Fort Peck Flow Modification Biological Data Collection Plan

Summary of 2002 Activities

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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. 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. Activities continued during 2002, and are summarized below. The multi-year Fort Peck Data Collection Plan is comprised of five monitoring components: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements by pallid sturgeon that inhabit areas immediately downstream from Fort Peck Dam, 3) examining flow- and temperature-related movements of paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus*, 4) quantifying larval fish distribution and abundance, and 5) examining food habits of piscivorous fishes. The Fort Peck Data Collection Plan is supported by the USACE, and implemented by the Montana Department of Fish, Wildlife, and Parks (MTFWP) and the U. S. Geological Survey Columbia Environmental Research Center.

Proposed flow modifications were not implemented in 2002 due to inadequate precipitation and insufficient reservoir levels. Continuous-recording water temperature loggers positioned at 17 locations provided baseline water temperature profiles to which changes in water temperatures resulting from modified dam operations could be compared. In the absence of modified dam operations in 2002, mean water temperature between mid-May and mid-October was 6.0^{o}C cooler immediately downstream from Fort Peck Dam (mean = 11.9^{o}C) than in the free-flowing Missouri River upstream from Fort Peck Dam (mean = 17.9^{o}C). Water temperature 288 km (179 miles) downstream from Fort Peck Dam averaged 1.2^{o}C less than above Fort Peck Dam. Similar to 2001, adult pallid sturgeon were not found in selected areas immediately downstream from Fort Peck Dam. Consequently, pallid sturgeon were not implanted with radio transmitters. Between April and November 2002, telemetry relocations were obtained for 16 blue suckers (160 relocations), 27 shovelnose sturgeon (276 relocations), and 18 paddlefish (134 relocations) in the Missouri River and Yellowstone River. One continuous-recording telemetry logging station positioned in the Milk River and five additional stations positioned at sites between Fort Peck Dam and Culbertson logged an additional 376 contacts of radio-implanted fish. Shovelnose sturgeon and paddlefish were highly migratory, and exhibited seasonal differences in use of the Missouri River and Yellowstone River. Blue suckers tended to be less migratory. In September 2002, an additional 21 shovelnose sturgeon, 21 blue suckers, and 3 paddlefish were implanted with transmitters. These individuals will be tracked during 2003. A total of 41,768 larval fish were sampled at six sites on the mainstem Missouri River and adjacent habitats. Larval sturgeon (*Scaphirhynchus* sp.) were sampled at Wolf Point (N = 5) and in the Yellowstone River (N = 9). Larval catostomids (suckers) were the dominant taxon sampled, and comprised 43-94% of the larval fishes sampled at all sites; however, taxa composition varied significantly among sites. Food habit data for burbot *Lota lota*, channel catfish *Ictalurus punctatus*, freshwater drum *Aplodinotus grunniens*, goldeye

Hiodon alosoides, northern pike *Esox lucius*, sauger *Stizostedion canadense*, shovelnose sturgeon, and walleye *Stizostedion vitreum* were obtained during July and August 2002. All species with the exception of shovelnose sturgeon exhibited piscivory, but there was no evidence that sturgeon larvae or juveniles were consumed. Six hatchery-raised juvenile pallid sturgeon and one adult pallid sturgeon were sampled during September in conjunction with associated field activities. In addition, two larval pallid sturgeon (21.6 mm, 23.1 mm) were sampled on September 4 and 5, 2002, downstream from the Yellowstone River confluence. These findings are the first documented account of larval pallid sturgeon in the Missouri River downstream from Fort Peck Dam, and indicate that successful spawning by pallid sturgeon did occur in 2002. However, it is not known whether spawning occurred in the Yellowstone River or in the Missouri River.

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 (U.S. Fish and Wildlife Service 2000). Modified dam operations are proposed to increase discharge and enhance water temperatures during late May and June to provide spawning cues and enhance environmental conditions for pallid sturgeon *Scaphirhynchus albus* and other native fishes. In contrast to "normal" cold water 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. A full-test of the flow modifications will occur when a maximum of 19,000 cfs will be routed through the spillway. Spillway releases will be accompanied by an additional 4,000 cfs 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 spring 2001 and 2002 precluded conducting the mini-test and full-test. Thus, pending favorable precipitation and adequate reservoir water levels in early spring 2003, the mini-test may be conducted in 2003 and the full-test conducted in 2004.

The Fort Peck Flow Modification Biological Data Collection Plan (hereafter referred to as the Fort Peck Data Collection Plan) is a 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. Components of the monitoring program include: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements by pallid sturgeon that inhabit areas immediately downstream from Fort Peck Dam, 3) examining flow- and temperature-related movements of paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus*, 4) quantifying larval fish distribution and abundance, and 5) examining food habits of piscivorous fishes. The Fort Peck Data Collection Plan is supported by the USACE, and 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. Western Area Power Administration serves as the contractual liaison between the USACE and MTFWP.

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 2,496 (RM 1,550; Figure 1). The study area also includes the lower 113 rkm (70 miles) of the Yellowstone River (Figure 1). See Gardner and Stewart (1987), White and Bramblett (1993), Tews (1994), and Bramblett and White (2001) 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 during early May at sites in the Missouri River, Yellowstone River, selected tributaries, and off-channel areas (Table 1). Duplicate loggers were secured adjacent to the north and south bank lines at sites in the Missouri River to assess lateral variations in water temperature. Water temperature loggers were positioned near 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. Stratified water temperature loggers were secured to either the north or south bank locations. Water temperature loggers were programmed to record water temperature at 1-hr intervals, and periodically downloaded during the deployment period.

Statistical analysis of water temperature. Analysis of variance and 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 2002, all water temperature loggers (except the logger deployed at Robinson Bridge) were subjected to a series of 15 common water bath treatments to evaluate precision and accuracy among loggers. The 15 water bath treatments were comprised of three temperature ranges (cold, < 10^{o}C; cool, 15-20^{o}C; warm, > 20^{o}C) with five temperature measurements recorded within each temperature range. During water bath treatments, water temperature was also measured with a YSI Model 85 meter (accuracy $\pm$ 0.1^{o}C) and a hand-held alcohol thermometer (accuracy $\pm$ 1.0^{o}C) at specific times. In late November following retrieval from the field, water temperature loggers were subjected to a similar series of common water bath treatments as conducted in pre-deployment assessments. In addition to pre- and post-deployment comparisons involving water bath treatments, water temperature measured with the YSI Model 85 meter during the course of larval fish sampling (late May through early August, see below) provided an additional data set to which accuracy and precision of the loggers could be evaluated. Larval fish sampling sites were generally within 1.6-3.2 km (1-2 miles) of a water temperature logger. Water temperature at the larval fish sampling sites was measured in the upper 1-m of the water column.

Statistical analysis of water temperature logger precision. 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), univarite statistics were computed again to assess precision. In addition to univariate statistics, a two-way analysis of variance was used to compare precision (i.e., temperature range) of water temperature loggers between pre- and post-deployment test and among the three water temperature treatments.

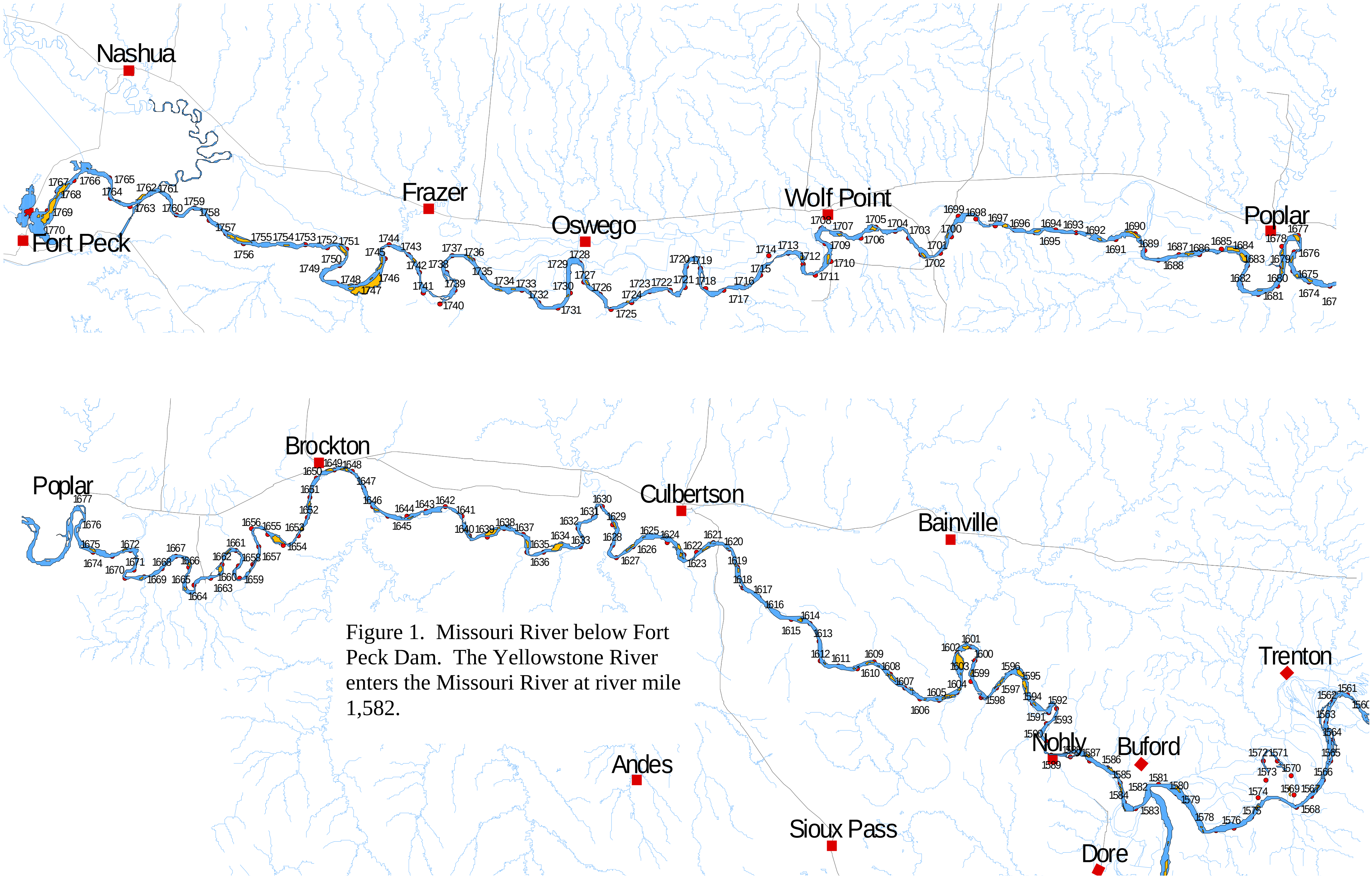


Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

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 2002. NR = not recovered at the end of the season.

Site	RM	Bank location	Logger serial no.	Deploy date	Retrieval date
Above Fort Peck Lake	1,921.2	South		4/26/02	11/6/02
Downstream from Fort Peck Dam	1,765.2	North	389503	5/10/02	10/21/02
		South	389561	5/10/02	10/21/02
Spillway			389574	5/10/02	10/21/02
Milk River	4.0		389560	5/9/02	10/21/02
Nickels Ferry	1,759.9	North	389495	5/9/02	10/21/02
		South	389488	5/9/02	10/21/02
		strat	407322	5/9/02	10/21/02
Nickels Rapids	1,757.5	North	389563	5/9/02	11/6/02
		South	389571	5/9/02	11/6/02
		strat	389504	5/9/02	11/6/02
Frazer Pump	1,751.5	North	389565	5/9/02	11/6/02
		South	389489	5/9/02	11/6/02
		Strat	389556	5/9/02	11/6/02
Frazer Rapids	1,746.0	North	389501	5/9/02	11/6/02
		South	389490	5/9/02	11/6/02
		Strat	429705	5/9/02	11/6/02
Grand Champs	1,741.5	North	389497	5/9/02	11/6/02
		South	389575	5/9/02	11/6/02
		Strat	407323	5/9/02	11/6/02
Wolf Point	1,701.5	North	389493	5/9/02	11/6/02
		South	389500	5/9/02	11/6/02
		strat	429703	5/9/02	11/6/02
Redwater River	0.1		389502	5/9/02	NR
Poplar	1,680	North	389491	5/9/02	NR
		South	389492	5/9/02	NR
		strat	429700	5/9/02	NR
Poplar River	0.4		314955		NR
Culbertson	1,620.9	North	389572	5/2/02	10/25/02
		South	389567	5/2/02	NR
		strat	429696	5/2/02	10/25/02
Nohly	1,591.2	North	429697	5/1/02	11/8/02
		South	389498	5/1/02	NR
		strat	429698	5/1/02	NR
Yellowstone River	3.5		389562	5/1/02	11/8/02
Below Yellowstone River	1,576.5	North	389566	5/1/02	11/8/02
		South	389564	5/1/02	11/8/02
		strat	429704	5/1/02	11/8/02

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

A*ssessments of turbidity logger precision.* Precision of turbidity loggers was assessed during field deployment and following retrieval from the field. Turbidity loggers at Nohly and in the Yellowstone River were located within larval fish sampling stations (see below) where turbidity was also measured at 2-3 day intervals between late May and early August. Turbidity at the larval fish sampling stations was measured using a Hach Model 2100P portable turbidimeter (measurement range 0 – 1000 NTU, accuracy ± 2%). Thus, time- and date-specific turbidity measurements logged by the turbidity loggers were compared to turbidities measured during larval fish sampling. After deployment in the field, turbidity loggers were subjected to a common water bath to assess precision of turbidity measurements among the turbidity loggers. The loggers were placed in a water bath to which sediment had been added. Sediments in the bucket were periodically mixed to increase turbidity. After turbidity declined due to particle settling, the sediments were again stirred to increase turbidity. Turbidity loggers were programmed to record turbidity at 15-min intervals during the post-deployment assessments. The 15-min sampling interval resulted in more than 90 individual measurements of turbidity during the post-deployment tests. A subsample of low (< 100 NTU), medium (200-500 NTU), and high (>500 NTU) turbidity measurements was randomly selected from the total number of observations for post-deployment comparisons.

Statistical analysis of turbidity logger precision. Correlation analysis was used to assess the degree of association between turbidities measured by the turbidity loggers and turbidities measured during larval fish sampling at Nohly and in the Yellowstone River. In addition, t-tests were used to compare mean turbidity recorded by the loggers and during larval fish sampling. For post-deployment assessments of turbidity, univariate statistics as calculated for water temperature (discussed above) were screened for precision. Analysis of variance was used to compare the turbidity range (i.e., precision) among low, medium, and high turbidity water bath treatments.

Monitoring Component 2 – Movements by pallid sturgeon.

Diving in areas immediately downstream from Fort Peck Dam was conducted periodically during a 6-week period in February and March 2001. Pallid sturgeon collected were to be implanted with transmitters and tracked during spring and summer.

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

Transmitter implantation.-Sampling for paddlefish, blue suckers, and shovelnose sturgeon for transmitter implantation was conducted in September 2002. Species were sampled using drifted trammel nets, hoop nets (primarily targeting blue suckers), and surface-drifted gill nets (primarily targeting paddlefish). A minimum of 20 suitable-sized individuals of each species were 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. Therefore, species were collected in several areas between rkm 2,842 (RM 1,765) and rkm 2,547 (RM 1,582; Figure 1).

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

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. Most blue suckers and shovelnose sturgeon were held overnight in streamside live cars, and released the following morning. A 5-10 minute period of facilitated acclimation following surgical procedures was used to stabilize paddlefish prior to release. Surgical implantation of transmitters was conducted at water temperatures between 10.3^{o}C and 16.4^{o}C.

Stationary telemetry logging stations.- Stationary telemetry logging stations were deployed in late April and early May 2002 at six sites (Milk River, RM 2.0; downstream from the Milk River, RM 1,759; near Wolf Point, RM 1,717; near Poplar, RM 1,681.5; near Brockton, RM 1,651; near Culbertson, RM 1,619). The logging stations (8 ft x 8 ft floating platform) were positioned away from the bankline, and secured to the bankline using cables and an iron arm. Each logging station was equipped with unidirectional hydrophones (one pointing upstream, one pointing downstream), solar panels, and an environmental enclosure kit containing dual 12-volt batteries, a receiver, two ultrasonic upconverters, and an antennae switchbox.

Manual tracking of implanted fish.- Manual tracking of fish implanted with CART tags in September 2001 was initiated in April 2002. The Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea (354 km, 220 miles), and the Yellowstone River from the confluence to Intake Diversion (113 km, 70 miles) were tracked at about weekly intervals. Two radio frequencies (149.760 MHz, 149.620 MHz) were simultaneously monitored during the boat-tracking run. A hydrophone was used to scan acoustic frequencies in deep areas of the two rivers. The entire study area could be tracked in a 3-4 day time interval. Several variables (frequency, code, latitude, longitude, river mile, water depth, habitat type, water temperature, turbidity, time-of-day) were recorded at fish relocations.

Data analysis.-A complete analysis of fish movements and tracking data is not warranted at this time because 2002 was the initial year of the multi-year study. Rather, fish movements and tracking data for 2002 were summarized for the study period as the number of relocations per km by river reach for the three species. Five river reaches were delineated, and included Reach 1 (Fort Peck Dam to Wolf Point, rkm 2,832 – rkm 2,723), Reach 2 (Wolf Point to the Yellowstone River confluence, rkm 2,723 – km 2,691), Reach 3 (Yellowstone River confluence to Highway 85 near Williston, ND, rkm 2,691 – rkm 2,485), Reach 4 (Yellowstone River from the confluence to Sidney, MT, rkm 0 – rkm 48), and Reach 5 (Yellowstone River from Sidney to Intake diversion dam, rkm 48 – rkm 114).

Monitoring Component 4 – Larval Fish

Sampling protocols. Larval fish were sampled at about 3-4 day intervals from late May through early August at six sites (Table 2). Similar to 2001, 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.

Table 2. Larval fish sampling locations, number of replicates, samples, and net locations for 2002. 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	1,762.8	2	4	S
Milk River	0.5-4.0	5	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	0.1-3.0	5	4	B/M

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 compliment of five replicates was available at the other sites. At 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). In the Milk River and spillway channel, irregular bottom contours, shallow depths, and silt substrates were not conducive to bottom sampling. 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 min. Larval fish samples were placed in a 5-10% formalin solution containing phloxine-B dye and stored.

Larval fish were sampled at the same replicate and subsample locations throughout the sampling period except when changes in discharge necessitated minor adjustments in the sampling location. For example, an attempt was made to sample larval fish at total water column depths between 1.5 m and 3.0 m. This protocol was used to minimize variations in larval fish density associated with vertical stratification of larvae in the water column. When river discharge decreased (or increased), water depth in a previously sampled location exceeded the required range. Therefore, the specific sampling location changed but was always near (± 300 m) the general vicinity of the earlier samples.

Laboratory methods. Larval fish were extracted from samples and placed in vials containing 70% alcohol. Larvae were identified to family when possible and enumerated. Damaged individuals that could not be identified were classified as unknown.

Changes in larval fish sampling protocols from 2001. Three sampling protocols were changed between 2001 (first year of the project) and 2002. First, the maximum number of replicates was increased from three (2001) to five (2002) for the Milk River, Yellowstone River, and Missouri River sites located near Wolf Point and Nohly. At the site downstream from the dam, the number of replicates was increased from two (2001) to three (2002). The number of replicates in the spillway channel was not increased because there are only two pools. Second, sample duration was decreased from a maximum of 15 min (2001) to 10 min (2002). Thus, although maximum sample duration was reduced in 2002, an increase in the number of replicates actually increased the total sampling time (see Results). Third, larval fish sampling extended to the first week of August in 2002; whereas, larval fish sampling was concluded the last week of July in 2001.

Monitoring Component 5 – Food habits of piscivorous fishes

Potential piscivores including walleye *Stizostedion vitreum*, sauger *S. canadense*, northern pike *Esox lucius*, burbot *Lota lota*, goldeye *Hiodon alosoides*, channel catfish *Ictalurus punctatus*, freshwater drum *Aploninotus grunniens*, and shovelnose sturgeon were sampled in the Missouri River between Wolf Point and Nohly (Figure 1). Fishes were sampled during July and August 2002 in off-channel habitats (e.g., tributaries, tributary confluences, backwaters, side channels) and main channel habitats (e.g., outside bend shoreline and thalweg, inside bend shoreline and channel border, channel crossovers) using stationary gill nets, drifting trammel nets, hoop nets, and electrofishing. Gill nets and hoop nets were usually set in late afternoon or evening and checked the following morning, but in some instances both gear types were left in a location throughout the day and periodically checked. Fishes were identified, weighed (g), and measured (mm).

Stomach samples were obtained in one of two ways. First, the entire stomach was removed via dissection and placed in a 10% formalin solution for storage. In the case of large stomachs, a slit was made in the stomach wall to facilitate formalin seepage into the stomach. The second method of stomach sampling involved the use of gastric lavage. The lavage apparatus consisted of a 12-V bilge pump connected to plastic hose. With the bilge pump operating and the fish held in a slightly inverted position, the hose was inserted down the esophagus of the fish and into the fish stomach. Running water flushed contents of the stomach into a sieve held under the fish mouth and gills. Stomach contents were rinsed from the sieve into a 10% formalin solution and stored. The lavage was used on sauger sampled to minimize mortality because sauger are listed as a species of special concern in Montana.

In the laboratory, stomach contents were initially identified to Class. Diet organisms were subsequently identified to Order (for Insecta) and to species (for Osteichthyes) when possible. Diet items that could not be identified beyond Insecta and Osteichthyes were designated as unknown for the Class. Diet items were also classified as detritus (e.g., woody debris, algae) and miscellaneous (e.g., sand, rocks). Diet items were enumerated and weighed for the lowest taxon identified. Wet weights (0.001 g) were measured after the diet items were blotted on paper towels to remove excess water. Body fragments were used to enumerate organisms. For example, the presence of a head capsule or partial body fragment was treated as indicative of a whole organism. For Osteichthyes, fish scales, bones or the presence of other body parts was treated as indicative that a whole organism was ingested.

Food habits data were summarized by three indices. Frequency of occurrence (%) was calculated as the number of individuals containing the specific food item/number of stomachs containing food. Numerical frequency (%) was computed as the total number of taxon-specific food items/total number of all food items. Weight frequency (%) was computed as the total weight of a taxon-specific food item/total weight of all food items.

Results and Discussion

Monitoring Component 1 - Water temperature and turbidity

General comments on water temperature loggers. Of the 38 water temperature loggers deployed during 2002, eight (21%) were not recovered. These included all three loggers deployed at Poplar, single loggers deployed in the Poplar River and Redwater River, one logger deployed at Culbertson, and two loggers deployed at Nohly. Excessive sedimentation and accumulation of woody debris prevented these loggers from being retrieved. With the exception of the Poplar site, at least one logger was recovered from Culbertson and Nohly thereby providing water temperature data at these sites. On September 5, it was observed that the water temperature logger in the Yellowstone River was in less than 15 cm of water. Subsequent checks of the data indicated large diel variations in water temperature during August and the first few days of September. These large diel variations most likely resulted from diel variations in air temperature rather than water temperature. Data for August was "corrected" by replacing the suspect temperature logger data with hourly water temperature data recorded by the Yellowstone turbidity logger located just downstream from the temperature logger.

Pre- and post-deployment assessments of water temperature logger precision. A total of 36 loggers was assessed for precision during the pre-deployment tests (Table 3). For all water temperature treatments during pre-deployment tests, the temperature range (i.e., maximum recorded temperature minus minimum recorded temperature) was narrow ($\leq 0.66^{o}$C; Table 3) indicating that precision of the loggers was good. For the post-deployment tests, only 26 loggers were screened for precision due to exclusion of loggers that were not recovered at the end of the deployment period. Post-deployment assessments of precision indicated that precision of the water temperature loggers remained good as evidenced by a narrow temperature range ($\leq 0.71^{o}$C) for all treatment temperatures (Table 3). Pre- and post-deployment comparisons indicated there was no significant difference ($F = 0.46$, $P = 0.64$, df = 2, 24) in water temperature range (i.e., precision) among the cold (mean = 0.53^{o}C), cool (mean = 0.51^{o}C), and warm

(0.55^oC) water temperature treatments. Thus, pre- and post-deployment precision was consistent among the different water temperature treatments. However, the range differed significantly between the pre- and post-deployment tests ($F = 4.86$, $P = 0.04$, df = 1, 24). Pooled across water temperature treatments, the range was significantly greater for the post-deployment tests (mean = 0.56^oC) than the pre-deployment tests (mean = 0.50^oC). These results suggest some "drift" of precision following deployment in the field. However, the difference in precision between pre- and post-deployment tests was minimal (0.06^oC) suggesting that the quality of water temperature data recorded by the loggers was still good. There was no significant ANOVA interaction term ($P = 0.39$). Results from the pre- and post-deployment tests suggest that the water temperature data recorded by the loggers at all sites during 2002 accurately depicted thermal conditions in the riverine areas.

Lateral and vertical comparisons of water temperature. There were 11 sites where water temperature loggers were positioned on the north and south banks, and stratified in the water column (Table 1). However, comparisons of water temperature among north bank, south bank, and stratified locations could only be conducted at nine sites due to the loss of loggers at the Poplar and Nohly. At the site located just downstream from Fort Peck Dam, there was no significant difference in water temperature between the north and south bank locations (Table 4). At the Nickels Ferry site, water temperature was significantly greater on the north bank and stratified location than on the south bank. The stratified logger at Nickels Ferry was positioned on the north bank along with the north bank logger. Lack of a significant difference between stratified and north bank logger indicates homeothermal conditions through the water column. Significant differences in water temperature occurred at the Nickels Rapids site where water temperature was greatest on the north bank and stratified location and least on the south bank. At the Nickels Rapids site, the stratified logger was positioned on the south bank along with the south bank logger. Lack of a significant difference between stratified and south bank logger indicates homeothermal conditions through the water column. No significant differences in water temperature among logger locations occurred at the Frazer Pump site, Frazer Rapids site, Grand Champs site, or Culbertson Site (Table 4). Similar to the Nickels Ferry and Nickels Rapids site, lack of significant differences in water temperature between stratified and either north or south bank locations at these sites indicate homeothermal conditions in the water column. At the site located downstream from the Yellowstone River, water temperature was significantly greater at the stratified and south bank locations than at the north bank location. However, there is some indication that water temperatures recorded by the north bank logger at this site were not representative of "true" water temperatures. For example, mean water temperature was higher at Nohly than at the north bank logger located downstream from the Yellowstone River. One would expect that water temperature at this site should be at least equal to or greater than water temperatures recorded at Nohly. Based on this consideration, the logger located on the north bank downstream from the Yellowstone River was likely recording slightly cooler ground water seepage than ambient river temperatures. Similar to the other sites, there was no significant difference between the stratified logger positioned on the south bank and the south bank logger located at the site downstream from the Yellowstone River.

Table 3. Pre- and post-deployment summary statistics for water temperature comparisons among YSI Model 85 meter (YSI), hand-held alcohol thermometer (Alcohol), and water temperature loggers in common water bath treatments.

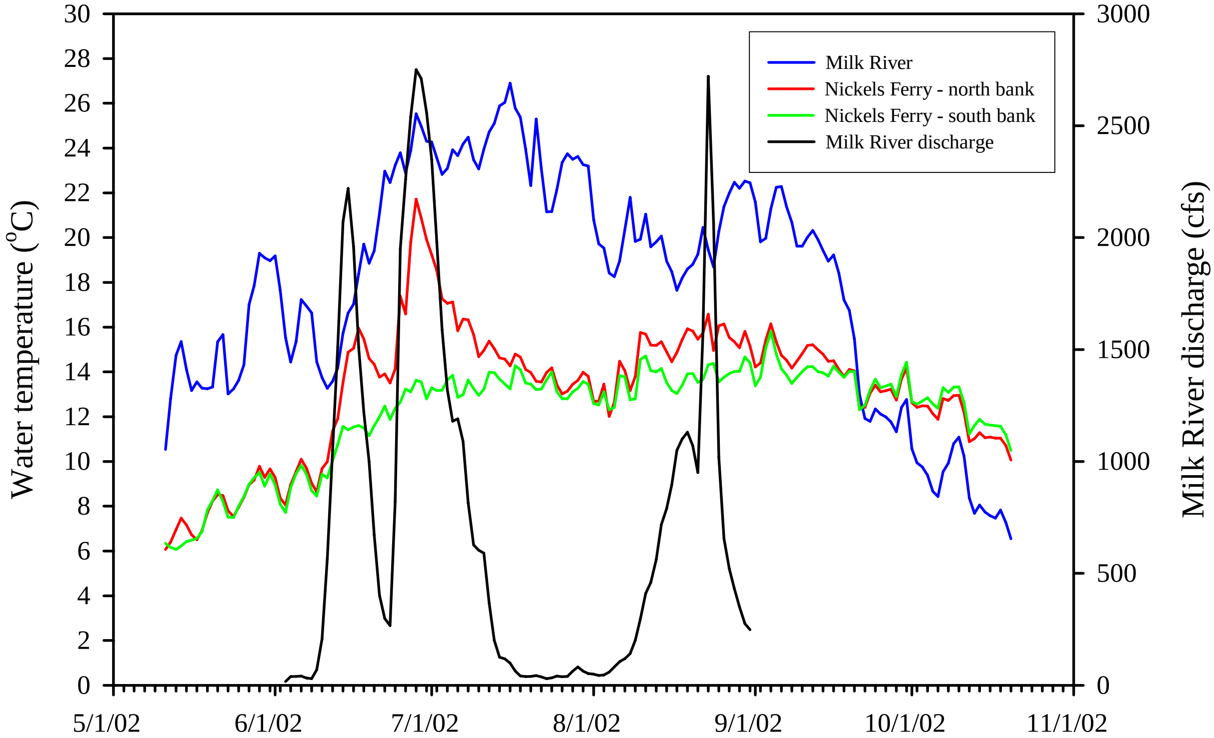
Sample	YSI	Alcohol	Logger mean	Logger minimum	Logger maximum	Logger range	Logger SD	Number of loggers
				Pre-deployment				
1	17.8	18.0	17.6	17.3	17.8	0.45	0.10	36
2	17.9	18.0	17.7	17.5	17.9	0.44	0.10	36
3	18.0	18.0	17.7	17.5	17.9	0.45	0.10	36
4	18.0	18.0	17.8	17.6	18.1	0.49	0.10	36
5	18.0	18.0	17.9	17.6	18.1	0.44	0.09	36
6	3.1	3.0	3.0	2.8	3.2	0.41	0.10	36
7	3.2	3.0	3.1	2.8	3.4	0.55	0.11	36
8	3.3	3.0	3.3	3.0	3.6	0.55	0.11	36
9	3.3	3.0	3.2	3.0	3.6	0.55	0.11	36
10	3.4	3.0	3.4	3.2	3.6	0.43	0.10	36
11	25.0	24.0	25.1	24.8	25.4	0.66	0.13	36
12	23.8	23.0	23.9	23.6	24.2	0.65	0.13	36
13	22.9	23.0	22.9	22.7	23.2	0.46	0.10	36
14	21.9	22.0	22.1	21.9	22.3	0.47	0.11	36
15	21.4	21.0	21.5	21.2	21.7	0.46	0.11	36
				Post-deployment				
1			7.2	6.9	7.5	0.55	0.11	26
2			7.2	6.9	7.5	0.55	0.10	26
3			7.3	7.1	7.6	0.55	0.12	26
4			7.5	7.2	7.6	0.43	0.09	26
5	8.1	8.0	7.6	7.2	7.9	0.71	0.16	26
6	20.9	22.0	21.7	21.4	22.0	0.64	0.13	26
7			21.2	20.9	21.5	0.63	0.12	26
8			20.8	20.6	21.0	0.46	0.12	26
9			20.4	20.1	20.7	0.61	0.13	26
10			20.2	19.9	20.4	0.45	0.12	26
11			18.5	18.3	18.7	0.45	0.12	26
12			18.5	18.1	18.7	0.61	0.13	26
13			18.5	18.1	18.7	0.61	0.13	26
14			18.5	18.1	18.7	0.60	0.13	26
15	18.6	18.0	18.5	18.1	18.7	0.60	0.13	26

Table 4. 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 2002. Means with the same superscript within sites are not significantly different (P > 0.05). Inclusive dates for comparisons at all sites are 5/11/02-10/20/02 (163 days).

Site	Logger location	Mean	SD	Minimum	Maximum	P
Below Fort Peck Dam	North	12.0 [a]	2.3	5.8	15.5	0.53
	South	11.8 [a]	2.2	5.8	15.3	
Nickels Ferry	North	13.2 [a]	3.0	6.1	21.7	0.0007
	South	12.2 [b]	2.3	6.1	15.8	
	Stratified	13.2 [a]	3.0	6.1	21.8	
Nickels Rapids	North	13.0 [a]	2.7	6.4	19.7	0.02
	South	12.3 [b]	2.3	6.3	16.0	
	Stratified	12.4 [a,b]	2.3	6.3	16.1	
Frazer Pump	North	13.1 [a]	2.7	7.0	18.9	0.11
	South	12.6 [a]	2.4	6.7	16.5	
	Stratified	13.1 [a]	2.7	6.9	18.9	
Frazer Rapids	North	12.7 [a]	2.6	6.6	18.0	0.53
	South	12.8 [a]	2.4	6.8	16.7	
Grand Champs	North	13.0 [a]	2.5	7.1	18.0	0.94
	South	13.1 [a]	2.5	7.4	17.0	
	Stratified	13.1 [a]	2.5	7.4	16.9	
Wolf Point	North	14.4 [a]	2.9	9.1	19.2	0.75
	South	14.6 [a]	3.3	7.9	19.8	
Culbertson	North	16.2 [a]	4.1	8.1	23.4	0.80
	Stratified	16.3 [a]	4.6	7.1	24.5	
Nohly	North	16.7	4.8	6.7	25.4	
Below Yellowstone River	North	15.8 [b]	3.8	6.5	21.6	0.0001
	South	17.8 [a]	5.1	6.7	27.2	
	Stratified	17.9 [a]	5.2	6.7	27.3	

Influence of tributary inflows on water temperature. Lateral differences in water temperature at some sites suggested that tributary inflows differentially influenced water temperatures on north and south bank locations due to incomplete lateral mixing. During 2002, the Milk River exhibited periods of increasing and decreasing flows between mid- and late-June, and during late August. During these time frames, water temperatures on the north bank of the river at Nickels Ferry, Nickels Rapids, Frazer Pump, Frazer Rapids, and Grand Champs increased and decreased with Milk River flows; whereas, water temperatures on the south bank of the river remained relatively stable (Figures 2, 3, 4). The influence of Milk River discharge on lateral differences in water temperature is also demonstrated by significant positive correlations between the difference in mean daily water temperature between the north and south banks (north bank minus south bank) and Milk River discharge at Nickels Ferry ($r = 0.85$, $P < 0.0001$, $N = 90$), Nickels Rapids ($r = 0.83$, $P < 0.0001$, $N = 90$), Frazer Pump ($r = 0.79$, $P < 0.0001$, $N = 90$), Frazer Rapids ($r = 0.81$, $P < 0.0001$, $N = 90$), and Grand Champs ($r = 0.84$, $P < 0.0001$, $N = 90$). The maximum difference in water temperature between the north and south banks decreased from upstream to downstream and was 8.1^{o}C at Nickels Ferry, 5.5^{o}C at Nickels Rapids, 3.5^{o}C at Frazer Pump, 1.8^{o}C at Frazer Rapids, and 1.1^{o}C at Grand Champs (Figures 2, 3, 4). Thus, lateral mixing of Milk River water and Missouri River water discharged through Fort Peck Dam was nearly complete at the Grand Champs site.

Earlier studies in the Missouri River downstream from Fort Peck have evaluated lateral variations in water temperature resulting from Milk River discharge inputs. Braaten and Fuller (2002) found that mean daily water temperature did not differ significantly between north and south bank locations for the time period spanning early May through October; however, there were specific instances when bank locations deviated in water temperature as a result of warm discharge inputs from the Milk River. Gardner and Stewart (1987) and Yerk and Baxter (2001) similarly showed that warm inputs from the Milk River differentially affected lateral water temperatures, but the effects are most pronounced in spring and early summer when Milk River discharge is high.



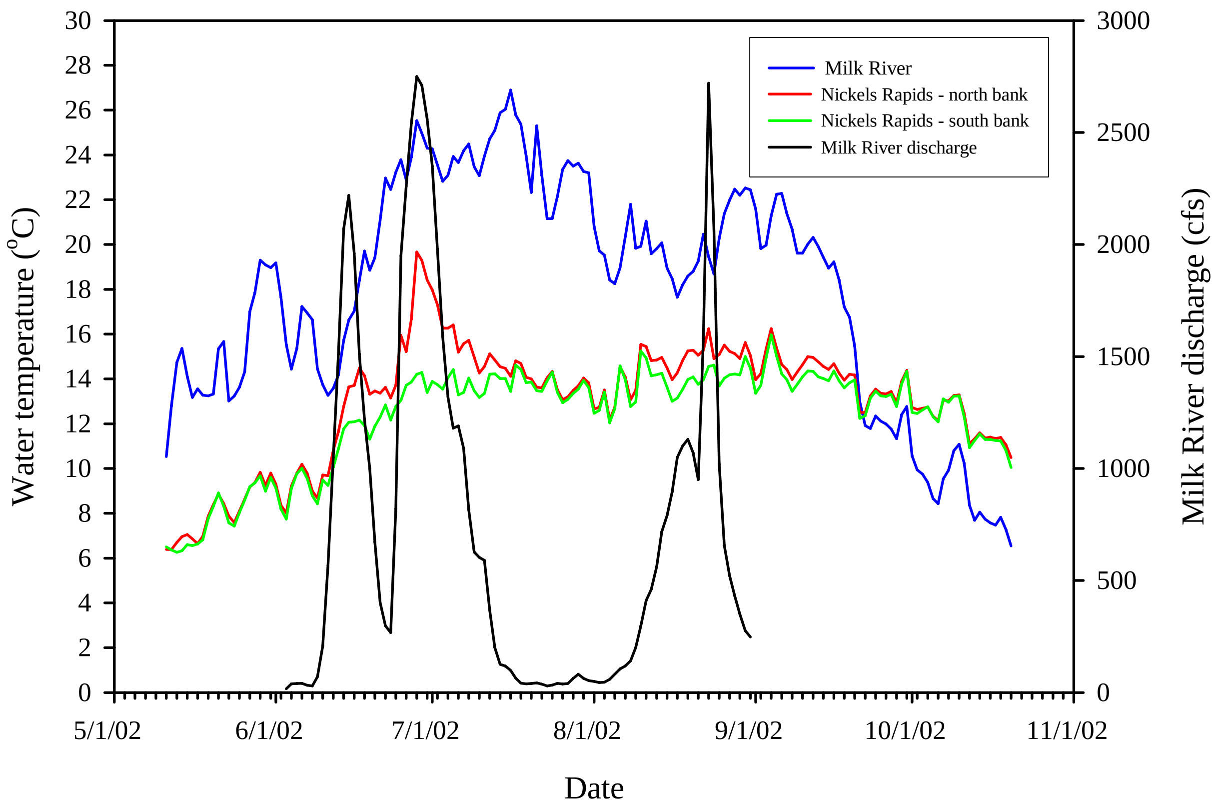


Figure 2. Water temperature profiles and discharge for the Milk River, and water temperatures profiles for the Missouri River at Nickels Ferry and Nickels Rapids during 2002.

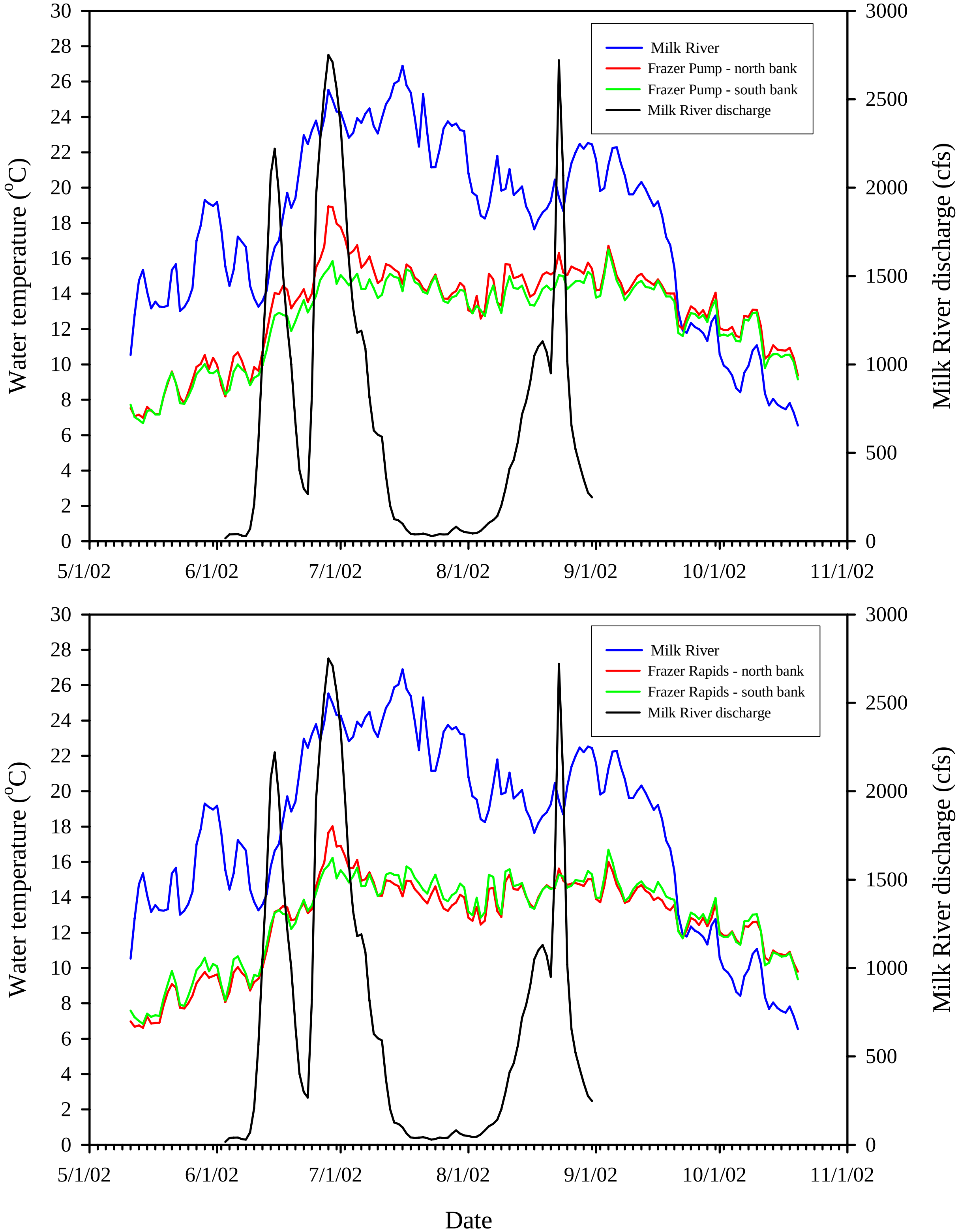


Figure 3. Water temperature profiles and discharge for the Milk River, and water temperatures profiles for the Missouri River at Frazer Pump and Frazer Rapids during 2002.

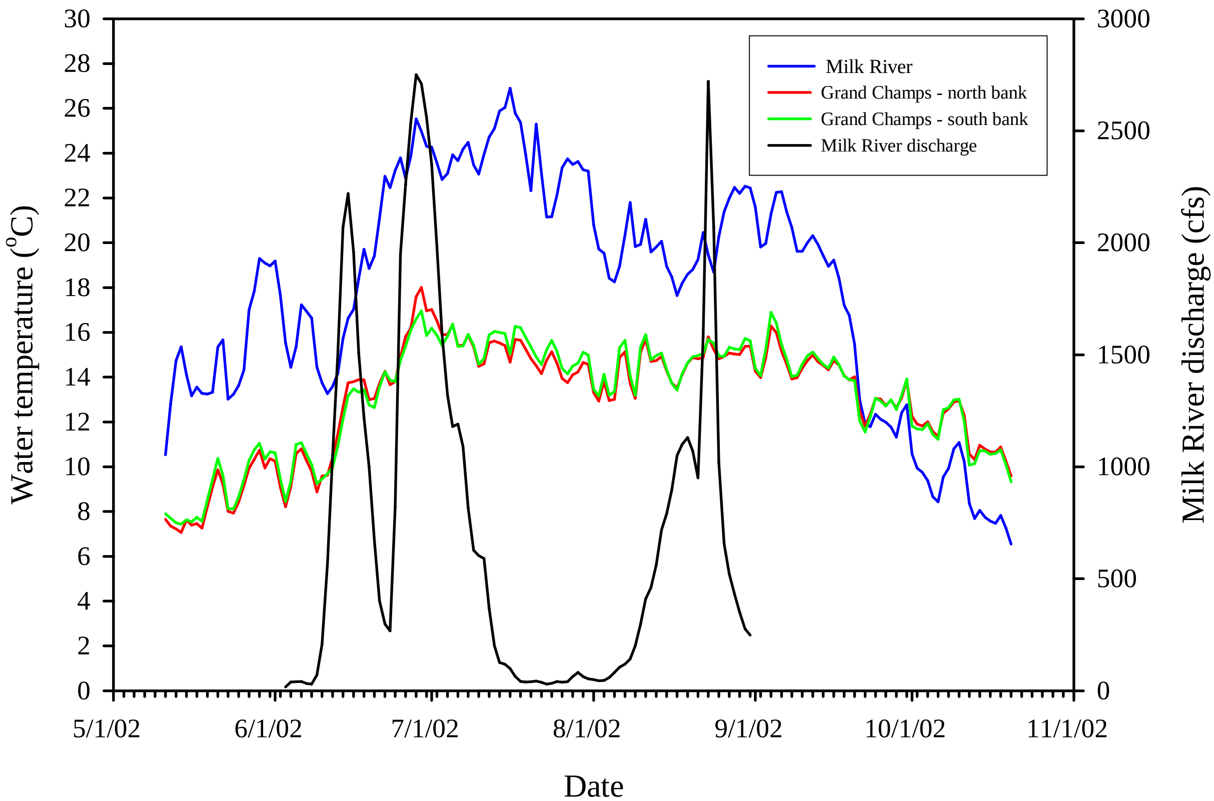


Figure 4. Water temperature profiles and discharge for the Milk River, and water temperatures profiles for the Missouri River at Grand Champs during 2002.

Longitudinal water temperature patterns. Daily water temperature for all sites was averaged across north bank, south bank, and stratified locations to depict average thermal conditions in the river. Mean water temperature for the common deployment period (5/11/02-10/20/02) differed significantly among the 11 Missouri River mainstem sites and three off-channel locations (ANOVA, $F = 64.35$, df = 13, 2,268, $P < 0.0001$; Table 5, Figure 5). Mean daily water temperature for Missouri River mainstem sites was greatest at the Robinson Bridge site (17.9^{o}C) located in the free-flowing reach of the Missouri River upstream from Fort Peck Lake and in the Missouri River downstream from the Yellowstone River (17.9^{o}C). The lowest mean daily water temperature occurred at the site just downstream from Fort Peck Dam (11.9^{o}C). Mean daily water temperature increased downstream from Fort Peck Dam, and was 16.7^{o}C at the Nohly site. Daily water temperature at the Missouri River mainstem locations was most variable in the Missouri River below the Yellowstone River confluence (CV = 28.8) and at Nohly (CV = 28.7), but least variable just downstream from Fort Peck Dam (CV = 11.9; Table 5). The USFWS (2000) mandated that a minimum water temperature of 18^{o}C be established and maintained at Frazer Rapids (rkm 2,811; RM 1,746) via the spillway releases. During 2002, a mean daily water temperature of 18.0^{o}C occurred on one date (June 29) on the north bank of the river at Frazer Rapids (Table 4). However, mean daily water temperature for the site on June 29 was 17.1^{o}C when cooler water on the south bank of the river was included in the mean daily temperature calculations (Figure 5). In the absence of spillway releases, water temperature in 2001 did not reach 18^{o}C at Frazer Rapids (Braaten and Fuller 2002). In 2000, Yerk and Baxter (2001) similarly showed that the maximum mean daily water temperature at Frazer Rapids slightly exceeded 17.0^{o}C in mid-July.

For off-channel locations, mean daily water temperature between 5/11/02-10/20/02 was highest in the Yellowstone River (18.4 ^{o}C) and Milk River (18.0 ^{o}C; Table 5). The Yellowstone River exhibited the highest variability in daily water temperatures (CV = 29.3) during the time interval.

Inter-annual comparisons of mean daily water temperature within sites. Comparisons of mean daily water temperature between 2001 and 2002 for dates spanning 5/17-10/9 indicated that 2002 was significantly cooler than 2001 at most sites (Table 6). In the free-flowing Missouri River upstream from Fort Peck Lake, water temperature averaged 1.4^{o}C warmer in 2001. Eight of nine mainstem Missouri River sites between Fort Peck Dam and the Yellowstone River confluence averaged 0.6-1.5^{o}C warmer in 2001 than 2002. The Nickels Ferry site (located just downstream from the Milk River confluence) was the only site between Fort Peck Dam and the Yellowstone River where water temperature was not statistically different between years (Table 6). Water temperature in the Milk River did not differ significantly between 2001. No significant differences in mean daily water temperatures were found between years in the Yellowstone River or in the Missouri River downstream from the Yellowstone River confluence (Table 6).

Mean daily air temperatures were obtained from the National Weather Service in Glasgow, MT to assess water temperature regimes during 2001 and 2002 in the context of air temperatures. For dates spanning May 1 through October 31 (N = 184 days), mean daily air temperature was significantly higher (t-test, $t = 2.54$, $P = 0.01$) in 2001 (mean = 16.5^{o}C) than 2002 (mean = 14.5^{o}C). These results corroborate findings from the water temperature analysis; however, between-year differences in air temperature (2.0^{o}C) were slightly greater than between-differences in water temperature (0.6-1.5^{o}C).

Table 5. Daily water temperature (^oC) summary statistics (mean; minimum; maximum; standard deviation, SD; coefficient of variation, CV) for Missouri River mainstem locations and off-channel locations in 2002. Summary statistics for all sites were calculated for common deployment dates (5/11/02-10/20/02, N = 163 days) to standardize comparisons among all loggers. See Figure 5 for a graphical representation of daily water temperatures. Means with the same superscript are not significantly different (P > 0.05).

Location	Site	Mean	Minimum	Maximum	SD	CV
Missouri River mainstem	Robinson Bridge	17.9 [a,b]	8.5	26.7	4.7	26.5
	Below Fort Peck Dam	11.9 [g]	5.8	15.4	2.3	18.9
	Nickel Ferry	12.9 [g]	6.2	19.1	2.7	20.9
	Nickels Rapids	12.6 [g]	6.4	16.1	2.4	19.2
	Frazer Pump	12.9 [g]	6.9	17.9	2.6	19.9
	Frazer Rapids	12.8 [g]	6.7	17.1	2.5	19.5
	Grand Champs	13.1 [f,g]	7.3	17.3	2.5	19.3
	Wolf Point	14.5 [e,f]	9.0	19.4	3.1	21.3
	Culbertson	16.3 [c,d]	7.6	23.9	4.3	26.6
	Nohly	16.7 [b,c]	6.7	25.4	4.8	28.7
	Below Yellowstone River	17.9 [a,b]	6.7	27.3	5.2	28.8
Off-channel or tributary	Spillway	15.1 [d,e]	7.4	20.0	3.1	20.6
	Milk River	18.0 [a,b]	6.5	26.9	5.1	28.5
	Yellowstone River	18.4 [a]	6.9	27.9	5.4	29.3

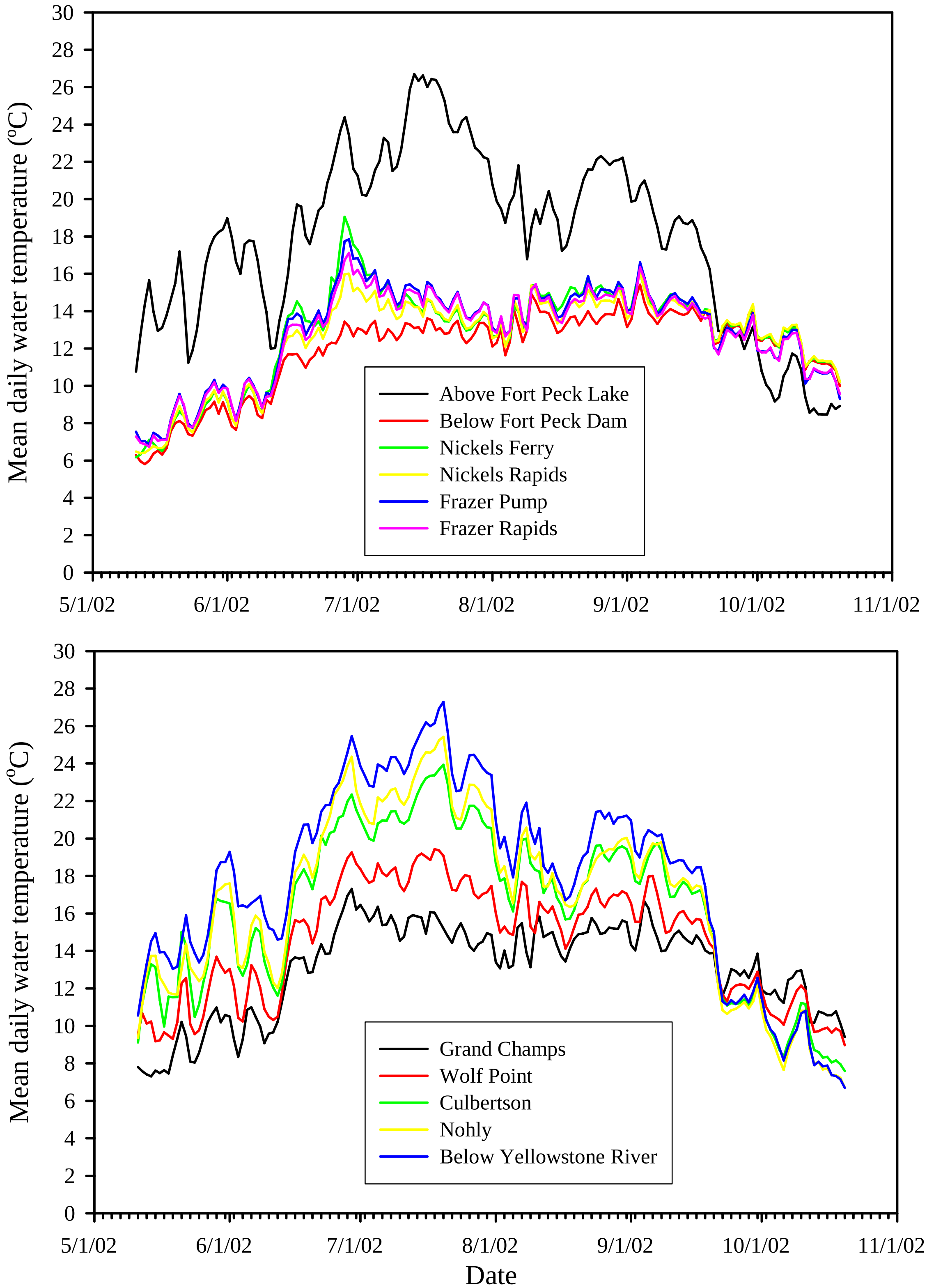


Figure 5. Mean daily water temperature (^{o}C) at 11 sites on the mainstem Missouri River during 2002.

Table 6. Summary statistics (mean, °C; standard deviation, SD; number of days, N; Probability value, P) for comparisons of mean daily water temperature between 2001 and 2002 at mainstem Missouri River sites and off-channel sites. Common dates for both years are 5/17-10/9. P-values denoted by an asterisk indicate t-test comparisons based on unequal variances.

Site	Year	Mean	SD	N	P
Missouri River above Fort Peck Lake	2001	20.1	3.7	146	0.002
	2002	18.7	4.2	146	
Below Fort Peck Dam	2001	13.0	1.5	146	< 0.0001*
	2002	12.2	2.0	146	
Spillway	2001	18.4	3.0	146	< 0.0001
	2002	15.7	2.7	146	
Milk River	2001	19.1	3.8	146	0.59*
	2002	18.9	4.5	146	
Nickels Ferry	2001	13.4	1.8	146	0.55*
	2002	13.2	2.5	146	
Nickels Rapids	2001	13.5	1.7	146	0.02*
	2002	12.9	2.2	146	
Frazer Pump	2001	13.9	1.8	146	0.03*
	2002	13.3	2.3	146	
Frazer Rapids	2001	13.8	1.84	146	0.005*
	2002	13.1	2.3	146	
Grand Champs	2001	14.4	2.0	146	0.0006
	2002	13.5	2.3	146	
Wolf Point	2001	16.5	3.1	146	< 0.0001
	2002	15.0	2.8	146	
Culbertson	2001	17.9	3.5	146	0.04
	2002	17.0	3.9	146	
Nohly	2001	18.9	3.8	146	0.005
	2002	17.5	4.3	146	
Yellowstone River	2001	19.3	4.2	146	0.96
	2002	19.3	4.8	146	
Below Yellowstone River	2001	19.4	4.1	146	0.22
	2002	18.8	4.5	146	

General comments on turbidity loggers. Two of four turbidity loggers deployed during 2002 malfunctioned during the deployment period. The turbidity logger deployed at Frazer Rapids functioned only between 5/28/02 and 6/3/02. The turbidity logger deployed near Poplar functioned only between 5/14/02 and 5/27/02. Thus, these loggers provided minimal turbidity data. However, turbidity loggers deployed in the Missouri River near Nohly (5/29/02-8/28/02) and in the Yellowstone River (5/31/02-8/31/02) functioned properly and logged hourly turbidity throughout the deployment period.

Precision of turbidity loggers. Measurements of turbidity obtained near the Nohly turbidity logger and Yellowstone turbidity logger during larval fish sampling facilitated an evaluation of turbidity logger performance during the deployment period. Mean turbidity from the turbidity loggers and larval fish sampling sites did not differ significantly at Nohly (t-test, $t = 0.30$, $P = 0.77$, $df = 36$) and in the Yellowstone River (t-test, $t = 0.43$, $P = 0.67$, $df = 34$; Table 7). Measurements of turbidity obtained from the turbidity loggers and larval fish sampling sites were highly correlated at Nohly ($r = 0.98$, $P < 0.0001$, $N = 19$) and in the Yellowstone River ($r = 0.98$, $P < 0.0001$, $N = 18$; Figure 6).

Table 7. Statistical comparisons and summary statistics (mean; standard deviation, SD.; minimum; maximum) for turbidity (NTU) measured at larval fish sampling locations (Hach meter) and by the turbidity loggers at Nohly and in the Yellowstone River. Probability values (P) are results from t-tests between instruments within sites.

Site	Instrument	N	Mean	SD	Minimum	Maximum	P
Nohly	Hach	19	325	337	72	1000	0.77
	Logger	19	294	303	14	972	
Yellowstone	Hach	18	380	338	61	1000	0.67
	Logger	18	333	311	15	1000	

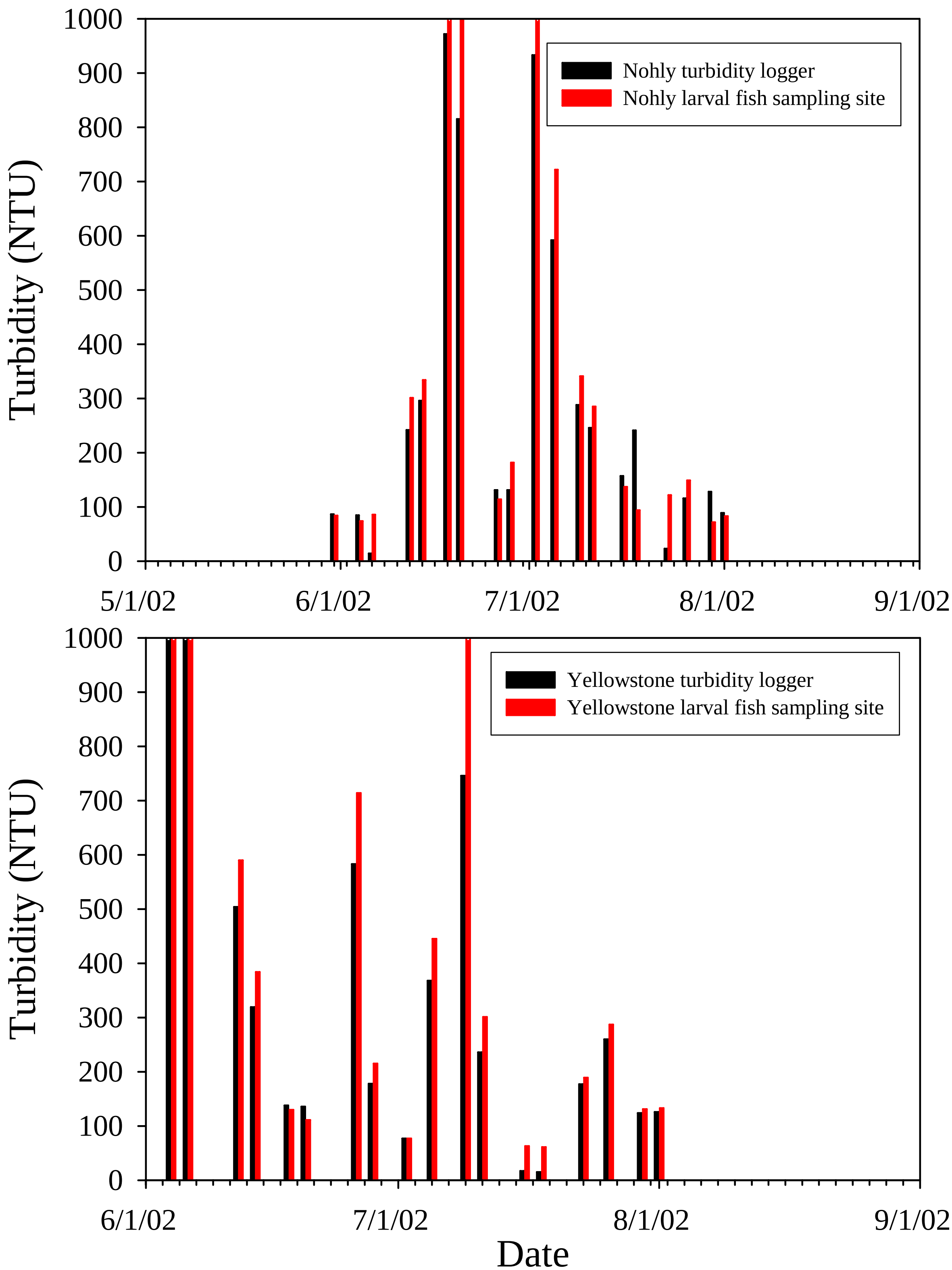


Figure 6. Mean daily turbidity (NTU) by date for Nohly (upper panel) and the Yellowstone River (lower panel).

Turbidity precision, as indexed by the range of turbidity, differed significantly ($F = 3.77$, $P = 0.04$, df = 2, 26) among the post-deployment turbidity levels for the Nohly and Yellowstone turbidity loggers (Table 8). Turbidity range was significantly greater ($P < 0.05$) in the high turbidity treatments (mean = 46.2 NTU) and intermediate turbidity treatments (mean = 33.2 NTU) than in the low turbidity treatments (mean = 9.2 NTU). These results indicate that turbidity range was not consistent among different turbidity levels. However, minimum turbidity and maximum turbidity differed by an average of 6% for the high turbidity treatment, 8% for the intermediate turbidity treatment, and 20% for the low turbidity treatment. Thus, although the range differed, the two turbidity loggers exhibited relatively high precision at intermediate and high turbidity levels.

Table 8. Post-deployment summary statistics for turbidity (NTU; mean, range, minimum, maximum) for the Nohly and Yellowstone River turbidity loggers in common turbidity bath samples.

Sample	Mean	Range	Minimum	Maximum
1	17.1	15.9	9.1	25.0
2	26.1	24.6	13.8	38.4
3	33.1	2.8	31.7	34.5
4	35.8	2.8	34.4	37.2
5	38.5	1.7	37.6	39.3
6	41.8	2.3	40.6	42.9
7	44.7	3.4	43.0	46.4
8	46.3	1.5	45.5	47.0
9	59.6	24.2	47.5	71.7
10	80.2	10.5	74.9	85.4
11	92.4	10.9	86.9	97.8
12	273.4	24.2	261.3	285.5
13	278.2	15.8	270.3	286.1
14	287.2	17.2	278.6	295.8
15	317.7	11.3	312.0	323.3
16	324.8	46.1	301.2	347.8
17	356.6	5.2	354.0	359.2
18	381.3	41.6	360.5	402.1
19	410.6	59.8	380.7	440.5
20	451.5	56.0	423.5	479.5
21	470.6	54.8	443.2	498.0
22	651.5	70.4	616.3	686.7
23	708.8	76.4	670.6	747.0
24	834.2	97.5	785.4	882.9
25	884.4	125.1	821.8	946.9
26	1000	0	1000	1000
27	1000	0	1000	1000
28	1000	0	1000	1000
29	1000	0	1000	1000

Field turbidity measurements. Hourly turbidity recorded by the turbidity loggers at Nohly and in the Yellowstone River varied greatly during late-May through August deployment period. At Nohly, hourly turbidity measurements exceeded 1000 NTU (maximum value of logger) on the following dates and number of times in a 24-hr period (in parenthesis): 6/17 (9), 6/18 (4), 6/19 (2), 6/26 (3), 6/30 (19), 7/1 (24), 7/2 (4), 8/21 (9), 8/23 (3), 8/24 (13), 8/25 (3), and 8/27 (7). In the Yellowstone River, turbidity exceeded 1000 NTU on the following dates and number of times in a 24-hr period (in parenthesis): 6/4 (18), 6/5 (24), 6/6 (23), 6/7 (1), 6/10 (7), 7/9 (5), 7/19 (11), 7/20 (16), and 7/21 (10). Because 1000 NTU was exceeded on specific dates, turbidity readings that exceeded 1000 NTU were truncated to 1000 NTU for estimations of mean daily turbidity. Truncation of turbidity data reduced the accuracy of mean daily estimates, resulted in conservative estimates of mean daily turbidity, and precluded quantitative statistical comparisons of spatial and temporal differences in mean daily turbidity. Nonetheless, qualitative comparisons based on conservative turbidity estimates facilitated interpretation of spatial and temporal turbidity trends. Spatially, mean daily turbidity between 5/31/02 and 8/27/02 was similar in the Missouri River at Nohly (mean = 261.6, SD = 238.3, N = 89 days) and in the Yellowstone River (mean = 255.7, SD = 244.5, N = 89 days).

Temporal patterns in mean daily turbidity varied between the Missouri River at Nohly and in the Yellowstone River. At Nohly, daily changes in turbidity generally followed increases or decreases in Missouri River discharge (Figure 7). The three periods of maximum turbidity (6/18, 7/1, 8/24) occurred 1-2 days following elevated discharges at Culberston. In the Yellowstone River, periods of elevated turbidity early in the deployment period (e.g., 6/1-7/1) generally followed periods of elevated discharge (Figure 7); however, turbidity late in the deployment period (7/1-8/31) exhibited elevated levels in the absence of significant increases in discharge.

Monitoring Component 2 – Movements by pallid sturgeon

No pallid sturgeon were found in areas immediately downstream from Fort Peck Dam. As a consequence, no pallid sturgeon were implanted with transmitters.

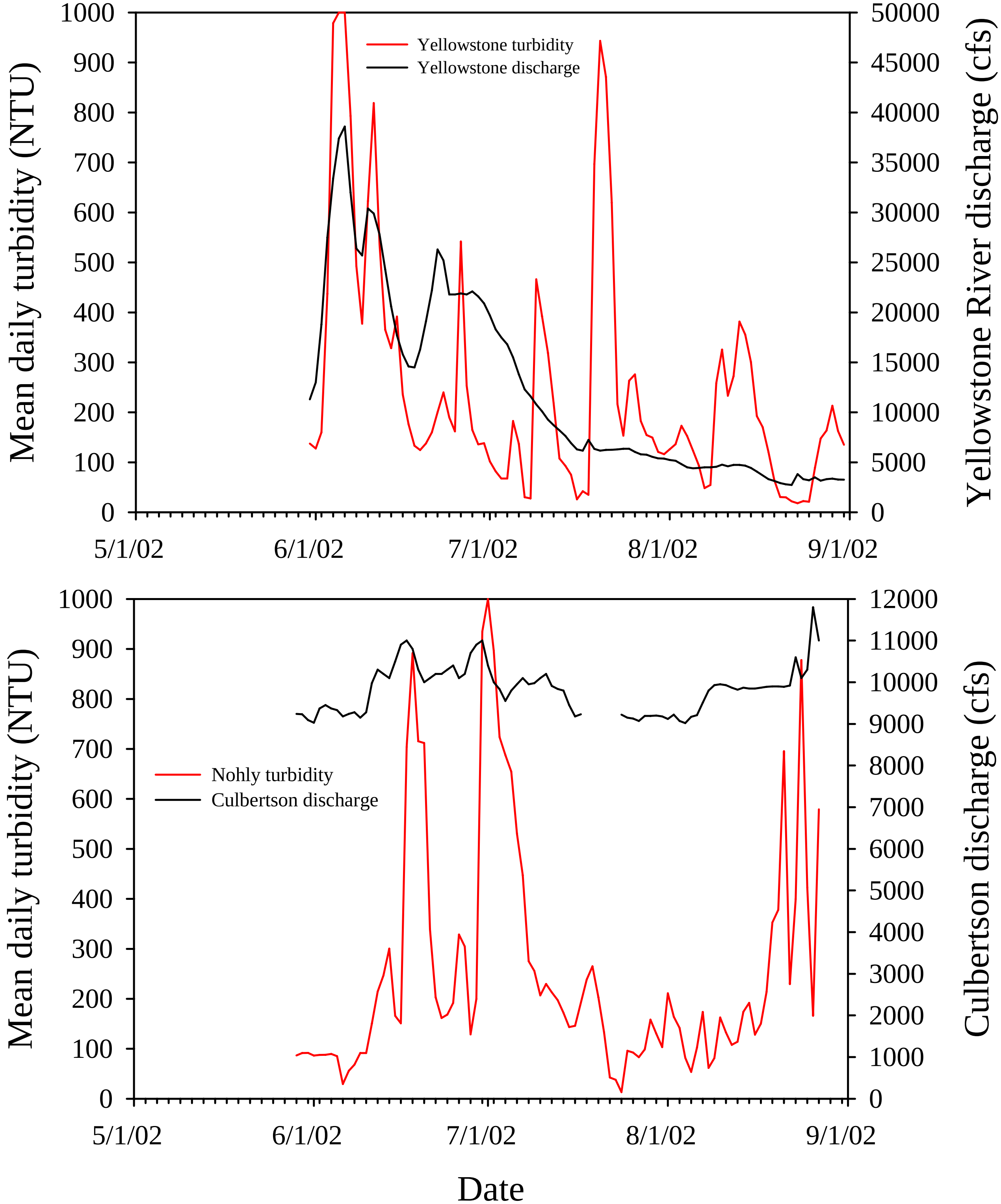


Figure 7. Mean daily turbidity (NTU; solid line) from turbidity loggers and discharge (cfs; dashed line) in the Yellowstone River (upper panel) in the Missouri River at Nohly (lower panel) during 2002.

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

Transmitter implantation.- Sampling throughout the study area in September 2002 resulted in the capture of 21 shovelnose sturgeon, 21 blue suckers, and 3 paddlefish suitable for transmitter implantation (Table 9). The blue suckers and shovelnose sturgeon sampled were captured throughout the study area spanning from near the Milk River to the Yellowstone River confluence. The three paddlefish captured were sampled at one location downstream from Wolf Point. Although paddlefish during fall are common in the Missouri River downstream from the Yellowstone River confluence, the Fort Peck Project was not granted permission to implant transmitters in paddlefish in this area. However, an additional 20 paddlefish (10 males, 10 females) were implanted with CART-32 transmitters in the Missouri River downstream from the confluence in fall 2002 by Dr. Dennis Scarnecchia (University if Idaho). Permission has been granted to use tracking and movement information from these individuals to augment the Fort Peck telemetry project. Individuals implanted with transmitters in 2002 will be tracked during 2003 in conjunction with fish that were implanted with transmitters in 2001.

Table 9. Number, sex ratio (male:female:undetermined), and length (mm) and weight (g) metrics for blue suckers, paddlefish, and shovelnose sturgeon implanted with transmitters during September 2002.

Species	Number	Sex ratio	Metric	Mean	Minimum	Maximum
Shovelnose sturgeon	21	2:18:1	Length	787	702	912
			Weight	2,280	1,550	3,650
Blue sucker	21	7:9:5	Length	702	637	789
			Weight	2,894	1,875	3,925
Paddlefish	3	2:0:1	Length	951	954	977
			Weight	11,833	8,900	14,050

Shovelnose sturgeon.- Of the 28 shovelnose implanted in 2001, 27 individuals were relocated in 2002. However, one individual shed the transmitter near Wolf Point in early July after swimming upstream approximately 125 kilometers. The remaining 26 fish were manually relocated five to 15 times (mean =11) throughout the season. The number of manual relocations of shovelnose sturgeon during the April to November tracking season varied from 18 to 62 among months (Table 10). Manual relocations for shovelnose sturgeon during this timeframe were augmented by 69 contacts at the logging stations (Table 10). Total movement of shovelnose sturgeon varied between 54 km and 885 km (mean = 241 km).

The number of relocations of shovelnose sturgeon varied greatly among reaches and months (Figure 8). In reach 1 (Fort Peck Dam to Wolf Point), the mean number of relocations per km was similar among months. There were five fish that resided in the reach 1 for the entire season. All these fish were implanted between Wolf Point and the Milk River. There were only three other fish that were implanted in this reach, and all eventually migrated to the Yellowstone River, one by early June, one by late June, and the other in early September. One of these fish returned to reach 1 in the fall after traveling twenty miles up the Yellowstone River. The other two remained in the Yellowstone River for the remainder of the season. Three other shovelnose sturgeon were found in this reach that had not been not implanted in reach 1. These included two fish that were implanted near Culbertson.

Table 10. Monthly totals of manual relocations and telemetry logging station contacts for shovelnose sturgeon, blue suckers, and paddlefish during 2002.

Species	Month	Manual relocations	Logging station contacts	Total contacts
Shovelnose sturgeon	April	27		27
	May	58	14	72
	June	62	15	77
	July	57	11	68
	August	19	21	40
	September	15	8	23
	October	20		20
	November	18		18
Blue sucker	April	13		13
	May	30	16	46
	June	30	17	47
	July	42	11	53
	August	11	9	20
	September	10	14	24
	October	12	5	17
	November	12		12
Paddlefish	April	27		27
	May	30	71	101
	June	42	58	100
	July	10	30	40
	August	3	34	37
	September	2	29	31
	October	10	13	23
	November	10		10

Use of reach 2 (Wolf Point to the Yellowstone River confluence) was low throughout the study period, and there was a trend of decreasing use of reach 2 from May through July (Figure 8). Nineteen shovelnose sturgeon were originally implanted in reach 2. Nine of these fish were found in the Yellowstone River on the first tracking run in April. Six additional shovelnose sturgeon were in the Yellowstone River between late April and early July. Three shovelnose sturgeon were mentioned earlier to have moved into reach 1 before migrating to the Yellowstone, and one shovelnose sturgeon shed the transmitter. Other than these early relocations, the only fish found in reach 2 were migrants passing through the reach. Bramblett and White (2001) reported the return of shovelnose that were in the Yellowstone River to this area above the confluence in the fall; however, this event did not occur in 2002. Rather, these individuals primarily stayed in the lower Yellowstone River (e.g., reach 4).

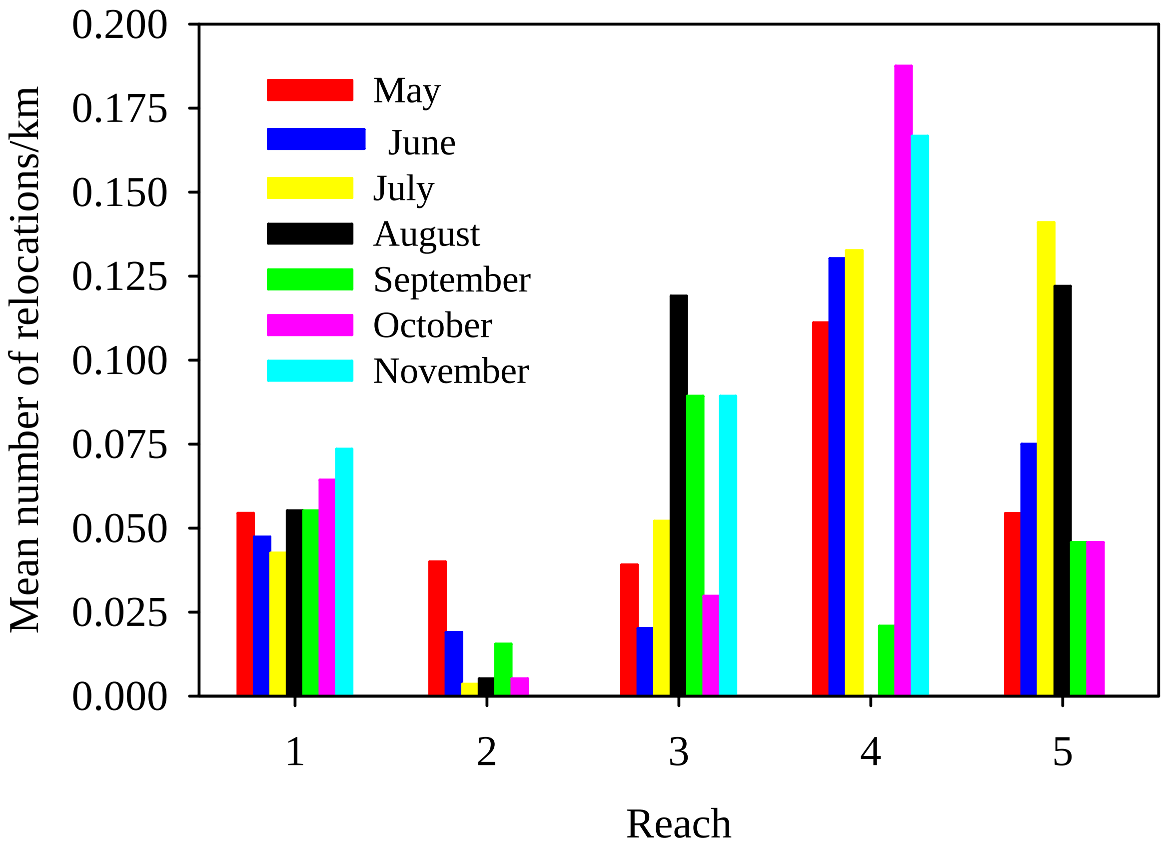


Figure 8. Mean number of shovelnose sturgeon relocations per km by month in five riverine reaches (Reach 1 = Missouri River between Fort Peck Dam and Wolf Point, Reach 2 = Missouri River between Wolf Point and the Yellowstone River confluence, Reach 3 = Missouri River from the Yellowstone River confluence to the headwaters of Lake Sakakawea, Reach 4 = Yellowstone River from the confluence to Sidney, MT, Reach 5 = Yellowstone River from Sidney, MT to Intake diversion dam).

There were relatively few relocations of shovelnose sturgeon in reach 3 (Yellowstone River confluence to Highway 85). Reach 3 is only 33.6 km; therefore, a single relocation accentuates the mean number of fish per km estimates relative to the other river reaches. The mean number of shovelnose sturgeon per km in reach 3 increased from a minimum in June to a maximum in August when four individual fish were found during one tracking run. However, three of these were found immediately below the confluence (< 1km). Only one shovelnose was found greater than 5 km downstream of the confluence.

The two reaches of the Yellowstone River generally had the highest concentration of shovelnose sturgeon; however, the mean number of shovelnose sturgeon per km varied among months within reaches. For example, the mean number of shovelnose sturgeon per km in reach 4 (Yellowstone River confluence to Sidney) minimally increased between May and July; whereas, the mean number of shovelnose sturgeon per km in reach 5 (Sidney to Intake diversion dam) greatly increased between May and July. In September, conductivities were unusually high, making the signals difficult to locate. Also of interest is the decline in the number of shovelnose sturgeon per km during August. Some of those fish moved downstream to just below the Yellowstone River confluence, and some moved above Sidney into reach 5. Although there is not an increase shown in reach 5 for August, we suspect that four individuals passed over the Intake diversion dam during the period from July to August. In addition, it is likely that one shovelnose sturgeon passed over the diversion in August. One of these fish was found later in the fall in the Yellowstone River, one was found below intake in April 2003, and three others have not been found. It should be mentioned that no tracking was conducted above Intake diversion dam to confirm passage over Intake; however, the last documented locations were at or near the diversion dam. No tracking was conducted in reach 5 during November.

Blue suckers.- Sixteen of 17 blue suckers were relocated in 2002. However, one individual shed its tag soon after being implanted, and one shed its tag near Fairview (Yellowstone River) in mid July after swimming over 300 km. The remaining 14 blue suckers were manually relocated one to 15 times (mean = 12) throughout the tracking season. A total of 160 manual relocations were obtained for blue suckers between April and November, and an additional 72 contacts were obtained from the logging stations (Table 10). Total movement of individuals varied from 5 km to 409 km (mean = 201.5 km).

Blue suckers did not exhibit large seasonal migrations as they tended to remain close to the riverine area in which they were implanted with transmitters. In reach 1, there was a slight increase in the mean number of relocations per km between June and September (Figure 9). Three fish were originally implanted with transmitters near the Milk River, and two of these fish did not leave this reach. One blue sucker was recorded on the Milk River logging station in July. The third fish went down to reach 2 for the month of July, but returned to reach 1 for the remainder of the season. One fish that was implanted near Culbertson area moved upstream to reach 1 soon after being implanted.

There was a slight decreasing trend in the number of blue suckers per km in reach 2 between May and September (Figure 9). Of the eight blue suckers implanted near Culbertson (reach 2), one individual was mentioned earlier to have moved upstream, and one was found near Williston in April and was never relocated again. We suspect this individual moved downstream into Lake Sakakawea. One blue sucker was found in reach 3 early in the year, moved to reach 2 for a month, and moved into reach 4 prior to shedding the transmitter near Fairview. The remaining five blue suckers implanted in reach 2 exhibited very little movement, and did not leave the reach.

Use of the Yellowstone River (reach 4, reach 5) by blue suckers varied among months (Figure 9). Three of the four blue suckers that were implanted at the confluence used the Yellowstone River. Use of the Yellowstone River did not appear to be related to a spawning migration because one fish moved up in April, one in May, and one in late June. Only one individual was relocated in reach 5 of the Yellowstone River, and this occurred from June through August. One blue sucker returned to reach 2 in early July while the other moved downstream to reach 3 in the fall. The other blue sucker that was implanted at the confluence spent the majority of time in reach 3 near Williston.

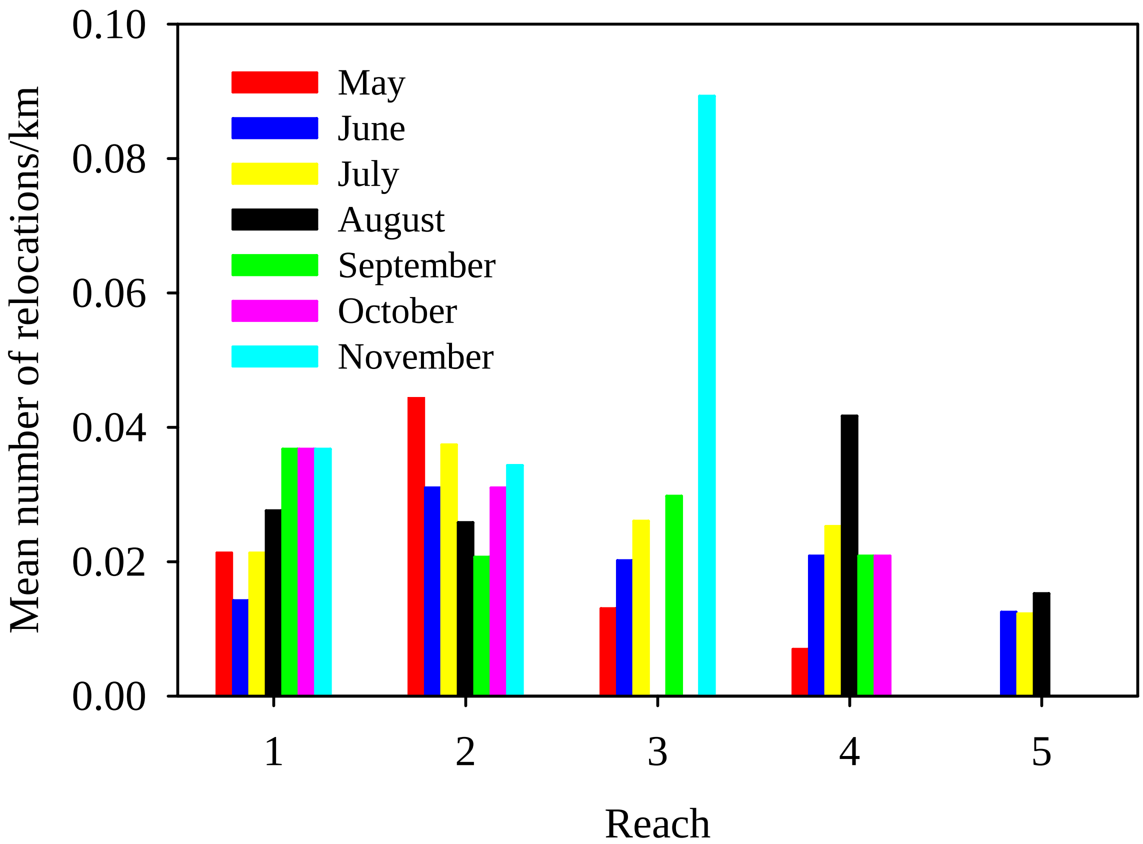


Figure 9. Mean number of blue sucker relocations per km by month in five riverine reaches (Reach 1 = Missouri River between Fort Peck Dam and Wolf Point, Reach 2 = Missouri River between Wolf Point and the Yellowstone River confluence, Reach 3 = Missouri River from the Yellowstone River confluence to the headwaters of Lake Sakakawea, Reach 4 = Yellowstone River from the confluence to Sidney, MT, Reach 5 = Yellowstone River from Sidney, MT to Intake diversion dam).

Paddlefish.-Transmitters from all nineteen paddlefish implanted in 2001 were relocated in 2002. The transmitter from one paddlefish was shed near Erickson Island soon after implantation occurred. Another paddlefish shed the transmitter in mid July near Oswego after swimming over 450 km. These 18 fish were manually relocated four to 14 times (mean = 8). Between April and November, a total of 134 manual relocations of paddlefish were obtained (Table 10). An additional 235 contacts were obtained by the telemetry logging stations. Total movement varied from 45 km to 820 km (mean = 332 km).

Paddlefish exhibited migratory patterns during the seasonal cycle (Figure 10). Ten of the eighteen paddlefish migrated up the Yellowstone River between May 16 and June 12. Four of these fish were relocated upstream from Sidney (reach 5) as determined from manual tracking and contacts at the Sidney logging station (operated by the USFWS). The maximum relocation distance upstream in the Yellowstone River was 99 km. All of these fish returned to reach 4 between June 5 and July 11. One paddlefish utilized the Missouri River and Yellowstone River, two paddlefish remained in reach 3, and the remaining five paddlefish migrated upstream the Missouri River into reaches 1 and 2. These individuals initiated migrations up the Missouri River between May 6 and June 14. Two of the five paddlefish migrated into the Milk River in mid- to late-June, and re-entered the Missouri River on July 6 and 8. Four fish returned to reach 3 between June 13 and August 16. One paddlefish shed the transmitter around July 15 near Oswego (within reach 1; Figure 1).

After the spring migrations, 11 paddlefish returned to the Erickson Island area (reach 3). These individuals were subsequently relocated several times during the fall in this area. The four paddlefish fish that used reach 1 and reach 2 of the Missouri River were not relocated in the Erickson Island area. Rather, logging stations data indicated that these individuals moved downstream below Williston.

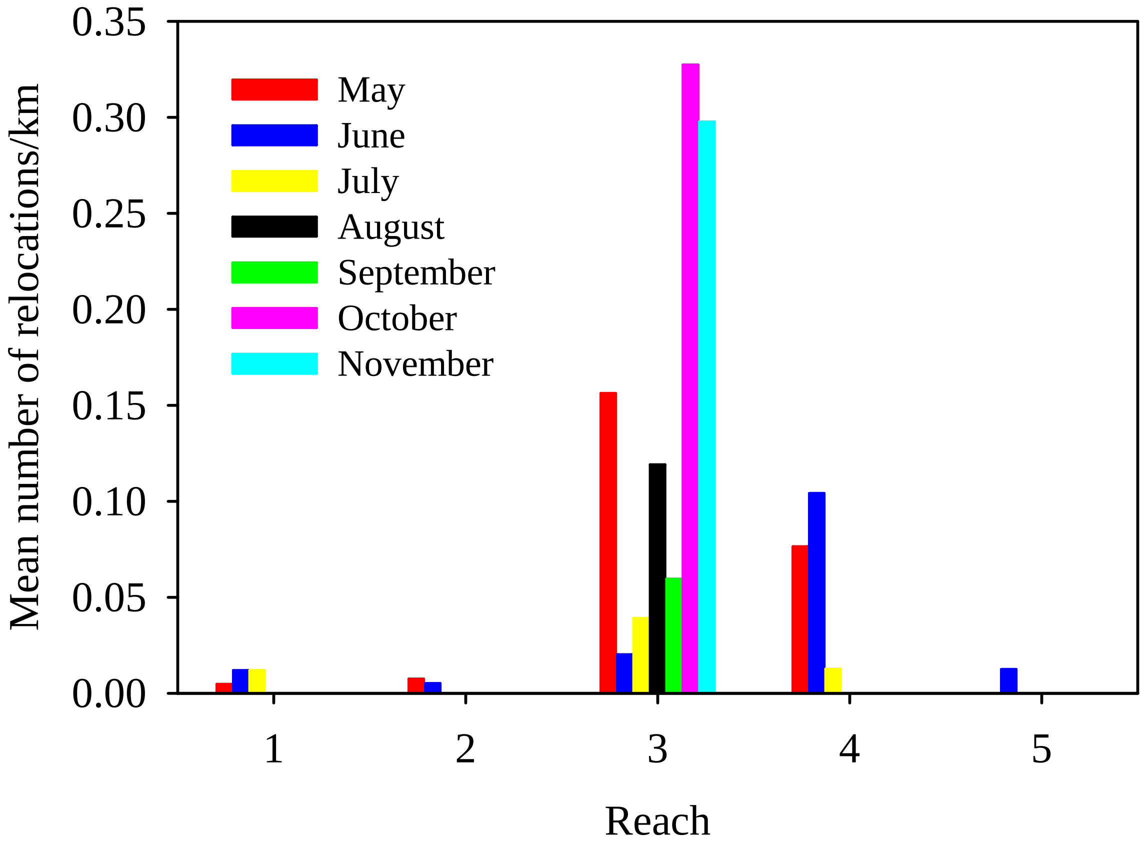


Figure 10. Mean number of paddlefish relocations per km by month in five riverine reaches (Reach 1 = Missouri River between Fort Peck Dam and Wolf Point, Reach 2 = Missouri River between Wolf Point and the Yellowstone River confluence, Reach 3 = Missouri River from the Yellowstone River confluence to the headwaters of Lake Sakakawea, Reach 4 = Yellowstone River from the confluence to Sidney, MT, Reach 5 = Yellowstone River from Sidney, MT to Intake diversion dam).

Monitoring Component 4 – Larval Fish

Larval fish were sampled on 21 individual sampling events between May 21 and August 2. However, three sites (spillway channel, Milk River, site downstream from the dam) were not sampled during one sampling event (May 31) due to equipment breakdown. The larval fish sampling regime resulted in a total of 1,965 larval fish subsamples (222 samples at the site just downstream from Fort Peck Dam, 156 samples in the spillway, 368 samples in the Milk River, 409 samples at Wolf Point, 414 samples at Nohly, 396 samples in the Yellowstone River). The volume of water sampled could not be estimated for six samples. Mean volume of water sampled per subsample was 61.9 m^3 at the site downstream from Fort Peck Dam (total = 13,740 m^3), 21.4 m^3 in the spillway (total = 3,342 m^3), 73.8 m^3 in the Milk River (total = 27,164 m^3), 74.3 m^3 at Wolf Point (total = 30,406 m^3), 63.5 m^3 at Nohly (total = 26,034 m^3), and 45.4 m^3 in the Yellowstone River (total = 17,887 m^3).

Relative abundance of larval fishes and eggs. A total of 41,768 larvae representing ten families were sampled from all sites during 2002, and nearly 77% of the larvae were sampled in the Milk River (Table 11). Catostomidae (suckers) and Cyprinidae (minnows and carps) were sampled at all sites. Two families (Hiodontidae, exclusively goldeye; Percidae, perches) were sampled at all sites except the site downstream from Fort Peck Dam. Polyodontidae (exclusively paddlefish) were sampled in the Milk River, Yellowstone River, and in the Missouri River

Table 11. Number (N) and frequency (%) of larval fishes, and numbers of juveniles, adults, and eggs sampled at six sites during 2002. 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							5	T			9	0.7
Catostomidae	158	93.5	291	87.9	25,601	79.9	5915	87.8	476	43.1	605	44.0
Centrarchidae									2	0.2		
Cyprinidae	4	2.4	12	3.6	4,447	13.9	363	5.4	118	10.7	469	34.1
Hiodontidae			3	0.9	818	2.6	67	1.0	101	9.1	175	12.7
Ictaluridae					8	T					3	0.2
Percidae			2	0.6	1	T	240	3.6	326	29.5	22	1.6
Polyodontidae					7	T	27	0.4	14	1.3	34	2.5
Salmonidae	3	1.8					14	0.2	35	3.2		
Sciaenidae			4	1.2	1,142	3.6	93	1.4	23	2.1		
Unknown	4	2.4	19	5.7	27	T	13	0.2	9	0.8	59	4.3
Total larvae	169		331		32,051		6,737		1,104		1,376	
Juveniles			3		413				12		5	
Adults	4		9		347		2		2		1	
Sturgeon/ paddlefish eggs							1					4
Unknown eggs	333		33		4,461		2,425		1,965			5,838

at Wolf Point and Nohly. Sciaenidae (exclusively freshwater drum) were identified from four sites (spillway, Milk River, Wolf Point, Nohly). Salmonidae were sampled at Wolf Point, Nohly, and at the site downstream from Fort Peck Dam. Families minimally represented in the samples included Ictaluridae (catfishes) that were sampled only in the Milk River and Yellowstone River, and Acipenseridae (sturgeons) that were found only at Wolf Point and in the Yellowstone River. Centrarchidae (sunfishes) were sampled only at Nohly. Excluding larvae that could not be definitively identified, the greatest number of families occurred in the Missouri River at Wolf Point (8 families) and Nohly (8 families). Seven families were identified from samples in the Milk River and Yellowstone River. The least number of families occurred in the spillway (5 families) and at the site downstream from Fort Peck Dam (3).

Composition of the larval fishes sampled in 2002 varied among taxa and sites (Table 11). Nearly 98% of larval fishes sampled were represented by Catostomidae (79.1%), Cyprinidae (13.0%), Sciaenidae (3.0%), and Hiodontidae (2.8%). Whereas Catostomidae was the dominant taxon sampled, the proportion of catostomids varied among sites. Catostomids comprised greater than 79% of the fish community at the site downstream from Fort Peck Dam, in the spillway channel, in the Milk River, and at Wolf Point, but the proportion of the community comprised of catostomids decreased to 43% at Nohly and 44% in the Yellowstone River. The majority of larval cyprinids (primarily common carp *Cyprinus carpio*) were sampled in the Milk River (82.2%) and at Wolf Point (6.7%). Similarly, of the 1,262 larval freshwater drum sampled, 90.5% were sampled in the Milk River and 7.4% at Wolf Point. The majority of larval goldeye (70.3%) were sampled in the Milk River, but goldeye were also common in the Yellowstone River (15.0%) and at Nohly (8.7%). The majority of larval percids (primarily *Stizostedion* sp.) were sampled at Nohly (55.2%) and Wolf Point (40.6%). Of the 82 larval paddlefish sampled, 41.5% were sampled in the Yellowstone River, 32.9% at Wolf Point, 17.1% at Nohly, and 8.5% in the Milk River. The 14 larval sturgeon sampled in 2002 were distributed between Wolf Point (35.7%) and the Yellowstone River (64.3%).

Spatial and temporal periodicity and densities of Acipenseridae and Polyodontidae larvae. Larval sturgeon were not sampled in the Milk River during 2002, but seven larval paddlefish were collected (Table 12). Collections of larval paddlefish in the drift occurred on June 25 and July 8, and mean densities were less than 0.50 larvae/100 m^3 (Table 12). No larval sturgeon were sampled from the Milk River in 2001, and only one paddlefish larvae was sampled from the Milk River in 2001 (July 2; Braaten and Fuller 2002).

Table 12. Number sampled, mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of paddlefish larvae sampled by date in the Milk River.

	Date 2002																			
	May		June								July									Aug
Metric	21	28	3	6	10	13	17	20	25	28	1	3	8	12	15	19	22	26	29	2
Number sampled									2				5							
Mean									0.50				0.29							
Median									0				0.31							
Min									0				0							
Max									1.35				0.57							

Samples of larval fishes at Wolf Point included sturgeon and paddlefish (Table 13). First collections of larval sturgeon at Wolf Point occurred on July 15 (mean density = 0.06 larvae/100 m^3). Larval sturgeon were also sampled on July 18 and August 2, but mean density was low (< 0.20 sturgeon/100 m^3). Collections of larval paddlefish (27 total) were distributed between early and late sampling dates. Mean density varied from 0.13 larvae/100 m^3 to 0.46 larvae/100 m^3 during June 24-July 5, and from 0.20 larvae/100 m^3 to 0.35 larvae/100 m^3 during July 15-July 25. Braaten and Fuller (2002) found six larval sturgeon at Wolf Point in 2001, and these were sampled on July 17 (1), July 19 (2), and July 24 (3). A total of eight larval paddlefish were sampled in 2001, and these were collected on June 19 (2), June 22 (1), June 26 (2), June 28 (2), and July 11 (1).

Table 13. Number sampled, mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of larval sturgeon (*Scaphirhynchus* sp.) and larval paddlefish sampled by date in the Missouri River at Wolf Point.

	Date 2002																				
	May			June								July									Aug
Metric	21	28	31	3	7	10	14	18	21	24	27	1	5	8	11	15	18	22	25	29	2
	Scaphirhynchus sp.																				
Number sampled																1	1				3
Mean																0.06	0.07				0.19
Median																0	0				0
Min																0	0				0
Max																0.32	0.35				0.60
	Paddlefish																				
Number sampled										2	6	6	2			4	3		4		
Mean										0.13	0.43	0.46	0.17			0.27	0.20		0.35		
Median										0	0.31	0.37	0			0.28	0		0		
Min										0	0	0	0			0	0		0		
Max										0.35	1.44	1.11	0.83			0.71	1.02		1.39		

Larval sturgeon were not sampled in the Missouri River at Nohly during 2002, but 14 paddlefish larval were sampled between July 2 and July 16 (Table 14). Mean density varied from 0.14 larvae/100 m^3 to 0.35 larvae/100 m^3. During 2001, Braaten and Fuller (2002) sampled ten larval sturgeon at Nohly on June 21 (1), June 28 (1), July 10 (2), July 13 (2), July 18 (1), July 24 (1), and July 25 (2). Only four larval paddlefish were sampled in 2001 and these were collected on June 28 (3) and July 25 (1).

Table 14. Total number (number), mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of paddlefish larvae sampled by date in the Missouri River at Nohly.

	Date 2002																				
	May			June								July									Aug
Metric	22	29	31	4	6	12	14	18	20	26	28	2	5	9	11	16	18	23	26	30	1
	Paddlefish																				
Number sampled												4	4	2	2	2					
Mean												0.35	0.34	0.19	0.14	0.14					
Median												0.38	0	0	0	0					
Min												0	0	0	0	0					
Max												0.99	0.90	0.93	0.69	0.68					

Larval fish samples from the Yellowstone River yielded a total of 9 larval sturgeon and 34 larval paddlefish (Table 15). Sturgeon larvae were sampled on three dates (June 28, July 5, July 9), and mean density varied from 0.09 larvae/100 m^3 to 0.64 larvae/100 m^3. Larval paddlefish were sampled nearly continuously from their first occurrence in the drift on June 6 to the last occurrence in the drift on July 5. Mean densities of larval paddlefish varied from 0.19 larvae/100 m^3 (June 28) to 1.48 larvae/100 m^3 (June 20). A total of eight larval sturgeon were sampled in the Yellowstone River during 2002 (Braaten and Fuller 2002), and these were found on June 25 (2), June 28 (1), July 3 (1), July 6 (2), July 17 (1), and July 25 (1). Twenty-three paddlefish were sampled from the Yellowstone River during 2001 (Braaten and Fuller 2002). Individuals during 2001 were sampled on May 29 (4), May 31 (2), June 12 (2), June 15 (2), June 18 (1), June 21 (1), June 25 (10), and July 25 (1).

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

	Date 2002																				
	May			June								July									Aug
Metric	22	29	31	4	6	12	14	18	20	26	28	2	5	9	11	16	18	23	26	30	1
	Scaphirhynchus sp.																				
Number sampled											2		6	1							
Mean											0.14		0.64	0.09							
Median											0		0.66	0							
Min											0		0	0							
Max											0.40		1.37	0.47							
	Paddlefish																				
Number sampled					1	3	3	5	11	3	3		5								
Mean					0.25	0.55	0.33	0.79	1.48	0.41	0.19		0.46								
Median					0	0	0	0.70	1.59	0.54	0.30		0								
Min					0	0	0	0	0.60	0	0		0								
Max					1.24	2.77	1.63	2.21	1.92	0.80	0.34		1.82								

Larval nets fished on the bottom tended to sample a greater number of larval sturgeon and larval paddlefish than nets fished in the mid-water column. Of the 14 larval sturgeon sampled during 2002, 9 larvae (64.3%) were sampled in larval nets fished on the bottom. Excluding Milk River samples that were fished exclusively on the surface, 47 larval paddlefish (62.7%) were sampled in larval nets fished on the bottom. In addition to larvae, five sturgeon/paddlefish eggs were sampled during 2002; these were collected at Wolf Point (July 18, N = 1) and in the Yellowstone River (June 12, N = 1; June 18, N = 1; June 26, N = 1; July 2, N = 1). Braaten and Fuller (2002) reported that 70.8% of the larval sturgeon sampled in 2001 were collected in bottom samples. About 62% of the larval paddlefish sampled in 2001 were obtained from bottom samples.

Spatial and temporal periodicity and densities of larval fishes exclusive of Acipenseridae and Polyodontidae. Mean density of larval fishes at the site downstream from Fort Peck Dam varied between 0 and 4.7 larvae/100 m^3 among sampling periods (Figure 11). Maximum densities of larvae occurred on July 3 (mean = 4.27 larvae/100 m^3) and July 12 (mean = 4.7 larvae/100 m^3) when catostomids averaged greater than 94% of the larvae densities. Salmonids comprised 100% of the larval fish densities on May 21 (mean 1.07 larvae/100 m^3) and June 6 (mean = 0.12 larvae/100 m^3). Cyprinids (exclusively common carp) were sampled on two dates (July 15, July 22), but at low densities (mean ≤ 0.44 larvae/100 m^3).

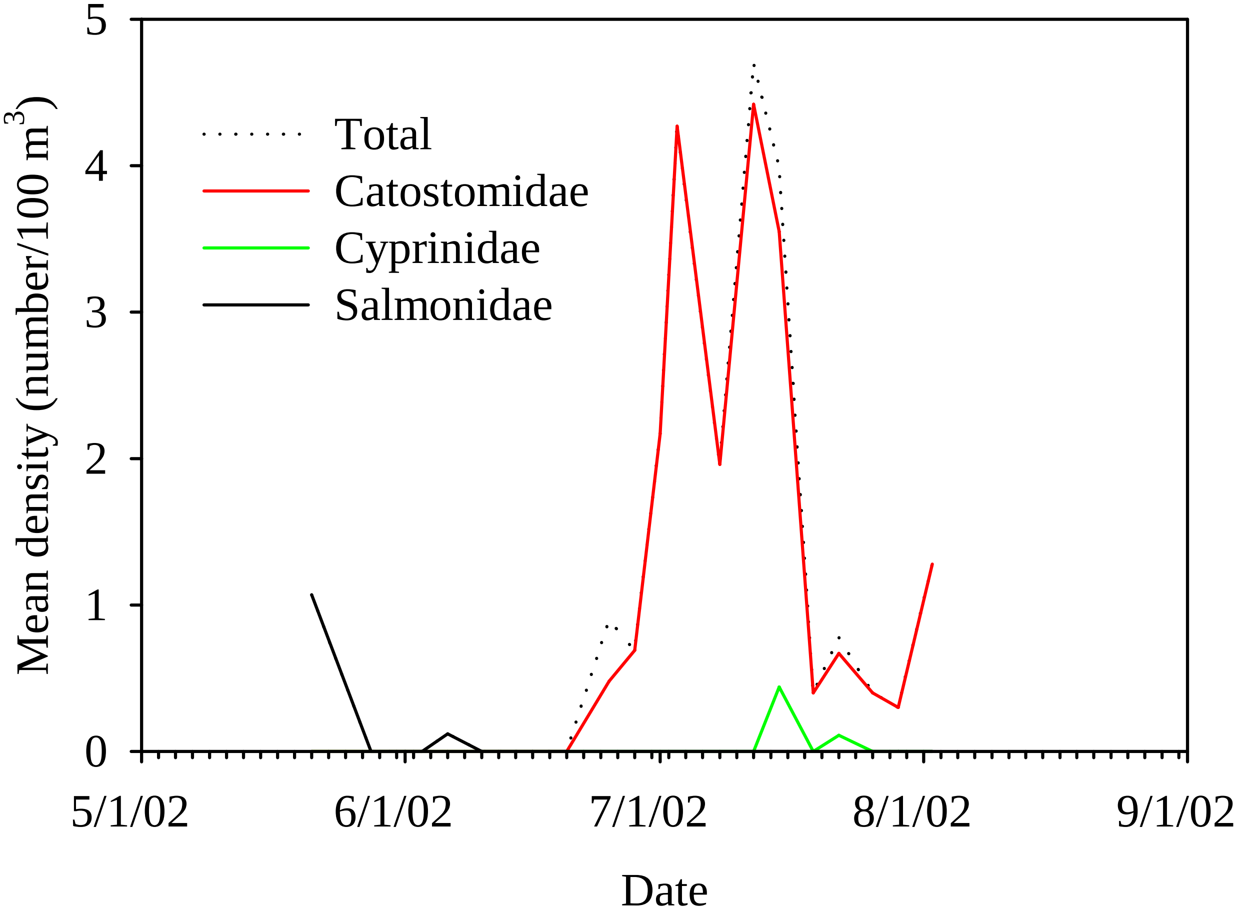


Figure 11. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, and Salmonidae sampled in the Missouri River at the site downstream from Fort Peck Dam during 2002.

In the spillway channel, mean density of larval fishes varied from 0 larvae/100 m^3 to 74 larvae/100 m^3 (Figure 12). Mean density was low through late June (< 18 larvae/100 m^3), peaked on July 1 as catostomids comprised greater than 98% of the larval fishes sampled, then declined through the beginning of August. Mean density of larval Cyprinidae, Hiodontidae, Percidae , and Sciaenidae were low (≤ 4.0 larvae/100 m^3) throughout the sampling period.

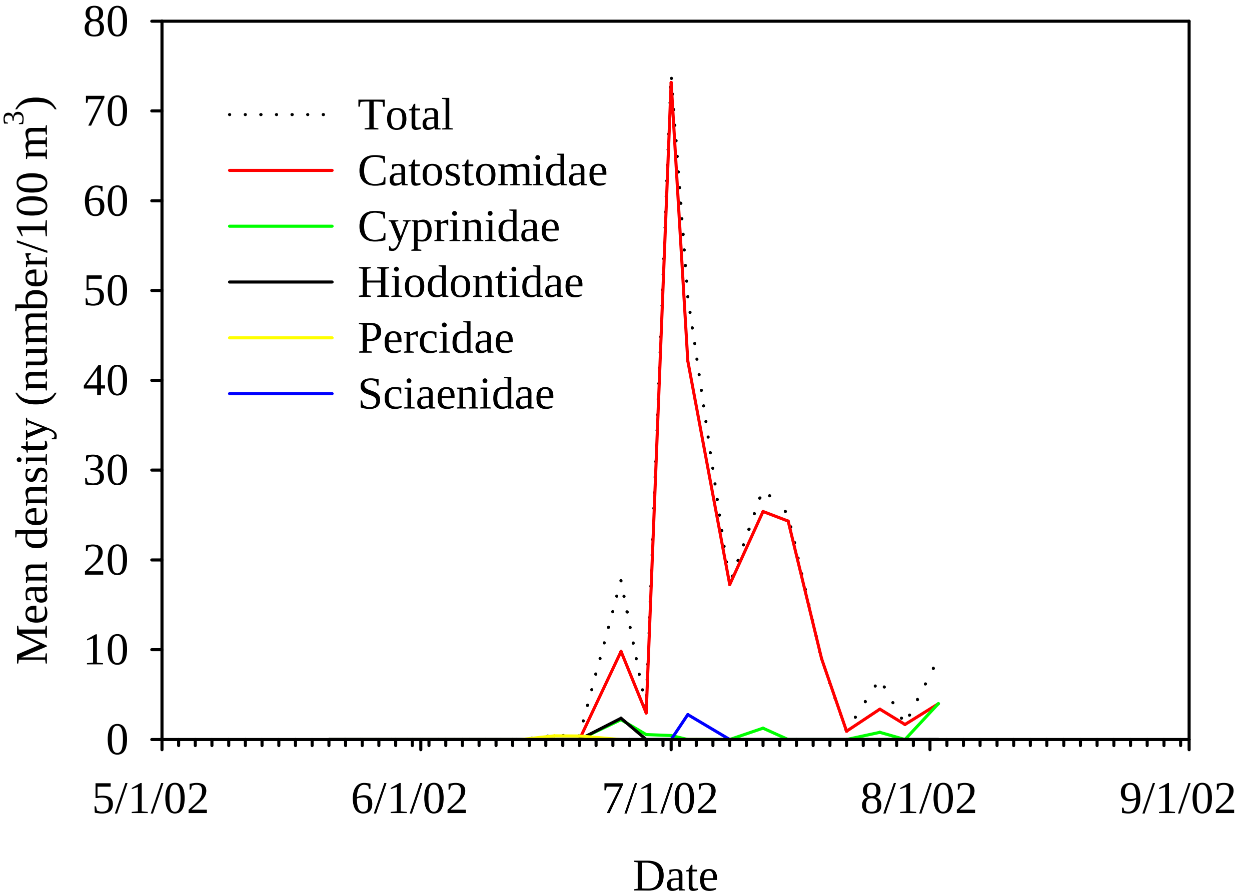


Figure 12. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, and Sciaenidae sampled in the Fort Peck spillway channel during 2002.

Composition and densities of larval fishes in the Milk River exhibited pronounced temporal variations (Figure 13). Densities of all taxa were low (< 27 larvae/100 m^3) through June 20. Mean density increased substantially to 3,673 larvae/100 m^3 on June 25 when catostomids (mean density = 3,205 larvae/100 m^3) comprised 87% of the larvae, cyprinids (mean density = 348 larvae/100 m^3) comprised 9.5% of the larvae, and hiodontidae (mean density = 105/100 m^3) comprised 2.9% of the larvae. Density of larval freshwater drum (Sciaenidae) peaked on June 28 (mean = 57.8 larvae/100 m^3) as densities of other taxa declined through late July. Whereas common carp larvae comprised 95-100% of the cyprinids sampled from June 13 to July 12, larval cyprinids exclusive of common carp comprised 100% of the cyprinid larvae from the July 19 through August 2 sampling periods.

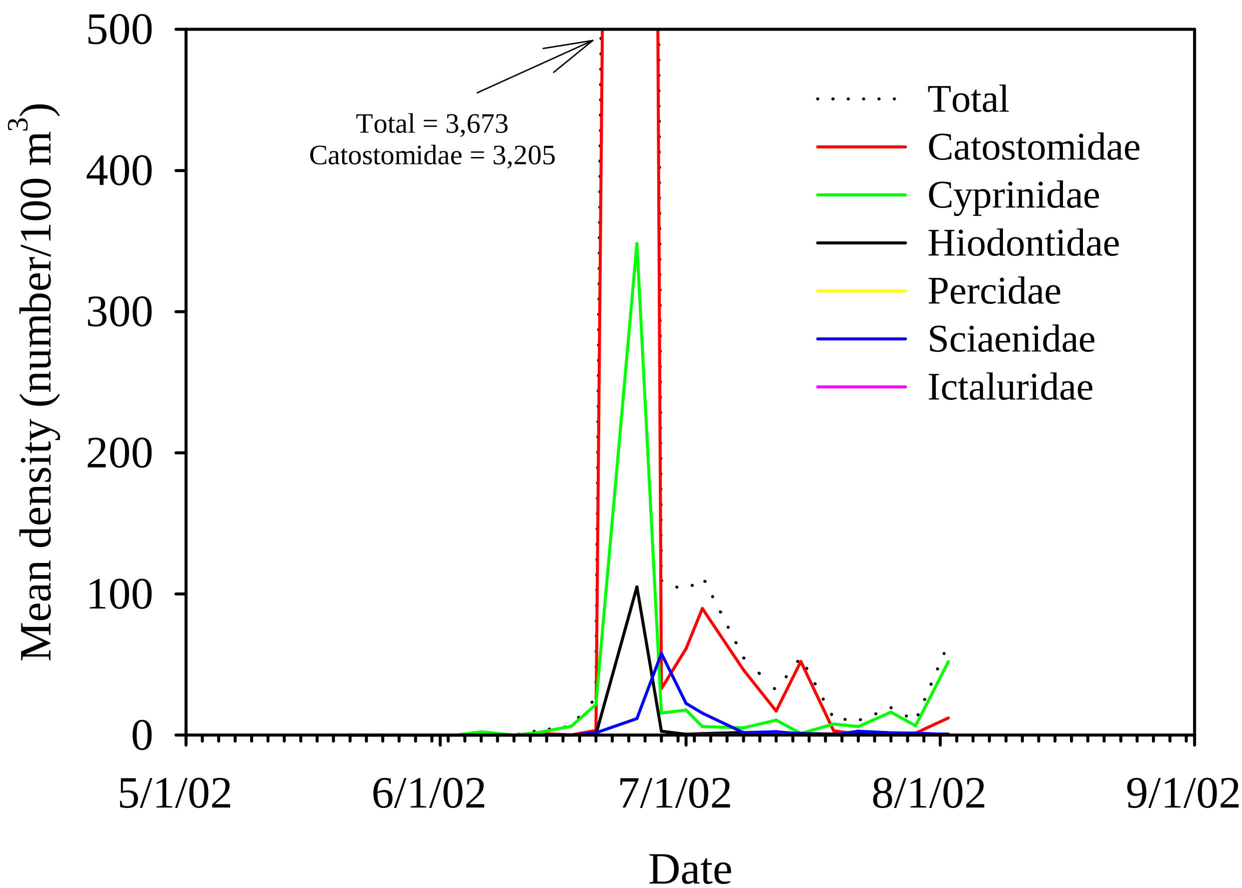


Figure 13. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Sciaenidae, and Ictaluridae sampled in the Milk River during 2002.

Larval fishes sampled at Wolf Point exhibited temporal variations in taxon composition and density among sampling periods (Figure 14). Between May 28 and June 18, larval densities were low (< 4.4 larvae/100 m^3) and were dominated by larval percids (primarily *Stizostedion* sp.). Mean density increased to a maximum of 338.4 larvae/100 m^3 on June 27 primarily as a result of an increase in density of catostomids (mean density = 316 larvae/100 m^3) and cyprinids (mean density = 18.1 larvae/100 m^3). Hiodontidae also exhibited maximum density on June 27 (mean density = 3.45 larvae/100 m^3). Mean density of catostomidae and cyprinidae decreased after June 27; whereas, density of Sciaenidae increased on July 1 (mean = 2.13 larvae/100 m^3) and July 5 (mean = 2.38 larvae/100 m^3). Between June 14 and July 1, common carp comprised 67-100% of the larval cyprinids sampled at Wolf Point.

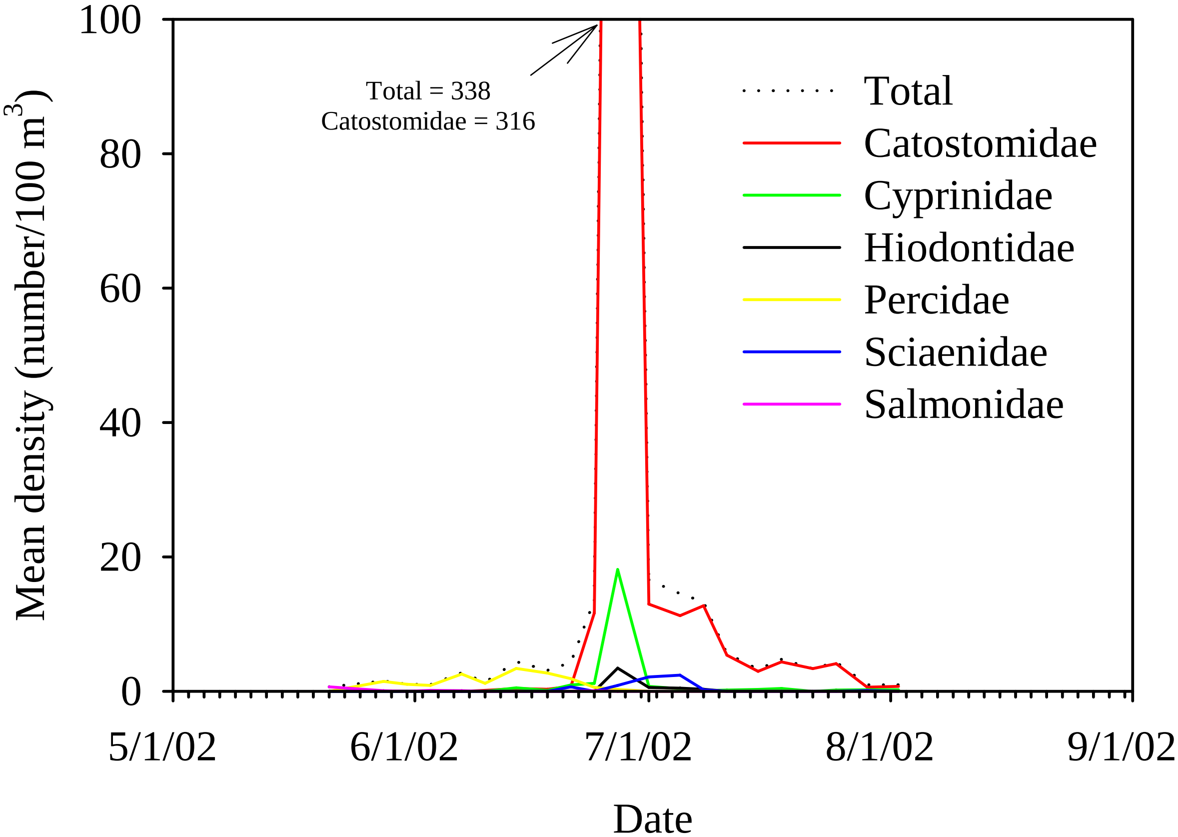


Figure 14. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Sciaenidae, and Salmonidae sampled in the Missouri River at Wolf Point during 2002.

Mean total density of larval fishes sampled at Nohly varied from 0.30 larvae/100 m^3 to 16.6 larvae/100 m^3 throughout the sampling period (Figure 15). Larval percids (primarily *Stizostedion* sp.) were the dominant taxon sampled between May 29 and June 20 (mean densities 1.31-5.8 larvae/100 m^3). Total density of larvae increased on June 28 as catostomids exhibited maximum density (mean = 9.44 larvae/100 m^3). Total density continued to increase through July 2 with contributions from catostomids (mean = 7.83 larvae/100 m^3), hiodontidae (mean = 5.0 larvae/100 m^3), cyprinidae (2.2 larvae/100 m^3), and sciaenids (1.2 larvae/100 m^3). Common carp comprised 40-100% of the cyprinidae sampled between June 12 and July 11. Total density declined after early July, and the larval community was composed exclusively of catostomids and cyprinid (non-common carp) larvae.

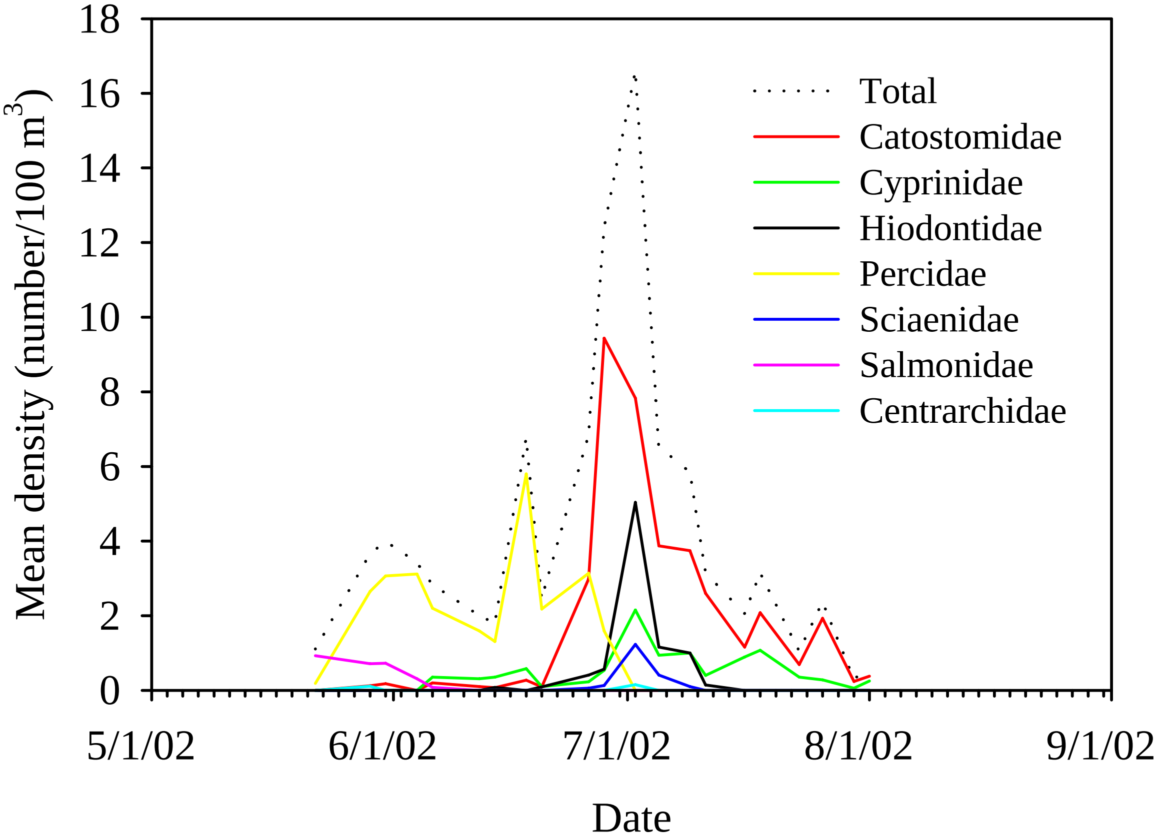


Figure 15. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Sciaenidae, Salmonidae, and Centrarchidae sampled in the Missouri River near Nohly during 2002.

Mean total density of larval fishes in the Yellowstone River varied between 0.3 larvae/100 m^3 and 45.9 larvae/100 m^3 during the late-May through early August sampling periods (Figure 16). Larval fish samples from late May through late June were composed predominately of larval goldeyes (mean density 0.3 - 5.7 larvae/100 m^3) and to a lesser extent catostomids (mean density = 0 – 2.5 larvae/100 m^3) and cyprinids (mean density = 0 – 2.9 larvae/100 m^3). Larval common carp comprised 62-100% of the cyprinid larvae sampled from late May through late June. The initial peak in total density occurred on July 9 when catostomids comprised 94% of the larval fish density. The second period of high larval densities occurred on July 16 and July 18 as cyprinds (non-common carp) comprised 86-93% of the larval fish densities.

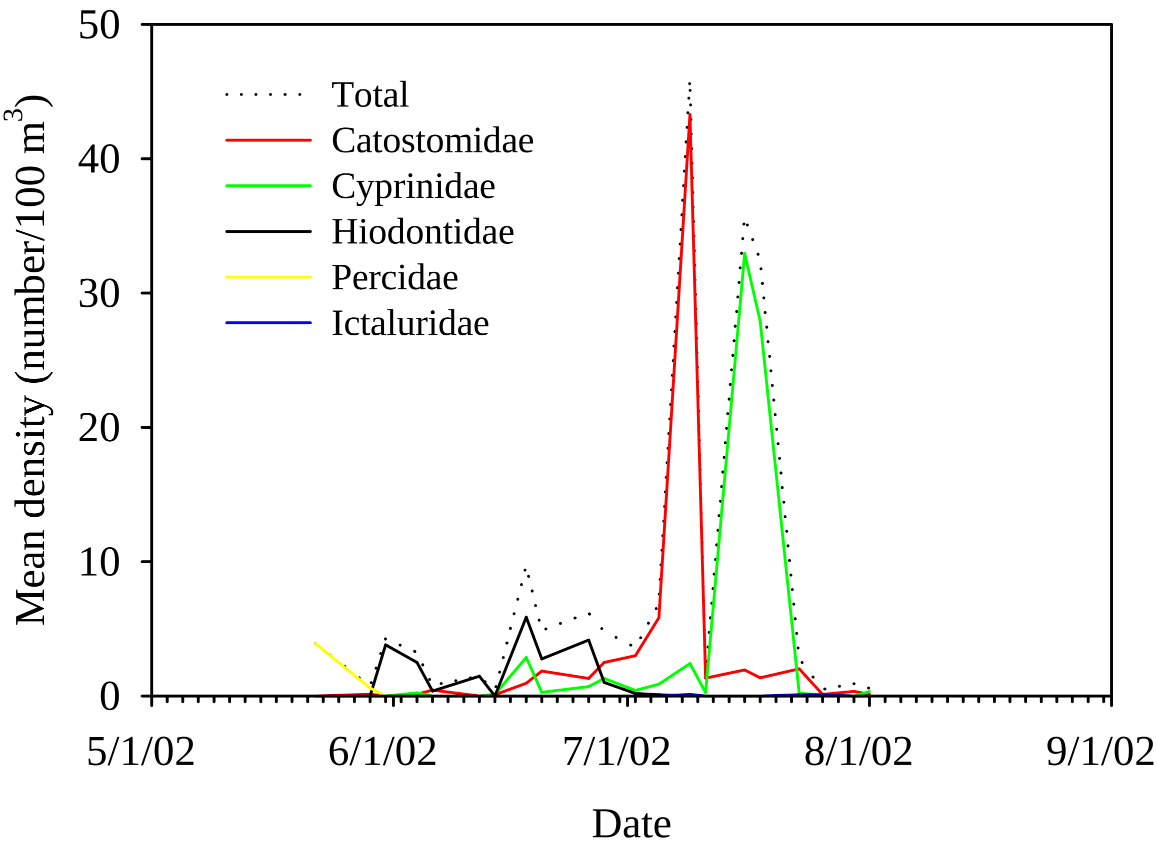


Figure 16. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, and Ictaluridae sampled in the Yellowstone River during 2002.

Inter-annual trends in larval fish densities.-A complete analysis of spatial and temporal changes in larval fish densities resulting from the Fort Peck spillway releases will be conducted after completion of the project. However, summary statistics from the 2001 and 2002 larval fish data sets were computed to illustrate inter-annual trends. Pooled across late-May through late July sampling dates (common dates for both years), larval fish densities (all taxa) were generally greater during 2002 than 2001 in the Milk River and in the Missouri River at Wolf Point (Figure 17). Mean densities were generally similar between years at the site downstream from the dam (2001 mean = 1.06 larvae/100 m^3; 2002 mean = 1.26 larvae/100 m^3), in the spillway channel (2001 mean = 19.79 larvae/100 m^3; 2002 mean = 13.66 larvae/100 m^3), at Nohly (2001 mean = 5.89 larvae/100 m^3; 2002 mean = 4.91 larvae/100 m^3), and in the Yellowstone River (2001 mean = 3.58 larvae/100 m^3; 2002 mean = 9.55 larvae/100 m^3). Elevated discharge in the Milk River during 2002 may have enhanced spawning success, and there is evidence to suggest that the increased density of larval fishes at Wolf Point was influenced by the higher densities originating from the Milk River during 2002. For example, peak densities at Wolf Point in 2002 occurred on June 27 (Figure 14), two days after peak densities were observed in the Milk River (Figure 13). Milk River discharge increased substantially during this time period (Figure 2) and likely transported larval fish downstream to Wolf Point. The benefit of enhanced larval production in

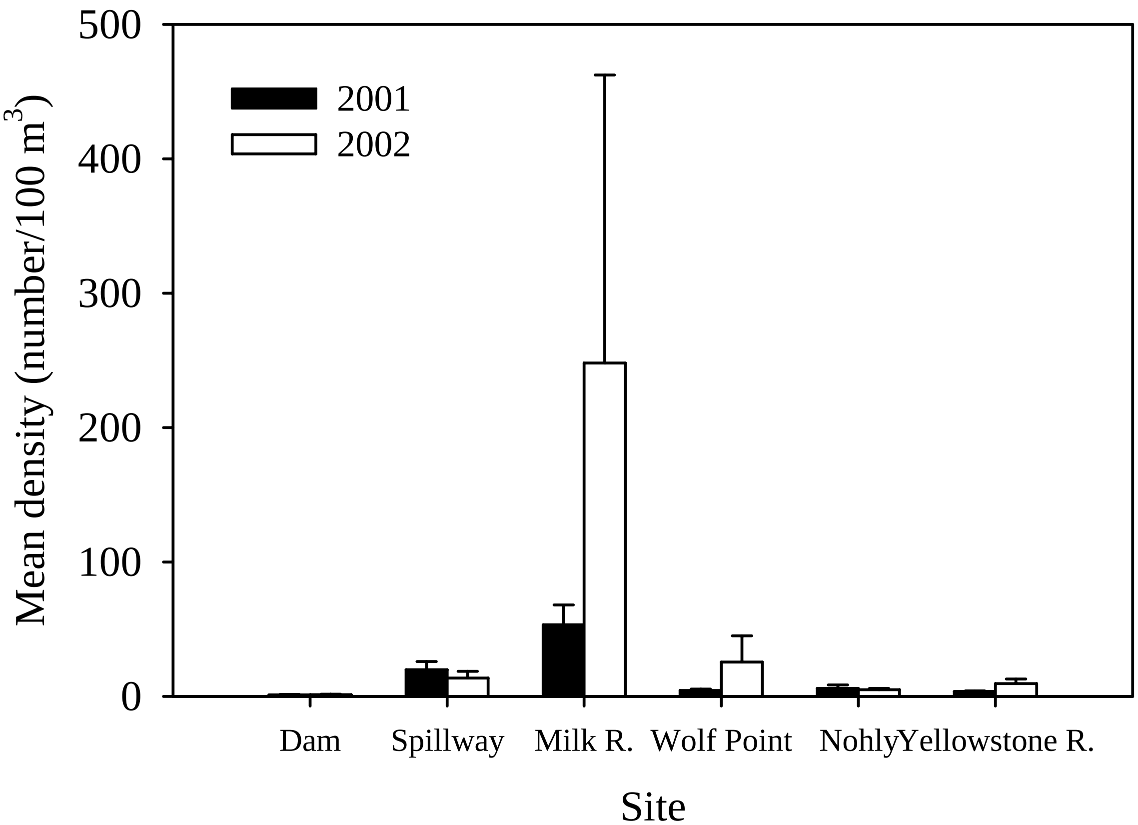


Figure 17. Mean total density (number/100 m^3; lines denote 1 standard error) of larval fishes sampled at six sites in 2001 and 2002.

the Milk River was not evident at the Nohly site suggesting that the larval fish either settled to benthic habitats upstream from Nohly or experienced high mortality levels during the drift-transport process to Nohly.

Monitoring Component 5 – Food habits of piscivorous fishes

Four burbot were sampled during July and August 2002. Individuals varied from 237 mm to 306 mm (mean = 286 mm), and from 50 g to 175 g (mean = 129 mm). The four stomachs were empty; thus, no information on food habits was obtained.

Stomachs from 62 channel catfish (mean length = 387 mm, 212 - 630 mm; mean weight = 610 g, 50 - 2,525 g) were obtained during July and August 2002. Five stomachs (8.1%) were empty. A variety of prey organisms was found in the stomach contents of channel catfish, but orthopterans (e.g., grasshoppers) represented the highest frequency of occurrence (43.9% of the stomachs) and frequency by number (66.2%) of food items ingested (Table 14). Fish (Class Osteichthyes) were found in 31.6% of the channel catfish, and identifiable fish in the diet included goldeyes and ictalurids (i.e., catfishes). Five diet components (miscellaneous material, orthopterans, unknown fish, goldeye, and mammals) comprised 81.7% of the diet weight.

Table 14. Frequency of occurrence (%, number of individuals containing the specific food item/ number of stomachs containing food), numerical frequency (%, total number of taxon-specific food items/total number of all food items), and weight frequency (%, total weight of a taxon-specific food item/total weight of all food items) of diet components for channel catfish sampled in the Missouri River during July and August 2002. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Coleoptera	19.3	7.4	0.3
	Ephemeroptera	3.5	0.6	T
	Hemiptera	3.5	1.3	T
	Lepidoptera	3.5	1.0	0.7
	Odonata	1.8	0.3	T
	Orthoptera	43.9	66.2	17.0
	Trichoptera	17.5	5.5	0.1
	Unknown	14.0	7.4	0.3
Crustacea	Decapoda	5.3	1.0	1.2
Gordoida	Nematomorpha	5.5	1.6	T
Mammalia		1.8	0.3	14.2
Osteichthyes		31.6		
	Goldeye	1.8	0.3	15.6
	Ictaluridae	3.5	0.6	6.7
	Unknown	26.3	4.8	16.1
Aves		3.5	0.6	1.0
Arachnida	Araneae	1.8	0.3	T
Fungi		1.8	0.3	3.7
Unknown		1.8	0.3	T
Detritus		28.1		4.1
Miscellaneous		42.1		18.8
			Total organisms = 311	Total weight = 423.99 g

Eight freshwater drum (mean length = 385 mm, 317 – 469 mm; mean weight = 797 g, 400 – 1,300 g) were sampled in July and August 2002, and all eight stomachs contained food items (Table 15). Fish represented the highest frequency of occurrence (75% of the stomachs), but insects and crustaceans were also present in the diet. Ephemeropterans (e.g., mayflies) represented the highest frequency by number (34.8%); whereas, decapods (e.g., crayfish) dominated the diet on a weight basis (88.3%).

Table 15. Frequency of occurrence (%, number of individuals containing the specific food item/ number of stomachs containing food), numerical frequency (%, total number of taxon-specific food items/total number of all food items), and weight frequency (%, total weight of a taxon-specific food item/total weight of all food items) of diet components for freshwater drum sampled in the Missouri River during July and August 2002. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Diptera	12.5	4.3	T
	Ephemeroptera	12.5	34.8	0.7
	Unknown	37.5	34.8	1.1
Crustacea	Decapoda	37.5	13.0	88.3
Osteichthyes	(all)	75.0		
	Unknown	75.0	13.0	0.7
Detritus		37.5		0.8
Miscellaneous		50.0		8.3
			Total organisms = 46	Total weight = 39.3 g

Stomachs were obtained from 93 goldeye (mean length = 260 mm, 146 – 353 mm; mean weight = 157 g, 25 – 325 g), and only one stomach (1.1%) was empty. Orthopterans were found in 71.7% of the stomachs, and comprised 86.1% of the ingested organisms (Table 16). Six additional insect orders (Coleoptera, Hemiptera, Lepidoptera, Odonata, Plecoptera, Trichoptera) were also found in the diet (frequency of occurrence = 1.1 – 18.5%), but these cumulatively comprised less than 9.0% of the ingested organisms. Fish, horsehair worms (Class Gordoida, Order Nematomorpha), and mammals were found in 1.1 – 14.1% of the stomachs. Orthopterans comprised 90.8% of the weight of ingested organisms

Table 16. Frequency of occurrence (%, number of individuals containing the specific food item/ number of stomachs containing food), numerical frequency (%, total number of taxon-specific food items/total number of all food items), and weight frequency (%, total weight of a taxon-specific food item/total weight of all food items) of diet components for goldeye sampled in the Missouri River during July and August 2002. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Coleoptera	18.5	5.3	0.8
	Hemiptera	8.7	1.1	0.5
	Lepidoptera	2.2	0.2	0.3
	Odonata	1.1	0.1	T
	Orthoptera	71.7	86.1	90.8
	Plecoptera	1.1	0.1	T
	Trichoptera	12.0	2.1	T
	Unknown	14.1	2.0	1.9
Gordioda	Nematomorpha	1.1	0.1	T
Mammalia		1.1	0.1	1.4
Osteichthyes	(all)	14.1		
	Unknown	14.1	2.6	1.8
Detritus		7.6		0.1
Miscellaneous		19.6		2.3
			Total organisms = 808	Total weight = 492.23 g

Stomachs were acquired from 47 northern pike (mean length = 573 mm, 406 – 835 mm; mean weight = 1,180 g, 450 – 3,525 g), but 16 stomachs (34.0%) were empty. Fish were found in 64.5% of the stomachs (Table 17). Identifiable fish prey included centrarchids (i.e., sunfishes), ictalurids (i.e., catfishes), sauger, and Stizostedion sp. (i.e., walleye or sauger). Northern pike also consumed decapods (12.9% of the stomachs) and orthopterans (3.2% of the stomachs). Unknown fish had the highest frequency by number (75% of organisms ingested). Fish comprised 92% of the weight of ingested organisms, but the high percentage was largely due to one ingested sauger that comprised 78.5% of the total weight.

Table 17. Frequency of occurrence (%, number of individuals containing the specific food item/ number of stomachs containing food), numerical frequency (%, total number of taxon-specific food items/total number of all food items), and weight frequency (%, total weight of a taxon-specific food item/total weight of all food items) of diet components for northern pike sampled in the Missouri River during July and August 2002. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Crustacea	Decapoda	12.9	8.3	7.5
Insecta	Orthoptera	3.2	6.3	0.2
Osteichthyes	(all)	64.5		
	Centrarchidae	3.2	2.1	0.2
	Ictaluridae	3.2	2.1	0.1
	Sauger	6.5	4.2	78.5
	Stizostedion	3.2	2.1	0.1
	Unknown	54.8	75.0	13.1
Detritus		12.9		0.1
Miscellaneous		29.0		0.3
			Total organisms = 48	Total weight = 349.23 g

Stomachs from 102 sauger (mean length = 368 mm, 206-526 mm; mean weight = 404 g, 50 – 1,275 g) were obtained, and 40 stomachs (39.2%) were empty. Fish represented the highest frequency of occurrence (93.5% of all stomachs); whereas, identifiable insects and crustaceans were found in only 1.6% to 3.2% of the stomachs (Table 18). Identifiable fish in the diet included common carp, emerald shiner, flathead chub, goldeye, *Hybognathus* sp., and ictalurids. Identifiable fish and unknown fish cumulatively comprised 85.7% of the total number of organisms found in the stomachs, and 98.5% of the total weight of organisms.

Table 18. Frequency of occurrence (%, number of individuals containing the specific food item/ number of stomachs containing food), numerical frequency (%, total number of taxon-specific food items/total number of all food items), and weight frequency (%, total weight of a taxon-specific food item/total weight of all food items) of diet components for sauger sampled in the Missouri River during July and August 2002. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Coleoptera	1.6	1.1	T
	Ephemeroptera	1.6	1.1	T
	Hemiptera	1.6	1.1	T
	Odonata	1.6	1.1	T
	Orthoptera	3.2	2.2	T
	Trichoptera	1.6	1.1	T
	Unknown	9.7	5.5	T
Crustacea	Argulus	1.6	1.1	T
Osteichthyes	(all)	93.5		
	Common carp	1.6	1.1	1.1
	Emerald shiner	6.5	4.4	12.3
	Flathead chub	4.8	3.3	50.2
	Goldeye	1.6	2.2	0.3
	Hybognathus	6.5	6.6	16.1
	Ictaluridae	1.6	1.1	5.8
	Unknown	82.3	67.0	12.7
	Eggs	1.6		T
Detritus		62.9		1.0
Miscellaneous		16.1		0.3
			Total organisms = 91	Total weight = 123.86 g

Stomachs from 64 shovelnose sturgeon (mean length = 563 mm, 162-722 mm; mean weight = 743 g, 100 – 1,350 g) were obtained. Of these, 5 stomachs (7.8%) were empty. The diet of shovelnose sturgeon was comprised primarily of insects (Table 19). Dipterans were the dominant insects consumed, and were found in 89.8% of the stomachs. Dipterans comprised 99.9% of the organisms consumed, and 87% of the weight of organisms in the stomachs.

Table 19. Frequency of occurrence (%, number of individuals containing the specific food item/ number of stomachs containing food), numerical frequency (%, total number of taxon-specific food items/total number of all food items), and weight frequency (%, total weight of a taxon-specific food item/total weight of all food items) of diet components for shovelnose sturgeon sampled in the Missouri River during July and August 2002. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Coleoptera	1.7	T	T
	Diptera	89.8	99.9	87.2
	Ephemeroptera	3.4	T	0.1
	Odonata	3.4	T	0.1
	Orthoptera	13.6	T	3.2
	Trichoptera	6.8	T	0.1
	Unknown	8.5	T	2.0
Crustacea	Decapoda	1.7	T	T
Detritus		5.1		T
Miscellaneous		11.9		7.1
			Total organisms = 85,965	Total weight = 249.20 g

Stomachs from 14 walleyes (mean length = 395 mm, 255 – 532 mm; mean weight = 609 g, 100 – 1,600 g) were obtained. Of these, 4 stomachs (28.6%) were empty. Fish were found in 80% of the stomachs, but fish prey could not be identified to species (Table 20). Although insects were present in the diet, fish comprised 84.6% of the total number of organisms and 98.6% of the weight of organisms in the stomachs.

Table 20. Frequency of occurrence (%, number of individuals containing the specific food item/ number of stomachs containing food), numerical frequency (%, total number of taxon-specific food items/total number of all food items), and weight frequency (%, total weight of a taxon-specific food item/total weight of all food items) of diet components for walleye sampled in the Missouri River during July and August 2002. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Ephemeroptera	10.0	7.7	0.1
	Odonata	10.0	7.7	0.5
Osteichthyes	(all)	80.0		
	Unknown	80.0	84.6	98.6
Detritus		40.0		0.5
Unknown		10.0		0.3
			Total organisms = 13	Total weight = 7.86 g

Related Activities

Incidental captures of adult and hatchery-raised juvenile pallid sturgeon.-Incidental captures of pallid sturgeon occurred in 2002 while conducting activities associated with the Fort Peck Data Collection Plan. First, an adult pallid sturgeon (1,362 mm, 12,150 g, PIT tag number 7F7D364B62) was sampled with a trammel net at rkm 2,600 (RM 1,615) on September 25. Second, a total of six hatchery-raised juvenile pallid sturgeon were sampled. Individuals were captured with trammel nets near Wolf Point on September 12 (231 mm, 38.9 g, PIT tag number 435E1D160C) and September 17 (245 mm, 44.1 g, PIT tag number 435D675A10), near Culberston on September 19 (416 mm, 211.7 g, PIT tag number 424F0D0226; 603 mm, 642.3 g, PIT Tag number 411D0B513C) and September 26 (369 mm, 176.5 g, no PIT tag, green and yellow elastomere implants), and at the Yellowstone River confluence on September 25 (430 mm, 243.0 g, PIT tag number 424F377447).

Young-of-year sturgeon sampling.-Benthic trawling was conducted between August 7 and September 5, 2002, to sample for young-of-year (YOY) sturgeon. Three riverine areas were sampled including the Missouri River above the Yellowstone River confluence (ATC; rkm 2,549-2,563, RM 1,583-1,592), the Yellowstone River (rkm 0-3.2, RM 0-2.0), and the Missouri River below the Yellowstone River confluence (BTC; rkm 2,497-2,547, RM 1,551-1,582). Young-of-year sturgeon (e.g., designated as less than 100 mm) sampled were measured in the field, preserved in a 10% formalin solution, and were tentatively identified as pallid sturgeon or shovelnose sturgeon in the laboratory using criteria established by Dr. Darrel Snyder (Colorado State University, Larval Fish Laboratory). If individuals were initially identified as pallid sturgeon, then they were sent to Dr. Darrel Snyder for expert identification.

A total of 116 benthic trawl samples was conducted among the three sampling areas resulting in a total of 475.5 minutes of sampling effort (Table 21). Three YOY sturgeon tentatively identified as shovelnose sturgeon were sampled in the Missouri River ATC on August 7, August 21, and September 4 (Table 21). These individuals varied from 20 – 58 mm. No YOY sturgeon were sampled from the Yellowstone River; however, sampling effort in the Yellowstone River was low in comparison to the other sites. A total of 30 YOY sturgeon was sampled in the Missouri River BTC (Table 21). The number of YOY sturgeon sampled was low (≤ 3 individuals) from August 13 to September 4, but increased to 20 on September 5. Two YOY sturgeon sampled from the Missouri River BTC exhibited characteristics specific to pallid sturgeon, and were tentatively identified as pallid sturgeon. These individuals were sampled on September 4 at rkm 2,537 (RM 1,576) and September 5 at rkm 2,500 (RM 1,553). The two individuals were sent to Dr. Darrel Snyder for species confirmation. The following quoted text from Dr. Snyder (dated 17 March 2003) highlights the results from his examination of the two YOY sturgeon:

"Based on my analyses, I have designated both specimens as tentative pallid sturgeon (*Scaphirhynchus albus*?). If these are pure pallid sturgeon, they display some characters observed only for shovelnose sturgeon in my comparison of hatchery reared larvae. However, I suspect they are impure pallid sturgeon or possibly F1 hybrids displaying mostly pallid sturgeon traits.

Both specimens were developmentally at or very near transition from the protolarval phase (without yolk) to the mesolarval phase and were therefore analyzed using criteria for both developmental phases; greater weight was given to criteria for protolarvae without yolk. The smaller specimen (21.6 mm TL, collected on 9/5/02 at H-85 site) has a torn caudal fin with a few rather indistinct or questionable caudal fin rays and no dorsal or anal fin rays. The larger specimen (23.1 mm TL, collected on 9/4/02 at US Erickson site) has a few "almost" distinct dorsal (but not caudal or anal) fin rays, depending on lighting and angle of view. Treated as protolarvae, both specimens matched pallid sturgeon criteria for all but one primary taxonomic character and about half of the secondary taxonomic characters. Treated as mesolarvae, criteria for all but one secondary character for both specimens and one primary character for the smaller specimen matched pallid sturgeon or both species. Had I analyzed the specimens only as mesolarvae, I would have designated the larger specimen positively as pallid sturgeon and the smaller specimen as unknown (probably a hybrid). Both specimens had fewer dorsal-fin pterygiophores than previously observed for larvae of either species. Considering the late date of capture relative to developmental state, it is possible that this and perhaps other meristic characters were affected by substantially warmer incubation and rearing temperatures than used for the developmental series I described. Results of the analyses are detailed on the following pages."

Table 21. Benthic trawl sampling locations, effort, dates, and number and lengths (minimum and maximum length in parentheses) of young-of-year sturgeon sampled in 2002. Asterisks denote that a pallid sturgeon was sampled. ATC = Missouri River upstream from the Yellowstone River confluence, BTC = Missouri River downstream from the Yellowstone River confluence.

		Date							
Location	Metric	8/7	8/13	8/21	8/22	8/27	8/28	9/4	9/5
Missouri River ATC	Effort (trawls)	8		12			9	5	
	Effort (minutes)	31		48			31	28	
	Number of sturgeon	1		1			0	1	
	Mean length	38		58				20	
Missouri River BTC	Effort (trawls)		21		22	18		10	6
	Effort (minutes)		81.5		85.5	69		50	32
	Number of sturgeon		1		3	3		3*	20*
	Mean length		58		49 (22-81)	29 (15-55)		24 (22-25)	21 (17-25)
Yellowstone River	Effort (trawls)				5				
	Effort (minutes)				19.5				
	Number of sturgeon				0				
	Mean length								

Other researchers have sampled larval pallid sturgeon in the Mississippi River (R. Hrabik, Missouri Department of Conservation, Jackson, MO, personal communication) and the lower channelized Missouri River (L. Mauldin, USFWS, Columbia, MO, personal communication). The two larval pallid sturgeon sampled in September 2002 provide the first documented account of larval pallid sturgeon in the Missouri River downstream from Fort Peck Dam, and indicate that successful spawning by pallid sturgeon did occur in 2002. However, it is not known whether spawning occurred in the Yellowstone River or in the Missouri River. Additional analyses will be conducted on the two larval pallid sturgeon to estimate age, hatch date, and spawning date.

Activities for 2003

All monitoring activities associated with the Fort Peck Data Collection Plan will continue through the 2003 field season with the exception of the piscivore food habit studies. The piscivore food habit studies will be initiated again when the full-test of the spillway releases is implemented. In addition to the monitoring activities, we will continue to sample for YOY pallid sturgeon and shovelnose sturgeon during August and September. Funding for the Fort Peck Data Collection Plan was expanded for 2003 to conduct a larval sturgeon drift study in the Missouri River downstream from Fort Peck Dam. This is a collaborative study involving the MTFWP (Dave Fuller), USGS Columbia Environmental Research Center, Fort Peck Project Office (Pat Braaten), and the USGS Conte Anadromous Fish Research Center (Boyd Kynard) designed to evaluate drift rates, drift distance, and drift behavior of larval pallid sturgeon and larval shovelnose sturgeon through a range of water velocities and environmental conditions. Results from this study will be presented at the annual Upper Basin meeting in December 2003.

Acknowledgments

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