m^3).

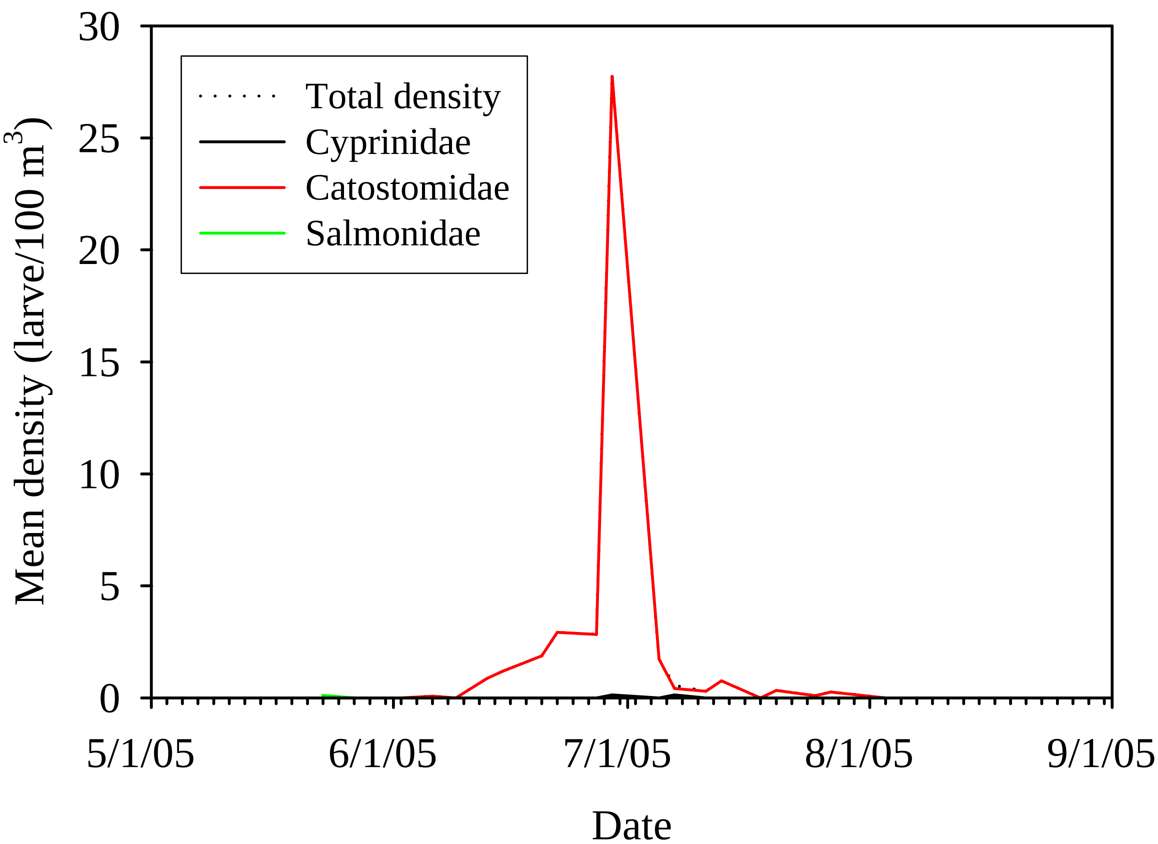


Figure 25. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, and Salmonidae sampled in the Missouri River at the site downstream from Fort Peck Dam during 2005.

Four families of larval fishes exhibited periodic occurrences in the Fort Peck spillway channel (Figure 26). Representatives of Percidae were sampled during late May and early June at mean densities of 4.3 – 12.4 larvae/100 m^3, and this taxon comprised 100% of the larvae during this time period. Mean density of larval fishes was less than 18.0 larvae/100 m^3 through late June as the community was comprised of Catostomidae, Cyprinidae, and Sciaenidae (freshwater drum). Densities of larval fishes peaked on June 29 (mean density = 277.4 larvae/100 m^3) when representatives of Catostomidae, freshwater drum, and Cyprinidae composed 97.5%, 2.3%, 0.2% of the community, respectively. Larval fish densities declined through the termination of sampling in early August, and the community was comprised exclusively of Catostomidae and Cyprinidae. Larval common carp composed 52 – 100% of the Cyprinidae on July 7, July 11, and July 13.

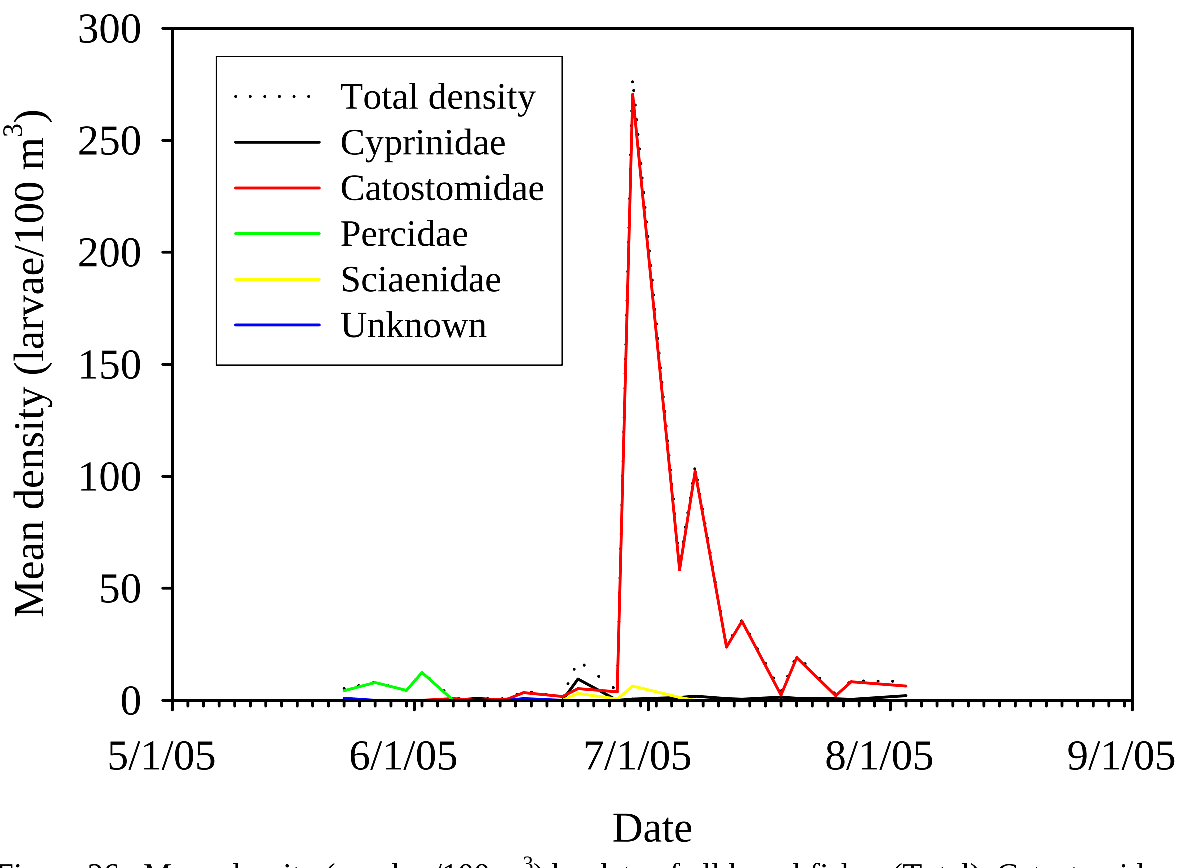


Figure 26. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Sciaenidae, and unknown sampled in the Fort Peck spillway channel during 2005.

Densities of larval fishes in the Milk River were low through early June, then exhibited three periods of elevated densities as several taxa occurred in the drift community (Figure 27). The first period of elevated densities occurred on June 9 (mean = 30.3 larvae/100 m^3) as Cyprinidae composed 98% of the larvae sampled. Between 86 – 99% of the larval Cyprinidae sampled on June 9, 13, and 15 was represented by larval common carp. Contributions of larval common carp to the community declined to zero by July 11 through the end of sampling. The second period of elevated density in the Milk River (mean = 89 larvae/100 m^3) occurred on June 22 as representatives of Catostomidae, Sciaenidae, Cyprinidae, and Hiodontidae composed 68.5%, 18.7%, 8.8%, and 3.7% of the larvae sampled, respectively. Density declined through late July then increased to 32 larvae/100 m^3 as larval cyprinids composed 99% of the larvae sampled. Larval representatives of Percidae were present only on June 13 and density was low (mean = 0.28 larvae/100 m^3).

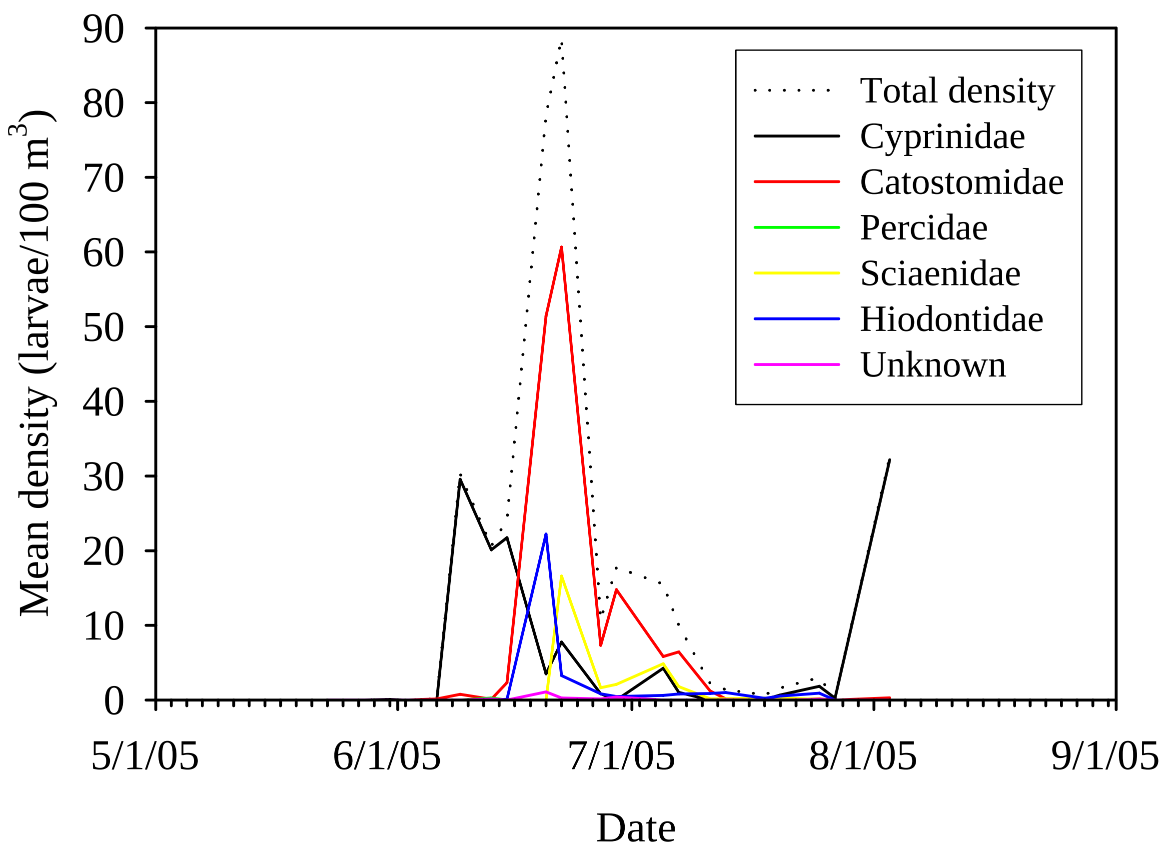


Figure 27. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Sciaenidae, Hiodontidae, and unknown sampled in the Milk River during 2005.

Exclusive of larval sturgeon and paddlefish, the larval fish community in the Missouri River at Wolf Point was comprised of Cyprinidae, Catostomidae, Percidae, Sciaenidae, and Hiodontidae (Figure 28). The temporal occurrence of these taxa accounted for temporal changes in density patterns through the sampling period. Representatives of Percidae were sampled from May 23 through June 30, but densities were highest (mean = 0.7 – 3.78 larvae/100 m^3) between May 23 and June 8. Representatives of Catostomidae were sampled on all dates, but exhibited highest densities on June 23 (mean = 27 larvae/100 m^3) when this taxon composed 92% of all larvae sampled. Densities of Catostomidae declined after June 23 with the exception of a secondary peak on July 5 (mean = 9.9 larvae/100 m^3) when Catostomidae composed 71% of the larvae sampled. Cyprinids were sampled on 19 of 21 dates, but density was greatest on June 13 (mean = 3.5 larvae/100 m^3). On this date, larval common carp composed 95% of the Cyprinidae sampled. Goldeye (Hiodontidae) were sampled between June 20 and July 5, but mean densities were less than 0.5 larvae/100 m^3. Freshwater drum (Sciaenidae) were sampled on seven dates between June 23 and July 21, and this taxon exhibited highest densities on July 5 (mean = 3.7 larvae/100 m^3).

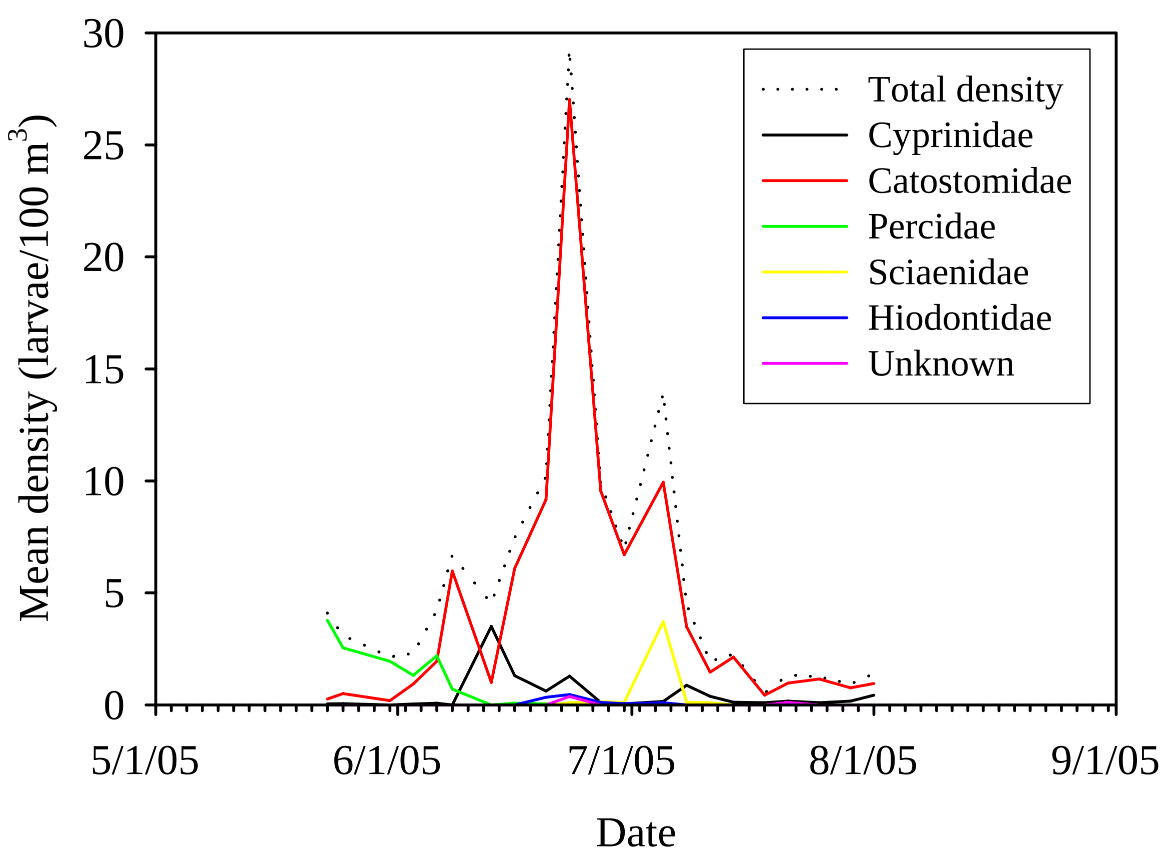


Figure 28. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Sciaenidae, Hiodontidae, and unknown sampled in the Missouri River at Wolf Point during 2005.

Densities of larval fishes in the Missouri River at Nohly exhibited significant variations throughout the sampling period in accordance with the periodicity of several larval taxa (Figure 29). Larval Percidae were sampled from May 24 through June 16, but percid density was greatest on May 26 (mean = 3.7 larvae/100 m^3) when this taxa composed 88% of all larvae sampled. Mean density of larval Cyprinidae was greatest on June 16 (5.9 larvae/100 m^3) as this taxon composed 62% of the larval fish community sampled. Common carp composed 100% of the Cyprinidae larvae on this date. Total densities of larval fish were highest on June 21 (mean = 22.9 larvae/100 m^3), June 23 (mean = 19.8 larvae/100 m^3), and June 28 (mean = 15.9 larvae/100 m^3) when Catostomidae, Hiodontidae, and to a lesser extent Cyprinidae contributed to the community. A small increase in total densities occurred on July 8 (mean total density = 6.5 larvae/100 m^3) when representatives of Hiodontidae, Catostomidae, Sciaenidae, and Cyprinidae contributed to population.

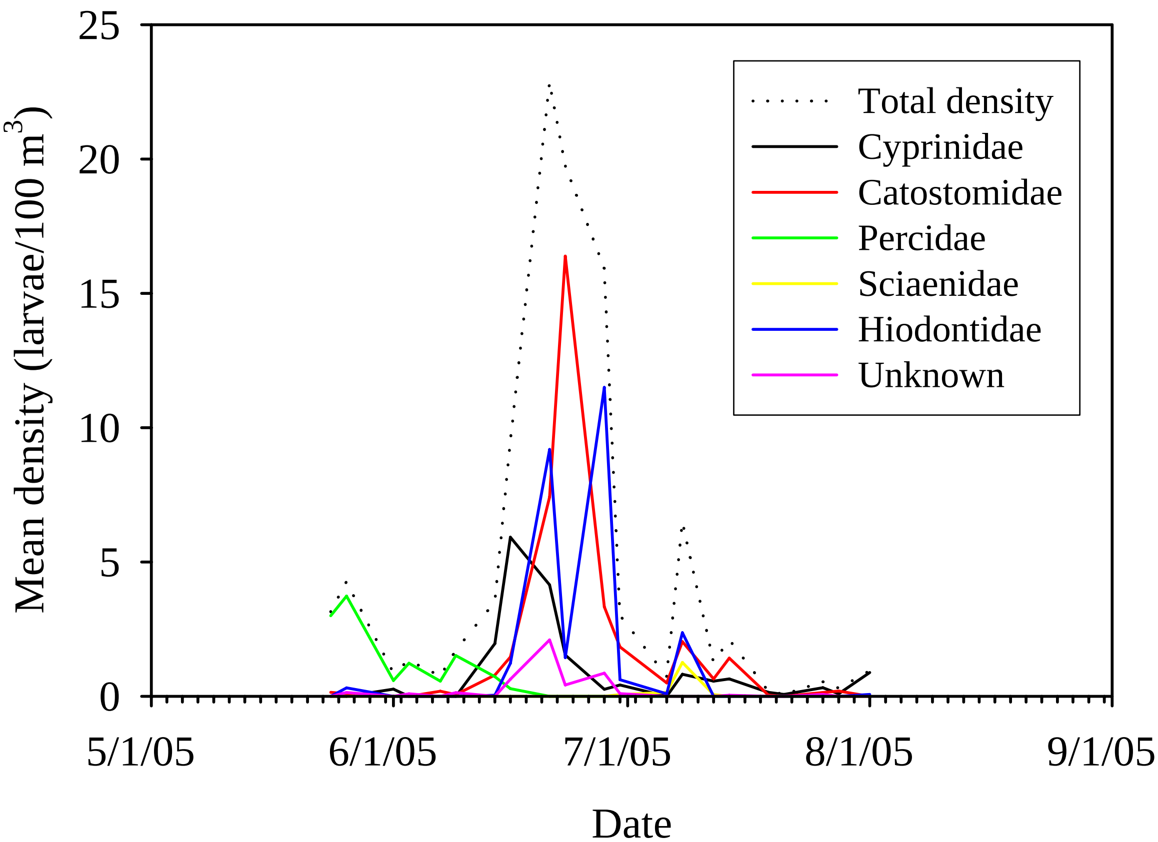


Figure 29. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Sciaenidae, Hiodontidae, and unknown larvae sampled in the Missouri River near Nohly during 2005.

The larval fish community in the Yellowstone River exhibited three major peaks in density during the sampling time frame (Figure 30). The initial peak in larval densities (mean = 12.0 larvae/100 m^3) occurred on May 24 when Hiodontidae and Cyprinidae composed 78% and 17% of the larvae sampled, respectively. Cyprinid densities were comprised exclusively of larval common carp. The second peak in larval densities occurred on June 23 (mean total density = 18.0 larvae/100 m^3) as significant increases in Catostomidae (76% of the larvae) and Cyprinidae (21% of the larvae) occurred. Common carp on this date composed 96% of the cyprinids sampled. The largest peak in total fish densities occurred July 14 (mean = 24 larvae/100 m^3), and the majority of this peak was associated with high densities of Catostomidae (78% of the total) and Cyprinidae (22% of the total). Larval Cyprinidae exhibited an increase in densities in late July; however, unlike earlier samples, the cyprinid samples did not contain common carp larvae. Representatives of Centrarchidae were sampled on only two dates (June 28, 30), but at low densities (mean < 0.10 larvae/100 m^3).

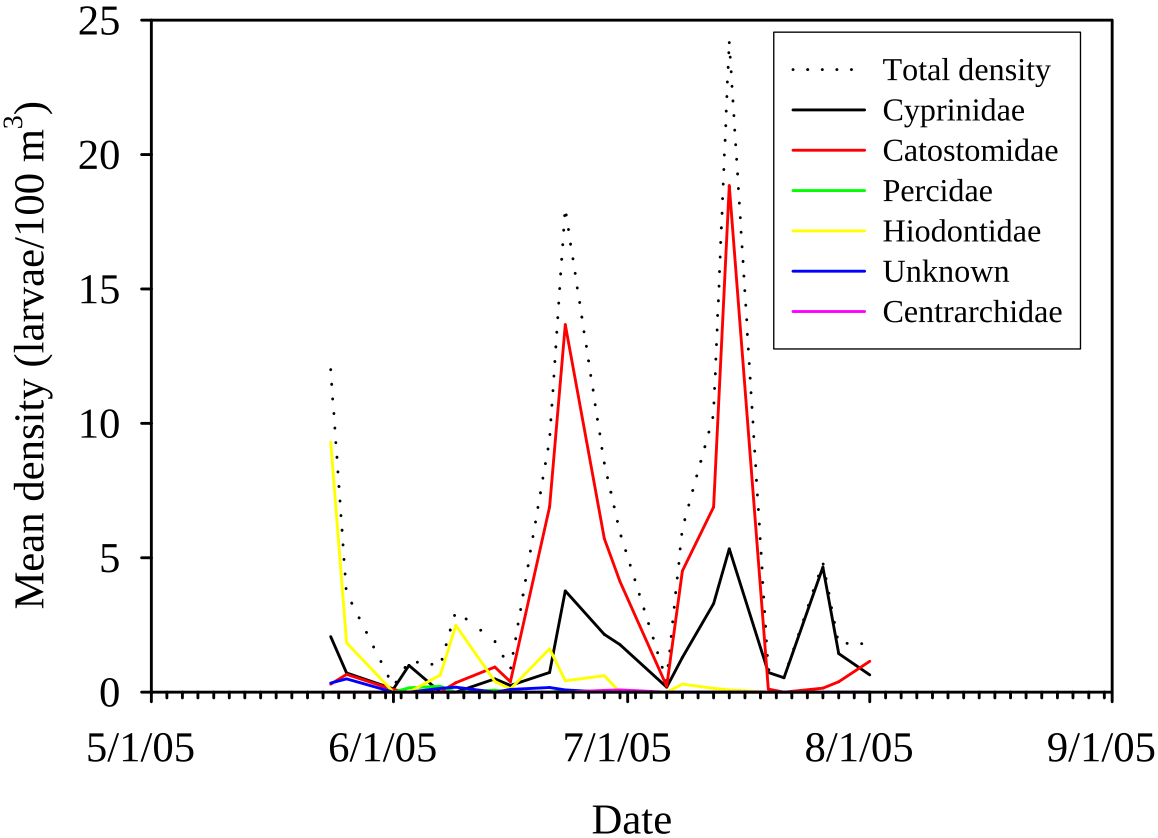


Figure 30. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Percidae, Hiodontidae, Centrarchidae, and unknown larvae sampled in the Yellowstone River during 2005.

Inter-annual trends in larval fish densities.- The final analyses of spatial and temporal patterns of larval fish densities will be conducted following completion of the Fort Peck Flow Modification Study. However, preliminary trends in larval fish densities among sites and years are illustrated below (Figure 31). Densities of larval fish at the site downstream from Fort Peck Dam have been relatively stable through the years at densities less than 1 larvae/100 m^3. Four sites (spillway channel, Milk River, Missouri River at Wolf Point and Nohly) have exhibited a fairly similar pattern through time as larval fish density was lowest in 2003, but larval densities increased in 2004 and 2005. Densities of larval fishes in the Yellowstone River have remained relatively stable among years at median densities less than 5 larvae/100 m^3.

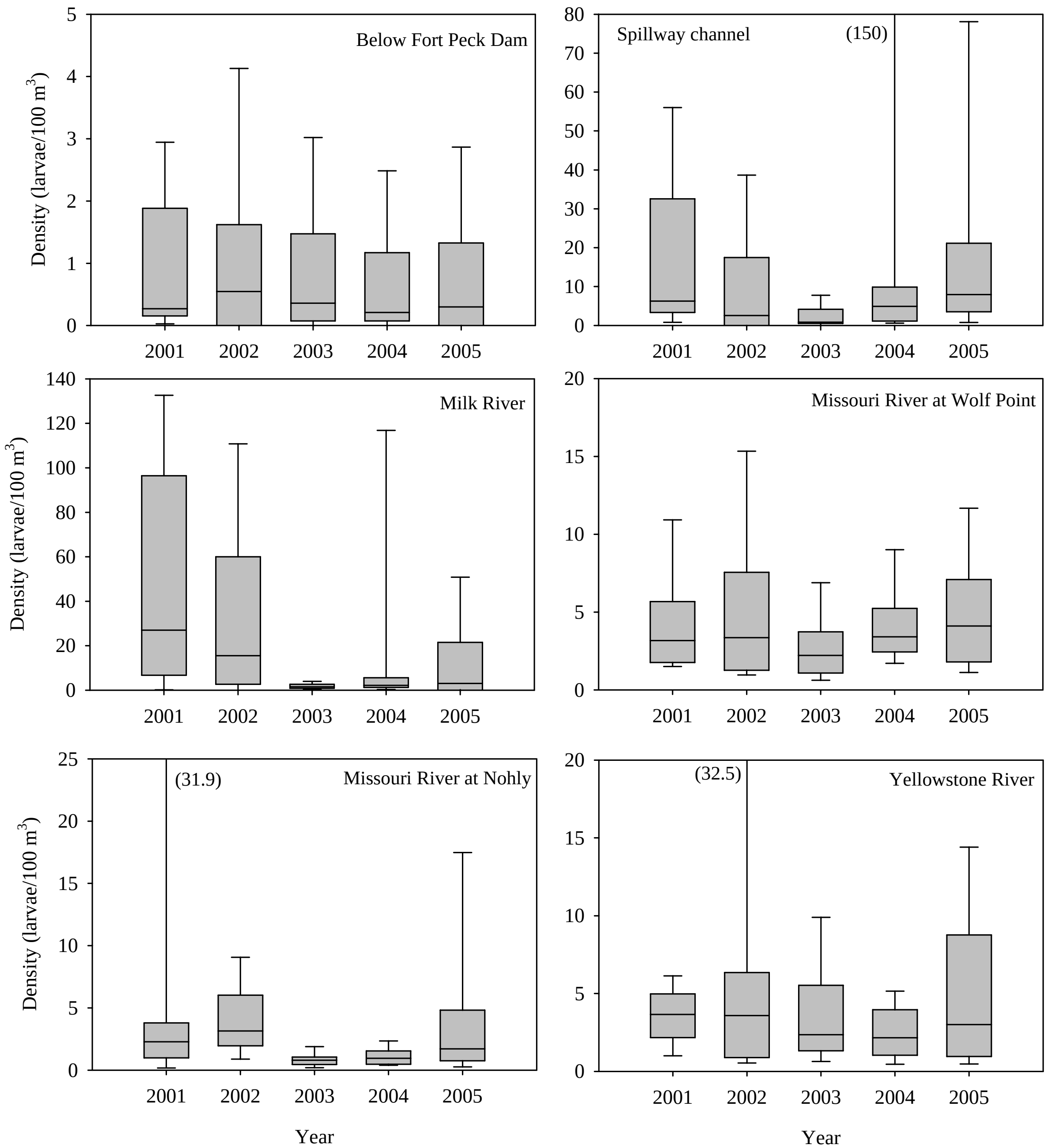


Figure 31. Box and whisker plots of total density (all taxa combined averaged among dates; number/100 m^3) of larval fishes sampled at six sites in 2001, 2002, 2003, 2004 and 2005. Boxes delimit the 25th and 75th percentiles of the data, line within the boxes denotes the median, and whiskers delimit the 10th and 90th percentiles. Data span from late May through early August with the exception of 2001 when sampling was terminated in late July.

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

Young-of-year sturgeon sampling.- A total of 535 standard, targeted, and extra trawls were conducted on eight sampling events between July 19 and September 7 (Table 19). Due to the standard and targeted sampling protocol, effort varied among sites and included 109 trawls in the Missouri River ATC, 313 trawls in the Missouri River BTC, and 113 trawls in the Yellowstone River. Sampling efforts resulted in a total of 178 young-of-year sturgeon. In the Missouri River ATC, standard and targeted sampling yielded six and five sturgeon, respectively. Standard sampling in the Missouri River BTC yielded 51 sturgeon; whereas, 89 sturgeon were collected during targeted sampling. Fifteen additional sturgeon from the Missouri River BTC were obtained during extra sampling efforts. In the Yellowstone River, eight and four sturgeon were collected during standard and targeted sampling, respectively. Genetic analyses are currently being conducted on all young-of-year sturgeon sampled during 2005 to differentiate these individuals as pallid sturgeon or shovelnose sturgeon.

Relative abundance of young-of-year sturgeon sampled during 2005 varied among sites and sampling dates (Table 19). In the Missouri River ATC, young-of-year sturgeon were collected on five of eight sampling events, but with the exception of the initial sampling event when two sturgeon were sampled, only individual sturgeon were sampled during standard trawling on the remaining three dates. Evidence for aggregations of young-of-year sturgeon was noted primarily in mid-July as targeted sampling yielded four additional sturgeon. In the Yellowstone River, young-of-year sturgeon were collected on three of eight sampling events. There was limited evidence for aggregations of young-of-year sturgeon in the Yellowstone River sites where targeted sampling yielded only one or two individuals. Young-of-year sturgeon were found during all sampling events in the Missouri River BTC. Based on standard trawls, relative abundance of young-of-year sturgeon BTC was highest between early and late August. Aggregations of young-of-year sturgeon occurred at several sites in the Missouri River BTC as evidenced by the high numbers of sturgeon collected during targeted trawling.

The size distributions of young-of-year sturgeon sampled varied among sites, and were indicative of different hatching events, recruitment, and growth through time. In the Missouri River ATC, young-of-year sturgeon were 29 – 39 mm on the initial sampling date (July 21; Figure 32). Samples on August 9 revealed the presence of smaller individuals (21 mm, 24 mm) indicative of later-hatched cohorts. The large number of young-of-year sturgeon sampled in the Missouri River BTC provided the best illustration of hatch events, recruitment, and growth through time (Figure 33). For example, initial samples on July 19 revealed the presence of different cohorts of sturgeon where lengths varied from 27 – 50 mm. On July 27, new and later-spawned cohorts were added to the population (24 mm) and there was growth of earlier-spawned cohorts to lengths between 31 and 67 mm. Samples on August 17 indicated the occurrence of later-spawned and hatched cohorts (21-23 mm) in addition to increased lengths of earlier-spawned cohorts. By September 7, size frequency distributions suggested the continued presence of the early-spawned cohorts (110 – 131 mm), but the lack of small individuals (< 80 mm) indicated that no new or late-spawned cohorts were present in the population. Despite small sample sizes in the Yellowstone River, size-frequency distributions suggested the presence of different hatch cohorts (Figure 34). For example, samples from July 20 suggest the presence of two hatch cohorts spanning 31 – 36 mm and 54-55 mm. Samples on later dates (July 27, August 16) suggested growth of these two cohorts, but the lack of smaller individuals on these dates indicate that no late-spawned cohorts were added to the population.

Table 19. Number of young-of-year sturgeon sampled and sampling effort expended in 2005 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 2005							
Site	Sampling protocol	Metric	Jul 19-21	July 26-28	Aug 2 -3	Aug 8-9	Aug 16-18	Aug 22-23	Aug. 29-30	Sept. 6-7
Missouri River ATC	Standard	Sturgeon sampled	2	1	0	1	1	0	0	1
		Number of trawls	9	12	12	12	12	12	12	12
		Total minutes	36	48	48	48	48	48	48	48
	Targeted	Sturgeon sampled	4	0	0	1	0	0	0	0
		Number of trawls	6	2	0	4	2	0	0	2
		Total minutes	24	8	0	16	8	0	0	8
Missouri River BTC	Standard	Sturgeon sampled	5	2	7	12	7	12	1	5
		Number of trawls	18	18	18	18	18	17	18	18
		Total minutes	71.7	72	72	72	72	68	72	72
	Targeted	Sturgeon sampled	2	11	18	24	18	9	0	7
		Number of trawls	8	8	28	40	24	20	2	12
		Total minutes	32.7	32	112	160	96	80	8	48
	Extra	Sturgeon sampled	0	10		0		3	2	
		Number of trawls	1	17		2		2	6	
		Total minutes	4	38.4		8		8	24	
Yellowstone River	Standard	Sturgeon sampled	5	1	0	0	2	0	0	0
		Number of trawls	12	12	12	12	12	12	9	12
		Total minutes	48	48	48	48	49.1	42	33.7	46.6
	Targeted	Sturgeon sampled	2	1			1			
		Number of trawls	10	4			6			
		Total minutes	37.3	16			24			

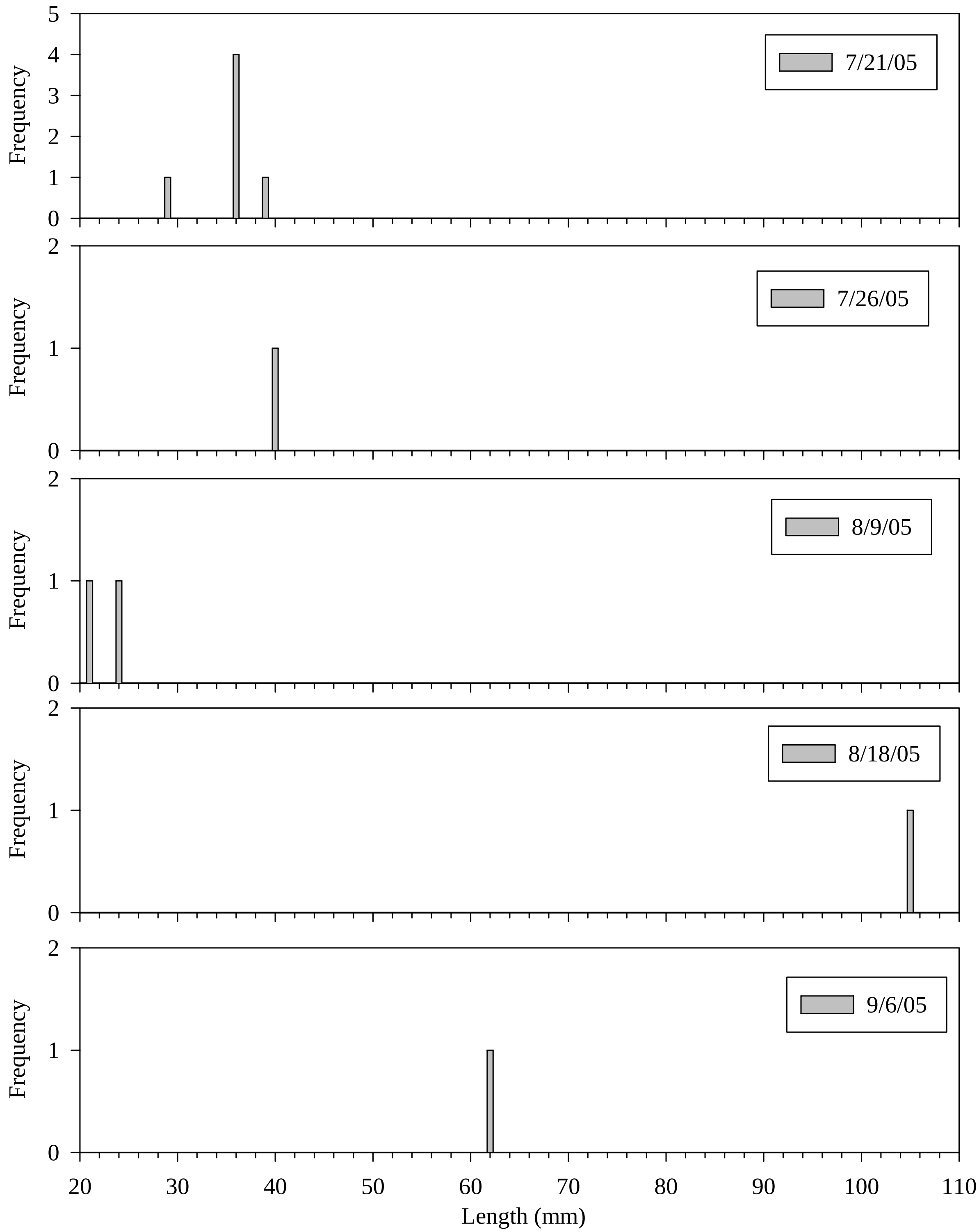


Figure 32. Length-frequency distributions for young-of-year sturgeon sampled during 2005 in the Missouri River ATC (upstream from the Yellowstone River confluence).

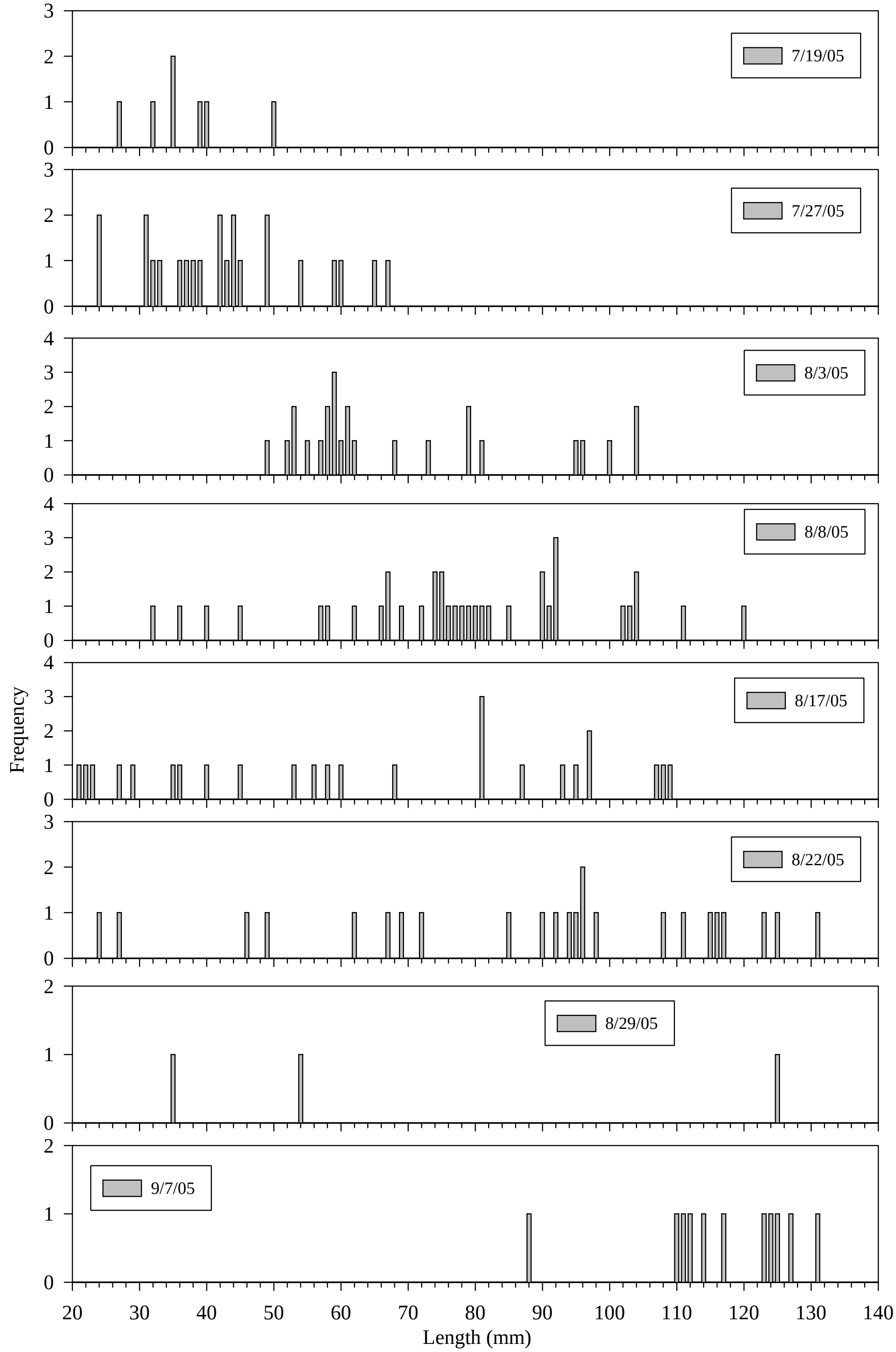


Figure 33. Length-frequency distributions for young-of-year sturgeon sampled during 2005 in the Missouri River BTC (downstream from the Yellowstone River confluence).

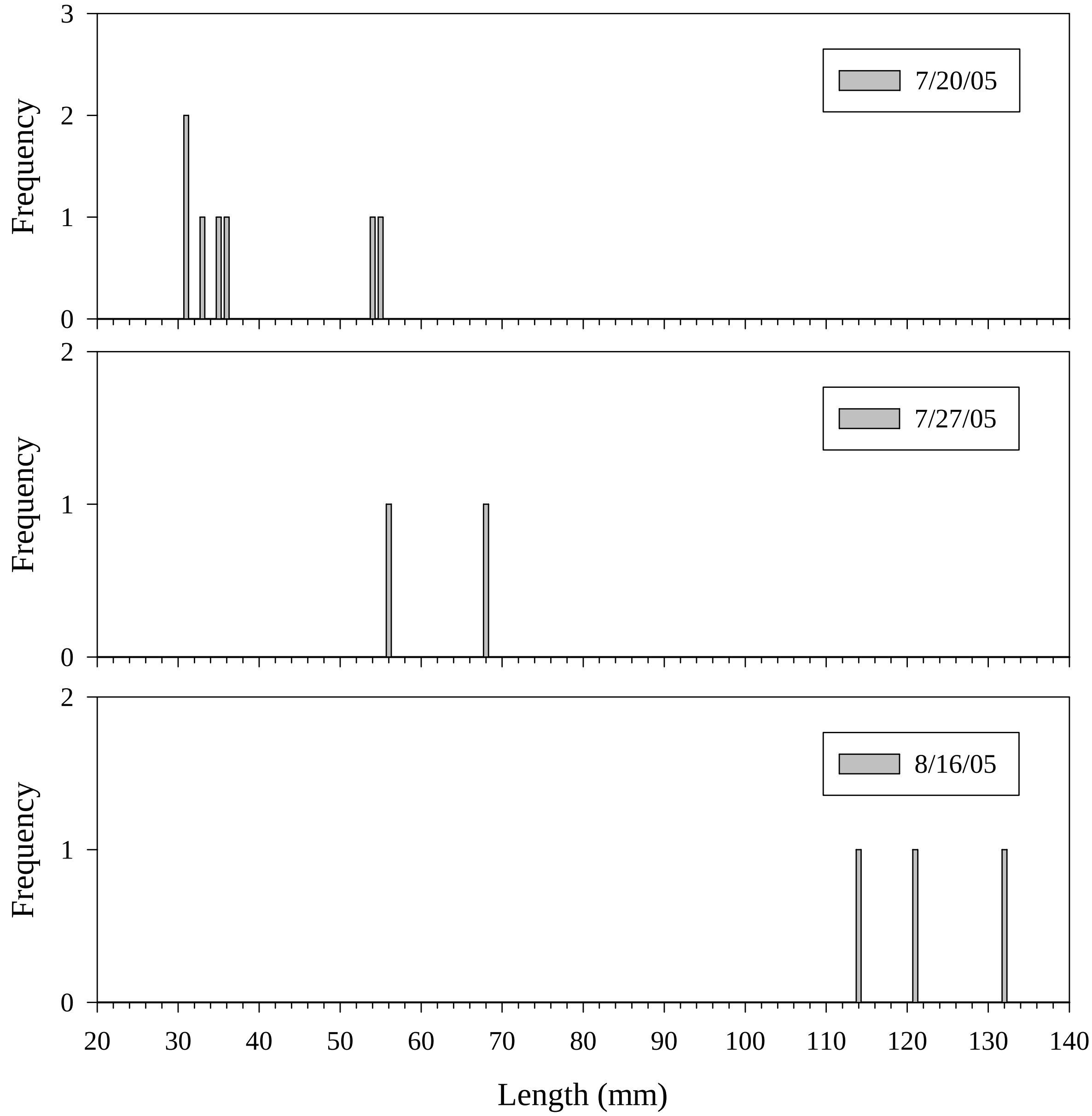


Figure 34. Length-frequency distributions for young-of-year sturgeon sampled during 2005 in the Yellowstone River.

Inter-annual trends in young-of-year sturgeon.- A complete analysis of young-of-year sturgeon catch rates among years will be conducted upon completion of the study to discern inter-annual variations in sturgeon reproductive and recruitment success. Preliminary analyses based on 2003 – 2005 data (standard trawls only) suggest that sturgeon recruitment quantified as catch-per-unit-effort (CPUE; sturgeon per minute of trawling) varied among years and sites (Figure 35). For example, averaged across years, CPUE tended to be greater during 2005 (mean = 0.039 sturgeon/min) and 2003 (mean = 0.028 sturgeon/min) than 2004 (mean = 0.005 sturgeon/min). Averaged across sites, CPUE tended to be about 9 - 12 times greater in the Missouri River BTC (mean = 0.060 sturgeon/min) than in the Missouri River ATC (mean = 0.007 sturgeon/min) and Yellowstone River (mean = 0.005 sturgeon/min)). However, closer inspection of the trawling data (Figure 35) suggests that high reproductive success and recruitment of sturgeon in 2003 and 2005 was especially evident at the Missouri River BTC sites.

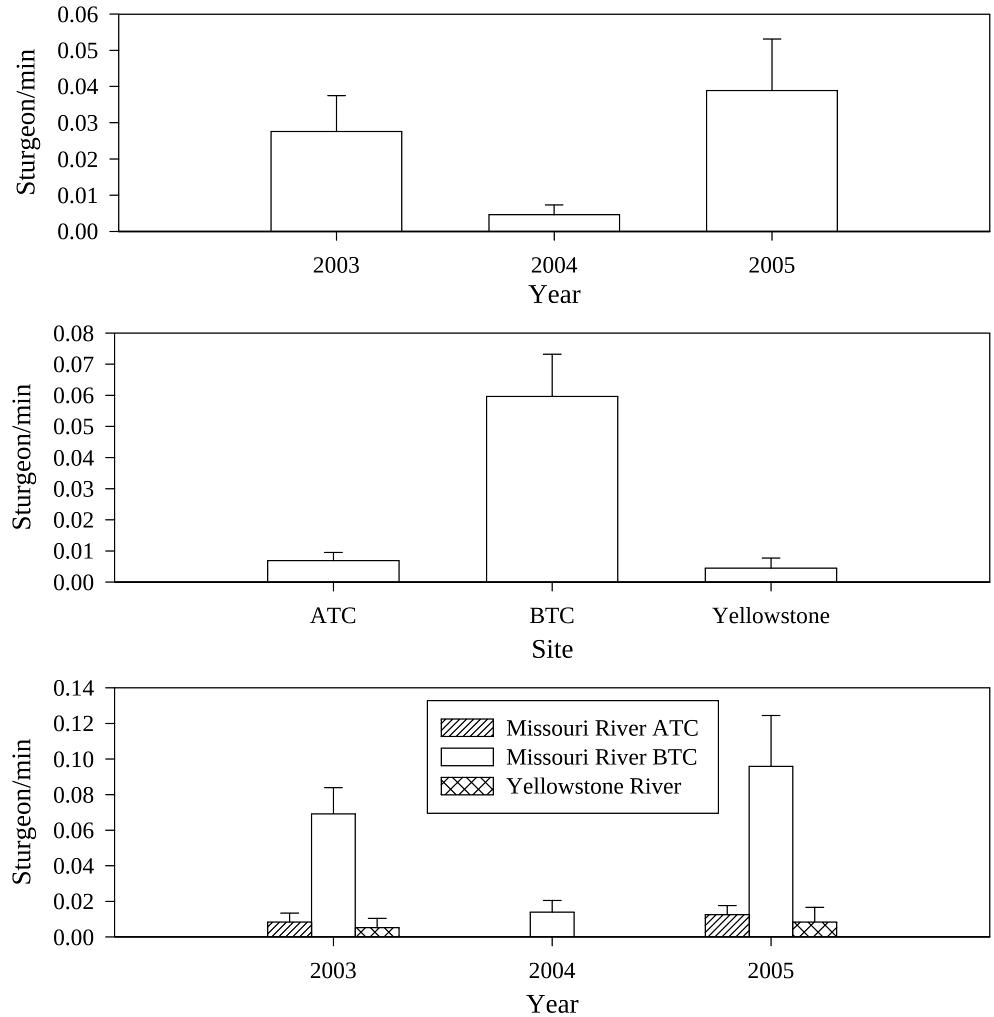


Figure 35. Mean catch-per-unit-effort (young-of-year sturgeon/min of trawling; error lines denote 1 standard error) by year (top panel), by site (middle panel), and individual sites by year (lower panel).

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

The Fort Peck Flow Modification Crew participated in brood stock collection activities during April and October 2005. Through these efforts, the crew sampled four adult pallid sturgeon during April and six adult pallid sturgeon during October. Selected individuals were transported to state and federal hatcheries. Collection records were submitted to the USFWS Bismarck Office for inclusion in the pallid sturgeon database.

Associated activities.

Netting activities conducted under the Fort Peck Data Collection Plan resulted in the by-catch of 44 juvenile pallid sturgeon (Table 20). Based on PIT tag numbers, elastomere color schemes, coded-wire tags, or lack of marks, 35 individuals could be assigned to specific year classes. One individual from the 1997 year class was sampled, and hatchery representatives from the 2001 year class (N = 7), 2002 year class (N = 13), 2003 year class (N = 10), 2004 year class (N = 3), and 2005 year class (N = 1) were collected. Of major significance was the finding that the three individuals from the 2004 year class represented survivors from the 2004 pallid sturgeon larval drift study. These individuals were released as 11- and 17-day post-hatch (dph) larvae during the drift study, and genetic analysis confirmed these fish as progeny from hatchery spawnings (Note: To date, genetic analysis has been completed for one of the individuals as definitive pallid sturgeon. Genetic analysis is currently being conducted on the other two individuals, but it is highly likely that these two individuals will be confirmed as pallid sturgeon from the drift study). Two juveniles from the larval drift study (collected on 9/28/05, length = 213 mm; collected on 9/29/05, length = 230 mm) were sampled within 24 km downstream from the larval drift side channel near Culbertson, MT (Figure 1). The 212 mm pallid sturgeon sampled on August 3 was found in the lower Missouri River near Williston, about 124 km downstream from the larval drift side channel. Two additional juvenile pallid sturgeon representing survivors from the drift study were sampled during 2005 in the Missouri River downstream from the Yellowstone River confluence (R. Wilson, USFWS, Bismarck, ND, personal communication). Thus, these results indicate that pallid sturgeon released between 11 and 17 dph can survive in the Missouri River and contribute to the juvenile population. Sampling in subsequent years will provide additional information on growth and survival of the juveniles released as larvae.

Table 20. Juvenile pallid sturgeon sampled as part of the Fort Peck Data Collection Plan activities during 2005. Abbreviations are as follows: Elastomere (G = green, R = red, Y = yellow, O = orange, H = horizontal, V = vertical), Lat = latitude, Long = Longitude, River (YS = Yellowstone, MO = Missouri), YC = year class (obtained from the USFWS juvenile pallid sturgeon PIT tag database; if the PIT was missing, elastomere color schemes were used to determine YC to the fullest extent possible and are designated with a ?). PIT numbers listed in parentheses could not be found in the USFWS PIT tag database.

	Elastomere						Capture		
PIT number or other mark	Right	Left	Date	Lat	Long	River	Length (mm)	Weight (g)	YC
4356637157	VG		5/03/05	47.87719	103.96041	YS		150	01
435E4A667A	VR	VY	5/03/05	47.87700	103.96026	YS		225	02
435E7B495D	HY		5/03/05	47.87700	103.96026	YS		100	03
444354093D*	VG	VY	5/03/05	47.87570	103.96023	YS		275	
44421B0E1D*	VY		5/04/05	47.97834	103.98377	MO	357	175	
444361032C	VR	VY	5/04/05	47.97190	103.99062	MO	333	125	02
435D705548	VG		5/04/05	47.97197	103.99044	MO	413	250	01
4442691830	VR	VY	5/04/05	47.97197	103.99044	MO	360	150	02
44435E206B*	VR	VY	5/04/05	47.96927	103.99315	MO	325	100	
444173774E	VR	VY	5/18/05	47.80106	104.01266	YS	352	175	02
435E480049	HY		5/18/05	47.80106	104.01266	YS	298		03
44436F7A71	VR	VY	5/18/05	47.80106	104.01266	YS	364		02
4425601569	VR	VY	5/18/05	47.80106	104.01266	YS	344		02
(4355D741F4F) 435D741F4F	VG		5/18/05	47.80106	104.01266	YS	401		01?
410947034F	VY	VY	6/07/05	47.98281	104.01408	MO	484	385	97
	VG		6/22/05	47.81599	103.98367	YS	416	300	01?
4424081D6A	VR	VY	7/14/05	48.00162	104.05927	MO	337		02
435E236E09	VG		7/20/05	47.97815	103.97597	YS	374		01
(435F16722C)	VR	VY	7/21/05	47.97198	103.96600	YS	409	210	
434D7B565D	VR	VY	7/26/05	48.02893	104.09046	MO	341		02
435E636C5C	VG		7/26/05	47.95033	103.96179	YS	370		01
435E7E6F68	HY		7/28/05	48.10831	103.71548	MO	179	42	03
None 2004 larval drift study survivor[1]			8/03/05	48.06140	103.71011	MO	212		04
435D6D410F	HY		8/09/05	47.98607	103.96767	MO	298		03
435F3F350C	HY		8/09/05	47.98607	103.96767	MO	160		03
435E0C326D	HY		8/16/05	47.97174	103.96581	YS	272		03
433D13717E	VR	VY	8/18/05	48.00277	104.10131	MO	373	165	02
430E512634*	VG		8/30/05	47.97888	104.01251	MO	349	150	01?
435F386740	HY		8/31/05	47.95736	103.90759	MO	312	95	03
435E006D7A	HY		9/21/05	47.97839	103.98459	MO	333	100	03

Table 20 continued.

	Elastomere						Capture		
PIT number or other mark	Right	Left	Date	Lat	Long	River	Length (mm)	Weight (g)	YC
44265D3074	VR	VY	9/21/05	47.98622	103.97505	MO	376	200	02
435F332224	HY		9/21/05	47.98484	103.96841	MO	311	100	03
44431E1154*		VG	9/21/05	47.98622	103.97505	MO	380	250	
None 2004 larval drift study survivor[2]			9/28/05	48.13394	104.59588	MO	213		04
4441654D46*	VR	VG	9/28/05	48.13385	104.59394	MO	360	150	
442241397A	VR	VY	9/28/05	48.10892	104.58133	MO	361		02
None 2004 larval drift study survivor[2]			9/29/05	48.08810	104.42387	MO	230		04
442234685C	VR	VY	9/29/05	48.09323	104.44084	MO	350	100	02
44436A285A*	VG	VY	10/05/05	48.07489	105.65454	MO	349	100	
44213E7C1B	VR	VY	10/05/05	48.04603	105.65514	MO	357	100	02
44432E7242*	VR	VY	10/07/05	48.01177	104.10741	MO	361	125	
435E29586A	HY		10/19/05	48.13175	104.58807	MO	333	75	03
Coded wire	VY	HO	10/20/05	48.10362	104.44881	MO	178		05?
(44231D2E74)	VR	VY	10/25/05	48.04093	104.16040	MO	324	125	

*New Pit Tag inserted
1 confirmed by genetic testing
2 highly probable pending genetic testing

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