Fort Peck Flow Modification Biological Data Collection Plan

Summary of 2001 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. In 2001, the Fort Peck Flow Modification Biological Data Collection Plan (hereafter Fort Peck Data Collection Plan) was implemented to evaluate the influence of proposed flow and temperature modifications on physical habitat and biological response of pallid sturgeon and other native fishes. The 4-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 2001 due to inadequate precipitation and insufficient reservoir levels.

Monitoring data collected in 2001 were representative of moderately low flow conditions. 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. For example, in the absence of modified dam operations, mean water temperature between mid-May and mid-October was 6.3°C cooler at Frazer Rapids (mean = 13.8°C) downstream from Fort Peck Dam than in the free-flowing Missouri River upstream from Fort Peck Dam (mean = 20.1°C). Turbidity increased longitudinally downstream from Fort Peck Dam, and generally increased during periods of elevated discharge. No pallid sturgeon were found or implanted with radio transmitters. Sixteen blue suckers, 19 paddlefish, and 29 shovelnose sturgeon were surgically implanted with radio/acoustic transmitters during September. These individuals will be intensively tracked beginning in April 2002 to examine discharge and temperature-related movement patterns. A total of 10,744 larvae fishes were sampled at six sites on the mainstem Missouri River and adjacent habitats. Larval sturgeon (*Scaphirhynchus* sp.) were sampled at Wolf Point (N = 6), Nohly (N = 10), and in the Yellowstone River (N = 8). Larval catostomids (suckers) were the dominant taxon sampled, and comprised 40-90% 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 2001. Although each species exhibited piscivory, there was no evidence that sturgeon larvae or juveniles were consumed. In addition to field results, analyses and results of precision and accuracy of water temperature loggers deployed during 2001 are presented.

Introduction

The pallid sturgeon *Scaphirhynchus albus* is a long-lived (> 40 years; Keenlyne and Jenkins 1993) species endemic to the Missouri River, lower Mississippi River, and large tributaries entering these river systems (Bailey and Cross 1954). Extensive habitat alterations throughout the geographical range of pallid sturgeon have negatively impacted populations. As a consequence, pallid sturgeon were designated as an endangered species in 1990 (Dryer and Sandvol 1993).

One of the few remaining concentrations of pallid sturgeon occurs in the upper Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea, North Dakota. Individuals in this population also inhabit the lower Yellowstone River in Montana and North Dakota (Bramblett and White 2001). Similar to pallid sturgeon in other regions, long-term viability of the pallid sturgeon population in the Missouri River downstream from Fort Peck Dam is in jeopardy. It is hypothesized that regulated flows from Fort Peck Dam coupled with a suppressed water temperature regime during the spring and early summer spawning period have failed to provide adequate spawning cues for pallid sturgeon. In addition, cold water releases from Fort Peck Dam have limited the amount of riverine habitat suitable for spawning. As a consequence, natural reproduction and recruitment of pallid sturgeon have not occurred for several years as evidenced by a population comprised of large (e.g., > 1200 mm; > 8 kg; Liebelt 1996, 1998) and presumably old individuals.

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 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 study area encompasses the Missouri River between river kilometer (rkm) 2,850 (river mile, RM 1,770) at Fort Peck Dam and rkm 2,523 (RM 1,567) downstream from the Yellowstone River confluence (Figure 1). The study area also includes the lower 5 km (3 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.

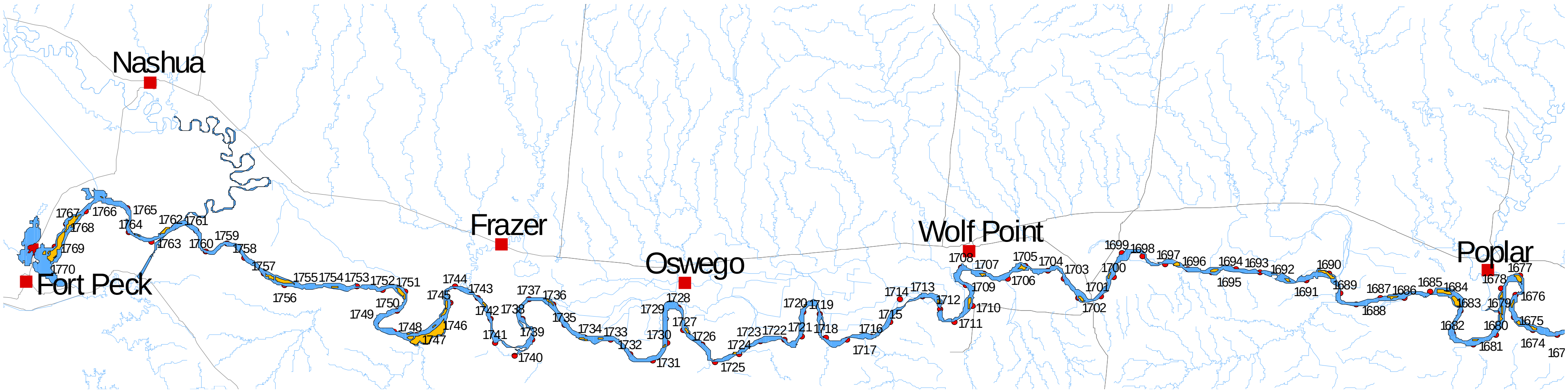
Methods

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 late April and early May at 17 sites in the Missouri River, Yellowstone River, selected tributaries, and off-channel areas (Table 1). Duplicate loggers were placed near the left and right bank (as viewed looking upstream) at most mainstem Missouri River sites to assess lateral variations in water temperature. Water temperature loggers were positioned near the bottom of the river channel. At two locations (Nickels Ferry, Frazer Pump), additional loggers were stratified in the water column. 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. Paired t-tests were used to compare mean daily water temperature between left and right bank locations at sites where duplicate loggers were deployed. Analysis of variance was used to compare mean daily water temperature among all logger locations.

Assessment of water temperature logger precision and accuracy. Following retrievel from the field, all water temperature loggers (except the logger deployed at Robinson Bridge) were subjected to a series of 11 common water bath treatments to evaluate precision and accuracy among loggers (Table 2). 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. Thus, the YSI meter and alcohol thermometer provided two independent methods of measuring the “true” water temperature of the water baths. The same YSI meter and alcohol thermometer were used in all field activities during 2001. All loggers did not record water temperature at the exact time temperature was measured with the YSI or alcohol thermometer; therefore, either a single temperature recorded within about 15 minutes of the actual measurement time was used or two temperatures spanning the actual measurement time period were averaged. In addition to post-deployment comparisons involving water bath



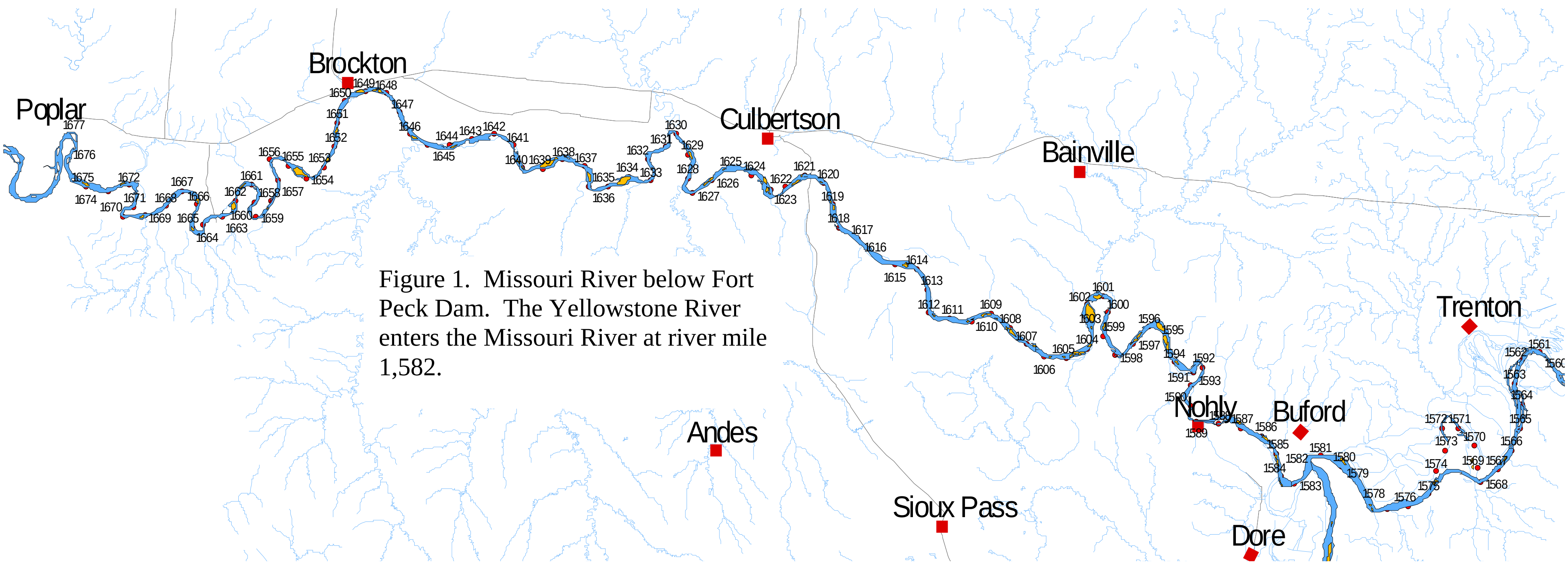


Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

Table 1. Sites, approximate river mile (RM; distance upstream from the Missouri River-Mississippi River confluence or distance upstream in a specified tributary), latitude (° North), longitude (° west), bank locations (left or right when looking upstream; 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 2001.

Site	RM	Latitude	Longitude	Bank location	Logger serial no.	Deploy date	Retrieval date
Above Fort Peck Lake (Robinson Bridge)	1,921.2	47 37.51	108 41.13	left		4/13/01	10/09/01
Downstream from Fort Peck Dam	1,765.2	48 03.345	106 21.874	right	389503	4/30/01	11/13/01
				left	389561		
Spillway		48 02.395	106 20.457	right	389574	4/30/01	11/13/01
Milk River	4.0	48 04.016	106 18.182	left	389560	4/30/01	11/13/01
Nickels Rapids	1,757.5	48 02.068	106 14.902	right	389563	5/2/01	11/13/01
		48 02.008	106 15.110	left	389571		
Nickels Ferry	1,759.9	48 02.662	106 17.300	right	389495	4/30/01	11/13/01
		44 02.390	106 17.448	left	389504		
		48 02.662	106 17.300	strat	394819		
Frazer Pump	1,751.5	48 01.897	106 07.547	right	389565	5/2/01	11/13/01
		48 01.800	106 07.522	left	389489		
				strat	389556	5/17/01	
Frazer Rapids	1,746.0	48 00.405	106 06.595	right	389501	5/2/01	11/13/01
		48 00.453	106 05.989	left	389490		
Grand Champs	1,741.5	48 00.300	106 01.873	right	389479	5/2/01	11/13/01
		48 00.215	106 01.855	left	389575		
Wolf Point	1,701.5	48 04.539	105 31.479	right	389500	5/3/01	11/14/01
		48 04.779	105 31.202	left	389493		
Redwater River	0.1	48 03.665	105 12.653	mid-channel	389502	5/3/01	11/15/01
Poplar	1,680	48 03.968	105 12.425	right	389558	5/3/01	11/15/01
		48 03.957	105 12.127	left	389491		
Poplar River	0.4	48 05.029	105 11.696	left	389488	5/3/01	11/15/01
Culbertson	1,620.9	48 07.471	104 28.433	right	389567	5/8/01	11/16/01
		104 28.59	104 28.590	left	389572		
Nohly	1,591.2	48 01.126	104 06.012	right	389498	4/19/01	11/16/01
		48 00.838	104 06.441	left	389496		
Yellowstone River	3.5	47 56.082	103 57.725	right	389562	5/8/01	11/16/01
Below Yellowstone River	1,576.5	47 57.650	103 53.751	right	389564	4/26/01	11/16/01
		48 57.511	103 53.835	left	389566		

Table 2. Post-deployment protocols for evaluating precision and accuracy of water temperature loggers.

Sample	Date	Procedure	Temperature recording time
1	11/19/01	Logger put in water bath at 1550	1550
2	11/20/01	Same water bath as sample 1 – room temperature	0820
3	11/20/01	Same water bath as sample 2 – room temperature	0900
4	11/20/01	Same water bath as sample 3 – room temperature	2100
5	11/21/01	Same water bath as sample 4 – room temperature	0900
6	11/21/01	Same water bath as sample 5 – room temperature	1400
7	11/21/01	Same water bath as sample 6 – room temperature	1600
8	11/23/01	Water bath moved outdoors at 1030	1200
9	11/23/01	Same water bath as sample 8	1300
10	11/26/01	Water bath moved outdoors at 0830	1000
11	11/26/01	Water bath from sample 10 brought indoors at 1000	1100

treatments, water temperature measured with the YSI Model 85 meter during the course of larval fish sampling (late May through July, 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. Similar to water bath trials, either a single time-specific temperature recording from the logger or two recordings (averaged) corresponding to time-specific temperature measurements obtained while larval fish sampling were used. 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 and accuracy. A suite of analysis was used to evaluate precision and accuracy of water temperature loggers. First, water temperature between the YSI and alcohol thermometer was compared with paired t-tests for the water bath trials. Second, water temperature 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. Third, paired t-tests were used to compare mean water temperature between the YSI and logger at larval fish sampling stations.

Field measurements of turbidity. Turbidity (nephelometric turbidity units; NTU) was measured during the larval fish sampling period (see below) using a Hach Model 2100P portable turbidimeter (serial number 950500007962, measurement range 0 – 1000 NTU, accuracy $\pm$ 2%). During August and September, continuous-recording turbidity data loggers (Hydrolab Datasonde 4a, serial numbers 39046, 39047, 39048, measurement range 0 – 1000 NTU, accuracy $\pm$ 2%) were deployed at three sites. Sites were located in the Missouri River at Frazer Rapids (rkm 2,811; RM 1,746), near Nohly (rkm 2,558; RM 1589), and in the Yellowstone River 0.81 km (0.5 miles) upstream from the confluence. Turbidity data loggers were programmed to record turbidity at 1-hr intervals.

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 2001.

Monitoring Component 3 - Movements of paddlefish, blue suckers, and shovelnose sturgeon.

Sampling for paddlefish, blue suckers, and shovelnose sturgeon for transmitter implantation was initiated in September 2001 and completed in early October. 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 and Lake Sakakawea. Therefore, species were collected in several areas between rkm 2,842 (RM 1,765) and rkm 2,523 (RM 1,567; Figure 1).

Transmitters varied in type and spanned a range of size, longevity, and frequency to accommodate differences in fish size among species and study objectives (Table 3). All species were implanted with combined acoustic/radio tags (CART) tags. Estimated life expectancy of the CART tags varied from about 1,049 days to 4,725 days to accommodate multiple spawning episodes. In addition to the CART tags, two types of radio transmitters were used on an experimental basis for blue suckers and shovelnose sturgeon. All transmitters were pre-programmed with unique codes to facilitate identification of individual fish (Table 3).

Table 3. Transmitter specifications and target species (BUSK = blue sucker, SNSG = shovelnose sturgeon, PDFH = paddlefish). Frequency-specific transmitter codes are as follows: CART 16-2S (2, 6, 8, 10, 14, 17, 18, 22, 25, 26, 30, 34, 38, 43, 44, 46, 50, 56, 62, 69, 70, 73, 74, 82, 86, 93, 94, 96, 98, 106, 110, 116, 119, 120, 128, 132, 143, 144, 145, 146); CART 32-1S (3, 4, 5, 7, 9, 11, 12, 13, 15, 16, 19, 20, 21, 69, 82, 93, 106, 119, 132, 145); MCFT-3A (1, 3, 4, 5, 7); MCFT-7A (9, 11, 12, 13, 15).

				Weight		
Lotek transmitter type and model	Radio frequency	Acoustic frequency	Longevity (days)	Water (g)	Air (g)	Target species
CART 16-2S	149.62	76.8	1,049	18.0	31.5	BUSK, SNSG
CART 32-1S	149.76	65.5	4,725	61.0	114	PDFH
MCFT-3A	149.62		1,139	6.7	16.0	BUSK, SNSG
MCFT-7A	149.62		494	12.8	29.0	BUSK, SNSG

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 water 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. Water temperature during the surgical implantation period was 13.5^{o}C to 17.1^{o}C.

Monitoring Component 4 – Larval Fish

Sampling protocols. Larval fish were sampled at about 3-4 day intervals from late May through July at six sites (Table 4). 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. Due to the lack of spillway releases during 2001, the spillway channel was narrow and consisted of two lentic pools connected to the mainstem Missouri River at the lowermost pool. 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 4. Larval fish sampling locations, number of replicates, samples, and net locations for 2001. 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	2	4	B/M
Spillway	1,762.8	2	4	S
Milk River	0.5-4.0	3	4	S
Missouri River near Wolf Point	1,701.0-1,708.0	3	4	B/M
Missouri River near Nohly	1,582.5-1,590.2	3	4	B/M
Yellowstone River	0.1-3.0	3	4	B/M

Specific larval fish sampling protocols varied among sites and were dependent on site characteristics (Table 4). Two to three 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). Similarly, only two well-defined bends were available for sampling at the site just downstream from Fort Peck Dam. The full compliment of three 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 a 9.1 kg (bottom sample) and 4.5 kg (mid-water column sample) lead weight to the net. Larval nets were fished for a maximum of 15 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 15 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 ($\pm$ 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. Individuals tentatively identified to Polyodontidae and Acipenseridae were sent to Dr. Darrel Snyder (Larval Fish Laboratory, Colorado State University) for species identification and confirmation.

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 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 about 50% of the 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 (0.1 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

Monitoring Component 1 - Water temperature and turbidity

General comments on water temperature loggers. At the time of logger retrieval, observations on logger characteristics that could influence accuracy of water temperature data were recorded. All water temperature loggers were retrieved in October and November 2001 except for the left bank logger (as delineated when looking upstream) located near Nohly (serial number 389496). This logger had been downloaded earlier during the deployment period; therefore, only a partial water temperature data set was available. However, the Nohly logger located on the right bank (serial number 389498) was retrieved and provided a complete data set for this site throughout the duration of the deployment period. The Culbertson logger located near the right bank (serial number 389567) was on shore when retrieved. The left bank logger at this site (serial number 389572) was retrieved, and provided a complete data set for the deployment period. An examination of data from the right bank logger suggested this logger had been pulled out of the water in early August. Therefore, data logged after early August is suspect.

Precision and accuracy of water temperature loggers. Precision of water temperature loggers varied among water bath sample treatment temperatures. At water bath sample treatment temperatures exceeding 20.0^{o}C (as indicated by the YSI and alcohol thermometer), precision of all water temperature loggers was moderate as indicated by the moderate range (0.4 to 3.5^{o}C) of water temperatures (Table 5). Precision of all water temperatures loggers declined at cooler water temperature treatments (e.g., < 15^{o}C) as indicated by an increase in the range (7.4 – 12.6^{o}C) of water temperatures (Table 5). The decrease in precision at cooler water temperatures suggested that one or more loggers was recording erroneous water temperatures. Further examination of individual loggers suggested that three loggers (Frazer Pump stratified, Serial Number 389556; Poplar River, Serial Number 389488; Redwater Creek, Serial Number 389502) exhibited extreme values at cool water bath treatment samples (e.g., < 15^{o}C). Exclusion of these three loggers from the analysis increased precision (e.g., decreased the range, especially the maximum) of water temperature measurements primarily in the cool water bath treatment samples (Table 5). After "suspect" loggers were identified omitted from the comparisons, water temperature loggers had a relatively high level of precision (0.4 to 1.2 ^{o}C) at warmer water temperatures and a reduced level of precision at cooler temperatures (1.4 to 5.2^{o}C).

Water temperatures measured with the YSI and alcohol thermometers (Table 5) provided a means to which accuracy of water temperature loggers could be evaluated. The maximum deviation in water temperature between the YSI and alcohol thermometer was 0.6^{o}C, but there was no significant difference in water temperature between the two measurement instruments (t-test, t = 0.57, df = 6, P = 0.59). Thus, this result suggests the "true" water temperature of the

Table 5. Summary statistics for water temperature comparisons among YSI Model 85 meter (YSI), hand-held alcohol thermometer (Alcohol), and water temperature loggers in 11 water bath samples. The first set of summary statistics (mean; number of loggers, N; standard deviation, SD; minimum, maximum, range) for each water bath sample included all loggers. The second set of summary statistics for water temperature loggers excluded data from three loggers that exhibited extreme values.

			Water temperature loggers					
Sample	YSI (^{o}C)	Alcohol (^{o}C)	Mean (^{o}C)	N	SD	Minimum	Maximum	Range
1	22.4	23.0	23.4	27	0.7	20.5	24.0	3.5
			23.4	24	0.3	22.8	24.0	1.2
2	20.3		20.2	27	0.2	20.0	21.0	1.0
			20.2	24	0.1	20.0	20.4	0.4
3	20.4	20.0	20.3	27	0.2	20.1	21.0	1.0
			20.2	24	0.1	20.1	20.5	0.4
4	20.7		20.6	27	0.1	20.4	20.9	0.5
			20.6	24	0.1	20.4	20.9	0.5
5	20.6	20.0	20.5	27	0.1	20.3	20.8	0.5
			20.5	24	0.1	20.3	20.8	0.5
6	20.8	21.0	20.8	27	0.1	20.6	21.0	0.4
			20.8	24	0.1	20.6	21.0	0.4
7	20.9		20.8	27	0.1	20.6	21.0	0.4
			20.8	24	0.1	20.6	21.0	0.4
8	13.3	13.0	14.9	27	2.1	13.2	20.6	7.4
			14.2	24	0.6	13.2	15.7	2.5
9	11.1		12.9	27	2.3	11.2	20.2	9.0
			12.1	24	0.3	11.2	12.6	1.4
10	7.5	7.0	9.7	26	3.1	7.5	20.1	12.6
			8.8	24	0.7	7.5	10.4	2.9
11	10.7	11.0	11.6	26	1.9	8.6	16.3	7.7
			11.2	24	1.5	8.6	13.8	5.2

water bath sample treatments was reasonably approximated with the YSI and alcohol thermometers. In water bath treatment comparisons between the YSI and loggers, the maximum deviation in temperature was 2.2^{o}C, and there was a significant difference in water temperature (t-test, t = -2.35, df = 10, P = 0.04). However, deviations in water temperature between the YSI and loggers were minimal (0-1.0 ^{o}C) at warm water temperatures, but greater (0.9-2.2 ^{o}C at lower water temperatures. Omission of the three "suspect" loggers mentioned above resulted in a maximum deviation of 1.3^{o}C, and there was no significant difference in temperature (t-test, t = -

2.15, df = 10, P = 0.06). Deviations in water temperature between the YSI and loggers were generally greater at lower than higher water temperatures.

Comparisons of date- and time-specific water temperatures measured at larval fish sampling stations to those recorded by water temperature loggers adjacent to larval fish sampling sites provided an additional means to evaluate accuracy of the water temperature loggers. Mean time-specific water temperature did not differ significantly at five of six sites (Table 6), and deviations in mean water temperature were minimal (0.1 - 1.5^{o}C). There was a significant difference in water temperature between the water temperature logger and YSI meter at the site below Fort Peck Dam (Table 6). At this site, the difference in mean temperature was 1.8 ^{o}C.

Table 6. Summary statistics and t-tests for comparisons of water temperature recorded from loggers and YSI Model 85 meter (YSI) at six larval fish sampling sites.

Site	Method	Mean (^{o}C)	N	SD	t-value	P-value
Missouri River below Fort Peck Dam	Logger	14.1	15	2.0	2.83	0.008
	YSI	12.3	15	1.3		
Milk River	Logger	20.9	17	3.5	0.94	0.357
	YSI	22.2	17	4.2		
Spillway	Logger	20.2	17	3.6	0.09	0.932
	YSI	20.3	17	3.1		
Missouri River near Wolf Point	Logger	18.0	16	4.2	0.78	0.442
	YSI	17.0	16	3.3		
Missouri River near Nohly	Logger	20.9	15	3.6	0.06	0.953
	YSI	20.8	15	3.2		
Yellowstone River	Logger	20.9	16	4.4	0.96	0.343
	YSI	22.4	16	3.9		

Lateral comparisons of water temperature. Water temperature did not differ significantly between right and left back locations at the nine locations where paired loggers were deployed (Table 7). Deviations between bank locations were small and varied from 0.1 ^{o}C to 0.9 ^{o}C.

Longitudinal water temperature patterns. Daily water temperature was averaged between left and right bank locations at nine sites where paired loggers were deployed due to the lack of significant differences in water temperature between bank locations (Table 7). Water temperature at the 13 Missouri River mainstem sites and 5 off-channel locations differed significantly among locations (ANOVA, F = 107.6, df = 17, 2610, P < 0.0001; Table 8, Figure 2). For the period spanning 5/17/01-10/09/01 (common deployment period for all loggers), mean daily water temperature for Missouri River mainstem sites was greatest (20.1^{o}C) at the Robinson Bridge site located in the free-flowing reach of the Missouri River upstream from Fort Peck Lake. Mean daily water temperature was lowest at the site just downstream from Fort Peck Dam (13.0^{o}C), but gradually increased to 18.9^{o}C at Nohly (the most downstream Missouri River site upstream from the Yellowstone River). Daily water temperature at the Missouri River mainstem locations was most variable in the Missouri River below the Yellowstone River confluence (coefficient of variation, CV = 20.9) and least variable just downstream from Fort Peck Dam (CV = 11.6; Table 8). The USFWS (2001) mandated that a minimum water temperature of 18^{o}C be established and maintained at Frazer Rapids (rkm 2,811; RM 1,746) via spillway releases. Mean daily water temperature did not reach 18^{o}C at Frazer Rapids during 2001 (Figure 2).

Mean daily water temperature between 5/17/01-10/09/01 for off-channel locations was highest in the Yellowstone River (19.3 ^{o}C) and Poplar River (19.4 ^{o}C; Table 8). The Redwater River exhibited the highest variability in daily water temperatures (CV = 22.3) during the time interval.

Table 7. Summary statistics and t-tests for comparisons of water temperature between water temperature loggers located on opposite banks of the river (looking upstream) during 2001.

Site	Bank location	Dates	N	Mean (^{o}C)	SD	t-value	P-value
Missouri River below Fort	Right	5/1-10/31	184	12.4	2.1	0.41	0.68
Peck Dam	Left	5/1-10/31	184	12.3	2.1		
Nickels Rapids	Right	5/2-10/31	183	12.9	2.3	1.43	0.15
	Left	5/2-10/31	183	12.5	2.2		
Frazer Pump	Right	5/3-10/31	182	13.2	2.6	1.56	0.11
	Left	5/3-10/31	182	12.8	2.4		
Frazer Rapids	Right	5/2-10/31	183	12.8	2.4	1.09	0.28
	Left	5/2-10/31	183	13.1	2.5		
Grand Champs	Right	5/2-10/31	183	13.3	2.7	0.52	0.61
	Left	5/2-10/31	183	13.5	2.7		
Wolf Point	Right	5/3-10/31	182	14.3	3.9	0.99	0.32
	Left	5/3-10/31	182	14.7	4.1		
Culbertson	Right	5/8-7/31	85	18.5	3.8	0.24	0.81
	Left	5/8-7/31	85	18.4	3.6		
Nohly	Right	5/1-6/22	53	14.7	2.1	1.51	0.13
	Left	5/1-6/22	53	15.3	2.1		
Below Yellowstone River	Right	5/1-10/31	184	17.1	5.3	1.60	0.11
	Left	5/1-10/31	184	18.0	5.7		

Table 8. Daily water temperature summary statistics (mean; standard deviation, SD; coefficient of variation, CV) for Missouri River mainstem locations and off-channel locations in 2001. Summary statistics for all sites were calculated for dates spanning 5/17/01-10/09/01 (N = 146) to standardize comparisons among all loggers. See Figure 2 for a graphical representation of daily water temperatures.

Location	Site	Mean (^{o}C)	SD	CV
Missouri River mainstem	Robinson Bridge	20.1	3.7	18.4
	Below Fort Peck Dam	13.0	1.52	11.6
	Nickel Ferry (stratified)	13.4	1.82	13.6
	Nickels Rapids	13.5	1.68	12.5
	Frazer Pump (stratified)	13.8	1.76	12.8
	Frazer Rapids	13.8	1.84	13.3
	Frazer Pump	13.9	1.86	13.4
	Grand Champs	14.4	2.03	14.1
	Wolf Point	16.5	3.07	18.7
	Poplar	16.8	2.83	16.8
	Culbertson	17.9	3.46	19.3
	Nohly	18.9	3.76	20.0
	Below Yellowstone River	19.4	4.05	20.9
Off-channel or tributary	Spillway	18.4	3.04	16.6
	Milk River	19.1	3.76	19.6
	Redwater River	19.0	4.23	22.3
	Poplar River	19.4	3.86	19.9
	Yellowstone River	19.3	4.19	21.7

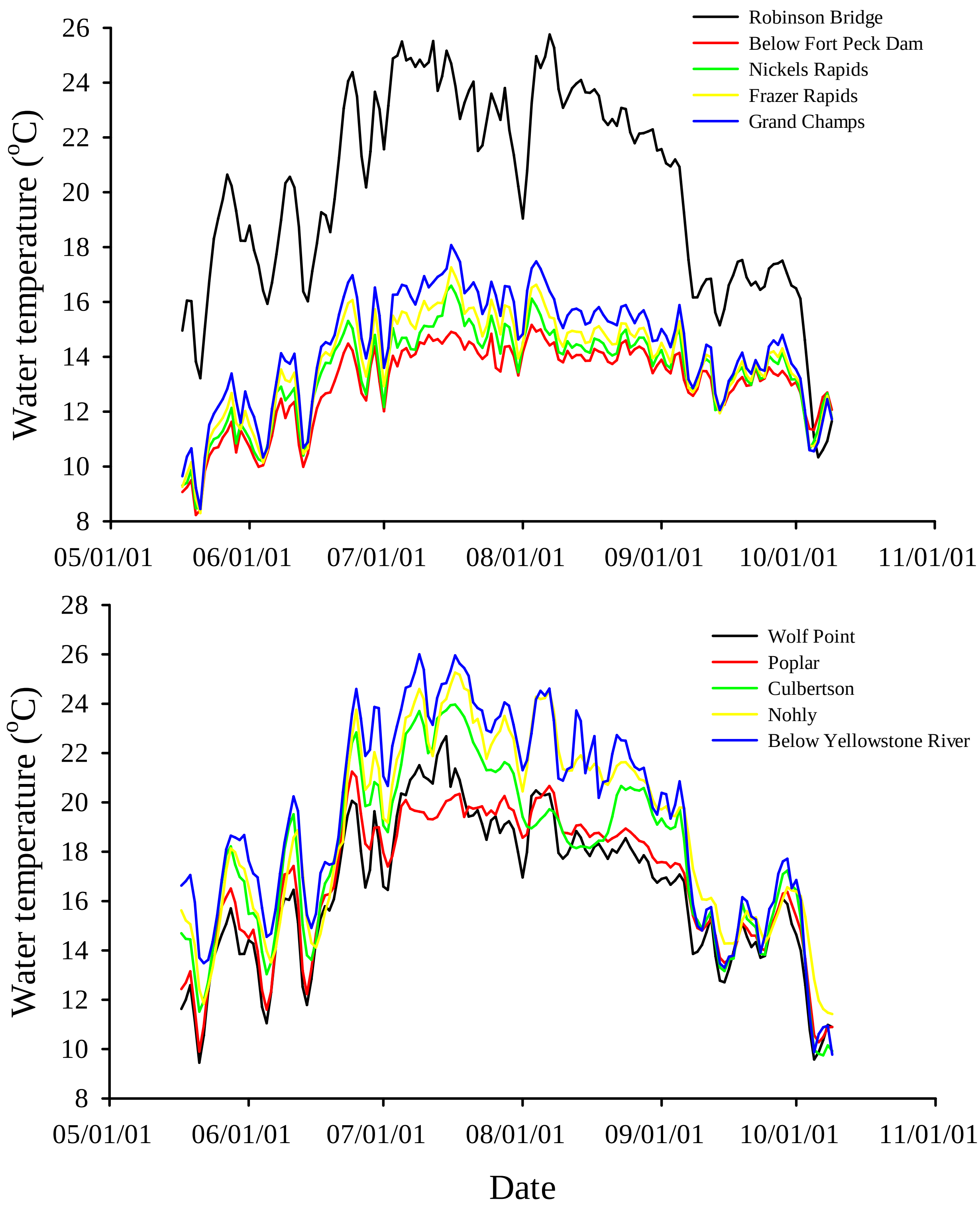


Figure 2. Mean daily water temperature (^{o}C) at 10 sites on the mainstem Missouri River during 2001.

Field turbidity measurements. Turbidity during the late-May through July larval fish sampling period exceeded the maximum turbidity limit (1000 NTU) of the turbidity logger at four of six sites on specific dates (Figure 3, 4). Because water samples were not diluted to measurable values on all dates when turbidity exceeded 1000 NTU, values exceeding 1000 NTU were truncated to 1000 NTU. Lack of accurate turbidity for these time periods precluded statistical spatial and temporal comparisons; nonetheless, qualitative comparisons facilitate interpretation of spatial and temporal trends. Turbidity was lowest at the larval fish sampling station just downstream from Fort Peck Dam, and did not exceed 10 NTU (Figure 3). Turbidity was also low in the spillway channel, and varied between 11 NTU and 73 NTU. In the Milk River, turbidity exceeded 1000 NTU on three occasions and varied between 45 NTU and 833 NTU on other sampling dates. Turbidity at Wolf Point varied between 20 NTU and 550 NTU during most sampling intervals, but exceeded 1000 NTU on three sampling dates (Figure 4). At the larval fish sampling station near Nohly, turbidity exceeded 1000 NTU on one sampling date, but varied between 40 NTU and 844 NTU during the other sampling dates. Among all locations, turbidity was generally greatest in the Yellowstone River. Turbidity in the Yellowstone River exceeded 1000 NTU on five of the 17 sampling dates, and varied between 100 NTU and 817 NTU on the other 12 sampling dates.

Temporal variations in discharge had differential influences on turbidity among sites (Figure 3, 4). Discharge from Fort Peck Dam had little influence on turbidity at the site downstream from Fort Peck Dam. Conversely, turbidity tended to increase or decrease with increases or decreases in discharge in the Milk River, and at Wolf Point and Nohly. Relations between discharge and turbidity were less defined in the Yellowstone River where increases in turbidity were not always associated with an increase in discharge.

Turbidity loggers. Turbidity loggers deployed in late summer 2001 provided a continuous, short-term assessment of spatial and temporal variations in turbidity at two of three sites. The turbidity logger deployed at Frazer Rapids failed to record data; therefore, no data was available from this site. Mean daily turbidity near Nohly was relatively low (15 - 103 NTU) during the recording period (Figure 5). Turbidity at Nohly increased during early September concomitant with a 2,250 cfs decrease in discharge. Turbidity in the Yellowstone River was relatively stable (23-40 NTU) from mid-August to early September. An abrupt increase in Yellowstone River turbidity occurred between early- and mid-September as discharge increased from 1,270 cfs to 4,500 cfs. During this time period, turbidity exceeded 1000 NTU on six dates.

Precision and accuracy of turbidity loggers. Periodic measurements of turbidity near the Nohly turbidity logger during the course of this and other projects (Dave Yerk, Montana Department of Fish,Wildlife, and Parks, pers. comm.) facilitated an evaluation of turbidity logger performance. Eight field tubidity measurements (7 measurements on day 1 of logger deployment, 1 measurement immediately preceding logger retrieval) were compared to turbidity values recorded by the Nohly turbidity logger. There was no significant difference (t-test, $t = -0.35$, $P = 0.78$, $df = 7$) between field turbidity measurements (mean = 52.9 NTU, SD = 15.2, N = 8) and logger turbidity measurements (mean = 56.2 NTU, SD = 21.4, N = 8).

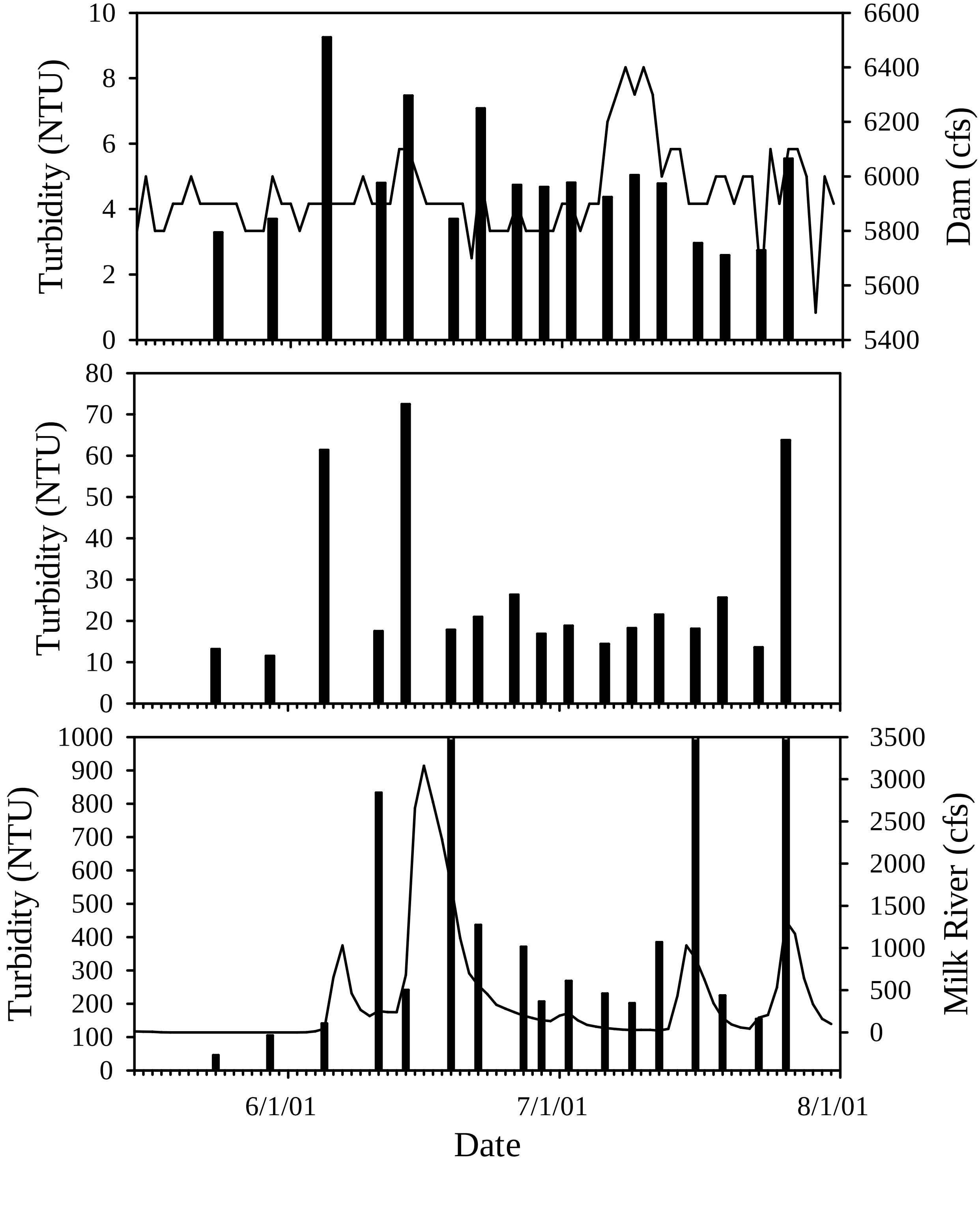

Turbidity (NTU)
Dam (cfs)
0
2
4
6
8
10
5400
5600
5800
6000
6200
6400
6600
Turbidity (NTU)
0
10
20
30
40
50
60
70
80
Turbidity (NTU)
Milk River (cfs)
0
100
200
300
400
500
600
700
800
900
1000
0
500
1000
1500
2000
2500
3000
3500
6/1/01
7/1/01
8/1/01
Date

Figure 3. Turbidity (NTU; vertical bars) and discharge (cfs; solid line) at larval fish sampling sites located downstream from Fort Peck Dam (top panel), in the spillway channel (middle panel), and in the Milk River (lower panel) during 2001.

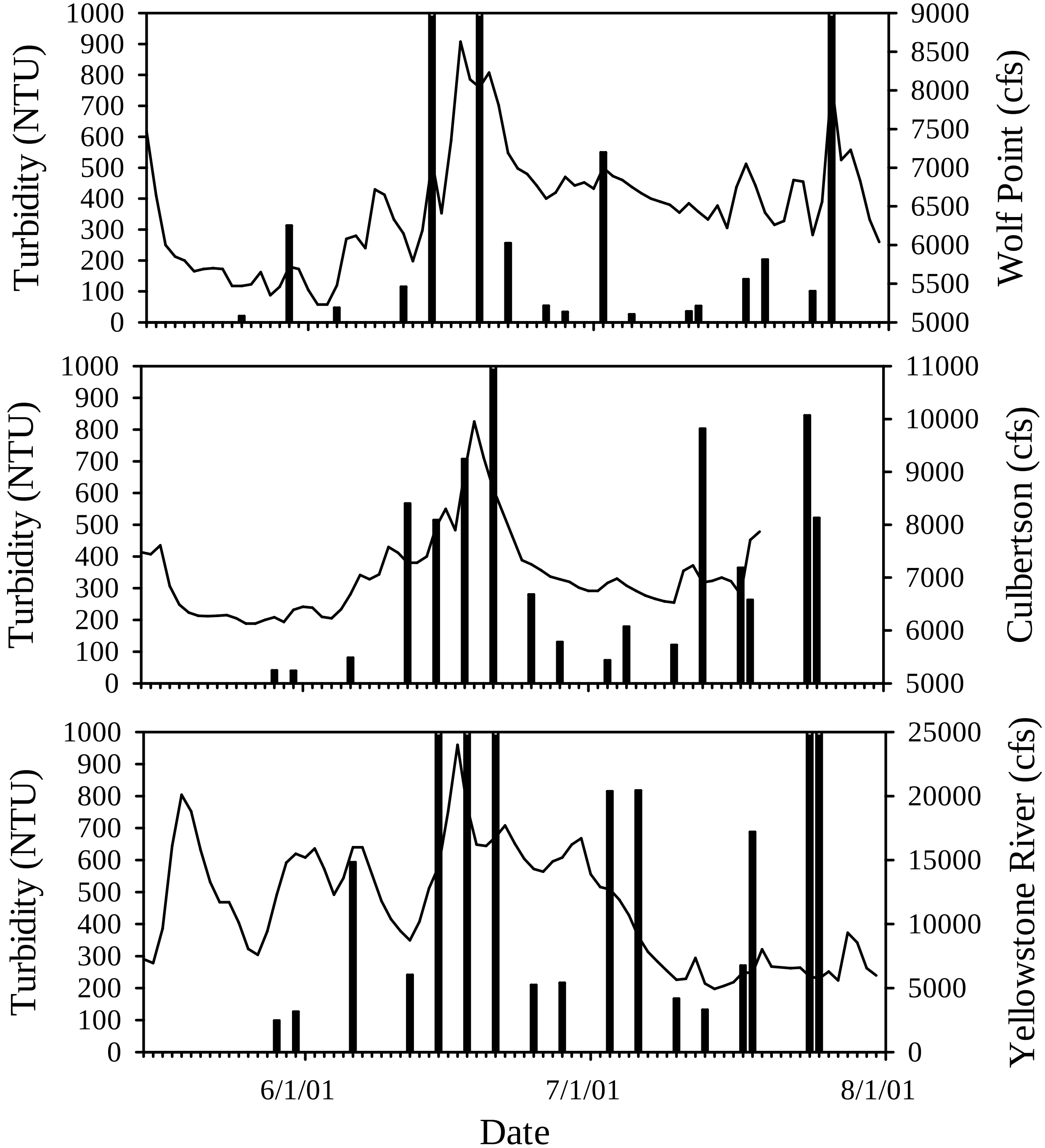


Figure 4. Turbidity (NTU; vertical bars) and discharge (cfs; solid line) at larval fish sampling sites located at Wolf Point (top panel), at Nohly (middle panel), and in the Yellowstone River (lower panel) during 2001.

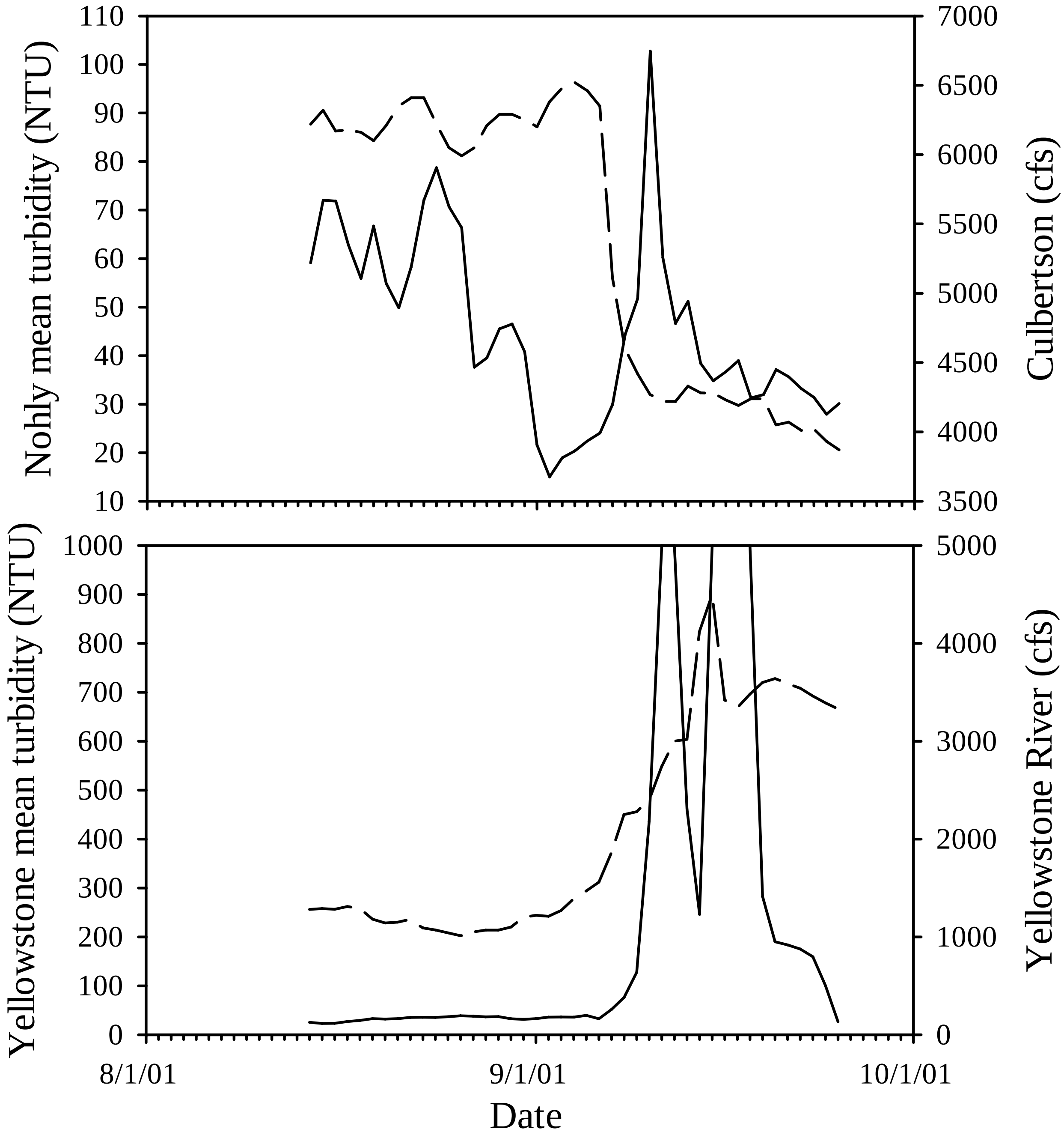


Figure 5. Mean daily turbidity (NTU; solid line) from turbidity loggers and discharge (cfs; dashed line) in the Missouri River at Nohly (top panel) and in the Yellowstone River (lower panel) during 2001.

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.

Monitoring Component 3 - Movements of paddlefish, blue suckers, and shovelnose sturgeon

Extensive sampling throughout the study area resulted in capturing 16 suitable-sized blue suckers for transmitter implantation. Blue suckers were collected just downstream from the Milk River (3 individuals), near Culbertson (9 individuals), and in the Missouri River near the Yellowstone River confluence (4 individuals). Mean length and weight of blue suckers was 669 mm and 2,336 g, respectively (Table 9). Seven individuals were identified as males, three were females, and the sex of seven blue suckers was not positively determined. Blue suckers were implanted exclusively with CART16-2S transmitters.

A total of 19 paddlefish were sampled for transmitter implantation, and all were netted in the Missouri River below the Yellowstone River confluence. Although extensive netting was conducted in other areas of the Missouri River between Fort Peck Dam and the Yellowstone River, only one other paddlefish was observed. This individual was caught just downstream from Wolf Point, but escaped from the net while being retrieved. Paddlefish were implanted exclusively with CART 32-1S transmitters, and averaged 996 mm and 15,732 g (Table 9). Of the 19 paddlefish implanted with transmitters, 14 individuals were identified as males, 1 individual was female, and the sex of four individuals was not determined.

Twenty-nine shovelnose sturgeon suitable for transmitter implantation were collected throughout the study area (4 individuals just downstream from the Milk River, 3 individuals near Wolf Point, 7 individuals near Culbertson, 7 individuals near Nohly, and 6 individuals in the Missouri River near the Yellowstone River confluence). Shovelnose sturgeon implanted with transmitters averaged 746 mm and 1,947 g (Table 9). Seven individuals were identified as male, 18 individuals as female, and the sex of 4 individuals was not determined. The CART16-2S transmitters were implanted in 21 shovelnose sturgeon, and an additional 8 individuals were implanted with either the MCFT-3A or MCFT-7A radio transmitters.

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 and early October 2001.

Species	Number	Sex ratio	Metric	Mean	Minimum	Maximum
Blue sucker	16	6:3:7	Length	669	596	738
			Weight	2,336	1,625	3,500
Paddlefish	19	14:1:4	Length	996	918	1,185
			Weight	15,732	11,339	32,205
Shovelnose sturgeon	29	7:18:4	Length	746	655	850

Weight	1,947	1,100	3,250

Radio tracking was conducted during November 2001 in selected areas of the river to obtain initial information on post-implantation movements. Three blue suckers and two shovelnose sturgeon were relocated in a reach of the Missouri River spanning from rkm 2,842 (RM 1,765) to rkm 2,829 (RM 1,757). Both shovelnose sturgeon and two of the three blue suckers relocated were originally implanted and released in the same reach. The third blue sucker was originally implanted with a transmitter and released near Culbertson indicating that this individual had migrated upstream about 211 km (131 miles) in a 2-month period. Tracking throughout a 39-km (24-mile) reach of the Missouri River between Wolf Point and Poplar provided relocation information on one shovelnose sturgeon. This individual was initially implanted and released near Culbertson, and had migrated about 109 km (68 miles) upstream in a 2-month period. In addition to manual tracking, a data logging station operated by the USFWS detected movements of paddlefish in the Missouri River downstream from the Yellowstone River confluence (Wade King, USFWS, personal communication).

Monitoring Component 4 – Larval Fish

The late-May through July sampling period resulted in a total of 1,078 larval fish samples (136 samples at the site just downstream from Fort Peck Dam, 136 samples in the spillway, 204 samples in the Milk River, 198 samples at Wolf Point, 200 samples at Nohly, 204 samples in the Yellowstone River). The full compliment of four subsamples per replicate was collected at all sites except on five occasions (Nohly, 7/5/01, replicate 2 and 3; Wolf Point, 7/19/01, replicate 1, 2, and 3) when only two subsamples per replicate were collected due to inclement weather. Mean volume of water sampled per subsample was 77.7 m^3 at the site downstream from Fort Peck Dam (total = 10,564 m^3), 21.2 m^3 in the spillway (total = 2,882 m^3), 90.7 m^3 in the Milk River (total = 18,510 m^3), 102.8 m^3 at Wolf Point (total = 20,364 m^3), 65.4 m^3 at Nohly (total = 13,086 m^3), and 47.9 m^3 in the Yellowstone River (total = 9,771 m^3).

Relative abundance of fishes and eggs. Ten families cumulatively represented by 10,744 fish sampled during 2001 comprised the larval fish collections at all sites (Table 10). Representatives of Catostomidae (suckers) and Cyprinidae (minnows and carps) were sampled at all sites, and two families (Hiodontidae, exclusively goldeye; Percidae, perches) were sampled at all sites except the site downstream from Fort Peck Dam. Representatives of Polyodontidae (exclusively paddlefish) and Salmonidae (salmonids) were sampled at four of six sites. Representatives from Sciaenidae (exclusively freshwater drum), Ictaluridae (catfishes), and Acipenseridae (sturgeons) were sampled at three of six sites. Centrarchids (sunfishes) were sampled at only two sites (spillway channel, Yellowstone River). Excluding larvae that could not be definitively identified, the greatest number of families occurred in the Missouri River at Wolf Point (9). Eight families were identified from samples collected in the Milk River, at Nohly, and in the Yellowstone River. The site downstream from Fort Peck Dam yielded the fewest families (3).

The proportion of the community comprised of various taxa varied among sites. Catostomidae was the dominant taxon sampled, and comprised greater than 40% of the fishes sampled at all sites (Table 10). Although catostomids comprised greater than 70% of the fish community at sites located downstream from Fort Peck Dam, in the spillway channel, and at Wolf Point, the proportion of the community comprised of catostomids decreased in the Milk River, at Nohly, and in the Yellowstone River as other taxa (primarily Cyprinidae and Hiodontidae) increased in abundance. Individuals identified as common carp *Cyprinus carpio* dominated the Cyprinidae at several sites. Common carp represented 71.5% of the cyprinids in the Milk River, 68.8% at Wolf Point, 50.0% at Nohly, and 15.8% in the Yellowstone River. Percids (primarily *Stizostedion* sp.) comprised 7.4-14.9% of the larval fishes sampled at Wolf Point and Nohly, respectively, but had minimal representation in the spillway (3.3%), Milk River (trace), and in the Yellowstone River (1%). The Milk River had the greatest proportion of freshwater drum (11.7%); whereas, freshwater drum comprised only 2.5-2.6% of the fish sampled at Wolf Point and Nohly. Larvae of Acipenseridae comprised 0.8%, 3.6%, and 2.6% of the individuals sampled at Wolf Point, Nohly, and in the Yellowstone River, respectively. It should be noted that final confirmation of Acipenseridae larvae and Polyodontidae larvae sampled in 2001 is in progress. Therefore, results presented for Acipenseridae and Polyodontidae are contingent on final family/species determinations. Paddlefish comprised less than 0.1% of the larvae sampled in the Milk River, 0.1% at Wolf Point, 0.7% at Nohly, and 7.7% of the larvae sampled in the Yellowstone River. In addition to larval fishes, a total of 7,435 eggs were sampled across all sites during 2001. Of these, nine eggs identified as sturgeon and/or paddlefish eggs were sampled Wolf Point, Nohly, and in the Yellowstone River.

Table 10. Number (N) and frequency (%) of larval fishes, and numbers of eggs sampled at six sites in the Missouri River during 2001. T = less than 0.1%.

	Below Fort Peck Dam		Spillway		Milk River		Wolf Point		Nohly		Yellowstone River	
Taxon	N	%	N	%	N	%	N	%	N	%	N	%
Acipenseridae							6	0.8	10	3.6	8	2.6
Catastomidae	81	90.0	399	81.4	4624	52.4	546	72.2	111	40.2	139	44.6
Centrarchidae			15	3.1							2	0.6
Cyprinidae	3	3.3	52	10.6	2240	25.4	64	8.5	40	14.5	57	18.3
Hiodontidae			1	0.2	879	10.0	10	1.3	40	14.5	45	14.4
Ictaluridae					23	0.3	1	0.1			13	4.2
Percidae			16	3.3	2	T	56	7.4	41	14.9	3	1.0
Polyodontidae					1	T	8	1.1	4	1.4	24	7.7
Salmonidae	2	2.2			2	T	1	0.1	2	0.7		
Sciaenidae					1029	11.7	20	2.6	7	2.5		
Unknown	4	4.4	7	1.4	20	0.2	44	5.8	21	7.6	21	6.7
Total	90		490		8,820		756		276		312	
Eggs												
Sturgeon/paddlefish							1		1			7
Unknown	687		13		3455		829		546			1887

Spatial and temporal periodicity and densities of Acipenseridae and Polyodontidae larvae. In the Milk River, one larval paddlefish was sampled on July 2, but no sturgeon larvae were collected. At Wolf Point, six sturgeon larvae and eight paddlefish larvae were sampled (Table 11). Larval sturgeon were sampled on July 17, July 19, and July 26, and mean density on these dates was 0.08 - 0.40 larvae/100 m^3 (Table 11). Larval paddlefish at Wolf Point were sampled on five dates (Table 11). Mean density of larval paddlefish on the five dates was 0.08 - 0.16 larvae/100 m^3.

Table 11. Total number (number), mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of Acipenseridae and Polyodontidae larvae sampled by date in the Missouri River at Wolf Point.

	Date 2001																
	May		June							July							
Metric	25	30	4	11	14	19	22	26	28	2	5	11	12	17	19	24	26
	Acipenseridae																
Number														1	2	3	
Mean														0.08	0.40	0.18	
Median														0	0	0.19	
Min.														0	0	0	
Max.														0.25	1.19	0.35	
	Polyodontidae																
Number						2	1	2	2			1					
Mean						0.16	0.08	0.15	0.15			0.11					
Median						0.22	0	0	0.18			0					
Min.						0	0	0	0			0					
Max.						0.26	0.25	0.46	0.27			0.33					

Ten sturgeon larvae and four paddlefish larvae were sampled at Nohly (Table 12). Larval sturgeon were first sampled on June 21, and subsequently sampled on June 28, July 10, July 13, July 18, July 24, and July 25. Mean density of larval sturgeon on the six dates was 0.07 - 0.23 larvae/100 m^3. Larval paddlefish at Nohly were sampled on only two dates (June 28 and July 25), and densities did not exceed 0.19 larvae/100 m^3 (Table 12).

Table 12. Total number (number), mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of Acipenseridae and Polyodontidae larvae sampled by date in the Missouri River at Nohly.

	Date 2001																
	May		June							July							
Metric	29	31	6	12	15	18	21	25	28	3	5	10	13	17	18	24	25
	Acipenseridae																
Number							1		1			2	2		1	1	2
Mean							0.08		0.07			0.21	0.16		0.23	0.20	0.22
Median							0		0			0	0		0	0	0
Min.							0		0			0	0		0	0	0
Max.							0.25		0.20			0.65	0.49		0.70	0.59	0.67
	Polyodontidae																
Number									3								1
Mean									0.18								0.19
Median									0.20								0

Min.	0	0
Max.	0.36	0.57

In the Yellowstone River, eight sturgeon larvae and 24 paddlefish larvae were sampled (Table 13). Larval sturgeon were sampled on 6 dates (June 25, June 28, July 3, July 6, July 17, and July 25), and mean densities were less than 0.44 larvae/100 m^3 (Table 13). Larval paddlefish were sampled on eight dates between May 29 and July 25. On those dates when larval paddlefish were collected in the Yellowstone River, mean densities varied from 0.08 larvae/100 m^3 to 2.1 larvae/100 m^3.

Table 13. Total number (number), mean density (mean; number/100 m^3), median density (median), minimum density (min.), and maximum density (max.) of Acipenseridae and Polyodontidae larvae sampled by date in the Yellowstone River.

	Date 2001																
	May		June							July							
Metric	29	31	6	12	15	18	21	25	28	3	6	10	13	17	18	24	25
	Acipenseridae																
Number								2	1	1	2			1			1
Mean								0.44	0.22	0.13	0.23			0.15			0.20
Median								0	0	0	0			0			0
Min.								0	0	0	0			0			0
Max.								1.32	0.67	0.39	0.70			0.44			0.60
	Polyodontidae																
Number	4	2		2	2	1	1	10									1
Mean	0.43	0.20		0.44	0.47	0.28	0.28	2.1									0.08
Median	0.53	0.28		0.64	0	0	0	0.59									0
Min.	0	0		0	0	0	0	0.44									0
Max.	0.76	0.31		0.68	1.41	0.85	0.83	5.28									0.24

Larval nets fished on the bottom tended to collect a greater number of larval sturgeon and larval paddlefish. For example, of the 24 larval sturgeon sampled during 2001, 17 larvae (70.8%) were sampled in larval nets fished on the bottom. Of the 37 larval paddlefish sampled, 23 larvae (62.2%) were sampled in larval nets fished on the bottom. In addition to larvae, sturgeon/paddlefish eggs were collected during 2001 at Wolf Point (June 19, N = 1), at Nohly (July 13, N = 1), and in the Yellowstone River (June 18, N = 1; June 21, N = 1; June 25, N = 2; July 3, N = 2; July 6, N = 1).

Spatial and temporal periodicity and densities of larval fishes exclusive of Acipenseridae and Polyodontidae. At the site downstream from Fort Peck Dam, mean density of larval fishes varied between 0 and 3.8 larvae/100 m^3 during the sampling period (Figure 6). Catostomids comprised the majority (90%) of the larval fishes below Fort Peck Dam, and exhibited highest densities on the June 19, June 22, and June 29 sampling dates. Salmonids were sampled on the initial sampling date (May 24), and had a mean density of 0.22 larvae/100 m^3. Cyprinids were sampled only on two dates (July 16, July 23), but at low densities (mean ≤ 0.23 larvae/100 m^3).

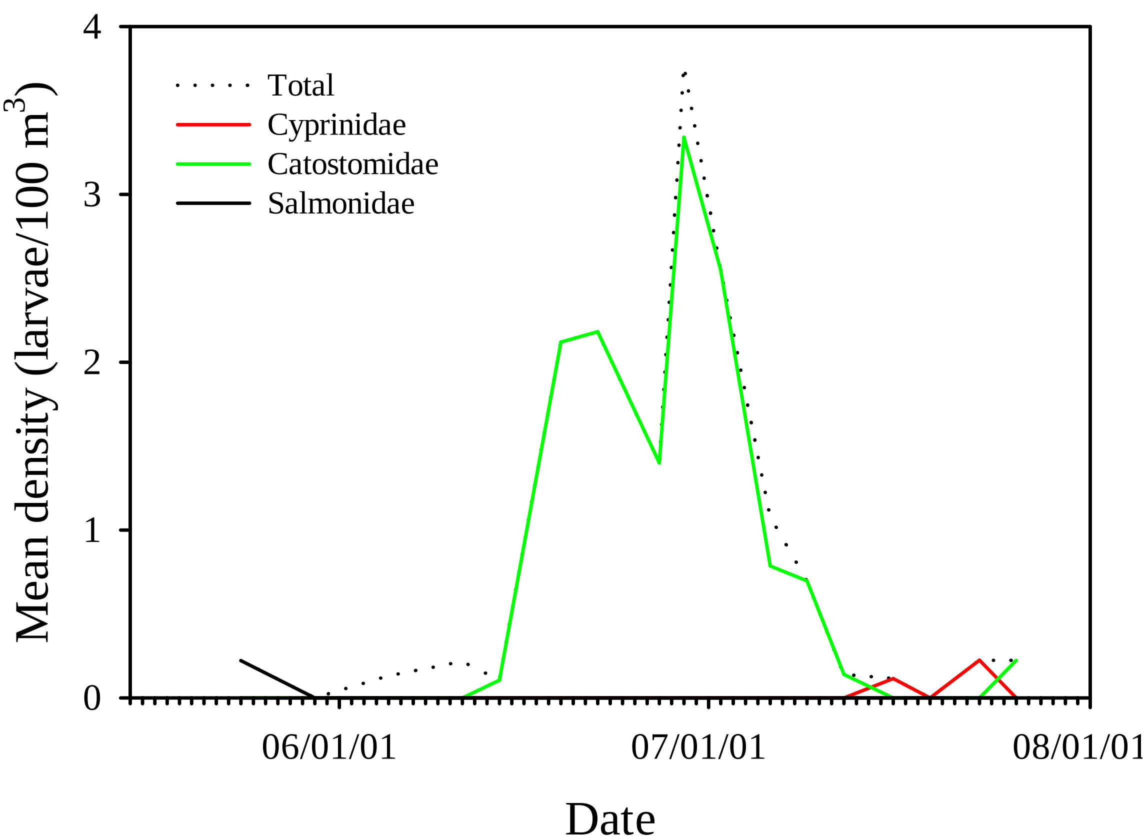


Figure 6. Mean density (number/100 m^3) by date of all larval fishes (Total), Cyprinidae, Catostomidae, and Salmonidae sampled at the site just downstream from Fort Peck Dam during 2001.

In the spillway channel, mean density of larval fishes varied from 0 larvae/100 m^3 on June 11 to a maximum of 74 larvae/100 m^3 on July 26 (Figure 7). Samples through June 14 were comprised predominantly of percids, centrarchids, and cyprinids (mean density $\leq$ 5.3 larvae/100 m^3). After June 14, catostomids increased in abundance and mean density exceeded 40 larvae/100 m^3 on three sampling dates (July 2, July 9, July 26).

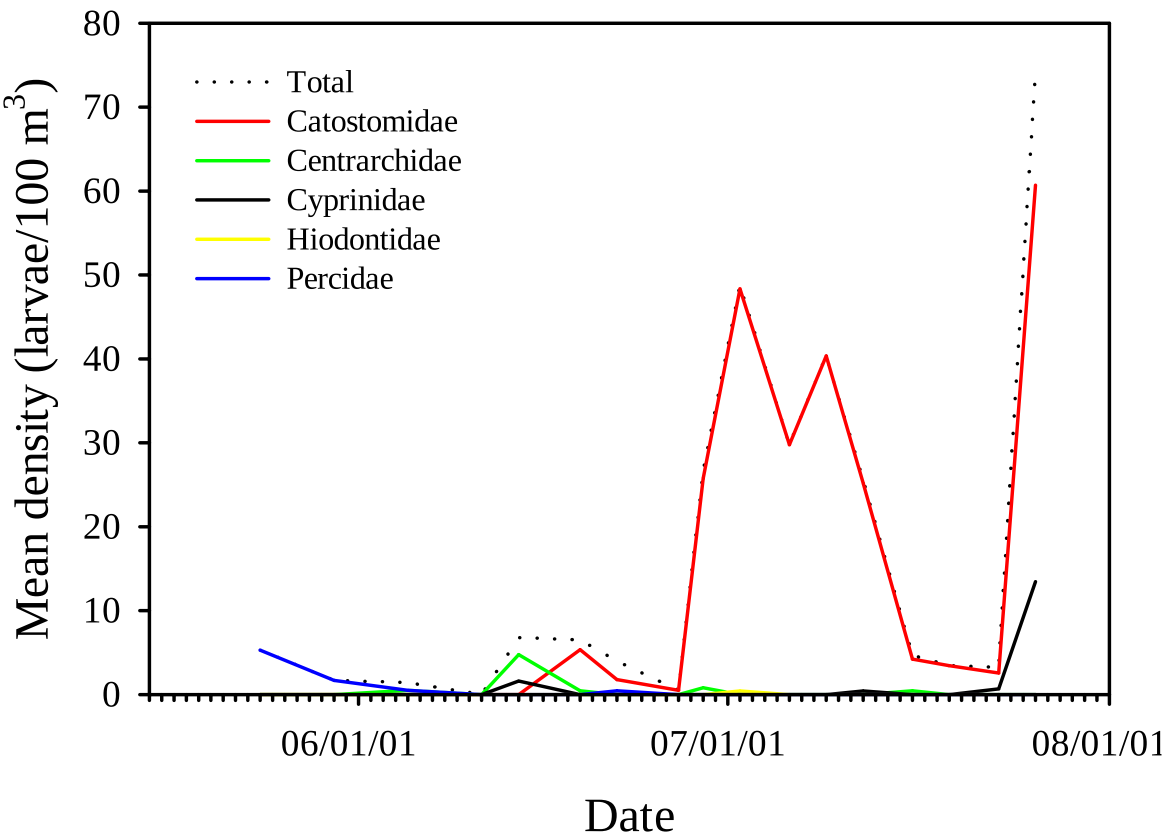


Figure 7. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Centrarchidae, Cyprinidae, Hiodontidae, and Percidae sampled in the spillway during 2001.

The larval fish community in the Milk River exhibited pronounced temporal variations in composition and density (0 – 180 larvae/100 m^3) that were associated with spawning periodicity of different taxa (Figure 8). Cyprinids (primarily common carp) exhibited maximum density (mean = 82 larvae/100 m^3) on June 19, and continued to be present in the community through July 26 but at reduced densities (mean < 22 larvae/100 m^3). A second peak in larval fish density occurred on June 27 (mean density = 76 larvae/100 m^3) as catostomids (mean density = 43 larvae/100 m^3), and to a lesser extent sciaenids (mean density = 15.4 larvae/100 m3) and hiodontids (mean density = 9.8 larvae/100 m3), increased in abundance. The greatest density of larval fishes in the Milk River occurred on July 9 (mean density = 180 larvae/100 m^3) when the density of catostomids was greatest (mean = 130 larvae/100 m^3). Cyprinids also exhibited a secondary peak in density on July 9 (mean = 22 larvae/100 m^3). Salmonids were sampled only on May 24 and May 30 at low densities (mean < 0.08 larvae/100 m^3). Ictalurids were represented during late samples (July 16 and July 26), but at low densities (mean < 3.1 larvae/100 m^3).

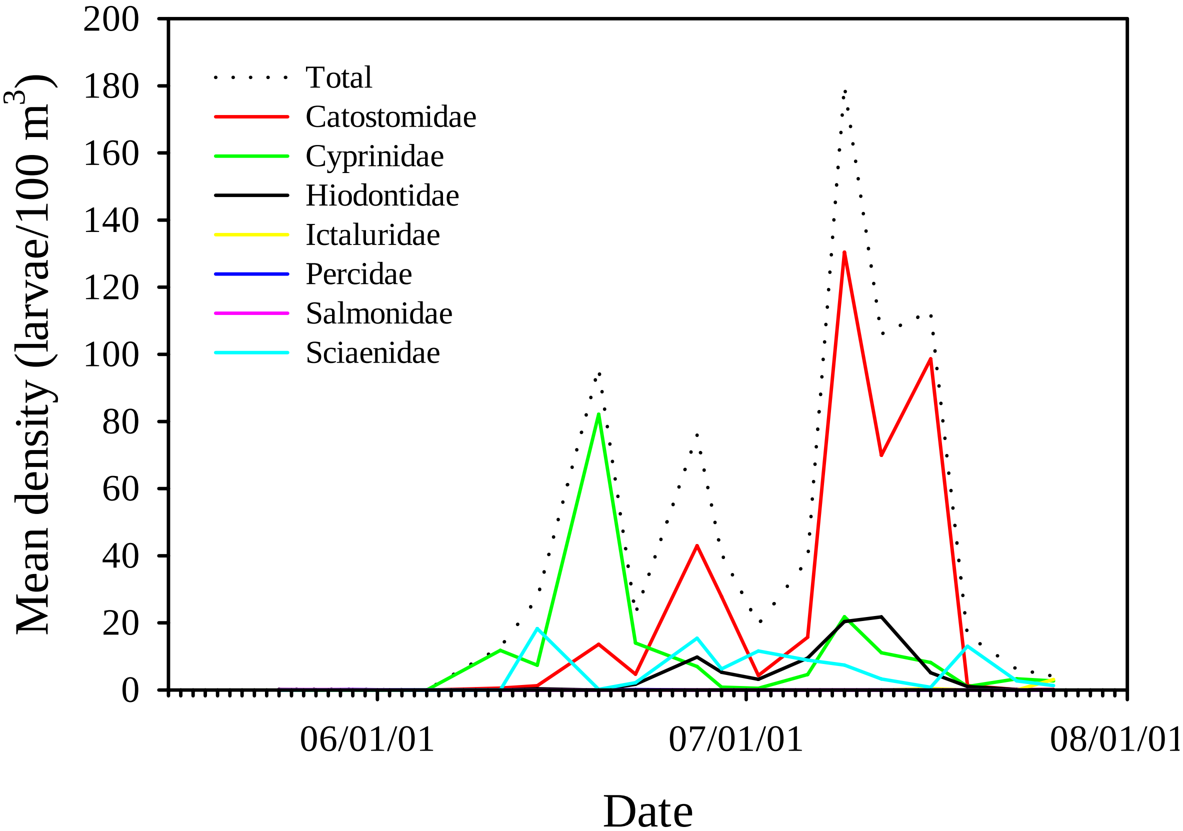


Figure 8. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Ictaluridae, Percidae, Salmonidae, and Sciaenidae sampled in the Milk River during 2001.

Temporal variations in the density of larval fishes at Wolf Point (mean 0.3 – 13.0 larvae/100 m^3) were primarily attributed to temporal changes in the abundance of catostomids and to a lesser extent percids and cyprinids (Figure 9). In early samples (May 25, May 29), percid (primarily *Stizostedion* sp.) densities averaged 0.9 – 1.2 larvae/100 m^3 and comprised 75 – 91% of the total density of larval fish. The second period of elevated densities occurred on June 11 as the density of catostomids increased to 2.8 larvae/100 m^3. The third peak in larval fish densities on June 19 (7.2 larvae/100 m^3) was associated with a continued increase in the density of catostomids (3.8 larvae/100 m^3) and a maximum density of cyprinids (2.9 larvae/100 m^3). After the June 19, densities of catostomids accounted for the majority of the larval fish sampled. Mean density of other taxa (i.e., Sciaenidae, Salmonidae, Ictaluridae, and Hiodontidae) did not exceed 0.71 larvae/100 m^3 on any sampling date.

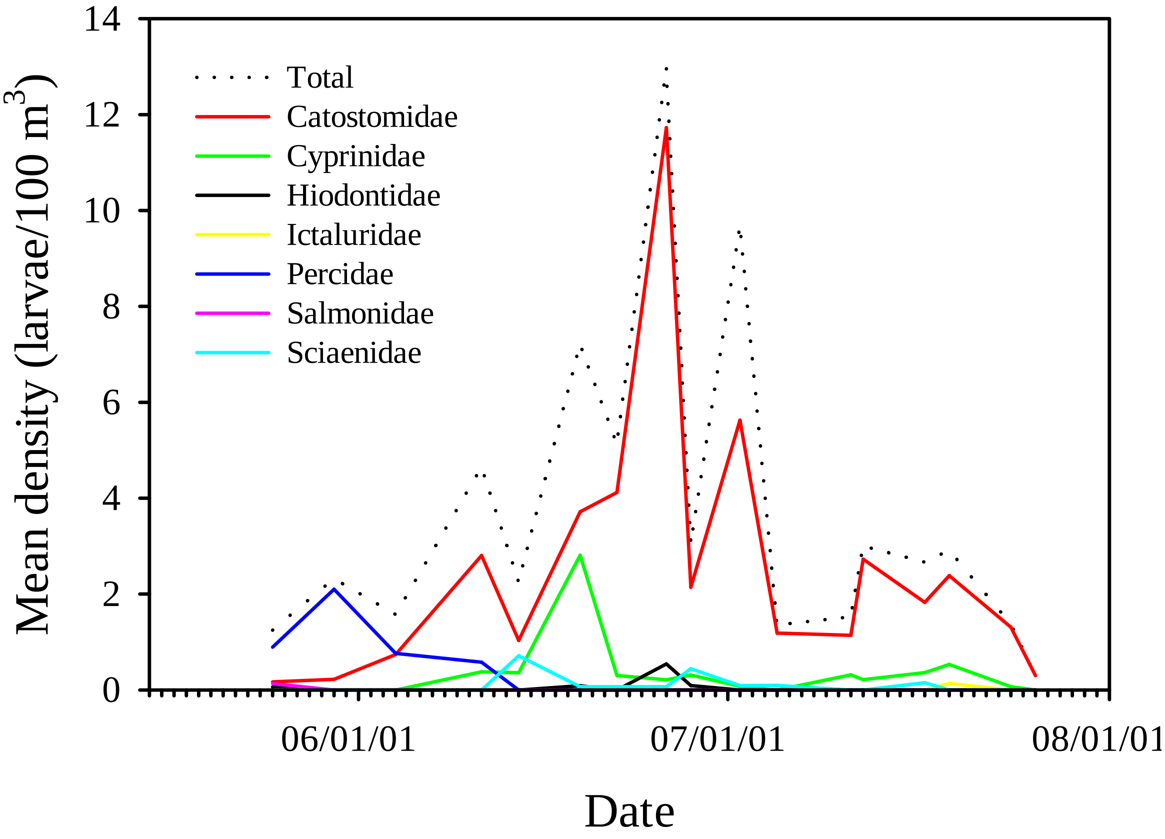


Figure 9. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Ictaluridae, Percidae, Salmonidae, and Sciaenidae sampled in the Missouri River at Wolf Point during 2001.

Mean density of larval fish at Nohly varied from 0 to 31.2 larvae/100 m^3 during the larval sampling period; however, two distinct modes in larval fish density characterized the periodicity and occurrence of larval fishes in the samples (Figure 10). On May 31, the larval fish community was comprised exclusively of percids (mean density = 26.8 larvae/100 m^3). Total density remained relatively low through June 21, then increased substantially on June 25 as catostomids (mean density = 13.5 larvae/100 m^3), cyprinids (12.0 larvae/100 m^3), and hiodontids (5.0 larvae/100 m^3) exhibited peak abundance. Densities of larval fish were low after June 25.

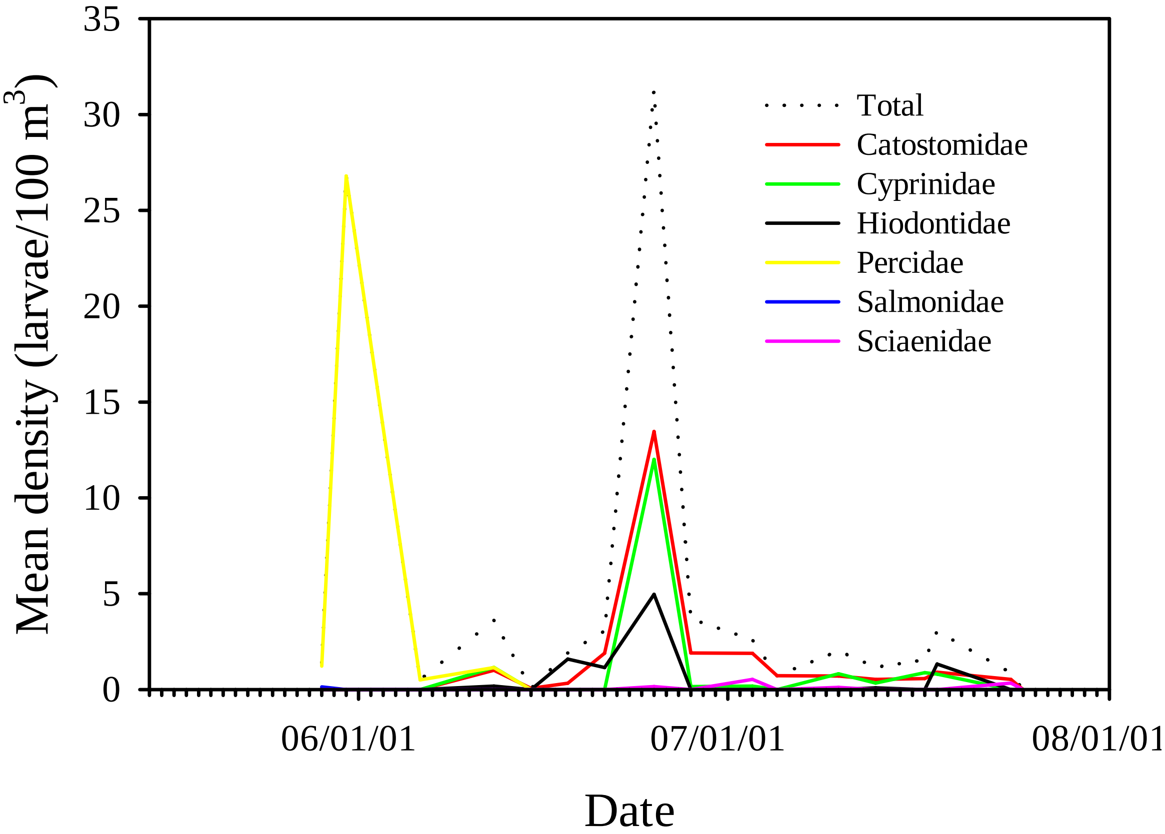


Figure 10. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Salmonidae, and Sciaenidae sampled in the Missouri River at Nohly during 2001.

Mean density of larvae fishes in the Yellowstone River varied from 0.6 larvae/100 m^3 on May 29 to 6.9 larvae/100 m^3 on July 10; however, temporal variations in larval density were primarily influenced by three taxa (Catostomidae, Hiodontidae, Cyprinidae) that exhibited cyclical periodicity in occurrence (Figure 11). Densities of Hiodonitidae and Catostomidae varied inversely on most sampling dates, and comprised 52-100% of the total densities through July 6. A shift in taxa composition occurred after July 6 when densities of catostomids peaked on July 10 (mean density = 5.9 larvae/100 m^3) and cyprinids exhibited a significant increase in density on July 13 (mean density = 2.4 larvae/100 m^3). Densities of other taxa (Centrarchidae, Percidae, Ictaluridae) in the Yellowstone River were low (≤ 0.5 larvae/100 m^3) throughout the sampling period.

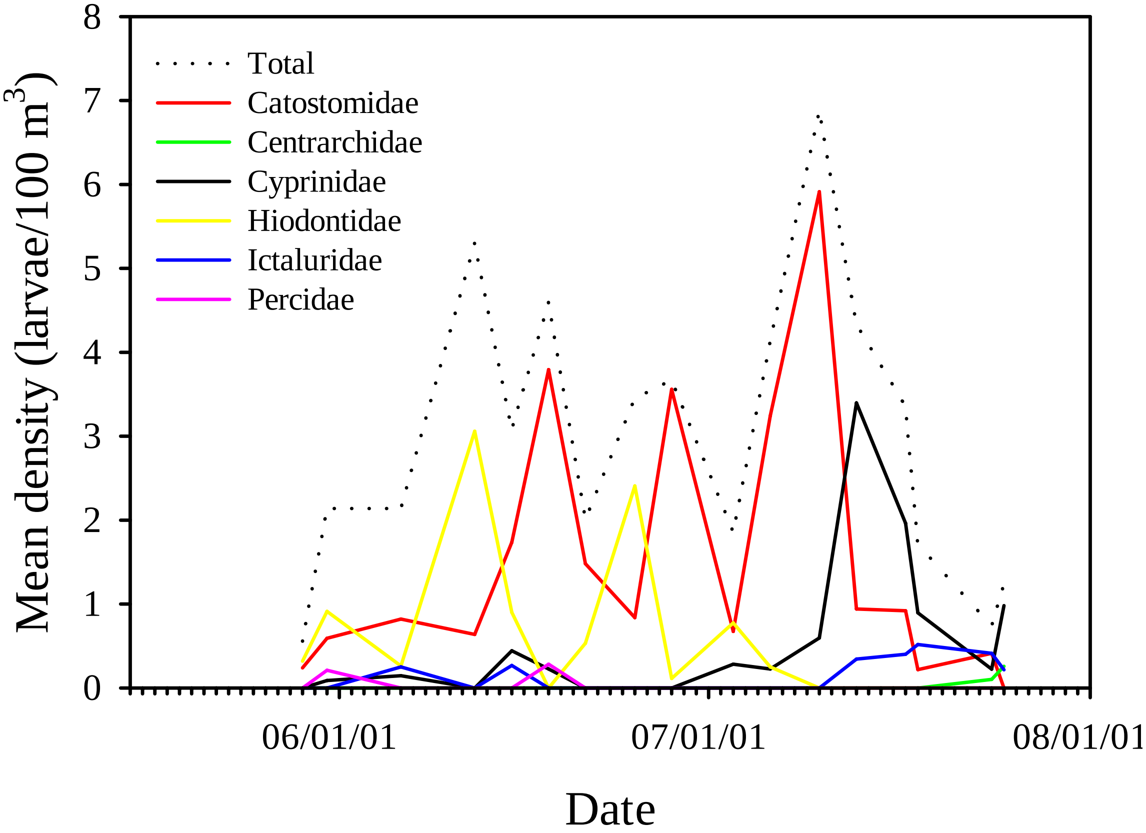


Figure 11. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Centrarchidae, Cyprinidae, Hiodontidae, Ictaluridae, and Percidae sampled in the Yellowstone River during 2001.

Monitoring Component 5 – Food habits of piscivorous fishes

Five burbot were sampled during July and August. Individuals varied from 335 mm to 456 mm (mean = 369 mm) and from 200 g to 425 g (mean = 247 mm). All five stomachs were empty; thus, no information on food habits was obtained.

Channel catfish were frequently sampled, and stomachs from 76 individuals were retained for diet analysis (Table 14). The sample of channel catfish covered a broad size distribution (mean length = 387 mm, 222 mm - 655 mm; mean weight = 550 g, 82 g – 3,000 g). Of the 76 stomachs obtained, 11 (14%) were empty. Diet material identifiable as fish (osteichthyes) or fish fragments (e.g., scales, bones) was found in 71% of channel catfish stomachs. Other organisms including orthopterans (e.g., grasshoppers), trichopterans (caddisflies), coleopterans (beetles), dipterans (true flies) and horsehair worms (Gordioida) were founded in greater than 10% of all stomachs. Representatives of ephemeroptera (mayflies), hymenoptera (ants, wasps), plecoptera (stoneflies), and decapoda (crayfishes) were found in less than 10% of the stomach samples. Detritus (e.g., algae, wood fragments) and miscellaneous material (e.g., sand, rocks) were found in 46% of all stomachs. Trichopterans and fish comprised greater than 20% of all ingested organisms on a numerical basis. On a weight basis, fish dominated the diet and comprised 63.4% of ingested material.

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 2001. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Coleoptera	23	13.8	0.4
	Diptera	11	6.7	0.3
	Ephemeroptera	9	2.8	0.1
	Hymenoptera	2	0.4	T
	Orthoptera	38	11.5	4.6
	Plecoptera	2	0.4	0.2
	Trichoptera	25	26.9	0.3
	Unknown	6	7.1	0.1
Crustacea	Decapoda	6	1.6	8.7
Osteichthyes	Unknown	71	20.6	63.4
Gordioida		11	8.3	0.1
Detritus		46		9.0
Miscellaneous		46		12.8
			Total number of organisms = 253	Total weight = 62.1 g

Stomach samples were obtained from 10 freshwater drum (Table 15). Freshwater drum varied from 290 mm to 450 mm (mean length = 372 mm) and 304 g to 1,400 g (mean weight = 780 g). All 10 stomachs from freshwater drum contained diet material. Seventy percent of the stomachs from freshwater drum contained fish or fish fragments. Of these, 20% of the stomachs contained identifiable common carp. Unknown fishes were found in 50% of the stomachs. Other diet components were found in 10-30% of the stomachs. Unknown fish or fish fragments comprised the greatest frequency (52.0%) on a numerical basis. Similarly, common carp and unknown fish and fish fragments cumulatively comprised about 80% of ingested material by weight.

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 2001. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Diptera	10	8.0	T
	Hemiptera	10	12.0	T
	Trichoptera	20	8.0	T
Crustacea	Decapoda	30	12.0	19.5
Osteichthyes	(all)	70		
	Common carp	20	8.0	40.2
	Unknown	50	52.0	39.6
Detritus		20		T
Miscellaneous		20		0.6
			Total number of organisms = 25	Total weight = 51.8 g

Stomachs from 91goldeye (mean length = 268 mm, 152 mm – 362 mm; mean weight = 171 g, 25 g – 339 g) were obtained for diet analysis (Table 16). Of the 91 stomachs obtained, 84 (92%) contained food items. Goldeye ingested a broad range of food items, but fish and fish fragments (58%), orthopterans (57%), and coleopterans (33%) had the greatest frequency of occurrence. The greatest number of individuals ingested included representatives from trichoptera (40.4%) and coleoptera (28.9%); however, orthoptera (55.9%) and fishes (23.5%) comprised the greatest proportion of food ingested based on weight.

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 2001. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Coleoptera	33	28.9	6.2
	Diptera	15	3.7	0.3
	Ephemeroptera	4	1.1	T
	Hemiptera	1	0.1	T
	Hymenoptera	5	0.8	0.1
	Odonata	2	0.3	0.6
	Orthoptera	57	14.3	55.9
	Trichoptera	18	40.4	4.2
	Unknown	17	1.7	2.8
Osteichthyes	Unknown	58	6.5	23.5
Gordioida		7	2.2	0.1
Detritus		11		1.3
Miscellaneous		21		5.0
			Total number of organisms = 757	Total weight = 64.9 g

A total of 59 stomachs was obtained from northern pike. The size distribution of northern pike included individuals varying from 285 mm to 1,140 mm (mean length = 642 mm) and 142 g to 8,550 g (mean weight = 2,055 g). Of the 59 stomachs obtained, 36 (61%) were empty. Northern pike were primarily piscivorous as indicated by the high frequency of occurrence (91%) of fish and fish fragments in the stomachs (Table 17). Of the prey fish ingested, common carp were found in 27% of the stomachs. Emerald shiners, flathead chubs, and northern pike were found 4% of the stomachs. Decapods and amphibians were found in 4% of the stomachs. On a numerical basis, common carp (38.6%) and unknown fish and fish fragments (48.6%) were the most common diet components consumed. Nearly 99% of the weight of food items ingested was comprised of fish. However, this proportion was strongly influenced by one 800-g northern pike that was found in the stomach of a 1,032 mm (7,000 g) northern pike.

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 2001. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Unknown	4	1.4	T
Crustacea	Decapoda	9	2.9	0.8
Osteichthyes	(all)	91		
	Common carp	27	38.6	18.6
	Emerald shiner	4	4.3	0.6
	Flathead chub	4	1.4	1.0
	Northern pike	4	1.4	64.5
	Unknown	83	48.6	14.1
Amphibia		4	1.4	0.4
Detritus		4		T
			Total number of organisms = 70	Total weight = 1240.5 g

Sauger sampled for diet analysis averaged 364 mm (178 mm – 511 mm) and 428 g (40 g-1,150 g). A sample of 47 sauger stomachs was obtained, and 14 (30%) stomachs were empty. Sauger were primarily piscivorous as 94% of the stomachs contained fish and fish fragments (Table 18). Of the fish consumed, common carp, emerald shiners, and goldeye were found in 3-6% of the stomachs. Unknown fish and fish fragments were found in 85% of the stomachs. The occurrence of coleopterans and emphemropterans in the diet was 3-6%. Numerically, unknown fish comprised 89.1% of all items ingested. Fish and fish fragments comprised 100% of the diet by weight of sauger, excluding trace contributions of other items.

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 2001. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Coleoptera	3	1.6	T
	Ephemeroptera	6	3.1	T
Osteichthyes	(all)	94		
	Common carp	6	3.1	4.2
	Emerald shiner	3	1.6	3.0
	Goldeye	3	1.6	0.9
	Unknown	85	89.1	91.9
Detritus		3		T
Miscellaneous		3		T
			Total number of organisms = 64	Total weight = 156.2 g

A sample of 29 stomachs was obtained for shovelnose sturgeon, and 1 stomach (3%) was empty. Shovelnose sturgeon averaged 551 mm (340 mm – 718 mm) and 771 g (114 – 1,850). Dipterans had the highest frequency of occurrence, and were found in 86% of all stomachs (Table 19). Other insect groups (ephemeroptera, orthoptera, trichoptera) were found in 7-36% of the stomachs. Fish and fish fragments occurred in 43% of the stomach samples. Similar to frequency of occurrence, dipterans comprised greater than 78% of the diet by number and weight. Ephemeroptera comprised 7.6-10.3% of the diet by number and weight. The high frequency of occurrence by number for shovelnose sturgeon was attributed to four individuals that had 945-2,538 larval dipterans in their stomach.

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 2001. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Diptera	86	92.0	78.1
	Ephemeroptera	36	7.6	10.3
	Orthoptera	7	T	0.1
	Trichoptera	29	0.3	0.3
	Unknown	11	T	0.8
Osteichthyes	Unknown	43	0.1	5.9
Detritus		32		1.7
Miscellaneous		36		2.7
			Total number of organisms = 9,769	Total weight = 27.8 g

A total of 34 stomachs was obtained from walleye. Walleye varied from 205 mm to 705 mm (mean length = 447 mm) and from 25 g to 2,450 g (mean weight = 942 g). Of the 34 stomachs obtained, 13 stomachs (38%) were empty. Walleye were primarily piscivorous (frequency of occurrence of fishes in the diet = 100%; Table 20). Insects (i.e. dipterans and ephemeropterans) were found in 5% of the stomachs. Of the fish consumed, common carp were identified in 19% of the stomachs. Common carp and fish cumulatively comprised 96.4% of all organisms in the stomach by number and 100% (excluding trace amounts) of all organisms by weight.

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 2001. T = less than 0.1%.

Diet component		Frequency of occurrence (%)	Frequency by number (%)	Frequency by weight (%)
Insecta	Diptera	5	1.8	T
	Ephemeroptera	5	1.8	T
Osteichthyes	(all)	100		
	Common carp	19	10.7	42.7
	Unknown	100	85.7	57.3
Detritus		5		T
			Total number of organisms = 56	Total weight = 181.9 g

Related Activities

Juvenile pallid sturgeon. Three hatchery-raised juvenile pallid sturgeon were sampled during 2001 in conjunction with monitoring activities. Juvenile pallid sturgeon were sampled near Wolf Point on September 12 (431 mm, 245 g, PIT tag number 424E2C054C), near Nohly on September 24 (440 mm, 255 g, PIT tag number 424E3F352E, and just downstream from the Yellowstone River confluence (370 mm, 151 g, PIT tag number 411D15473C).

Young-of-year sturgeon sampling. Benthic trawling was conducted on September 6 and 7 to sample young-of-year (YOY) pallid sturgeon and shovelnose sturgeon. Seven trawls were conducted between Nohly and the Yellowstone River confluence, and 37 trawls were conducted in the Missouri River from the Yellowstone River confluence to below the Highway 85 bridge rkm 2,500 (RM 1,553) in North Dakota. No YOY sturgeon were sampled upstream from the Yellowstone River confluence. Three YOY shovelnose sturgeon were sampled near rkm 2,541 (RM 1,578; 63 mm, 46 mm, 49 mm) and two YOY shovelnose sturgeon were sampled at the Highway 85 bridge (43 mm, 44 mm).

Discussion

Physical and biological data collected under the Fort Peck Data Collection Plan during 2001 provides baseline information that will be used to evaluate physical and biological changes resulting from modified flow releases. In addition to this information, baseline information collected by the Montana Department of Fish, Wildlife and Parks and the U. S. Fish and Wildlife Service will also be used to examine the influence of modified flow releases on pallid sturgeon and other native fishes.

Monitoring Component 1 - Water temperature and turbidity

Water temperature loggers deployed during 2001generally had a good level of precision and accuracy during water bath comparisons with the exception of the three aforementioned "suspect" loggers. However, accuracy and precision were generally greater at warm water bath treatment temperatures (e.g., > 20^{o}C) than at cooler treatment temperatures (< 15^{o}C). Warm water bath treatments were conducted at relatively stable room temperatures that created homeothermal conditions in the water bath; therefore, recorded values represented temperature in a minimally changing, homeothermal environment. When the water bath was moved outside into cooler conditions, it is possible that the water did not cool at the same rate throughout the water bath. As a consequence, loggers positioned near the edge of the water bath may have recorded a different temperature than loggers positioned near the middle of the water bath. Water temperature was measured with the YSI and alcohol thermometer near the middle of the water bath. Because the position of each logger was not recorded, it was not possible to more thoroughly address position-related variations in water temperature. In 2002, water temperature loggers will be subjected to additional pre- and post-deployment tests to examine precision and accuracy through a range of water temperatures.

Comparisons between water temperature collected during larval fish sampling and water temperature recorded by loggers near the larval fish sampling sites provided an extended (> 2 months) in situ assessment of logger accuracy. No significant differences in water temperature were found at five of six sites despite differences in measurement location (i.e., loggers recorded water temperature near the bottom, water temperature during larval fish sampling was measured in the upper 1-m of the water column). These results suggest the loggers maintained a high level of accuracy during the deployment period and that the water column was homeothermal. In contrast, water temperature differed between the logger and YSI at the site just downstream from Fort Peck Dam. A clear explanation for this difference is not known. Similar to 2001, water temperature measured during larval fish sampling in 2002 will be compared to logger data.

The good level of precision and accuracy exhibited by water temperature loggers (with the exception of the three suspect loggers) facilitates a discussion of lateral and longitudinal water temperatures recorded in 2001. Mean daily water temperature at nine sites did not differ significantly between left and right bank locations during the period when data from duplicate loggers were available (Table 7). These results suggest that the Missouri River was laterally homeothermal and that tributary inputs had minimal influence on lateral variations in water temperature during 2001. These conclusions are based on comparisons spanning the entire period from early May through October (at most sites); however, there were specific instances within the entire time period when lateral variations in water temperature occurred. For example, downstream from the Milk River at the Nickels Rapids site, water temperature near the right (north) bank on June 18 and July 16 was 1.9 - 2.3^{o}C warmer than near the left (south) bank. Increased discharges of warm water from the Milk River elevated water temperatures on the north bank due to incomplete lateral mixing of Milk River-Missouri River water at Nickels Rapids. Earlier studies have also shown that inputs from the Milk River differentially affect water temperature at downstream sites, but the effects are most prevalent in spring and early summer when the Milk River exhibits greatest flows (Gardner and Stewart 1987; Yerk and Baxter 2001).

Longitudinal water temperature profiles obtained during 2001 provided baseline data that will be used to evaluate the influence of Fort Peck flow modifications on water temperature. Between mid-May and mid-October, water temperature in the Missouri River upstream from

Fort Peck Lake averaged 7.1°C greater than directly downstream from Fort Peck Dam, and 1.2°C greater than at Nohly. Given natural increases in water temperatures from upstream to downstream that would be expected in the unmodified Missouri River (Galat et al. 2001) and other rivers (Allan 1995), water temperature should be greater at Nohly than upstream from Fort Peck Dam. However, despite 303 km (188 miles) of free-flowing river downstream from the dam, water temperature remained suppressed below ambient conditions upstream from the reservoir. Gardner and Stewart (1987) similarly found that June – September water temperatures below the dam, at Wolf Point, and at Culbertson were 8.0°C, 4.5°C, and 3.3°C lower, respectively, than water temperatures upstream from the reservoir. Specifically related to the Missouri River Biological Opinion (USFWS 2000), a primary goal of the Fort Peck Flow Modification project is to establish and maintain a minimum water temperature of 18°C at Frazer Rapids (rkm 2,811, RM 1746) during May and June. The maximum mean daily water temperature recorded at Frazer Rapids during 2001 was 17.2°C on July 16 and 17.4°C on July 17. In 2000, Yerk and Baxter (2001) similarly showed that the maximum mean daily water temperature at Frazer Rapids slightly exceeded 17.0°C in mid-July.

Turbidity measurements from late May through mid September provided a baseline assessment of spatial and temporal turbidity patterns. Fort Peck Lake serves as a sediment trap; therefore, turbidity was lowest at the site directly downstream from the dam. Inputs from the Milk River and other tributaries elevated turbidity at sites further downstream from Fort Peck Dam similar to conditions described by Gardner and Stewart (1987). On a temporal scale, changes in river discharge influenced turbidity at all sites except the site directly downstream from the dam. Elevated turbidities typically occurred on the ascending limb, peak, or descending limb of the hydrograph. Hourly turbidity measurements recorded by the turbidity loggers provided a more refined examination of relations between discharge and turbidity. For example, mean daily turbidity in the Yellowstone River increased rapidly as discharge increased; whereas, mean daily turbidity at Nohly increased as discharge declined by about 2,000 cfs. Declines in discharge flush organic material and organisms from dewatered backwaters and side channels into the main channel (Modde and Schmulbach 1977). This process may partially explain the turbidity increase at Nohly concomitant with the declining hydrograph. It should be noted that the increase in turbidity that occurred at Nohly in early September (15 – 103 NTU) was small in comparison to discharge-related variations in turbidity that occurred between late May and August (e.g., 40 – >1000 NTU).

Limited comparisons of turbidity measured with the Hach turbidimeter and turbidity loggers suggested accuracy of the turbidity loggers was good during the limited deployment period. However, periodic field observations indicated the turbidity loggers accumulated debris in their flowing water locations that could influence the accuracy of turbidity measurements. Turbidity loggers deployed in 2002 – 2004 will be cleaned on a weekly basis to maintain measurement accuracy. In addition, pre- and post-deployment calibrations will be conducted.

Monitoring Component 2 – Movements by pallid sturgeon

Pallid sturgeon were not found in the Fort Peck tailwaters in winter 2001. The last recorded observation of pallid sturgeon in the tailwaters occurred in 1996 (Liebelt 1998) when three individuals were captured by SCUBA. However, anecdotal information from an independent diver reported that pallid sturgeon were observed in the tailwaters in winter 1997. Attempts to locate and capture pallid sturgeon for transmitter implantation will continue in the tailwaters throughout the duration of the study. Information on seasonal movements of pallid sturgeon from the tailwaters would be complimentary to existing movement-related studies being conducted by the USFWS in the Missouri River-Yellowstone River confluence area.

Monitoring Component 3 - Movements of paddlefish, blue suckers, and shovelnose sturgeon

Similar to pallid sturgeon, paddlefish, blue suckers, and shovelnose sturgeon are migratory during the spawning season, respond to discharge and thermal cues for spawning migrations, and spawn in gravel substrates (Breder and Rosen 1966; Needham 1979; Berg 1981; Penkal 1981; Moss et al. 1983; Hurley et al. 1987; Gardner and Stewart 1987; Pflieger 1997; Bramblett and White 2001). Successful implantation of transmitters in paddlefish, blue suckers, and shovelnose sturgeon was a critical first-step towards examining biological response of native Missouri River fishes to changes in the operations of Fort Peck Dam. Beginning in late April or early May 2002, individuals will be manually tracked at 1 – 4 day intervals through June and perhaps longer. Manually tracking efforts will be complimented by a network of seven fixed logging stations that will continuously monitor fish movements in the Missouri River between Fort Peck Dam and the confluence of the Yellowstone River. Additional logging stations operated by the USFWS in the lower Missouri River and Yellowstone River may also be used to record discharge- and temperature-related movements.

Monitoring Component 4 – Larval Fish

The number of larval sturgeon sampled during 2001 (Wolf Point = 6; Nohly = 10; Yellowstone River = 8) generally exceeded numbers reported in earlier studies, but the number of larval paddlefish sampled during 2001 (Milk River = 1; Wolf Point = 8; Nohly = 4; Yellowstone River = 24) was generally similar to earlier investigations. For example, in samples conducted during 1994, Liebelt (1996) reported that no larval sturgeon were sampled at Wolf Point and only four sturgeon were sampled near Nohly. The Yellowstone River was not sampled in 1994. Samples conducted during 1995 resulted in one larval sturgeon near Nohly and nine larval sturgeon in the Yellowstone River (Liebelt 1996). In 1996, three larval sturgeon were sampled in the Yellowstone River, but none were sampled at Wolf Point or Nohly (Liebelt 1998). Liebelt (2000) sampled one larval sturgeon at Nohly during 1999, but did not sample any sturgeon at Wolf Point or in the Yellowstone River. Larval fish sampling was not conducted at Nohly or in the Yellowstone River during 2000, and only one larval sturgeon was sampled at Wolf Point in 2000 (Yerk and Baxter 2001). For paddlefish, Liebelt (1996) sampled three individuals at Nohly during 1994, but did not sample any larval paddlefish in the Milk River or at Wolf Point. Liebelt (1996) sampled 47 larval paddlefish (15 at Nohly, 32 in the Yellowstone River) during 1995. In 1996, two larval paddlefish were sampled in the Yellowstone River, seven larval paddlefish were sampled upstream from the Yellowstone River confluence (presumably in the Wolf Point, Culbertson, and Nohly areas), and no larval paddlefish were sampled in the Milk River (Liebelt 1998). Samples conducted during 1999 resulted in the collection of one larval paddlefish in the Milk River, three in the Yellowstone River, but no larval paddlefish were sampled at Nohly (Liebelt 2000). In 2000, one larval paddlefish was sampled at Wolf Point, but no larval paddlefish were sampled in the Milk River (Yerk and Baxter 2001). Differences in the number of larval sturgeon and larval paddlefish collected among studies may be due to several factors including differences in sample number and sample intensity among studies, and annual variations in spawning success related to inter-annual variations in discharge and water temperature regimes.

The temporal periodicity of larval sturgeon and paddlefish observed in 2001 was consistent with species-specific spawning characteristics. Because paddlefish spawn at lower water temperatures than sturgeon (Wallus 1990; Yeager and Wallus 1990), concentrations of paddlefish generally occurred earlier during the larval fish sampling period as evidenced by results from Wolf Point and the Yellowstone River. Although there were similarities in the periodicity of larval paddlefish and larval sturgeon between sites, concentrations of sturgeon larvae typically appeared earlier in the Yellowstone River than at sites in the Missouri River. Concentrations of larval sturgeon were sampled in the Yellowstone River from late June through July; whereas, concentrations of larval sturgeon did not occur until early July at Nohly and mid July at Wolf Point. In earlier studies, larval sturgeon were first sampled upstream from the Yellowstone River confluence on July 16, 1999 (Liebelt 2000), on July 18 – 19, 2000 at Wolf Point (Yerk and Baxter 2001), at Nohly on July 8 – 14, 1994 (Liebelt 1996), in the Yellowstone River on June 15 –16, 1995 (Liebelt 1996), and in the Yellowstone River on July 9 – 12, 1996 (Liebelt 1998). Warmer water in the Yellowstone River likely promotes earlier spawning by sturgeon in comparison to the Missouri River at Nohly and Wolf Point where water temperature increases are delayed. Larval fish sampling in subsequent years will more thoroughly investigate this hypothesis especially in regard to modified flow releases from Fort Peck Dam.

Statistical analyses examining spatial and temporal patterns in taxa composition and larval density will be conducted following fieldwork in 2002, 2003, and 2004. However, larval fish data collected in 2001 provides preliminary information that can be evaluated in the context of earlier studies. Similar to our results, earlier studies have also found that the least number of larval fish taxa typically occurs in the coldwater reaches directly downstream from Fort Peck Dam and that taxon composition increases in mainstem or tributary locations with warmer water temperatures (Gardner and Stewart 1987; Liebelt 2000; Yerk and Baxter 2001). Pooled among sampling periods, catostomids dominated the larval fish community at all sites and comprised 40% (Nohly) to 90% (downstream from Fort Peck Dam) of the larval fishes sampled. Gardner and Stewart (1987) similarly reported that catostomids comprised 100% of the larval fishes just below Fort Peck Dam, and 39% of the larval fishes sampled near Culbertson (their sampling station closest to Nohly). Stewart (1983) also found that catostomids comprised about 90% of the larval fish sampled at 25 sites in the mainstem Missouri River downstream from Fort Peck Dam.

Earlier larval fish studies did not sample at the same intensity as was conducted during this study; therefore, it is not appropriate to directly compare densities of larval fish obtained in this study with densities obtained in earlier studies. Nonetheless, qualitative comparisons can be made. In this study, greatest densities of larval fishes occurred in mid to late June at sites downstream from the dam, at Wolf Point, and at Nohly (with the exception of Percidae). Maximum densities in the Milk River and spillway occurred in early to mid July. Maximum density of larval fish in the Yellowstone River occurred in early July, but earlier samples also had high densities. Gardner and Stewart (1987) found highest densities of larval fish occurred during June in three of four years. Averaged across sampling periods, Gardner and Stewart (1987) reported average densities of larval fish in 1979 were 0 larvae/100 m^3 below Fort Peck Dam, 8.7 larvae/100 m^3 in the Milk River, and 0.2 larvae/100 m^3 at Wolf Point and Culbertson. In larval fish sampling conducted in 2000, Yerk and Baxter (2001) reported mean densities of 0.3 fish/100 m^3 below Fort Peck Dam, 11.5 larvae/100 m3 in the Milk River (only one date), and

2.1 larvae/100 m^3 at Wolf Point. Trends in larval fish densities during 2001 were similar as mean density across sampling periods was lowest downstream from the dam (0.9 larvae/100m^3), increased in the Milk River (44.6 larvae/100 m^3), then declined at Wolf Point (3.7 larvae/100 m^3) and Nohly (4.9 larvae/100 m^3). The annually consistent larval fish sampling protocols outlined in the Fort Peck Data Collection Plan, in conjunction with larval fish information generated from the existing WAPA-supported monitoring program, will provide a comprehensive understanding of how changes in Fort Peck Dam operations influence spawning success of sturgeon, paddlefish, and other native Missouri River fishes. These studies will more stringently address the hypothesis that reproductive success and densities of larval fishes are directly related to river discharge (Gardner and Stewart 1987). In addition, we have initiated a power analysis of the 2001 larval fish data set to guide larval fish sampling activities in 2002, 2003, and 2004. For example, the analysis will help determine whether the existing effort (e.g., subsamples, replicates) in the context of sample variance provides sufficient power to detect inter-annual differences in larval fish density. Results from this analysis will be prepared by May 15, 2002.

Monitoring Component 5 – Food habits of piscivorous fishes

The primary impetus for this monitoring component was to determine whether sturgeon larvae and juveniles are consumed by the piscivore fish assemblage in the Missouri River. In 2001, stomach contents from all species except burbot contained identifiable fish or miscellaneous fish body parts; however, there was no evidence of piscivory on sturgeon. Fish parts were primarily scales and ossified bone – skeletal features not characteristic of sturgeon.

Variations in the diet of species sampled in this study were evident. Fish comprised greater than greater than 63% of the biomass of ingested items in channel catfish, freshwater drum, northern pike, sauger, and walleye; whereas, orthopterans comprised nearly 60% of the diet biomass in goldeyes. Dipterans comprised about 78% of the diet biomass in shovelnose sturgeon. In a Missouri River backwater downstream from the Yellowstone River, Fisher et al. (2001) found fishes comprised 49 – 100% of the wet mass diet in sauger, northern pike, and walleye during July. Contrary to our findings, Fisher et al. reported that corixids and coleopterans were the dominant food item in goldeyes, and that chironomids comprised 36 – 58% of the diet in freshwater drum. For channel catfish, Fisher et al. (2001) found that individuals 400 – 549 mm fed predominantly (44%) on coleopterans, but individuals greater than 549 mm fed predominantly (47.1%) on fish. Similar to our study, Stewart (1983) and Gardner and Stewart (1987) found sauger in the Missouri River downstream from Fort Peck Dam fed predominantly on fishes during the summer. For shovelnose sturgeon, Gardner and Stewart (1987) found individuals fed predominantly on dipterans. Piscivores will be sampled in late June, July, and August of 2002. A more complete analysis and discussion of piscivore food habits will be presented following completion of 2002 field activities.

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