APPENDIX L
FORT PECK BIOLOGICAL MONITORING DATA

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Movements and Habitat Preferences of Adult Post Spawn Pallid Sturgeon
Pallid Sturgeon Telemetry Study

2001 Progress Report

by

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Introduction

This progress report summarizes telemetry research field activities conducted in the 2001 field season in accordance with the US Fish and Wildlife Service's (USFWS), Post Spawn Pallid Sturgeon Telemetry Study. Funding for this project has been provided by Western Area Power Administration (WAPA), the US Army Corps of Engineers (USACE) and the USFWS.

Due to limited amounts of data concerning post spawn movements of pallid sturgeon, the USFWS initiated a long term study in an attempt to answer some of the unresolved questions about these unique, native river fish.

The main goals of this study are to monitor post spawn migrational movements to help identify pallid sturgeon spawning areas, determine pallid sturgeon response to " Spring Test Flows " out of Fort Peck Dam to see if mimicking natural flows will expand pallid use and habitat into the Missouri River above the confluence of the Yellowstone River, and to evaluate reproductive stages of known post spawn females. We also hope telemetered pallid sturgeon will serve as an important tool for future broodstock capture by utilizing and netting possible aggregations in relation to telemetered fish as Tews (1993) demonstrated during fall tagging. Netting additional fish and marking them with Passive Integrated Transponder (PIT) tags will also serve to help strengthen current population estimates.

Study Area

The pallid sturgeon study area (See Figure 1, for core study area), for the most part, is a semi-confined stretch of approximately 290 river miles encompassing the Missouri River from Fort Peck Dam to the head waters of Lake Sakakawea and from the Yellowstone River confluence (~ RM 1582.0) up the Yellowstone River to the Intake Diversion Dam, Intake, Montana.

Within our study core area, we placed three fixed data logging stations to shorten tracking zones into more manageable reaches. This served dual purposes because it aided researchers in tracking fish and gives us continual movement data within this area.

As suggested in the Post Spawn Telemetry Study Plan, fixed data logging station locations had to be adjusted due to a variety of factors, but eventually all three stations were placed in well suited areas that met the criteria needed to work effectively. Our first station initially was placed up the mouth of the Yellowstone River a few hundred yards (576506 E, 5314283 N) adjacent to or above the confluence on the west river bank below the high water line. Later in the summer, it was moved to the east bank on private property, due to low water conditions. The second station, which is identified as the Fort Union Station (586880 E, 5315030 N), is approximately five river miles up the Missouri River above the confluence, and as its name suggests, lies due east of Fort Union State Park on the north shore of the Missouri River on State owned land . The third station was located down the lower Missouri River approximately 11 river miles below the confluence and is adjacent to the Erickson Island State Game Production Area. The Erickson Island Station is located on the north shore of the management area (572089 E, 5316011 N).

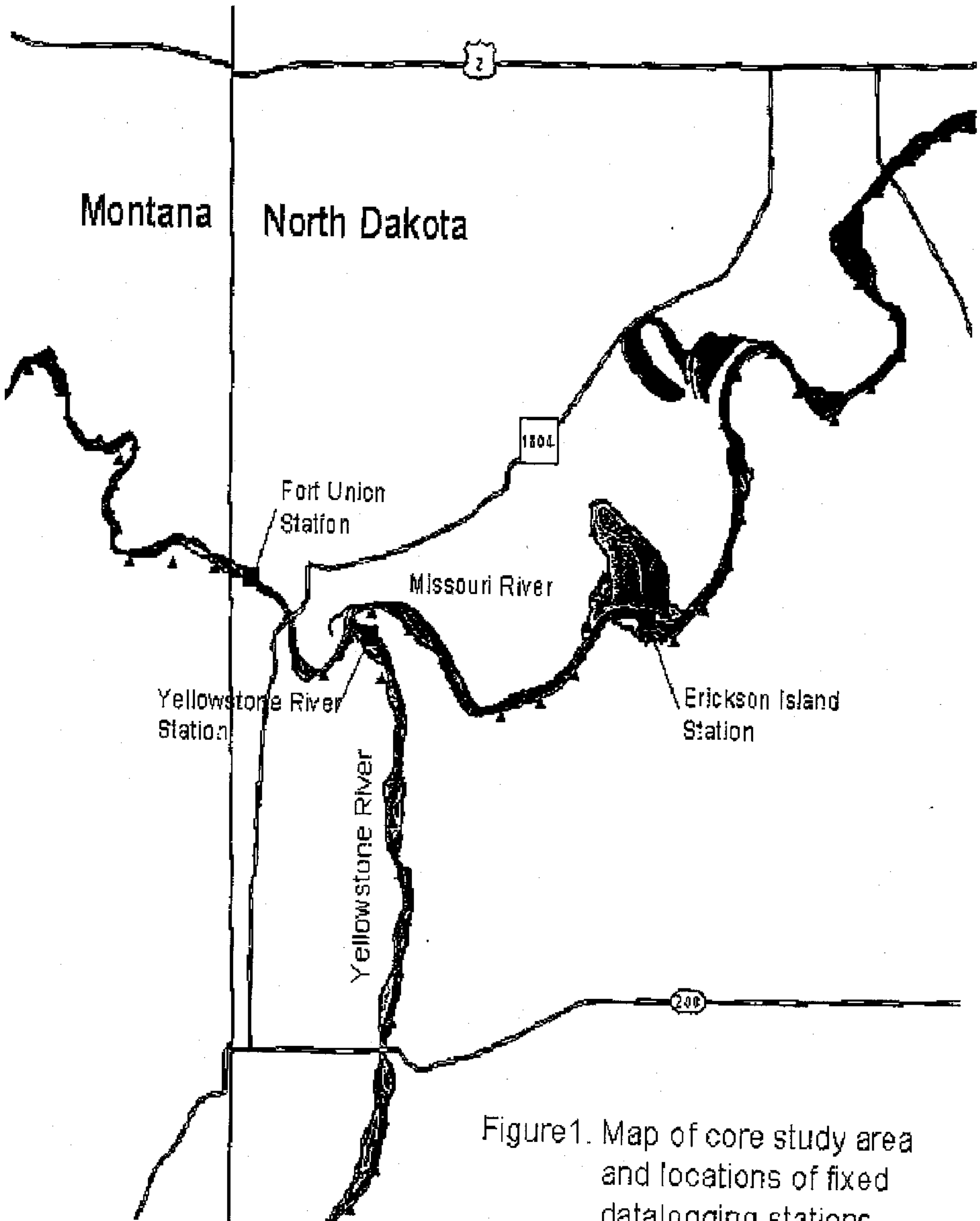

Figure1. Map of core study area and locations of fixed datalogging stations.

Methods

Adult pallid sturgeon used for our telemetry study are products of the 2000 and 2001 spawning activities performed at Garrison Dam National Fish Hatchery (GDNFH 2000), Riverdale, North Dakota, and the Miles City State Fish Hatchery (2001) at Miles City, Montana.

Crews from Montana Fish, Wildlife and Parks (MTFWP), Fort Peck Field Office, and the USFWS, Bismarck, North Dakota, worked cooperatively to provide hatcheries with gravid broodstock pallid sturgeon. Fish were collected by drifting 150' long by 6' high trammel nets with two panels (6" inside panel and 10" outside panel) along the bottom of the river with one end connected to the boat and the other end free floating. Predominantly, most pallid sturgeon were caught within the true confluence of the two rivers or directly downstream in the lower Missouri within a few hundred yards of the confluence, as well as a few hundred yards up the Yellowstone River.

Once a fish was netted, the pallid sturgeon was brought back to the boat ramp where morphometric and meristic data were taken. In addition, the fish was staged by hatchery personnel (Rob Holm, GDNFH) to assess if it was a male or female, gravid or nongravid, and whether the fish would be transported to the hatchery for propagation purposes. If found to be a candidate for propagation, the fish was vaccinated with an antibiotic (Biomyocin) and loaded on a fifth wheel distribution trailer and transported to the appropriate hatchery.

The "Class of 2000" fish were spawned at GDNFH on June 14, 2000, and telemetry transmitters were surgically fitted at the hatchery on August 28. Ten fish, two females and eight males were tagged with transmitters (Table 1). These fish were kept at the hatchery to recover from the induced stress caused by handling at spawning time, as well as the surgical procedures used to deploy tags. The pallids were returned to the confluence on October 10 through the 12, 2000.

Due to the virus issues associated with GDNFH, the Upper Basin Pallid Workgroup decided that 2001 pallid sturgeon spawning would take place at the Miles City State Hatchery in Miles City, Montana. Six fish (Class of 2001, Table 2) were spawned at Miles City hatchery on June 26th, 2001. Due to room shortage at the hatchery, fish were surgically tagged on July 3 and were returned to the confluence on July 9 and 10, 2001. Unfortunately, one of the female pallid sturgeon died after tagging, thus leaving one female and four males to return back to the river for study purposes. (A total of 15 were tracked during the study).

Pallid sturgeon were surgically implanted with Combined Acoustic Radio Transmitters (CART), manufactured by Lotek Engineering Inc. of New Market, Ontario. The transmitter utilized in the study, Model CART 32_1S, is an internal tag with an external antennae (~ 18 inches) with a listed longevity rate of five years, based on a five second burst rate. Diameter of the tag is 32 mm in length, and weighs 61.0 grams (weight in water).

We chose to employ CART tags to utilize the dual aspect of the tags, using the radio aspect in wide shallow reaches of the river or in and around island complexes, and using the sonic aspect in deep, highly turbid areas where radio telemetry would be compromised.

Name	Code	Sex	PIT tag #	Weight in Pounds	Weight in Kilograms	Fork Length in Inches	Fork Length in Millimeters
Art	18	M	1F4849755B	33	14982	51	1295
Al	22	M	1F4A004552	26	11793	52	1335
Annie	25	F	1F47715752	55	24970	62 +	1580
Andre	26	M	7F7B081579	32	14528	56	1444
Alex	34	M	115525534A	36	16344	55	1404
Aaron	38	M	1F477B3A65	45	20430	57+	1468
Arnie	44	M	2202236E31	61	27694	60+	1542
Archie	46	M	1F4A33194B	45	20340	57+	1468
Andrew	50	M	1F4A143350	28	12712	53+	1352
Amber	62	F	115713555A	57	25878	59+	1516

Table 1. Class of 2000. Pallid sturgeon tagged and spawned in 2000 at the Confluence of the Yellowstone and Missouri Rivers. Name, code, sex, Pit tag numbers, weight, and lengths are listed.

Name	Code	Sex	PIT tag #	Weight in Pounds	Weight in Kilograms	Fork Length in Inches	Fork Length in Millimeters
Butch	2	M	1F4A27214F	50	22657	61	1541
Bridget	10	F	220E345E09	61	27971	63+	1615
Bart	14	M	115631222A	29	13257	52+	1340
Bob	116	M	7F7D3C5708	30	13714	55+	1405
Ben	144	M	1F4A111C6A	43	19657	55	1394

Table 2. Class of 2001. Pallid sturgeon tagged and spawned in 2001 at the Confluence of the Yellowstone and Missouri Rivers. Name, code, sex, Pit tag numbers, weight, and lengths are listed.

CART tags also work exclusively with Lotek receivers and fixed data logging stations, allowing researchers to download movement and direction data of individual fish to support manual tracking.

CART tags were surgically implanted using a combination of methods of Bramblett (1996), Clancey (1992), and procedures implemented by researcher's listed in the Hatchery Manual for the White Sturgeon (Conte et al.1988). The only deviation from past researchers methods was the addition of anesthetizing the incision with a local anesthetic (lidocaine), to lesson stress. In addition, an application of SuperGlue was applied to incisions and sutures to help seal tissue together and strengthen suture knots. The use of the local anesthetic seemed to have a positive effect on pallid sturgeon, as most fish seemed to be more docile during the initial incision and insertion of tags.

To ensure CART tags were operating properly, tags were tested on three different occasions with the accompanying SRX_400 W5 Lotek receiver. All tags were tested and cycled upon arrival of shipment in Bismarck, ND, tested upon insertion into the fish at the previously mentioned fish hatcheries, and finally retested again at the boat ramp before fish were released back into the wild at the Confluence of the Yellowstone and Missouri Rivers. All fifteen tags performed perfectly on all occasions and hopefully will continue to do so long-term.

We tracked fish from April until October at two different tracking intensities. In April, May, and June, we tracked fish extensively five days per week throughout the entire three month time span to try to maximize locations per fish during spring flows and suspected spawning periods. Beginning in July, we went to a less aggressive tracking regime consisting of tracking for five days every three weeks throughout the rest of the field season until October 8, when fixed data logging stations were removed from the river.

Typical tracking protocol consisted of traveling daily to all three fixed datalogging stations to download movement data which assisted in ascertaining directions of individual fish. This helped determine the section of river to be sampled. For the majority of the tracking season, the acoustic aspect was utilized exclusively for relocating tagged fish. Relocation of fish was accomplished by lowering the 360 degree hydrophone beneath the bottom of the boat, floating for approximately two minutes, then raising the hydrophone and powering down river 300 meters, and repeating this process until we found a fish or finished sampling a study section.

Upon receiving signals from a fish, a handheld baffled 180 degree directional hydrophone was used to home in on the coded pallid sturgeon. Several drifts were then made to get directly above the fish and to obtain a power signal from our SRX_400 receiver of 200 or above with a gain reading of zero percent. Once a power rating of 200 or above was achieved and maintained, we anchored above the fish and started recording data.

Relocation data included fish name, code number, date and military time of location. A Global Positioning System (GPS) waypoint was taken with a Rockwell Precision Lightweight PLGR+96. Waypoint numbers, as well as their corresponding Easting and Northing values were recorded into a field logbook in case PLGR+96 data was lost or erased before it could be downloaded.

A fish's physical location also was noted in the field logbook. Two different categories were used: 1) main channel or side channel, main channel inside bend, and main channel outside bend, and 2) whether the fish was associated with main or side channel island, main or side channel upstream of island, and main or side channel downstream of island.

Additionally, depth, water temperature, and turbidity were also recorded. Turbidity was measured with a handheld Hach 2100P Portable Turbidimeter and data was recorded in NTU's. A laminated field map also was utilized to record rivermiles which were used to backup GPS values and provide quick reference of past locations. Flow data downloaded weekly from the United States Geological Survey's (USGS) Sidney and Culbertson gauging stations was also added to the logs.

Finally, a small, rough map was sketched in the field logbook to help document yardage values to islands, sandbars, nearest shore, far shore, and total distance of river width. Yardages were determined with a Bushnell Laser Rangefinder, model Yardage Pro 1000. All data collected in the field was later entered into an EXCEL spreadsheet which is compatible for exporting files into various statistical programs.

Results and Discussion

Due to different unanswered questions concerning the feasibility of the long term Pallid Sturgeon Telemetry Study, the 2001 field season was converted into a "pilot phase" for upcoming research. Concerns were raised about effectiveness of equipment at the Fort Peck coordination meeting, as fixed data logging stations are somewhat of a new concept for this part of the region and our water quality parameters. Contingent on effectiveness of Lotek's telemetry equipment, another profound concern was whether biologists could relocate individual fish effectively, or enough times to provide adequate samples for statistical analysis. For these reasons, coupled with the fact that USACE warm water flow tests have been delayed due to low water conditions until 2003, a pilot phase at this juncture afforded us time to answer questions and collect important baseline movement data.

An important aspect of the pilot study phase of this project was to evaluate the functionality of the fixed datalogging stations, assess their proper placement to fragment study zones, and to measure overall usefulness in remotely collecting large amounts of data during times of the year when biologists are not on the river. On April 17 and 18, fixed datalogging stations were installed with the help of a multi-agency effort on the Missouri and Yellowstone Rivers. Personnel from MTFWP, USGS, and the North Dakota Game and Fish Department (NDGFD) all played roles in the deployment of stations. WAPA provided funding to our telemetry project by covering expenses for technological representatives from Advanced Biotelemetrics Inc. (ABI) from New Market, Ontario, to help in the initial setup of the telemetry station equipment. Doctor Richard Booth and Eric Bombardier of ABI spent four days aiding in fixed datalogging station setup, assisting in the calibration of station receivers, providing technical support concerning trouble shooting problems, and rendering much useful information on tips and techniques pertaining to our project.

The Fort Union and the Yellowstone Stations were set up to monitor both acoustic and radio frequencies, while the Erickson Island Station was set up experimentally to monitor acoustic only. Overall, all three stations performed to our satisfaction and much valuable movement data was collected throughout the course of the tracking field season. The Erickson Island Station proved to be our most consistent and trouble-free unit throughout the field season, most likely because of its location and single frequency scanning. The other two stations performed well, except for a couple of different time spans when we experienced technical difficulties with power sources and receivers shutting down. Unfortunately, during one of the time spans, both of the stations shut down simultaneously, resulting in the loss of valuable directional and movement data for a few fish over a 60 to 90-day period. We believe we have resolved the power source issue for the upcoming field season and will monitor it closely.

As mentioned previously in the report, our tracking regime primarily used the acoustic aspect for relocating tagged pallid sturgeon, with the exception of a brief period in October when water quality parameters were conducive to using radio frequency. Although the dual combined acoustic/radio aspect is supposed to be the strong point of Lotek's CART tag; unfortunately, we were unable to utilize the radio frequency most of the time due to water quality factors. This was most prevalent in the Yellowstone River where turbidity, total dissolved solids, and conductivity levels proved to be too high for optimum efficiency, therefore, we questioned the effectiveness of this aspect to locate fish.

However, within a short window of time this past fall we had varied success using the radio frequency to locate pallids by use of a boat under power (3000 rpm's). We ran the Missouri River from the confluence down to the Highway 85 bridge and found eight pallids using radio only. Using buoys to mark transmitters, we conducted some distance/depth tests to get a better grasp on the pros and cons of these tags. Relative to range, upstream detection of the tags was relatively poor, around 50 to 80 yards, while approaching the fish from downstream resulted in detection ranges of 150 to 330 yards. The most likely explanation might be that the fish were pointed upstream, thus blocking the signal with the body, versus coming from behind the fish and getting a better signal from the more exposed dangling antenna. Favorable water quality parameters were probably responsible for the limited success at that time; conditions were definitely more favorable than they had been all season.

All radio observed fish were found in eight feet of water or less, turbidity averaged around 20 NTU's, and the conductivity hovered around 560 to 590. Unfortunately, we don't see these kind of physical characteristics very often. Although the radio aspect has limitations, there are definitely applications when it could prove to be useful, especially during low flow and low turbidity conditions. Another useful application of the radio aspect is for diel movement information once we are on top of a fish. Using it for close range telemetry should not be a problem.

Manual tracking acoustically is more labor and time intensive, but proved to be highly effective for relocating fish in both river systems. Typically, we could start detecting signals of fish 300 to 400 yards away, and have occasionally picked up signals as far away as 600 yards. With these types of ranges, we felt highly confident about our method of acoustic sampling.

Two hundred thirty seven observations were made during the 2001 pilot study field season, 72 relocations by boat and 165 observations at fixed datalogging stations. This number of observations probably is a fairly low representative of relocation numbers that should be achieved in the future, based on the fact our manual tracking didn't officially start until May and we had several problems with our boat and hydrophones late in the summer.

Fourteen of 15 fish surgically implanted with internal CART tags were relocated during the pilot study. The only fish unable to be located was Aaron (# 38), a 27-pound male from the class of fish released in 2000. Upon his release in the fall of 2000, he was followed for a couple of days along with the rest of the study group and exhibited the same behavior as other tagged and released pallid sturgeon. A few possible explanations for the absence of #38 in 2001 exist. The fish may have moved out of the study area into reaches of the Upper Missouri River or the head waters of Lake Sakakawea or, simply the CART 32_1S tag may have stopped working after the fall of 2000. Another theory existing may be that the tag was expelled from the fish and buried in sediment or sand.

A large majority of the study group stayed within the confines of the lower nine miles of the Yellowstone River. Most spent considerable amounts of time around the confluence, and ranged down the lower Missouri River to the Highway 85 Bridge near Williston, North Dakota. Although Annie (# 25), was never located by boat in the Yellowstone River, she roamed extensively and set the upper limits for a boat relocated fish furthest up the Upper Missouri River (RM 1592.3) and the lower limits for a fish below the confluence, down the Lower Missouri River (RM 1551.4). We located two different males at RM's 9.5 and 9.6 on the Yellowstone River which marks the farthest point up the Yellowstone for boat relocations. However, during the periods when our stations shut down we are fairly confident two males went up the Yellowstone River above Sidney, Montana. We did not relocate them until late summer when they returned back to the confluence area.

One anomaly worth mentioning from this season's field notes was the behavior of the study's three females, Annie (# 25), Amber (# 62), and Bridget (# 10). Throughout the tracking season, a total of ten observations occurred in the upper Missouri River above the confluence; nine of the ten observations were by the above mentioned females. One male (# 34) selected the upper Missouri for a day and returned back to the confluence.

Data collected in 2001 provides baseline information for our long term study, but is insufficient for any statistical or correlation analysis. Data collected in the 2002 field season will be added to this years data and will be preliminarily analyzed for the 2002 progress report submitted to all agencies providing funding, including: USACE, WAPA, Upper Basin Pallid Workgroup, as well as the Bureau of Reclamation and the NDGFD which will be providing funding in 2002. Northern Prairie Wildlife Research Center will assist in data analysis, development and critical review of models, and aid in future project design and assessment of discrepancies.

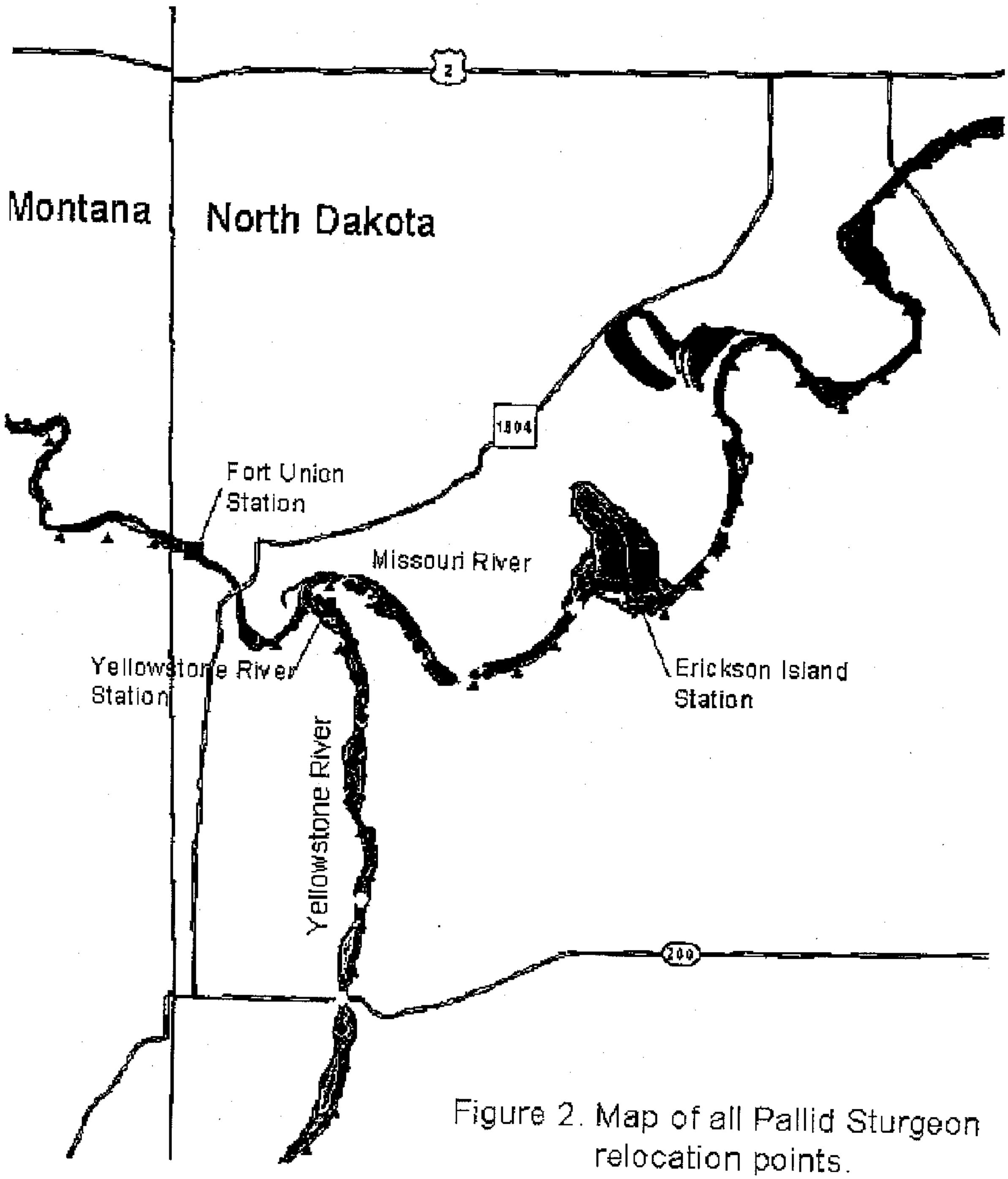

Figure 2. Map of all Pallid Sturgeon relocation points.

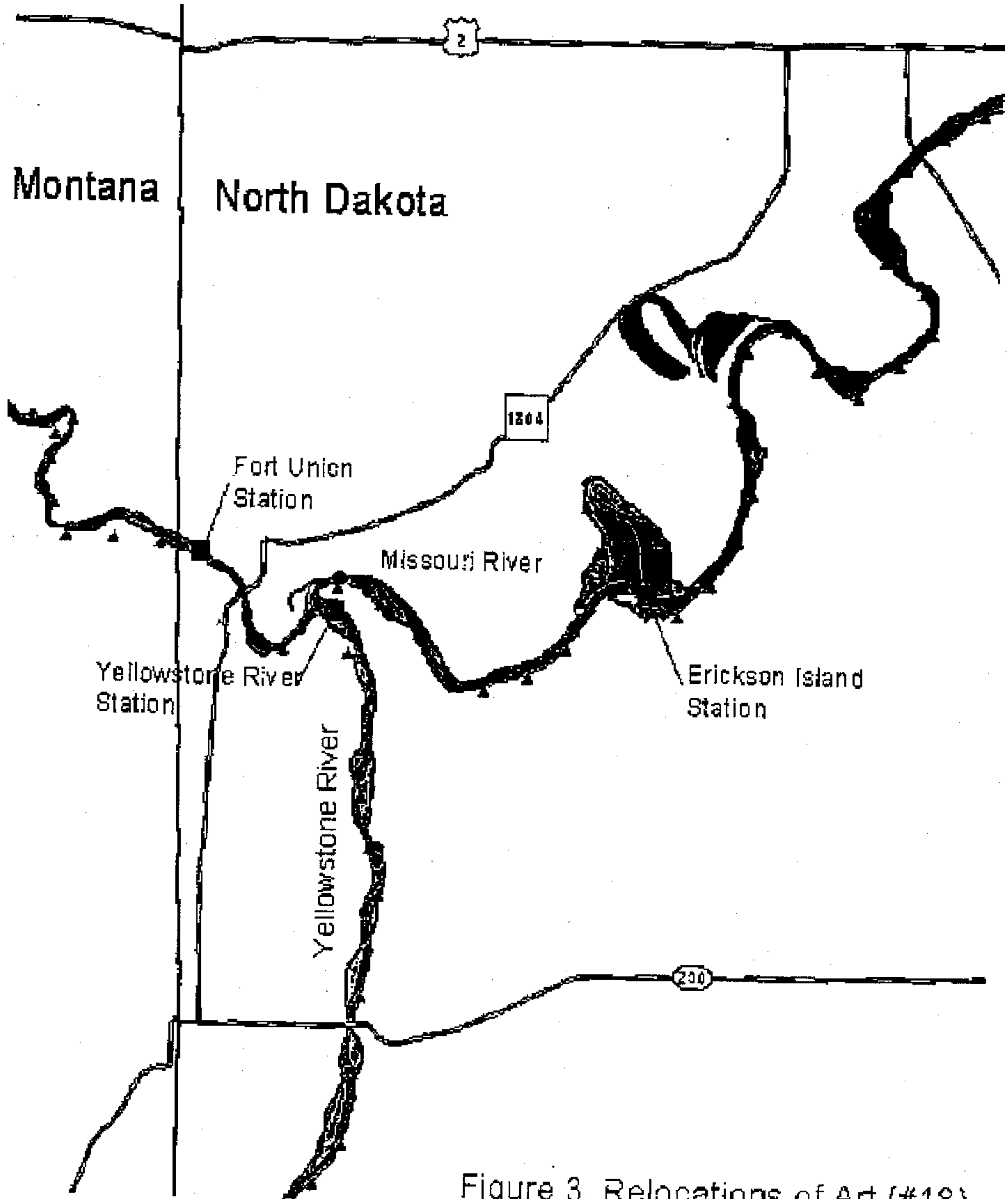

Figure 3. Relocations of Art (#18)

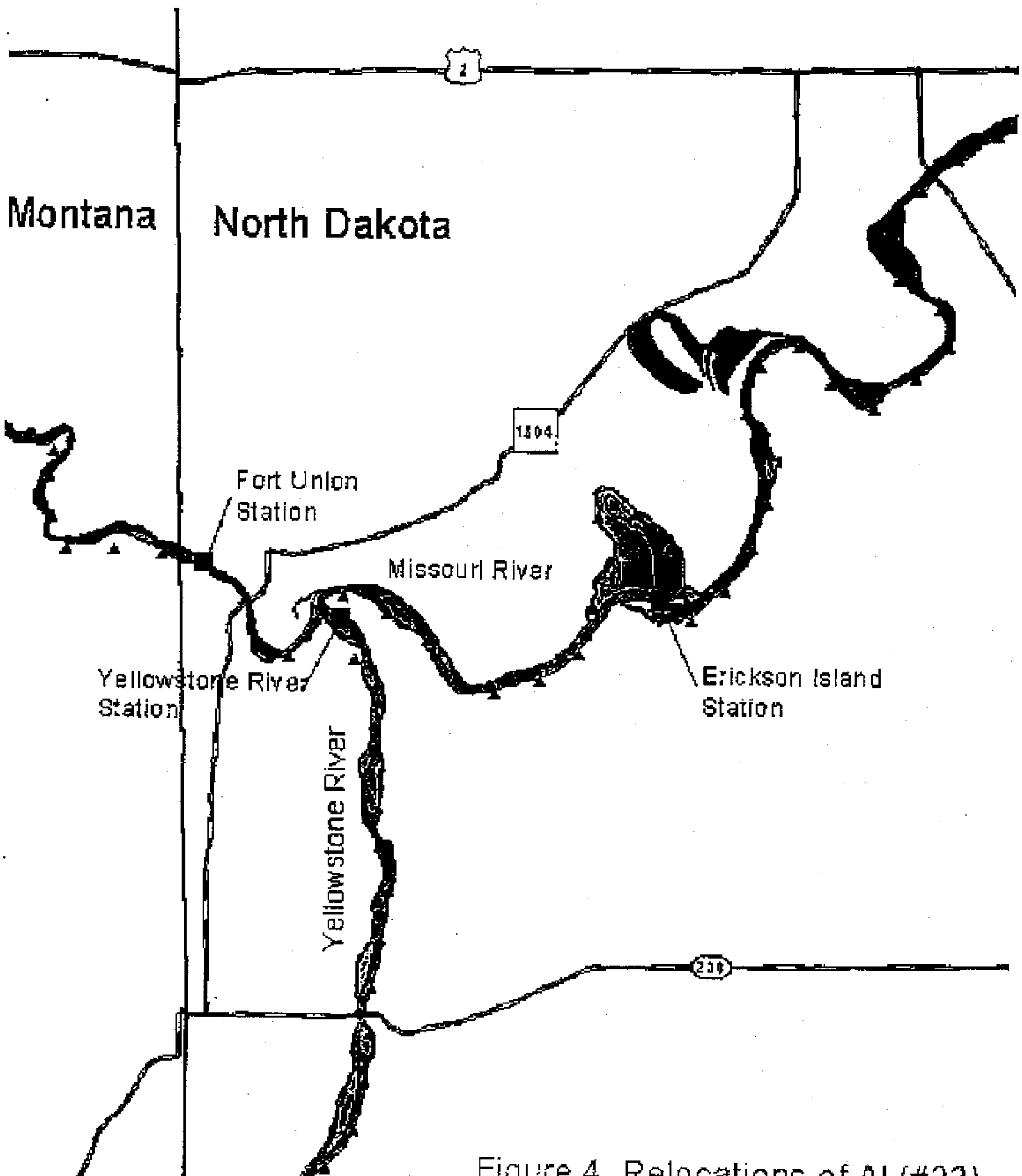

Figure 4. Relocations of Al (#22)

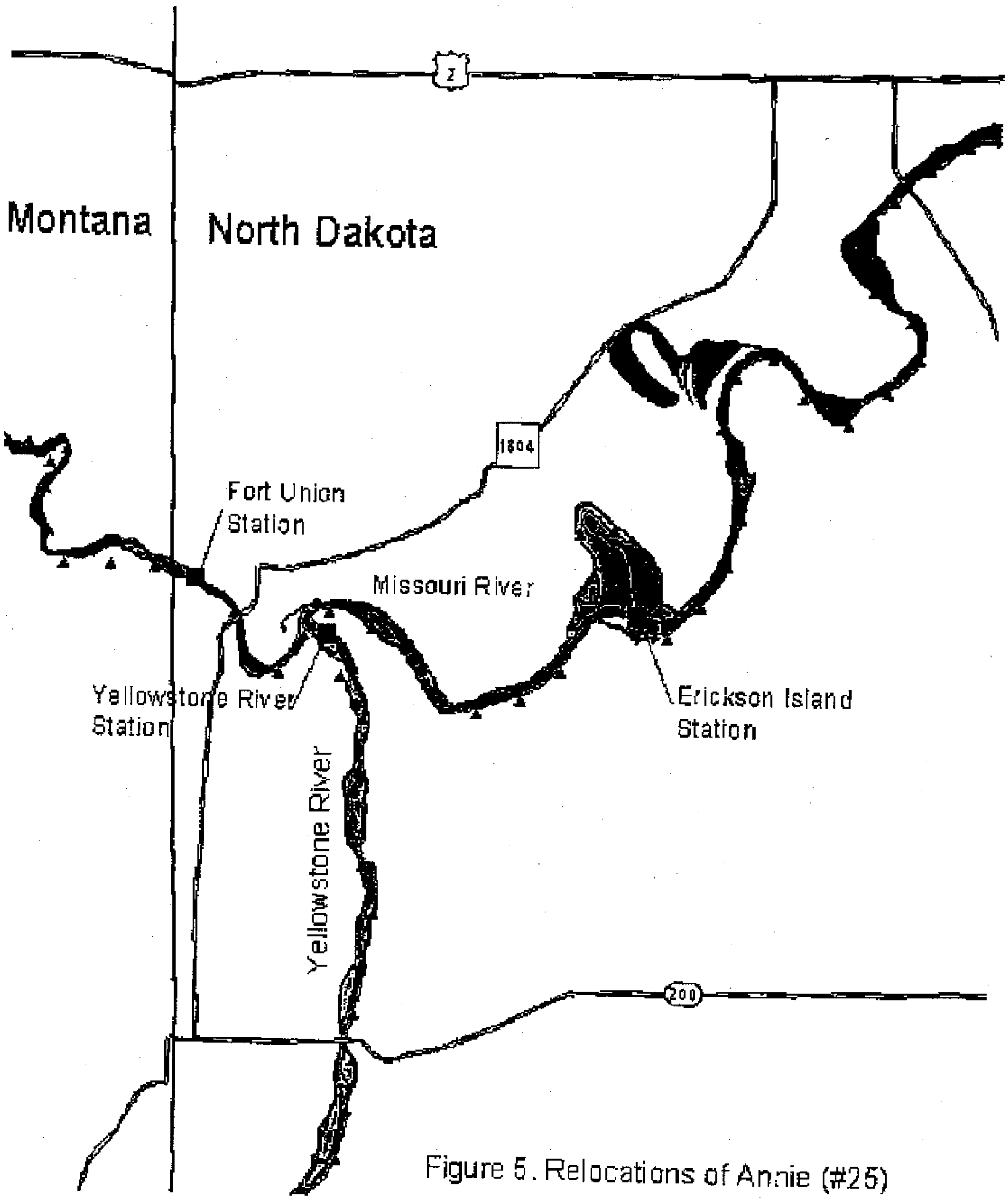

Figure 5. Relocations of Annie (#25)

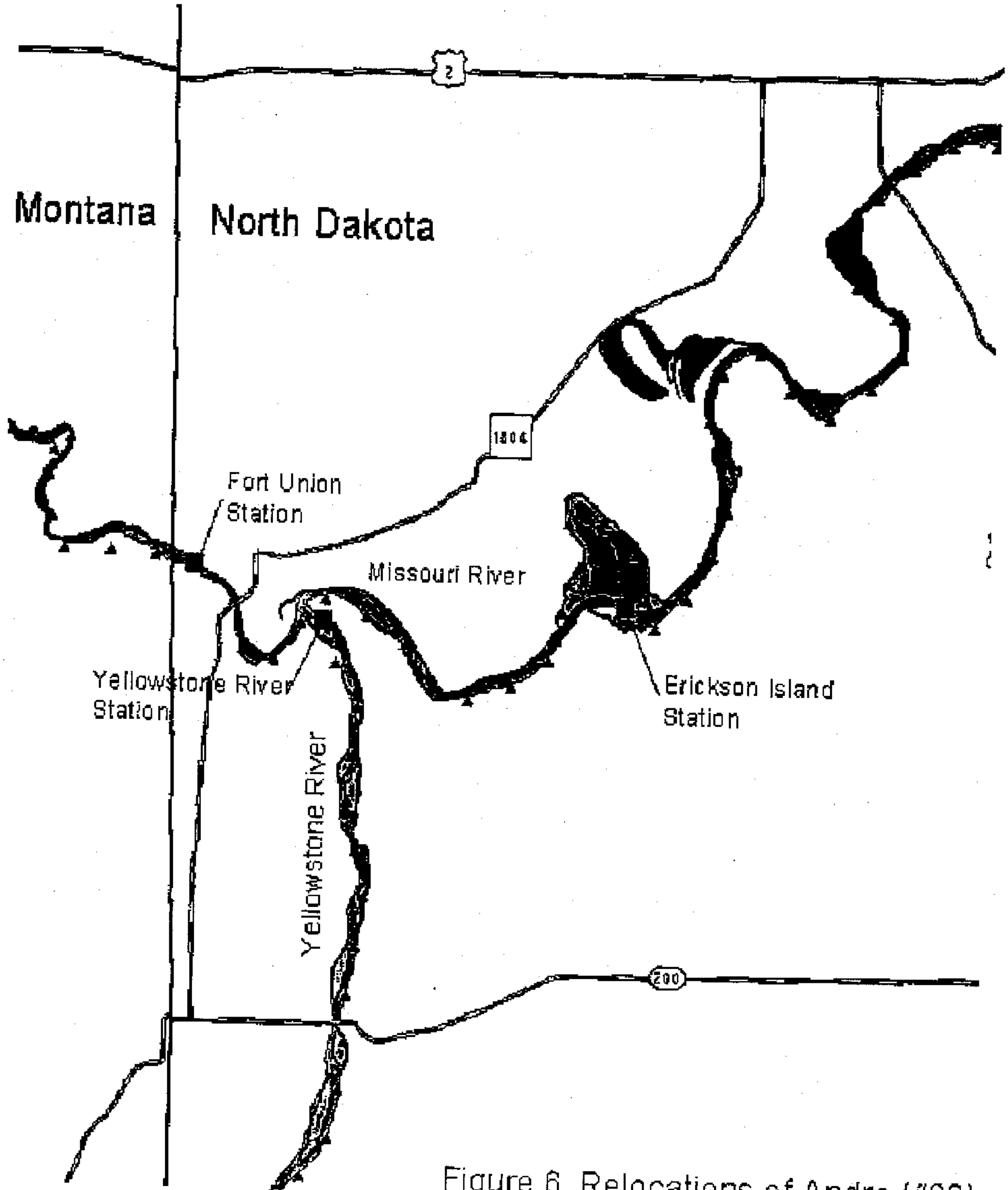

Figure 6. Relocations of Andre (#26)

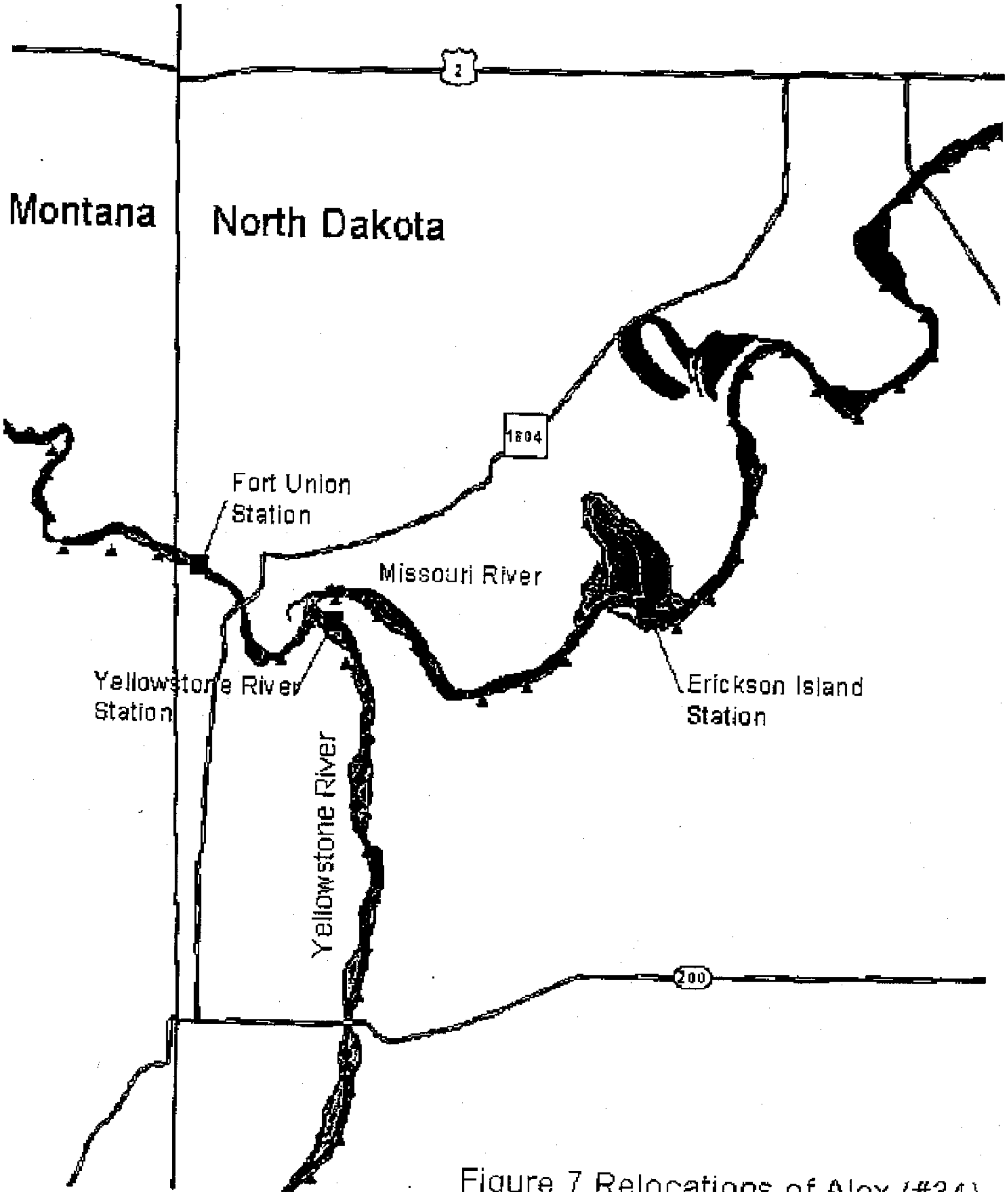

Figure 7.Relocations of Alex (#34)

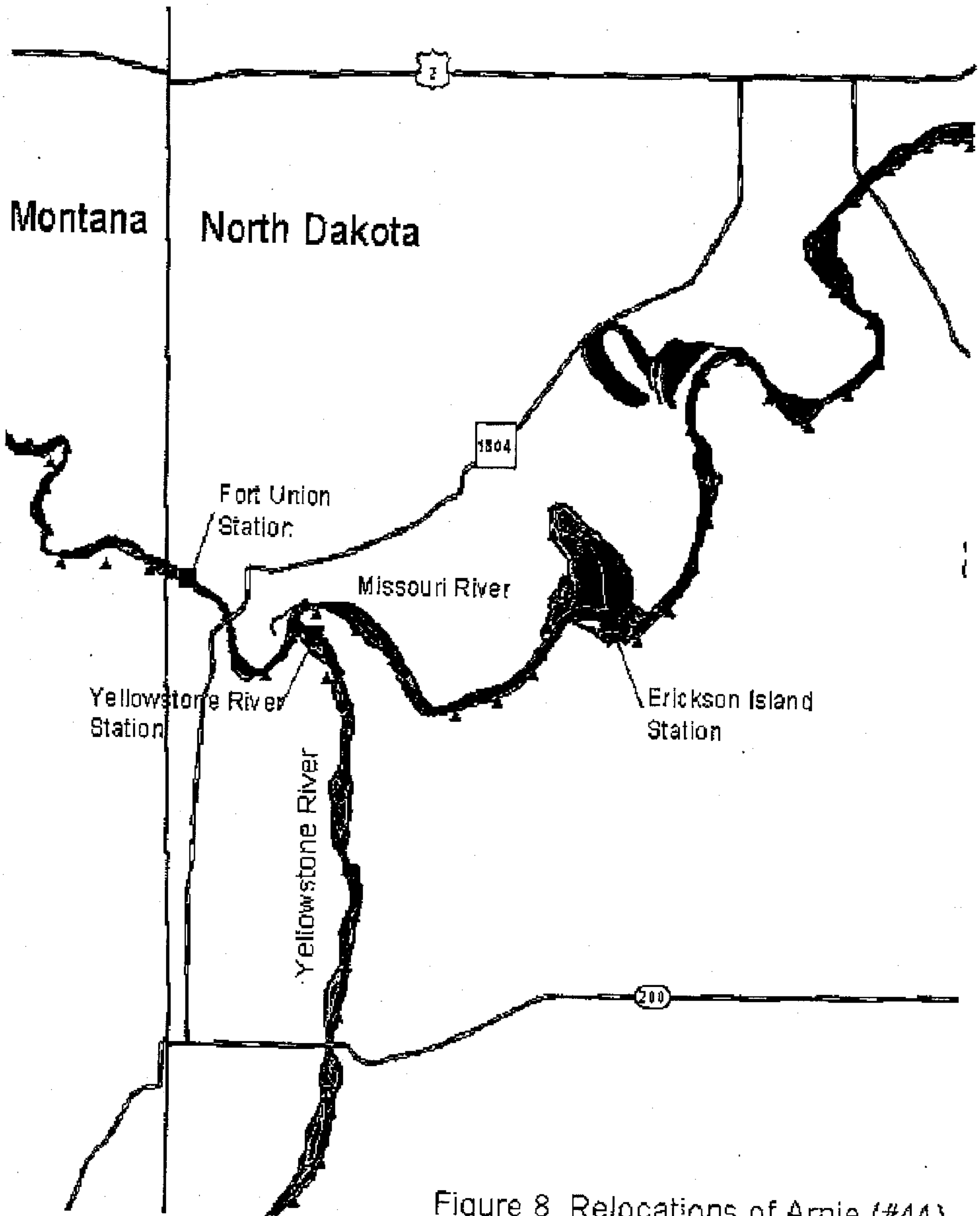

Figure 8. Relocations of Arnie (#44)

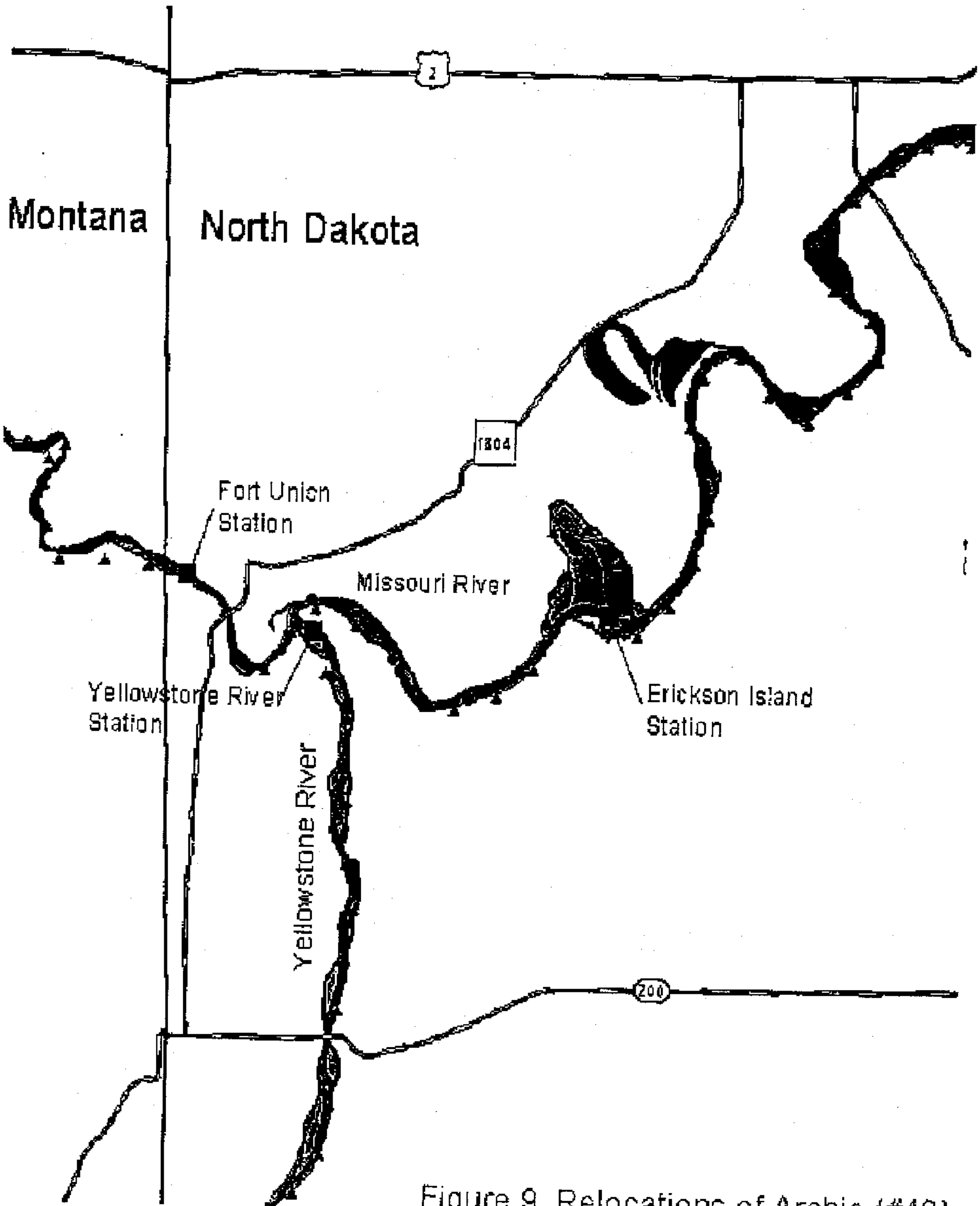

Figure 9. Relocations of Archie (#46)

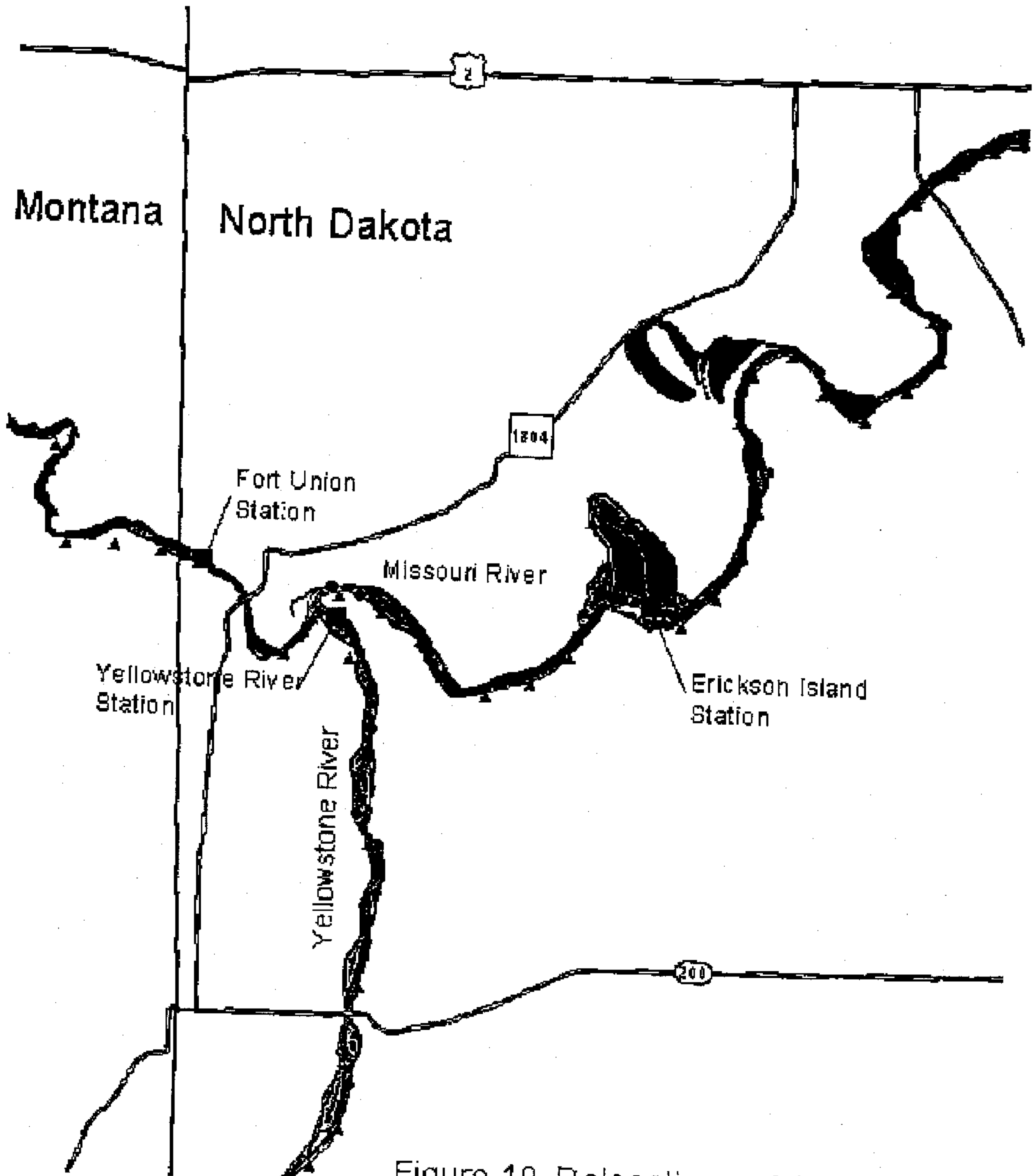

Figure 10. Relocations of Andrew (#50)

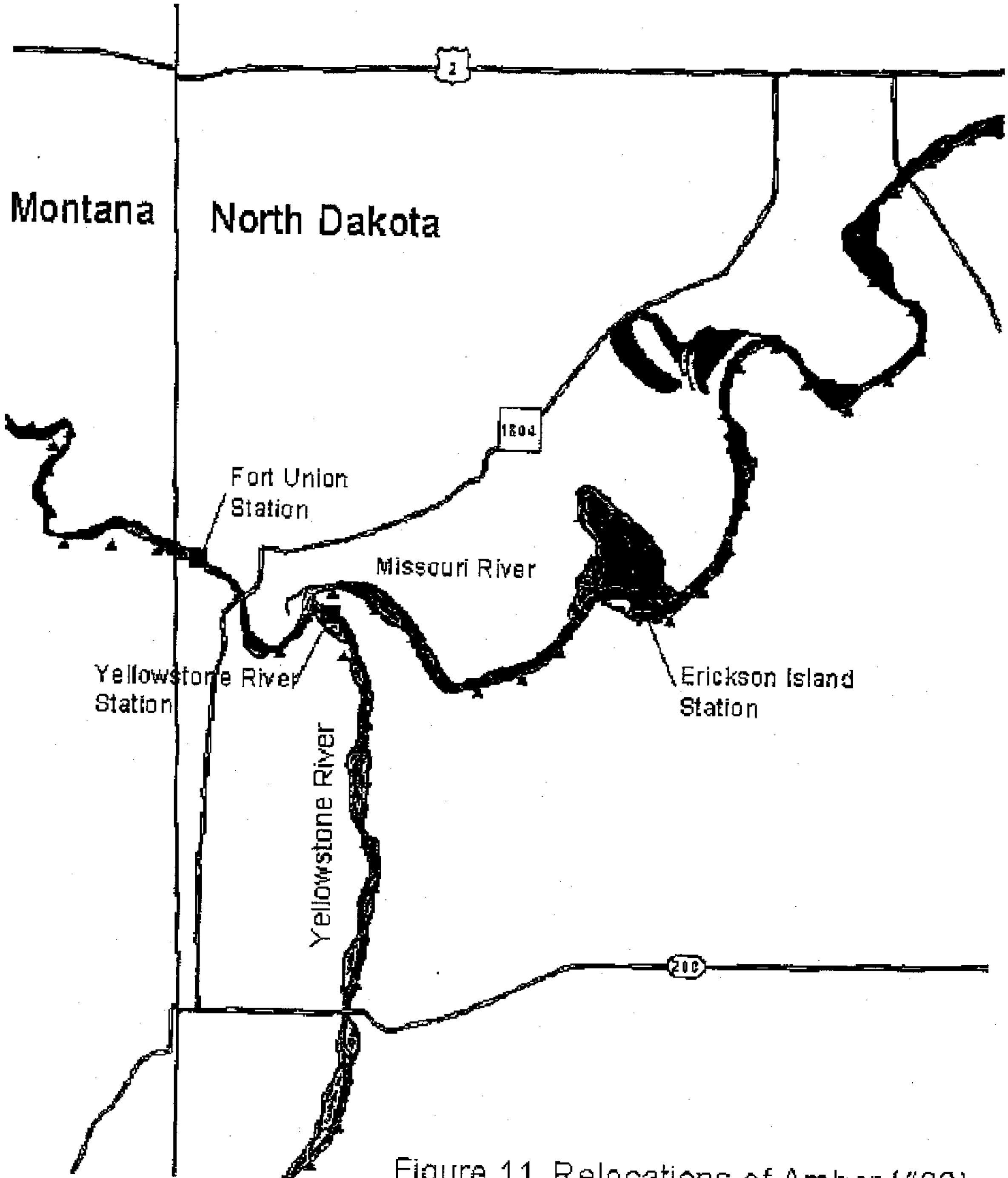

Figure 11. Relocations of Amber (#62)

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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°C – +37°C, 4 min response time, accuracy ± 0.2°C from 0 - 21°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 ± 0.1°C) and a hand-held alcohol thermometer (accuracy ± 1.0°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

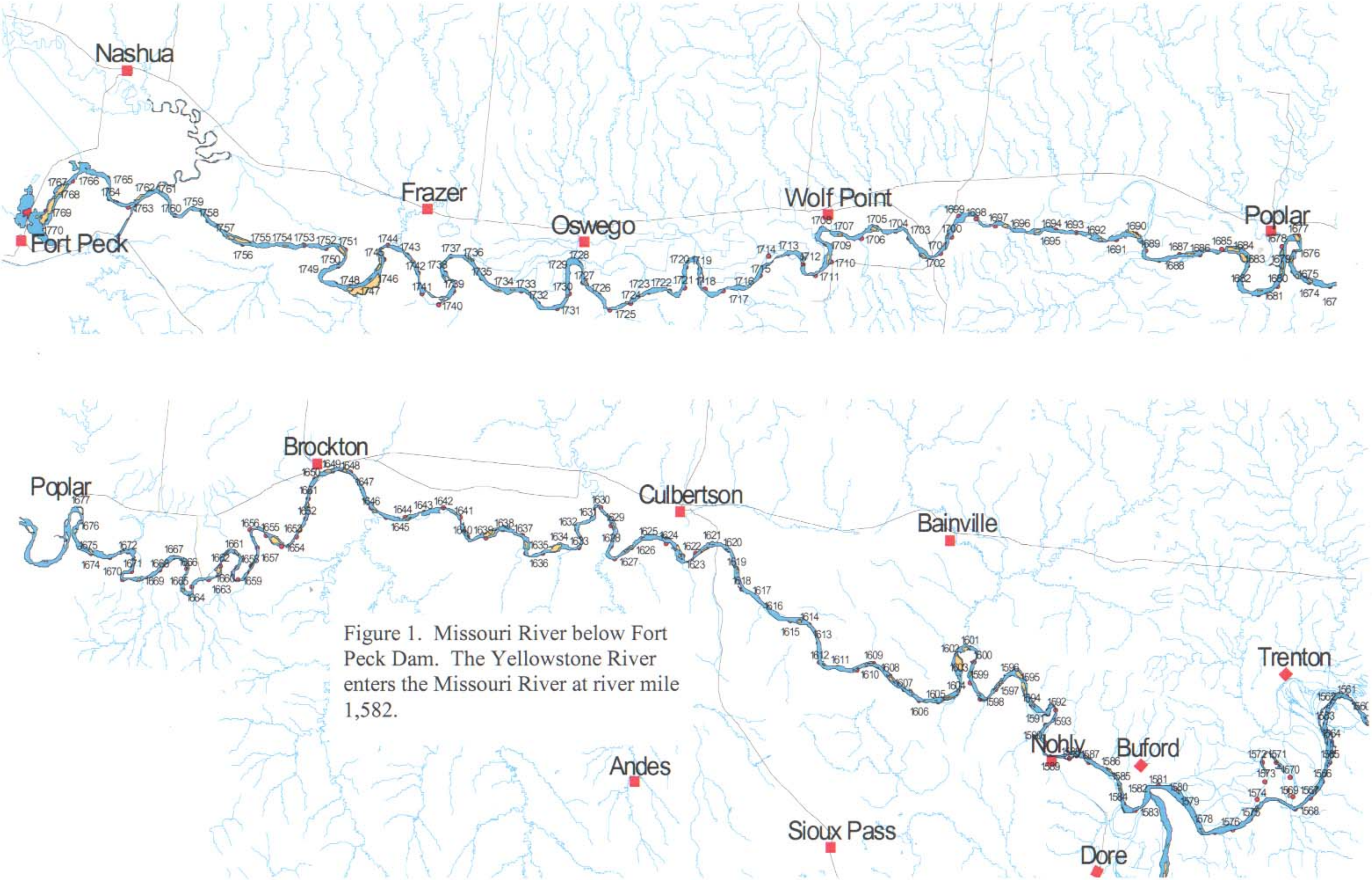

Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

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 left	389503 389561	4/30/01	11/13/01
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 48 02.008	106 14.902 106 15.110	right left	389563 389571	5/2/01	11/13/01
Nickels Ferry	1,759.9	48 02.662 44 02.390 48 02.662	106 17.300 106 17.448 106 17.300	right left strat	389495 389504 394819	4/30/01	11/13/01
Frazer Pump	1,751.5	48 01.897 48 01.800	106 07.547 106 07.522	right left strat	389565 389489 389556	5/2/01 5/17/01	11/13/01
Frazer Rapids	1,746.0	48 00.405 48 00.453	106 06.595 106 05.989	right left	389501 389490	5/2/01	11/13/01
Grand Champs	1,741.5	48 00.300 48 00.215	106 01.873 106 01.855	right left	389479 389575	5/2/01	11/13/01
Wolf Point	1,701.5	48 04.539 48 04.779	105 31.479 105 31.202	right left	389500 389493	5/3/01	11/14/01
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 48 03.957	105 12.425 105 12.127	right left	389558 389491	5/3/01	11/15/01
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 28.59	104 28.433 104 28.590	right left	389567 389572	5/8/01	11/16/01
Nohly	1,591.2	48 01.126 48 00.838	104 06.012 104 06.441	right left	389498 389496	4/19/01	11/16/01
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 48 57.511	103 53.751 103 53.835	right left	389564 389566	4/26/01	11/16/01

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°C to 17.1°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 (± 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°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°C) of water temperatures (Table 5). Precision of all water temperatures loggers declined at cooler water temperature treatments (e.g., < 15°C) as indicated by an increase in the range (7.4 – 12.6°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°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 °C) at warmer water temperatures and a reduced level of precision at cooler temperatures (1.4 to 5.2°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°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 (°C)	Alcohol (°C)	Mean (°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°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 °C) at warm water temperatures, but greater (0.9-2.2 °C at lower water temperatures. Omission of the three "suspect" loggers mentioned above resulted in a maximum deviation of 1.3°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°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 °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 (°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 °C to 0.9 °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°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°C), but gradually increased to 18.9°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°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°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 °C) and Poplar River (19.4 °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 (°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 (°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

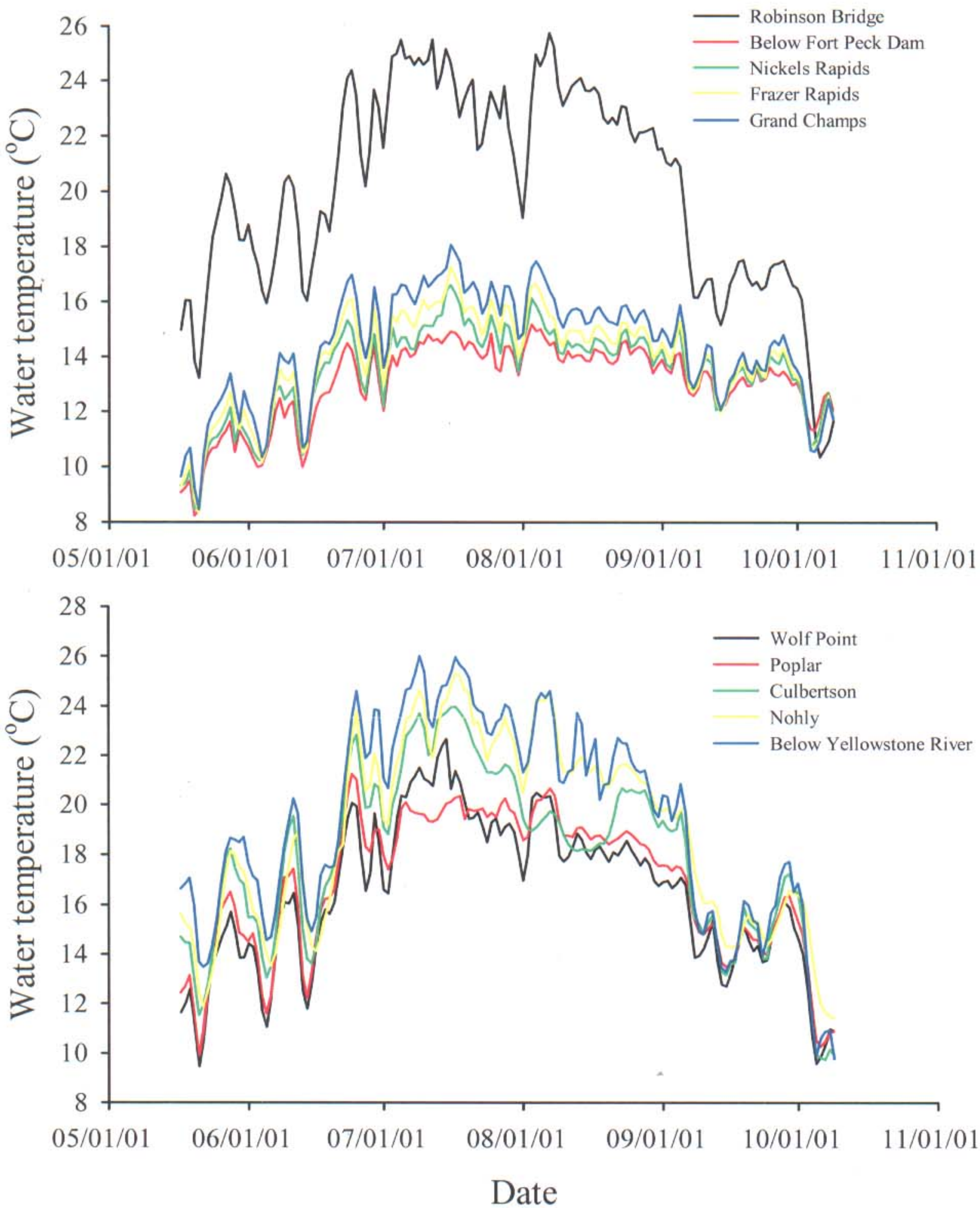

Figure 2. Mean daily water temperature (°C) at 10 sites on the mainstem Missouri River during 2001.

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).

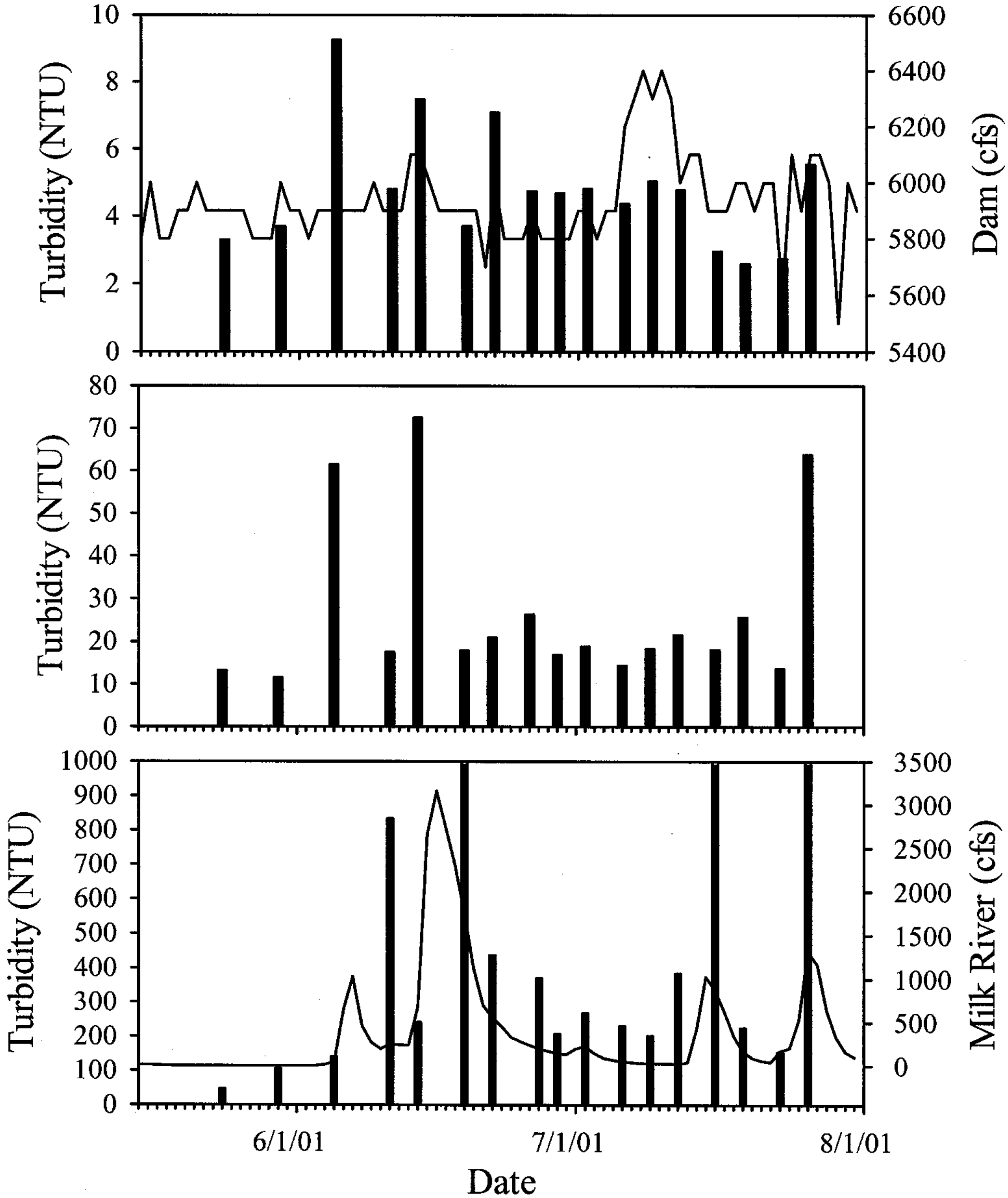

Figure 3. Turbidity (NTU; vertical bars) and discharge (cfs; solid line) at larval fish sampling sites located downstream from Fort Peck Dam (top panel), in the spillway channel (middle panel), and in the Milk River (lower panel) during 2001.

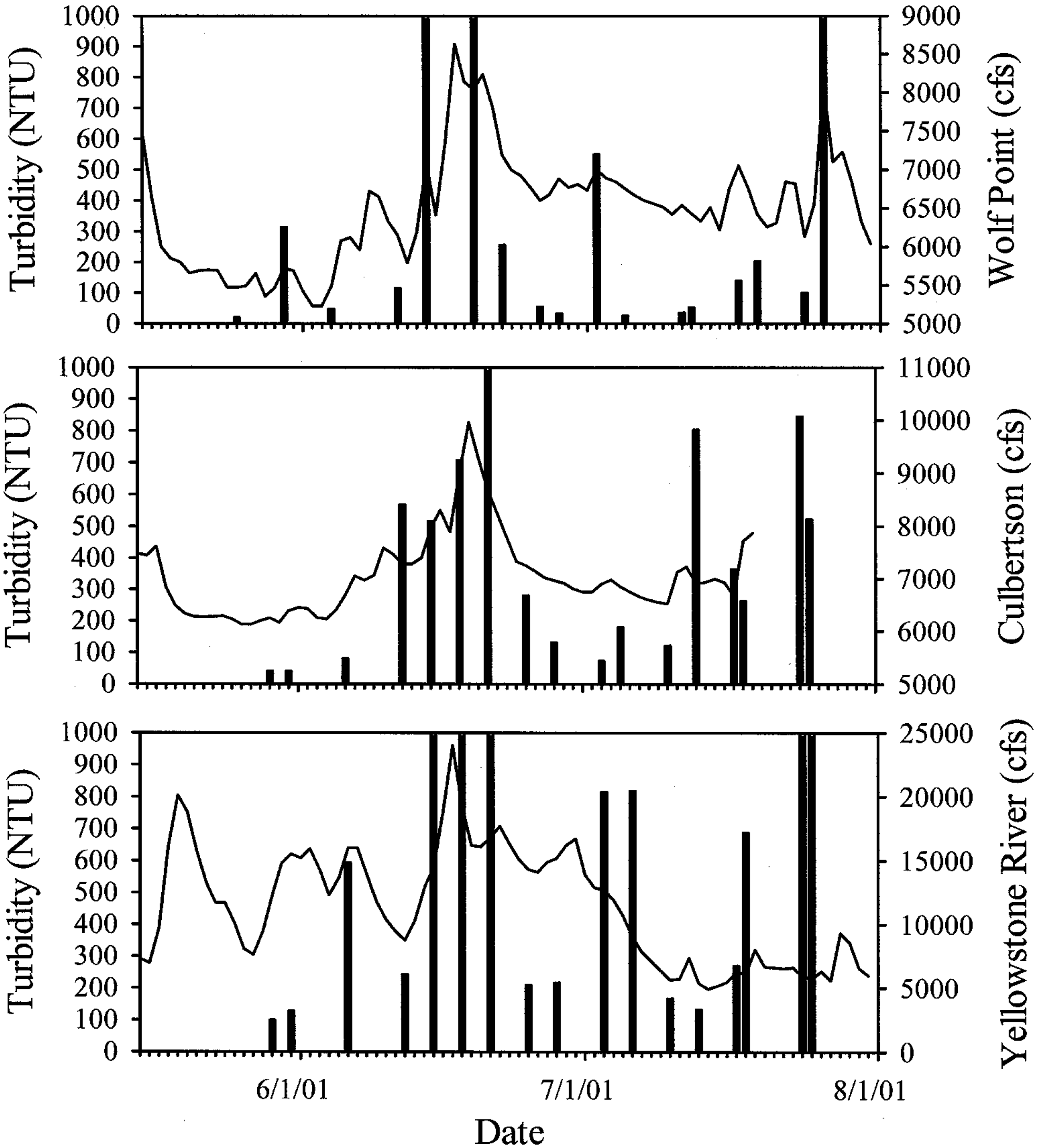

Figure 4. Turbidity (NTU; vertical bars) and discharge (cfs; solid line) at larval fish sampling sites located at Wolf Point (top panel), at Nohly (middle panel), and in the Yellowstone River (lower panel) during 2001.

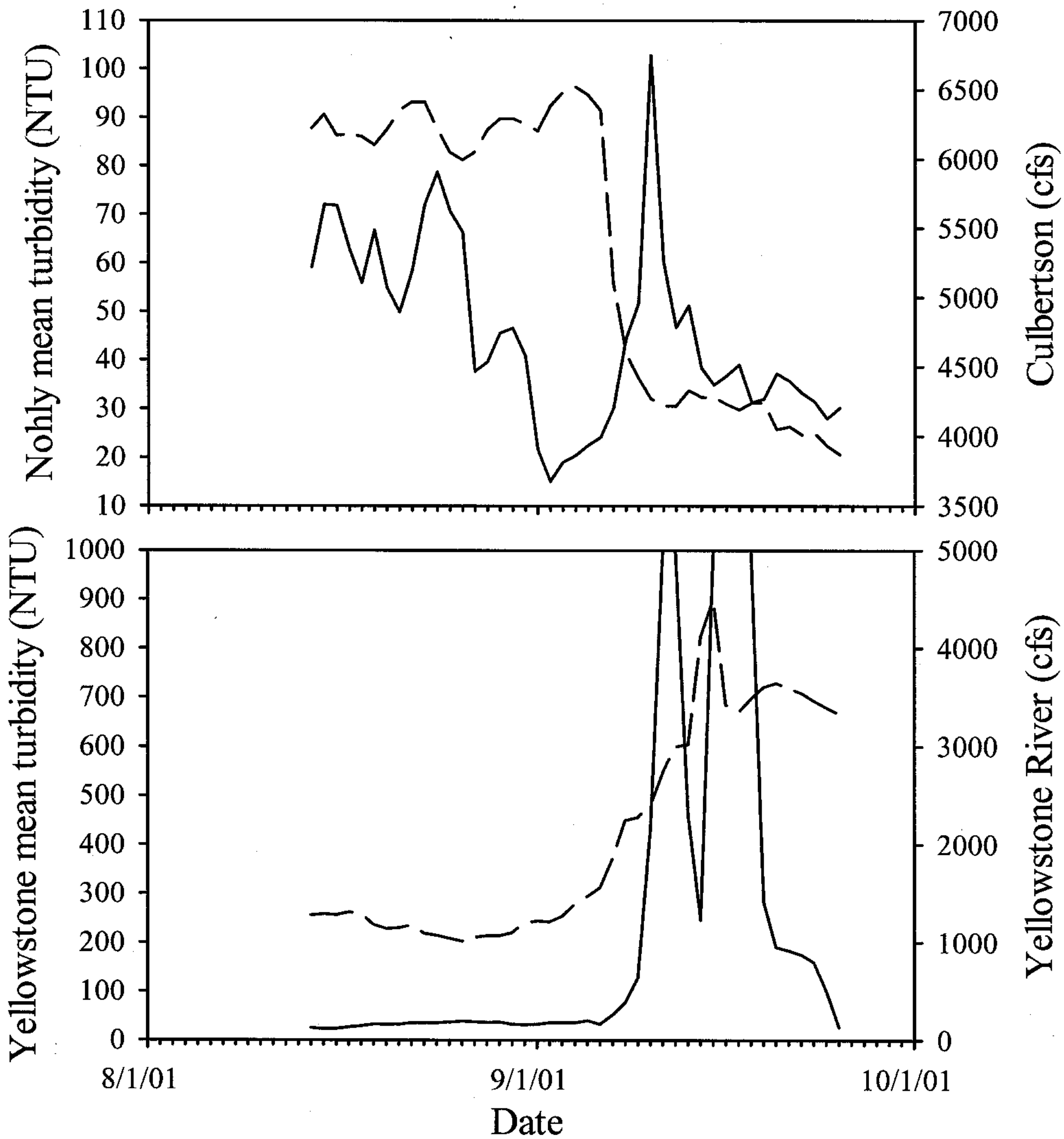

Figure 5. Mean daily turbidity (NTU; solid line) from turbidity loggers and discharge (cfs; dashed line) in the Missouri River at Nohly (top panel) and in the Yellowstone River (lower panel) during 2001.

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 $\leq$ 0.23 larvae/100 m^3).

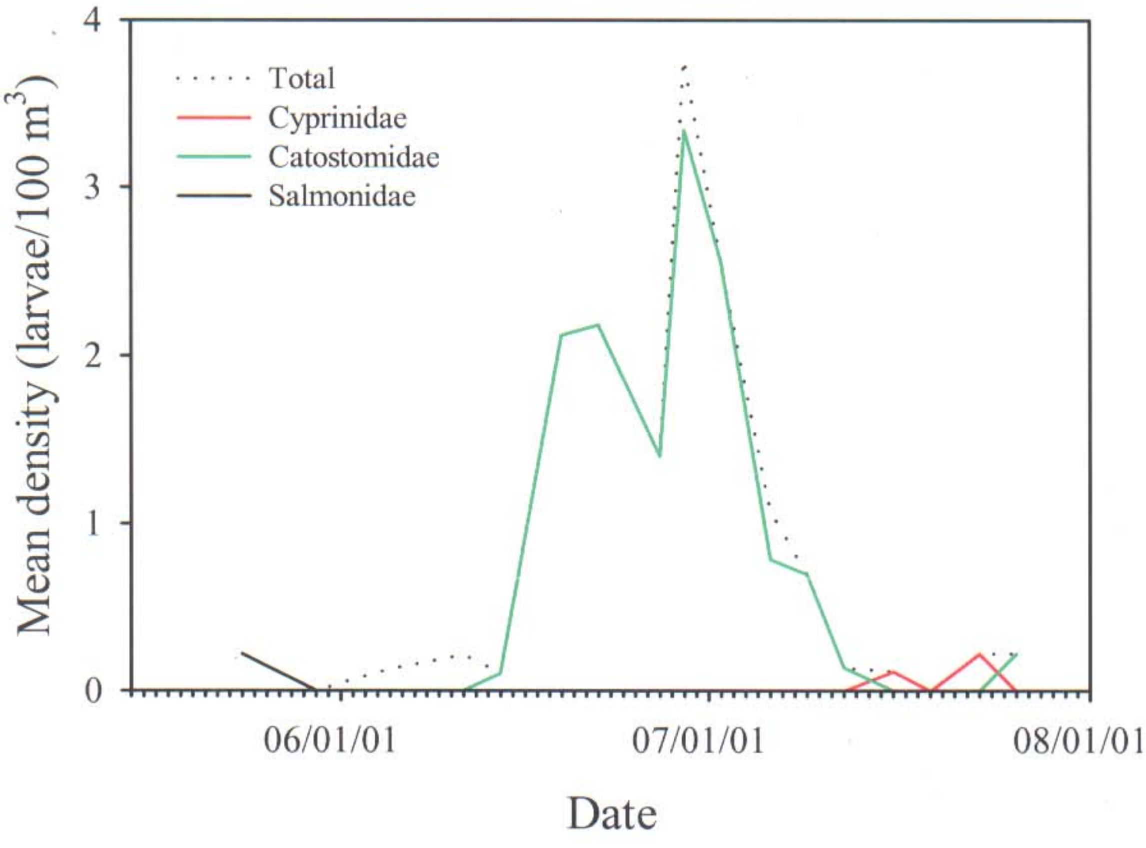

Figure 6. Mean density (number/100 m^3) by date of all larval fishes (Total), Cyprinidae, Catostomidae, and Salmonidae sampled at the site just downstream from Fort Peck Dam during 2001.

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 ≤ 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).

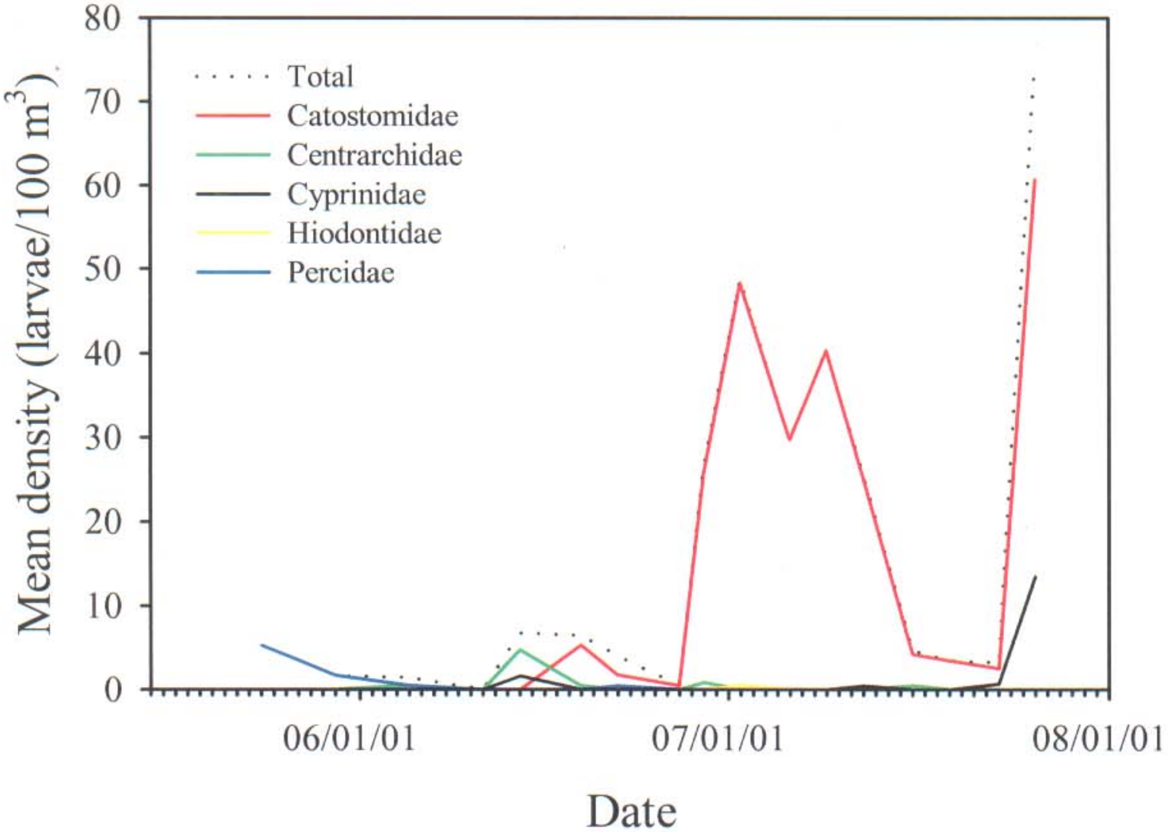

Figure 7. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Centrarchidae, Cyprinidae, Hiodontidae, and Percidae sampled in the spillway during 2001.

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).

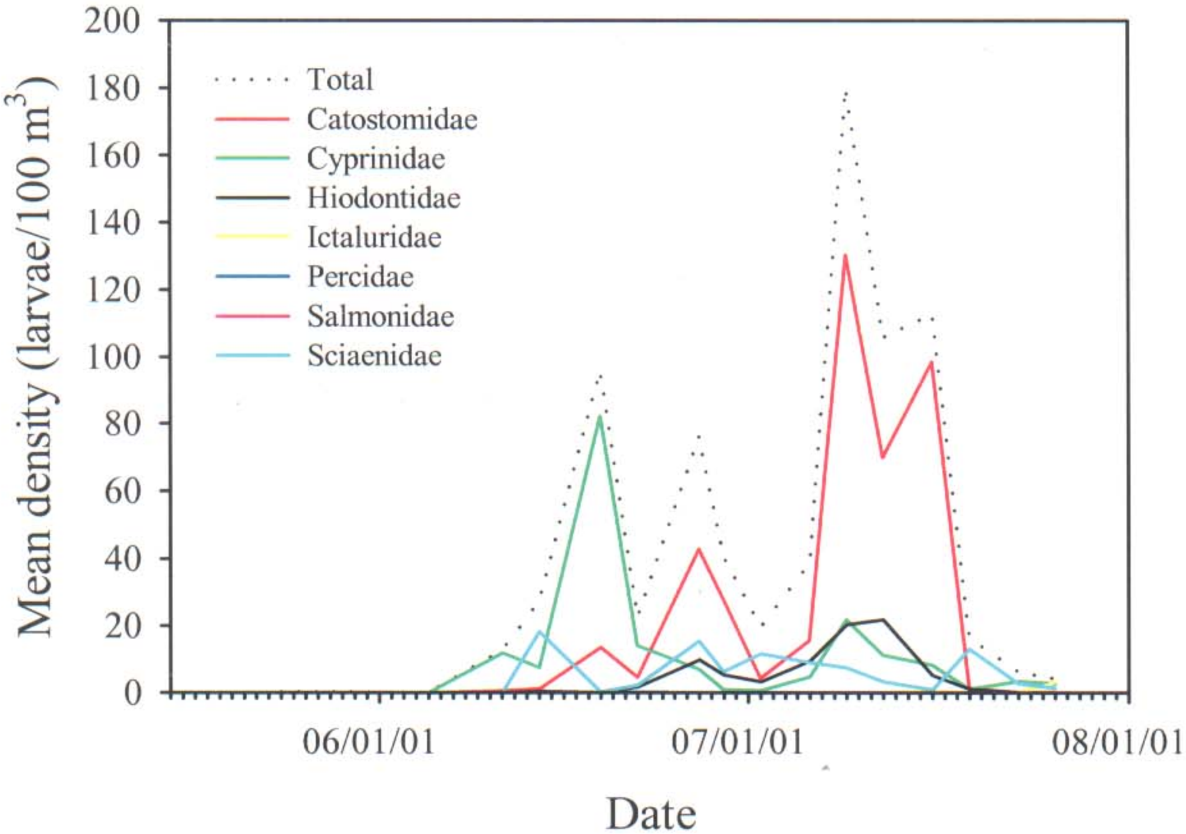

Figure 8. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Ictaluridae, Percidae, Salmonidae, and Sciaenidae sampled in the Milk River during 2001.

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.

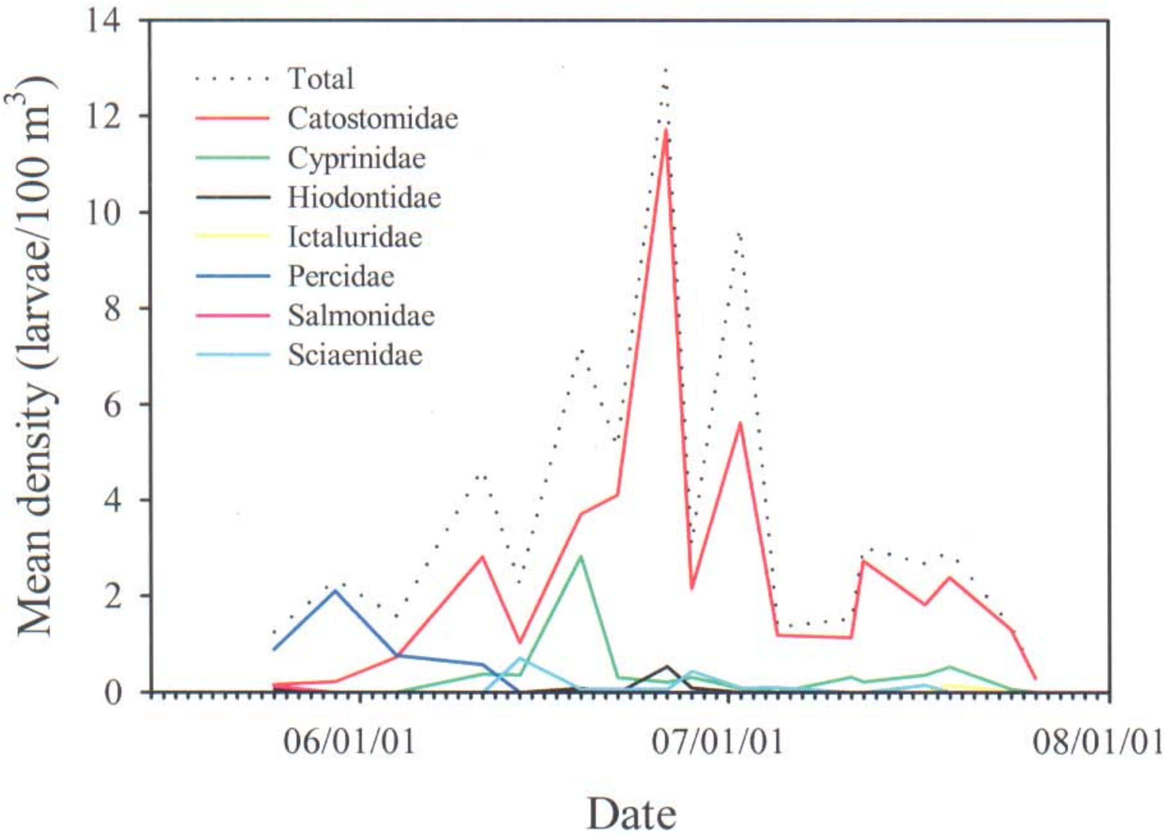

Figure 9. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Ictaluridae, Percidae, Salmonidae, and Sciaenidae sampled in the Missouri River at Wolf Point during 2001.

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.

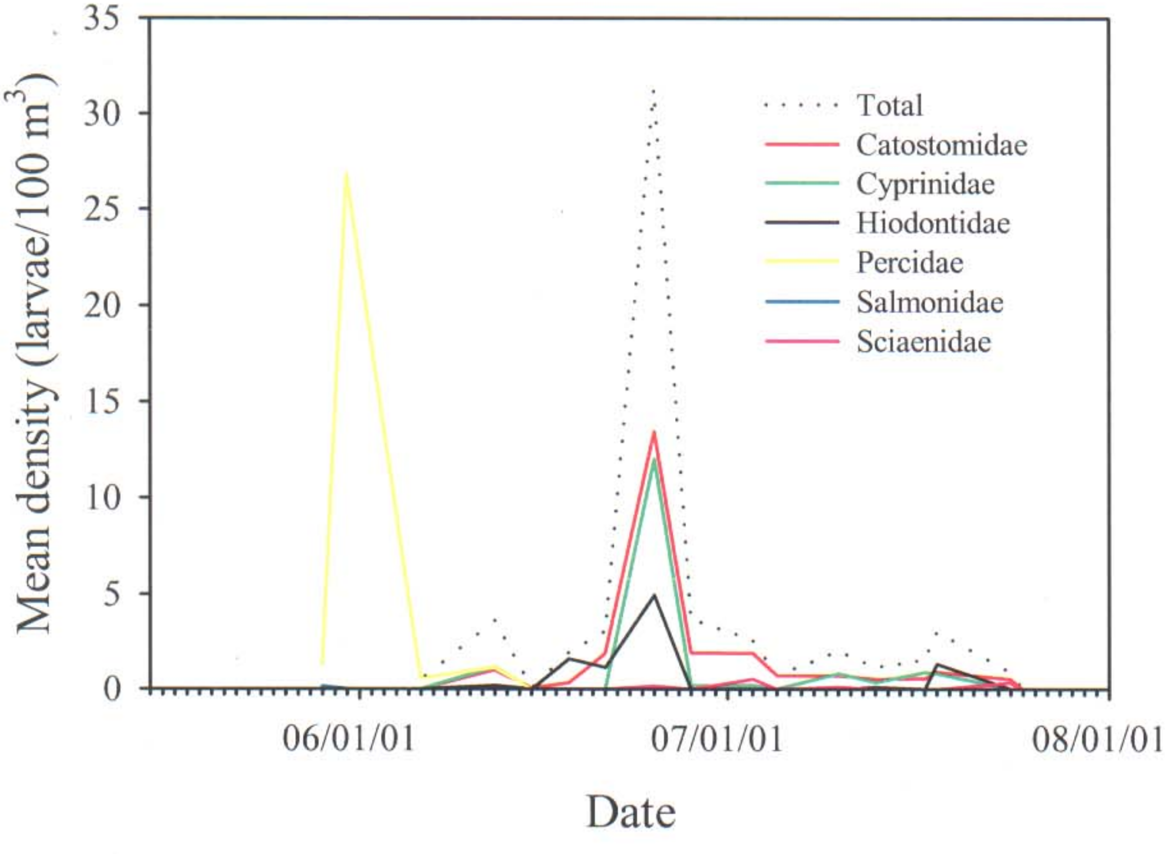

Figure 10. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Salmonidae, and Sciaenidae sampled in the Missouri River at Nohly during 2001.

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.

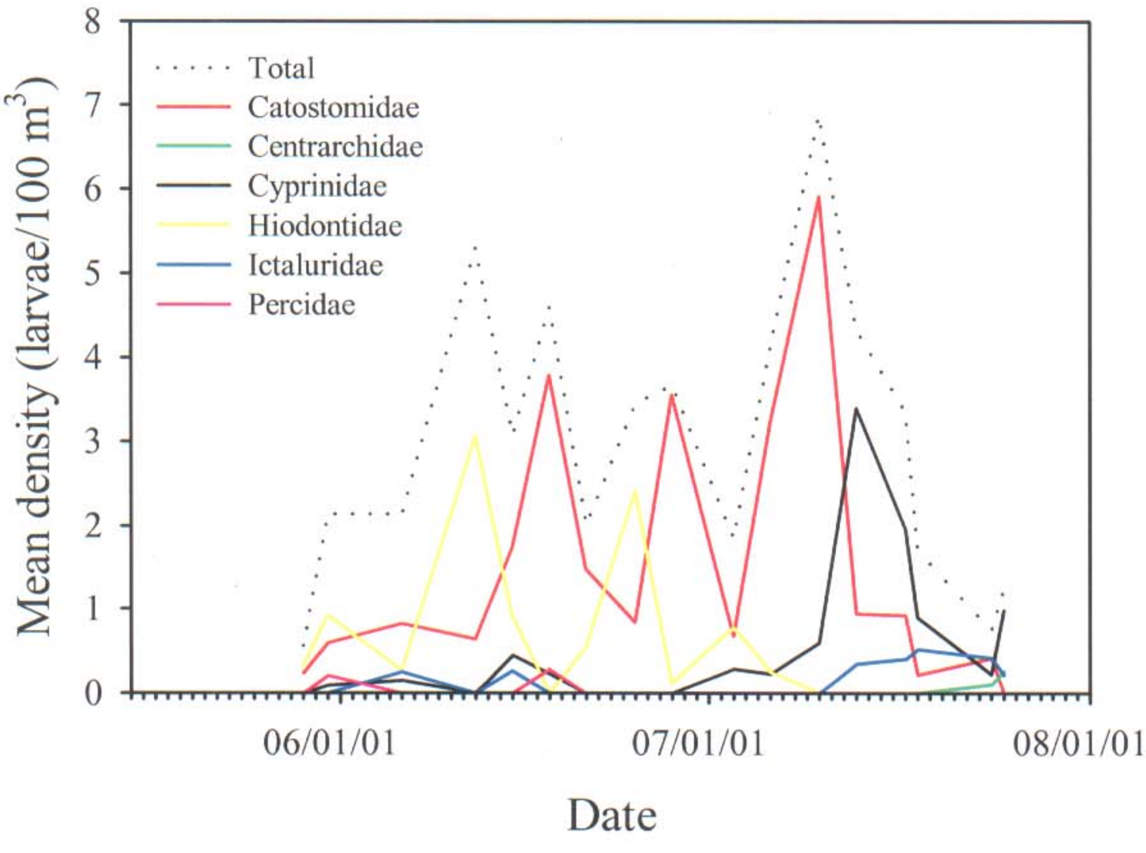

Figure 11. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Centrarchidae, Cyprinidae, Hiodontidae, Ictaluridae, and Percidae sampled in the Yellowstone River at Nohly during 2001.

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°C) than at cooler treatment temperatures (< 15°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°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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MISSOURI RIVER COTTONWOOD STUDY
FORT PECK RESERVATION, MONTANA

September 2001

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INTRODUCTION

The Fort Peck Assiniboine and Sioux Tribes (Tribes) are concerned that Great Plains cottonwood (*Populus deltoides*) woodlands, along the Missouri River on the Fort Peck Reservation (Reservation), in eastern Montana are dying out (i.e., declining in spatial extent and vigor and may not be regenerating young trees to replace older trees that are dying). The riparian cottonwood woodlands along the Missouri River on the Reservation are of cultural, aesthetic, spiritual, and biological importance to the Tribes.

Cottonwood woodlands are declining due to several factors. Construction and operation of the Fort Peck Dam, upstream from the western boundary of the Reservation, has altered flow regimes of the Missouri River, channel morphology, and vegetation on the floodplain of the river. Fires have killed stands of cottonwood and agricultural operations have replaced cottonwood communities with hay fields and crops. Livestock grazing and trampling has degraded the vegetation on some sites.

An indirect effect of historic operation of the Fort Peck Dam on cottonwoods might be the proliferation of beavers along the Missouri River. High densities of beavers are causing substantial mortality to cottonwoods along the river.

In response to concerns expressed by the Tribes, the Army Corps of Engineers funded this study to document the status of riparian cottonwood woodlands along 141 miles of Missouri River shoreline on the Reservation. The purpose of the study is to establish baseline conditions concerning the demography, seral ecology, volume and growth rates, species composition, and structural features of cottonwood communities along the Missouri River. These studies establish baseline conditions so that effects of future operations of the Fort Peck Dam can be assessed and a management plan prepared for regeneration of cottonwoods on a sustained basis.

This report presents results of the cottonwood study conducted by Joe C. Elliott, Ecological Consultant, under contract to the Tribes This report also presents a literature review of riparian cottonwood ecology and beaver-cottonwood interactions and suggests measures to mitigate resource losses associated with the decline of cottonwood woodlands on the Reservation.

REVIEW OF COTTONWOOD ECOLOGY

The following is a review of scientific studies of cottonwood ecology in the western United States and Canada. This review documents the interaction of seasonal hydrology, sediment deposition, and other factors that affect reproduction of riparian cottonwood communities. The following studies provide information on aspects of riparian plant ecology that are relevant to assessing the status of cottonwood communities on the reservation.

Riparian Vegetation

Riparian vegetation is comprised of plant communities that occur in transitional zones between aquatic and terrestrial ecosystems. These plant communities are "pulse-stabilized" systems maintained in continual ecological transition (disclimax) through the pulse of periodic flooding. Scouring by floodwaters and deposition of water-borne sediment (alluvium) creates optimum habitat for seedlings of cottonwood and willow species. Seeds of these species germinate almost exclusively on recently deposited, fully exposed alluvium.

According to Mahoney and Rood (1993), the following factors are important for cottonwood seedling establishment: 1) peak flows to prepare germination sites; 2) receding flows at the time of seed release to expose new germination sites; 3) gradually declining water table to limit seedling drought stress and promote root growth; 4) adequate summer flows to meet high water demands; and 5) adequate autumn flows to maintain water balance and over-winter survival. A detailed discussion of life history, ecology, and conservation of North American cottonwood forests is presented by Braatne and others (1996), Johnson (1992), and Hansen and Suchomel (1990). Fluvial processes associated with establishment and maintenance of riparian forests are discussed by Scott and others (1996)

Construction and operation of dams can affect riparian ecology by altering the seasonal timing and magnitude of stream flows, sediment transport potential of downstream waters, and ice formation. These influences of dams on hydrology can affect amounts of water available to vegetation; meandering rate of streams; formation and erosion of stream banks, bars, and islands; establishment of cottonwood and willow species; and regeneration of senescent riparian plant communities.

Studies of riparian vegetation on the Reservation were conducted by Miles et al (1993) and Hansen et al (1995). These researchers studied three plots along the Missouri River and suggested that altered flows from damming the Missouri River have drastically reduced Great Plains cottonwood regeneration. Using 1979 aerial photographs, these researchers mapped riparian plant communities on the Reservation.

Ecology of riparian forests on the St. Mary, Waterton, and Belly rivers in Alberta were studied by Rood and Heinze-Milne (1989). They found that riparian forests downstream from the St. Mary and Waterton dams declined by 48 and 23 percent, respectively. There was negligible reduction in cottonwood forests on the undammed Belly River, downstream from an irrigation diversion. The decline in cottonwood forests was attributed to low summer flows, resulting from dam operation that led to drought-induced mortality.

Rood and others (1995) also addressed cottonwood decline on the St. Mary River. Analyses of historical stream flows indicated that cottonwood mortality was drought-induced as a result of insufficient flows during the hot dry, summer periods and abrupt flow reductions following the high-flow period in spring.

The collapse of riparian poplar forests downstream from dams in western North American prairies was investigated by Rood and Mahoney (1990). They reviewed literature that reported vegetation impacts, downstream from dams on the Missouri, Big Horn, South Platte, Milk, St. Mary, Waterton, and Belly rivers and concluded that dams contribute to forest failure by: reducing downstream flows, altering flow patterns to attenuate spring flooding, and stabilizing summer flows. Reduced downstream flows can cause drought stress. Moderation of spring flooding can inhibit formation of seedbeds essential for germination and growth of riparian species.

Flooding patterns associated with ecological succession of riparian vegetation along the Red Deer River in southern Alberta were studied by Cordes and others (1997). They found that cottonwood regeneration was initiated on the floodplain by major floods (recurrence interval greater than 1 in 50 year events). Construction of the Dickson Dam has led to attenuation of floods, reduced the occurrence of extensive floods, and lowered potential for cottonwood forests downstream from the dam to be regenerated.

Impacts of the Fresno Dam on the Milk River in northern Montana and southern Alberta were studied by Bradley and Smith (1984 and 1985). They found that cottonwood densities on the Milk River floodplain were reduced 25 kilometers downstream from the dam in Montana. Cottonwood densities upstream from the dam in Alberta were significantly higher. They interpreted the results of their studies to suggest that cottonwood decline is due to a marked reduction in flood magnitude and frequency, rates of sedimentation, and channel meandering.

Impacts on cottonwoods, along the Marias River in Montana, downstream from the Tiber Dam, were reported by Rood and Mahoney (1995). Their studies found that: 1) reduced flooding allowed dense growth of grass, shrubs, and sedges to compete with cottonwood seedlings; 2) hydrological patterns of spring flooding and subsequent gradual flow decline required for seedling establishment is lacking; 3) formation of point bars and lateral bars, necessary for seedling establishment, has been inhibited; and 4) suspended sediment settles out in the reservoir, which may contribute to channel entrenchment.

Lesica and Miles (1998) also studied the ecology of cottonwoods along the Marias River downstream from the Tiber Dam. They observed that cottonwood recruitment that once occurred over large areas of the floodplain is now confined to a narrow zone along the channel. Seventy-seven percent of cottonwood trees in all age classes were damaged by beavers, effectively preventing cottonwoods from developing close to the river. They found that preference of beavers for cottonwood over the exotic invader species, Russian olive, is leading to replacement of cottonwood on some areas of the floodplain by Russian olive.

Flood dependency of cottonwoods along the Missouri River in Montana was studied by Scott and others (1997). They found that 72 percent of cottonwood trees established following floods with recurrence intervals greater than 9 years. Flows of this magnitude are necessary to create moist alluvium at elevations high enough to allow cottonwoods to survive subsequent floods and ice jams. Almost all cottonwoods that have survived recent floods were established higher than 1.2 meters above the lower limit of perennial vegetation (active channel shelf).

Studies of the Platte River in Nebraska (Johnson 1994) found that cottonwood forests have colonized formerly active channels of the Platte River as a result of lowering of stream flows for irrigation and to fill dams. This finding differs from results reported by researchers in Montana and Alberta. Accordingly, Johnson (1994) observed that responses of the Platte River differed from responses of other rivers. He states that the divergent response observed, despite similar disturbances, indicates complex relationships among plants and geomorphic processes operating on floodplains and the difficulties in understanding, generalizing, and predicting the impacts of modification of stream flow on natural ecosystems.

Beaver Ecology

Studies on beaver ecology and field observations on the Reservation indicate that beaver depredation on cottonwood is a major factor in declines of cottonwood forest on the Fort Peck Reservation. It is probable that historic operation of the Fort Peck Dam has influenced beaver population densities, distribution, and effects on cottonwoods.

General information on life history, behavior, and ecology of beavers is presented Olson and Hubert (1994) and Jenkins and Busher (1979). Beavers generally breed in January or February and give birth in May or June in lodges, constructed of mud and sticks, or in burrows excavated into riverbanks. Typically, bank burrows have underwater entrances that deter predators such as coyote and wolves and remain free of ice in winter.

Beavers live in family groups called colonies. Each colony of beavers occupies a reach of stream in common, uses a common food supply, and lives in the same burrows or lodges. Each colony is territorial and marks its territory with scent posts to deter use of space and food by neighboring colonies. Density of colonies and numbers of individuals varies depending on food supply, availability of sites suitable for winter burrows, history of flooding, and levels of mortality (e.g., from starvation, predation, trapping, and disease). Bergerud and Miller (1977) found that territorial behavior spaces colonies, dispersing populations within limits of food and water resources. However, territorial behavior does not prevent overutilization of food resources and population declines from reduced reproduction and increased mortality.

Beavers eat relatively large amounts of herbaceous vegetation in summer, but rely on trees and shrubs for critical winter nutrition. In order of preference, beavers eat aspen, willow, cottonwood, alder, and red-osier dogwood most frequently (Olson and Hubert 1995).

Dams can influence beaver populations by converting riparian areas to reservoir pools. Reservoir pools typically provide poor habitat for beavers because: shoreline vegetation is sparse, often lacking in favored food plants; reservoirs typically have unstable banks unsuitable for construction of burrows because wave action erodes banks and formation of winter ice separates beaver from water (burrows and security from predation) and food (Brown 1989, Bissell and Brown 1987).

Mack and others (1990) studied how Kerr Dam on the Flathead River has affected beaver and other wildlife. They found that stream flow fluctuations caused by Kerr Dam caused winter colony sites to be de-watered, flooded, and subjected to extreme shoreline icing. Heavy icing followed by rising water levels dislodged beaver food caches.

Lesica and Miles (1998) found that high beaver populations on the Marias River of Montana greatly affect riparian ecology by destroying cottonwoods and allowing proliferation of Russian olive. They speculate that the Tiber Dam that increases the number of potential den sites safe from flooding and severe drawdown may have enhanced beaver populations through flow regulation. This effect on population is supported by studies of Collins (1976), which found dramatic population movements occurred when beavers abandoned dwelling sites (lodges and burrows) due to seasonally high and low stream flows.

Beaver populations are controlled largely by dispersal (Olson and Hubert 1994). Two-year old beavers leave the colony in late spring in search of mates. Dispersing two-year old beavers usually move 5 to 10 miles with moves of over 100 miles being reported. Mortality during dispersal is usually substantial.

METHODS

Data on cottonwoods were collected at 30 randomly located circular plots, 0.1-acre in size, located on tribal or allotted lands. Sample plots were located on floodplain terraces, usually about 10-15 feet above the surface of the river at the time of sampling (i.e., September). Major floods that occurred prior to construction of the Fort Peck Dam periodically inundated these terraces. Map of plot locations are included in Appendix A.

Data was collected for number of trees, tree height, tree diameter, age, crown condition, and reproduction of seedlings and saplings. Tree ages were estimated by coring trees with an increment borer. Appendix B includes the field forms and data collected for each plot. Trees that were dead or damaged by beavers were also recorded. Joe Elliott and Drake Barton collected data during the week of September 10-14, 2001. Access to randomly located plots was by gained by working from a canoe.

Mark Teply of Larix Systems, Inc. generated random plot locations and statistically analyzed the data collected in this study. Tree data were summarized on a plot basis for the following parameters: average diameter at breast height (DBH), trees per acre, basal area, and cubic volume. With the exception of volume, parameters were summarized for both live and dead trees. Volume estimates were calculated for live trees only and were based on gross volume tables prepared by Edminster et al. (1997) for plains cottonwood. Log-linear diameter-height relationships were developed from these data to support volume estimation. Live tree data were also summarized based on stocking classes described by Meyer and Buchman (1984) by way of descriptive statistics for each parameter of interest and DBH class distributions.

RESULTS

Relatively open stands of Great Plains cottonwood (*Populus deltoides*) are the dominant forest community on upper floodplain terraces (10-15 above the level of the river during low-flow periods) along the Missouri River. Although the spatial extent of cottonwood woodlands have been reduced by clearing of land for agriculture and other factors, cottonwood woodlands still are present on substantial areas of the Missouri River floodplain, often extending a mile or more from the river.

Riparian communities along the Missouri River, on the Reservation, typically consist of an overstory dominated by Great Plains cottonwoods (40-80 percent canopy cover). Cottonwood stands tend to be even-aged with relatively consistent diameters ranging from 12-40 inches in diameter. Although it was not possible to accurately determine tree ages because most mature trees have heart rot, it appears that nearly all the trees are more than 70 years old with many trees being over 100 years old. Most cottonwoods are declining in vigor as evidenced by numerous dead tops, many missing branches, and numerous cavities in the boles. No cottonwood reproduction (i.e., no seedlings or saplings) was recorded for any of the sites sampled. Photographs of sites in the study area are included as Appendix C.

Table 1 presents plot summaries for live and dead trees sampled along the Missouri River. Figure 1 presents graphically live tree stand structure results reported in Table 1 where plot number increases with distance traveled down river. Live tree stand structure was predominated by cottonwoods. On a basal area basis, percent contribution by cottonwoods ranged between 89 and 100 percent. About three-quarters of these plots would be considered overstocked according to basal area and trees per acre guidelines presented in Meyers and Buchman (1984). Remaining plots were mostly fully stocked with few plots that would be considered understocked. Though there is an evident periodic trend in parameter data over distance down river, the lack of ancillary data makes it difficult to interpret.

Table 2 summarizes live tree data by stocking class and Figure 2 presents diameter at breast height (DBH) class distributions for each stocking class. Generally, average DBH among stocking classes did not vary; however, there were expectedly increases in trees per acre, basal area, and cubic volume as stocking class increased. The most apparent distinguishing feature among these stocking classes was DBH class distribution. Fully stocked plots are closest in exhibiting a "J"-shaped DBH class distribution. Highest contribution was coming from trees 5 to 10 inches DBH and stocking levels generally decrease through to the 35-inch and greater DBH class. Understocked plots were predominated by mid-sized trees (15 to 20 inches DBH) and almost no trees 20 inches and greater are represented. Overstocked plots differ from fully stocked plots by higher numbers of trees 5 to 20 inches DBH, represented in greater proportion by shade tolerant species such as green ash.

Table 1. Plot Data Summaries, Riparian Cottonwood Study, Missouri River, Fort Peck Reservation, Montana.

		Live Trees				Dead Trees (3)		
Plot	Stocking Class (1)	Average DBH (in)	Tree per Acre (#)	Basal Area (sqft/ac)	Cubic Vol. (2) (cuft/ac)	Average DBH (in)	Tree per Acre (#)	Basal Area (sqft/ac)
01	Fully Stocked	14.2	60	104.8	3,431			
02	Overstocked	15.7	120	172.1	6,237			
03	Overstocked	18.6	70	144.6	6,070			
04	Overstocked	12.4	100	163.6	7,759	26.0	10	36.9
05	Overstocked	15.5	110	148.4	5,282			
06	Fully Stocked	13.3	80	88.1	3,002	18.0	10	17.7
07	Fully Stocked	18.3	60	117.2	4,916	17.0	20	32.5
08	Overstocked	29.3	30	143.4	6,007			
09	Understocked	17.4	50	83.4	3,302	17.5	20	33.7
10	Overstocked	17.1	90	146.5	5,496			
11	Overstocked	12.0	160	140.8	4,621	7.0	10	2.7
12	Understocked	17.0	50	79.6	2,872			
13	Understocked	11.2	90	79.2	2,780	25.0	10	34.1
14	Overstocked	16.0	100	151.0	5,665	11.0	10	6.6
15	Overstocked	17.7	110	205.5	8,139	8.7	30	13.0
16	Overstocked	16.5	80	129.8	4,960			
17	Overstocked	14.0	120	131.2	4,407			
18	Overstocked	12.6	160	153.0	5,140			
19	Fully Stocked	11.7	100	89.8	3,061	7.0	30	8.3
20	Overstocked	14.7	90	123.2	4,631			
21	Overstocked	11.0	210	154.3	4,415	7.4	100	31.3
22	Overstocked	12.6	200	187.1	6,242			
23	Overstocked	10.6	250	168.4	5,133			
24	Overstocked	8.9	230	109.2	3,059	7.0	10	2.7
25	Overstocked	17.7	90	191.3	7,844			
26	Overstocked	16.8	90	153.9	6,048			
27	Overstocked	20.5	80	221.9	9,850			
28	Fully Stocked	19.8	50	122.3	5,130			
29	Overstocked	20.3	60	138.0	5,714			
30	Overstocked	18.9	70	138.8	5,417			

Notes: (1) - Based on trees per acre and basal area per acre as described in Myers and Buchman (1984).
(2) - Based on gross volume tables for plains cottonwood in Edminster et al. (1977).
(3) - Includes standing dead trees (snags) and recent downed dead trees due to beaver kill.

Figure 1. Live Tree Stand Structure, Riparian Cottonwood Study, Missouri River, Fort Peck Reservation, Montana.

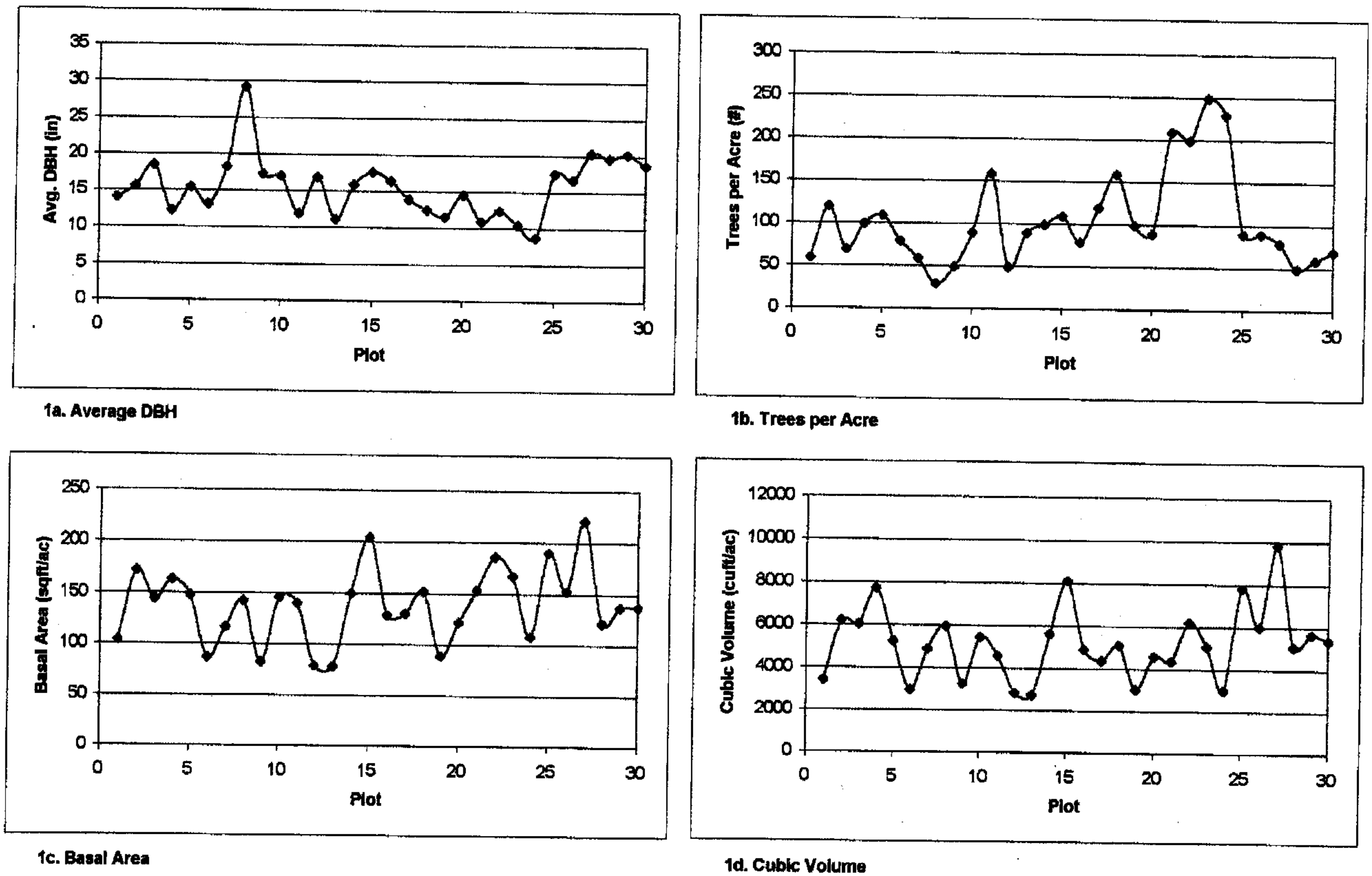
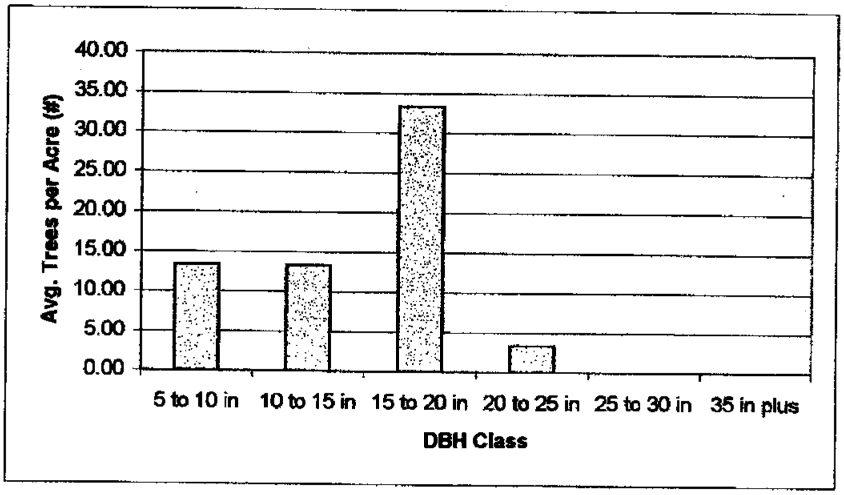


Table 2. Live Tree Summary Statistics by Stocking Class, Riparian Cottonwood Study, Missouri River, Fort Peck Reservation, Montana.

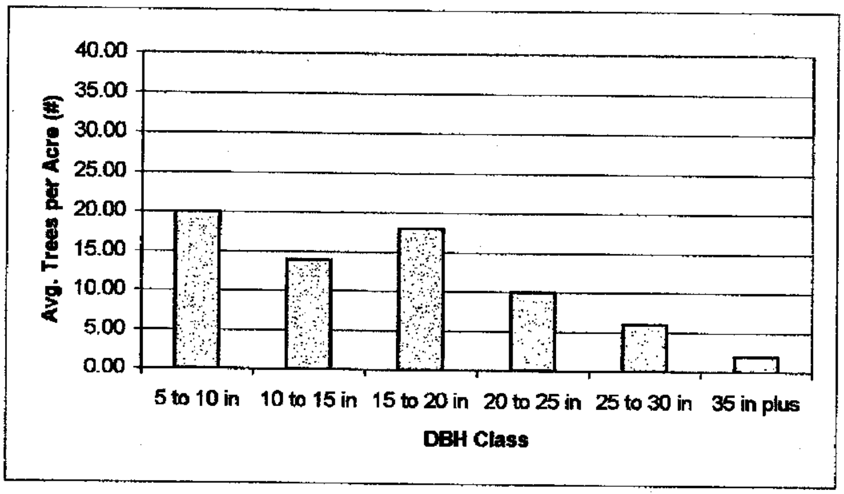
Parameter	Statistic	Stocking Class			
		Understocked	Fully Stocked	Overstocked	All Plots
Number of Plots	n	3	5	22	30
Average DBH (in)	min	11.2	11.7	8.9	8.9
	max	17.4	19.8	29.3	29.3
	avg.	15.2	15.5	15.9	15.7
	sd	3.5	3.5	4.4	4.1
Trees per Acre (#)	min	50	50	30	30
	max	90	100	250	250
	avg.	63	70	119	105
	sd	23	20	58	56
Basal Area (sqft/ac)	min	79.2	88.1	109.2	79.2
	max	83.4	122.3	221.9	221.9
	avg.	80.7	104.4	155.3	139.3
	sd	2.3	15.5	27.0	36.3
Cubic Volume (cuft/ac)	min	2780	3002	3059	2780
	max	3302	5130	9850	9850
	avg.	2985	3908	5824	5221
	sd	279	1034	1491	1689

Figure 2. Live Tree DBH Class Distribution by Stocking Class, Riparian Cottonwood Study, Missouri River, Fort Peck Reservation, Montana.

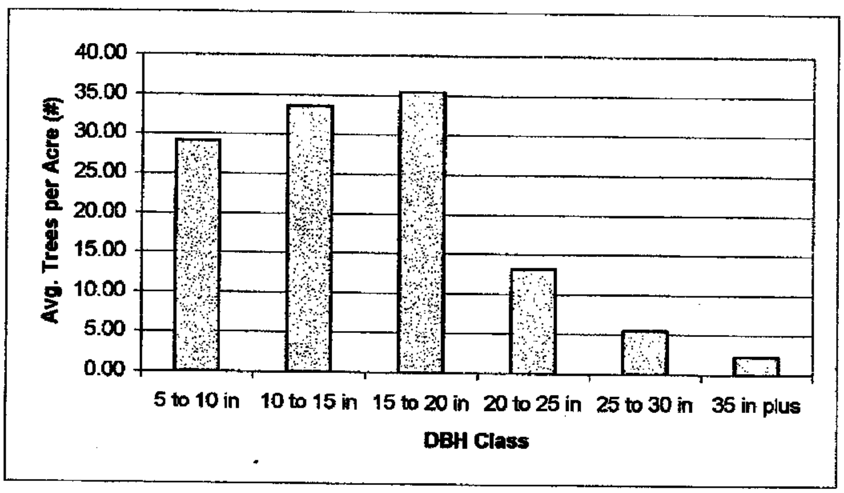
2a. Understocked



2b. Fully Stocked



2c. Overstocked



Cottonwoods are relatively short-lived trees. The average live expectancy of a Great Plains cottonwood is 125 years (Miles et al 1993, Hansen et al 1995, and Wilson 1970). After about 125 years, green ash, box elder, and Russian olive replace cottonwoods if cottonwood regeneration is not initiated by flooding and sediment deposition.

Hanson et al (1995) classified the plant communities sampled in this study as the Great Plains cottonwood/western snowberry community type. Common understory shrubs and trees in this community include green ash *(Fraxinus pennsylvanica)*, silver buffaloberry (*Sheperdia argentea*), chokecherry (*Prunus virginiana*), snowberry (*Symphoricarpos occidentalis*), poison ivy (*Toxicodendron rydbergii*), and Wood's rose (*Rosa woodsii*). Several stands sampled had dense stands of the exotic small tree, Russian olive (*Eleagnus angustifolia*) forming a secondary canopy from 25-30 feet in height, under taller cottonwoods (mostly from 85 to 95 feet in height). Common herbaceous species include smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), wildrye (*Elymus canadensis*), wild licorice (*Glycerrhiza lepidota*), western needlegrass (*Stipa occidentalis*), and western wheatgrass (*Agropyron smithii*).

Green ash and Russian olive are the only trees reproducing on the higher river terraces of the study area. At some sites, green ash and Russian olive form a canopy layer under an aging, decadent canopy of cottonwoods. Unlike cottonwoods, neither green ash nor Russian olive requires periodic flooding to reproduce.

Where fire or beavers have killed cottonwoods, green ash and Russian olive increase in density. These two species respond to fire or cutting by sprouting from root crowns or stumps whereas older cottonwoods are usually killed and often do not sprout from roots or severed trunks.

Beavers also show a marked preference for cottonwoods over green ash and Russian olive. Lesica and Miles (2001), in studies on the Marias and Yellowstone rivers in Montana found that beavers were far more likely to kill cottonwoods than Russian olive. The preferential selection of beavers for cottonwoods over Russian olive increases the rate of conversion of cottonwood communities to Russian olive communities.

Green ash is a native species common in riparian areas of eastern Montana. Russian olive is an exotic, invasive species that is rapidly spreading in many riparian plant communities on the northern Great Plains. There is concern that Russian olive will replace native riparian forests, resulting in a loss of biological diversity (Lesica and Miles 2001, Knopf and Olson 1984).

Large populations of beavers are having a substantial effect on cottonwood trees in the study area. Many trees within 50 meters of the river have been gnawed or felled by beavers. Beaver populations have increased throughout most of Montana because trapping has declined due to low fur prices. Large beaver populations below the Fort Peck Dam may also be due to the release of controlled flows from the Dam. With control of large floods, beaver dens are at reduced risk of being flooded or removed by bank erosion. Ice formation, which can also adversely affect beavers, has also been influenced by discharge of relatively constant temperature water from the Fort Peck Dam.

DISCUSSION

Cottonwood woodlands on the higher terraces along the Missouri River are declining because reproduction is not replacing trees that are dying or being killed by beavers and fire. The average life span of a Great Plains cottonwood is about 125 years or less. Most cottonwoods on floodplain terraces are older than 80 years. Within 20-50 years the cottonwood woodlands that often extend a mile or more from the Missouri River will be replaced by woodlands dominated by green ash, Russian olive, and shrubs such as choke cherry, silver buffaloberry and silver sagebrush (*Artemisia cana*).

Cottonwoods are not reproducing because overbank flooding of the higher stream terraces along the Missouri River has been eliminated by containment of major floods by the Fort Peck Dam. Also, the rate at which lateral channel migrations take place has been greatly reduced due to operation of the Fort Peck Dam. Reduced rates of channel migration reduce the potential for cottonwood regeneration on sandbars, islands and stream banks.

Another influence of the Fort Peck Dam on vegetation concerns downcutting (degradation) of the channel downstream from the Dam. Sediment normally carried suspended in the Missouri River settles out in the reservoir behind the dam. Water discharged from the dam has very low suspended sediment loads; consequently, the river tends to downcut the channel, thereby increasing the elevation of the floodplain terraces above the river level. Increased height of the floodplain terraces above the channel decreases soil moisture levels in terraces causing moisture stress in cottonwoods especially during the late summer and fall when river levels are lowest.

Although cottonwood reproduction is not taking place on higher floodplain terraces, cottonwoods are reproducing on recent sand bars, islands, and lower terraces that are periodically inundated with current operation of the Fort Peck Dam. Numerous sand bars and islands, within a few feet of the water surface during the low-flow period (i.e., September) have dense stands of cottonwood seedlings. A few higher sites (5-7 feet above the river level during the base-flow period), that are not flooded and scoured every year by high flows, have developed stands of young cottonwood trees and saplings.

Cottonwood reproduction is occurring only along a very narrow zone where fluctuations of river flows periodically inundate low floodplain terraces immediately adjacent to the river or on instream sandbars and islands that are unstable and shift due to erosion and deposition that accompany changing river flows. Although young seedlings and saplings often form dense stands on alluvial deposits close to the river, these young colonies of cottonwood experience high levels of mortality from frequent flooding, erosion, and ice scouring

As the more extensive, mature and decadent cottonwood forests on the upper river terraces gradually decline and are replaced by green ash and Russian olive, beavers, will concentrate their foraging on the cottonwoods that are reproducing on lower terraces, islands, and sand bars. Because cottonwood reproduction is taking place on only a narrow zone along the river, these young cottonwoods will become extremely vulnerable to beaver-caused mortality.

Areas on higher terraces, where beavers are now killing cottonwoods will be devoid of cottonwoods in the future, forcing beaver populations to concentrate on a smaller food supply. The result will likely be that beavers decimate cottonwood reproduction before trees can reach maturity.

RECCOMMENDATIONS

The current study established that extensive cottonwood stands on river terraces are not reproducing and will likely be largely gone in 20-50 years. Since it is not feasible or desirable to allow the Missouri River to flow unimpeded by the Fort Peck Dam, regenerating cottonwoods through flooding, scouring, and sediment deposition is not an option. Artificial regeneration of cottonwoods could be initiated on sites where maintaining cottonwood forests is desirable from an ecological, cultural, or spiritual perspective.

Manipulation of diameter classes would provide limited improvement in the cottonwood component. In overstocked stands, thinning of trees 20 inches and less could yield DBH class distributions that approximate those in fully stocked stands. However, residual trees in these would be either tolerant species, such as green ash, or cottonwoods that have been suppressed and would therefore be unlikely to respond to thinning. Improvements in the cottonwood component would likely only occur through artificial establishment of cottonwoods as noted above.

Because beavers are having a substantial influence on cottonwood mortality and will likely limit future cottonwood regeneration (which is occurring on a limited area), reductions of beaver populations may be desirable. Alternatively, protecting cottonwood stands with mesh or fencing could also reduce beaver damage.

Sites where cottonwoods are regenerating are limited to low terraces, sand bars, and low islands. These areas are limited in size and may be too unstable with regard to erosion and deposition dynamics to support cottonwood communities until the communities develop into mature stands. Mapping the spatial extent of areas where cottonwoods are regenerating and monitoring changes of these sites would provide information on the future probability that some cottonwood stands might reach maturity.

To accurately map areas of cottonwood regeneration, aerial photographs (scale 1: 24,000 or larger) taken in late summer, would be necessary. Interpretation of aerial photographs, combined with on-the-ground reconnaissance, would be needed to delineate areas with viable cottonwood stands. Comparison of aerial photography of the Reservation, taken in

1979, with new photography for the Reservation would allow comparisons to be made concerning changes in the spatial extent of various seral stages of riparian communities. Rates of channel migration, sand bar and island formation, and losses of cottonwoods due to fire and beavers could be determined by comparison of recent aerial photographs with historic aerial photographs.

Monitoring changes of cottonwood mortality, reproduction, and growth could be conducted through establishment of continuous forest inventory (CFI) plots randomly located in the forest. Tree measurements would be similar to that conducted for this study, but trees would be numbered and tracked through time. Parameter summaries would also be similar to that conducted for this study and, additionally, the following components of growth could be evaluated upon remeasurement: survivor growth, mortality, ingrowth, and removal. Overall, these data would support trend analysis explaining and predicting the change in cottonwood stand conditions over time.

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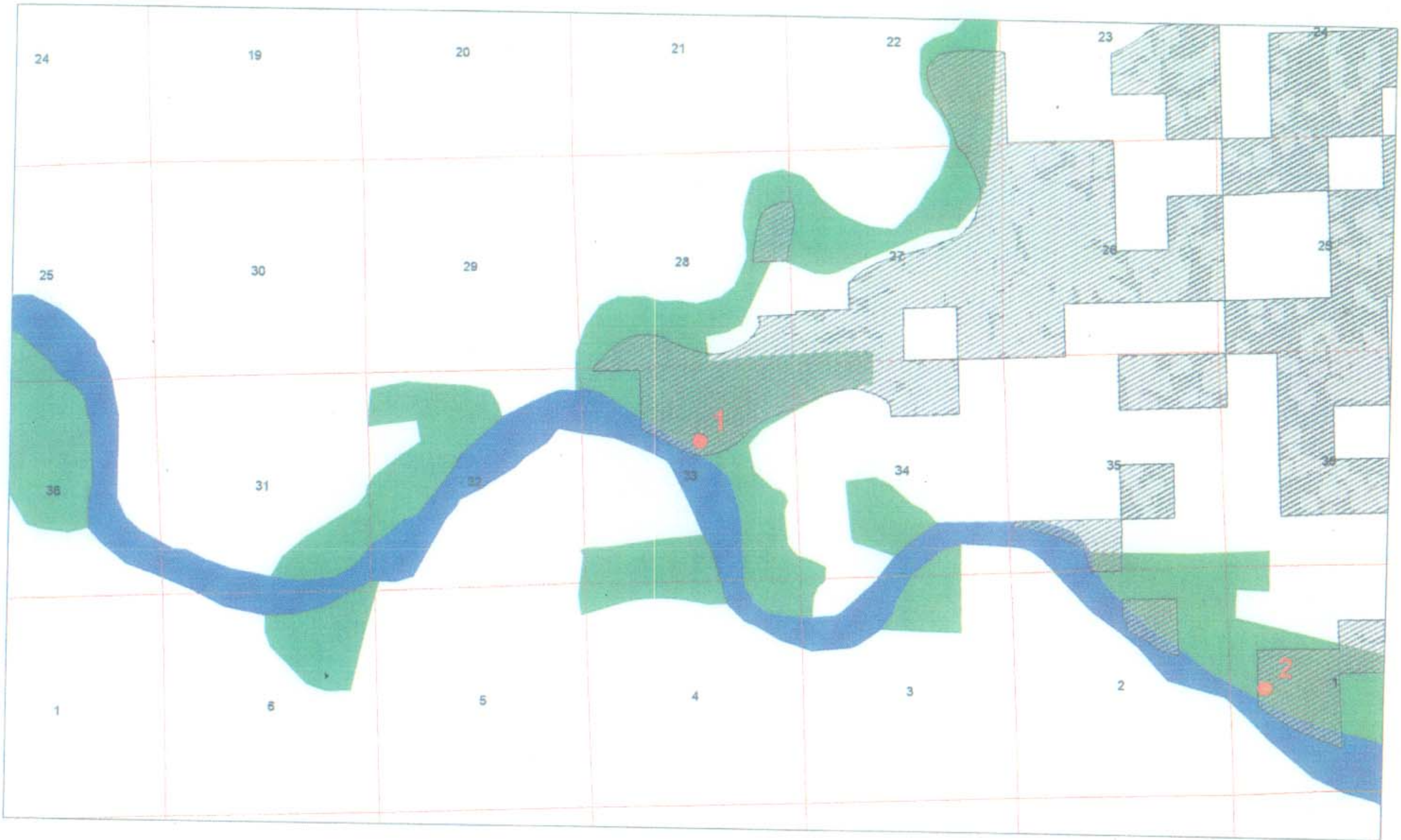
APPENDIX A

MAPS OF SAMPLE SITES



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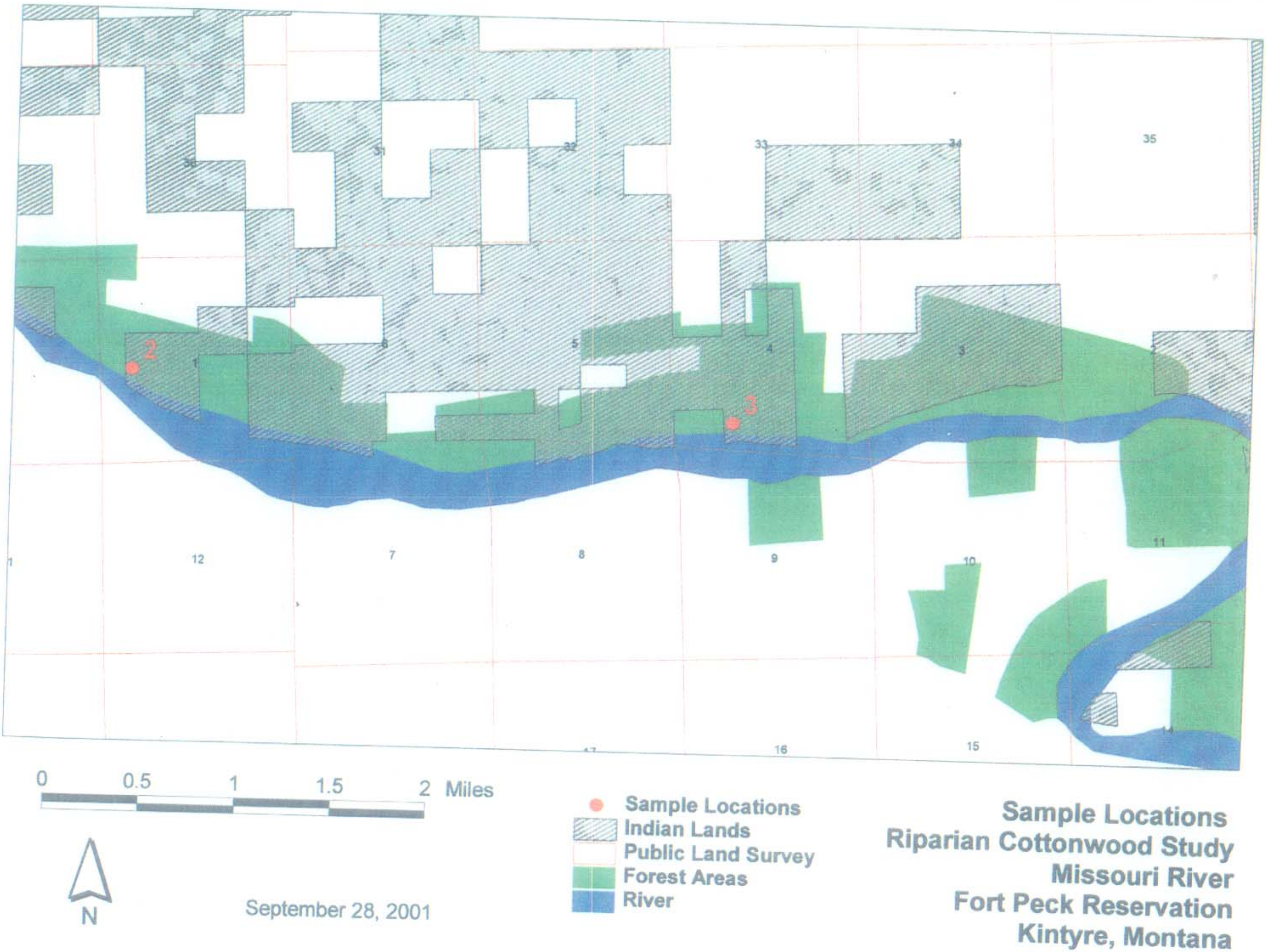
September 28, 2001

- Sample Locations
- Indian Lands
- Public Land Survey
- Forest Areas
- River

Sample Locations
Riparian Cottonwood Study
Missouri River
Fort Peck Reservation
Milk River Hills, Montana



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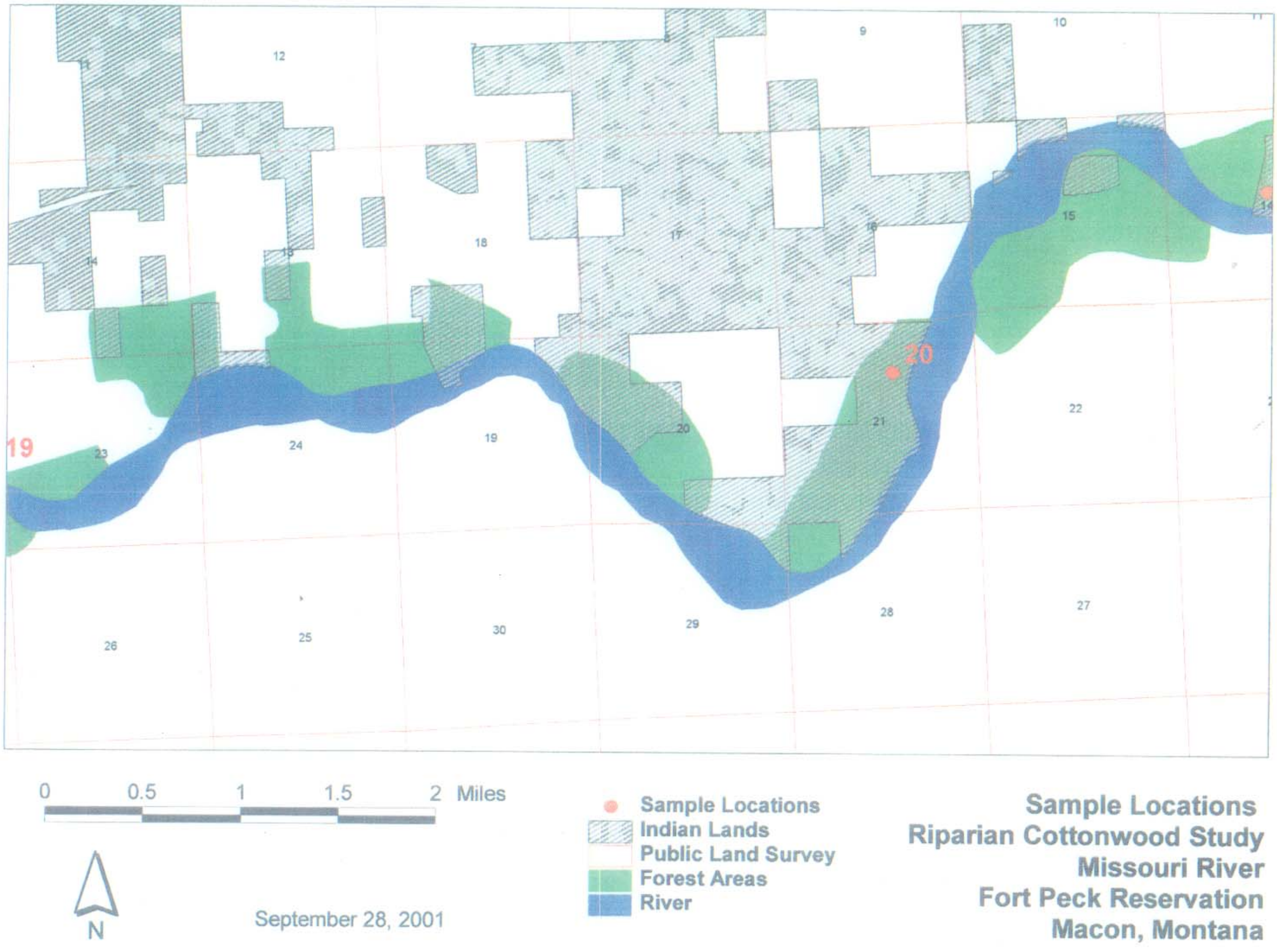
Riparian Cottonwood Study
Missouri River
Fort Peck Reservation
Kintyre, Montana



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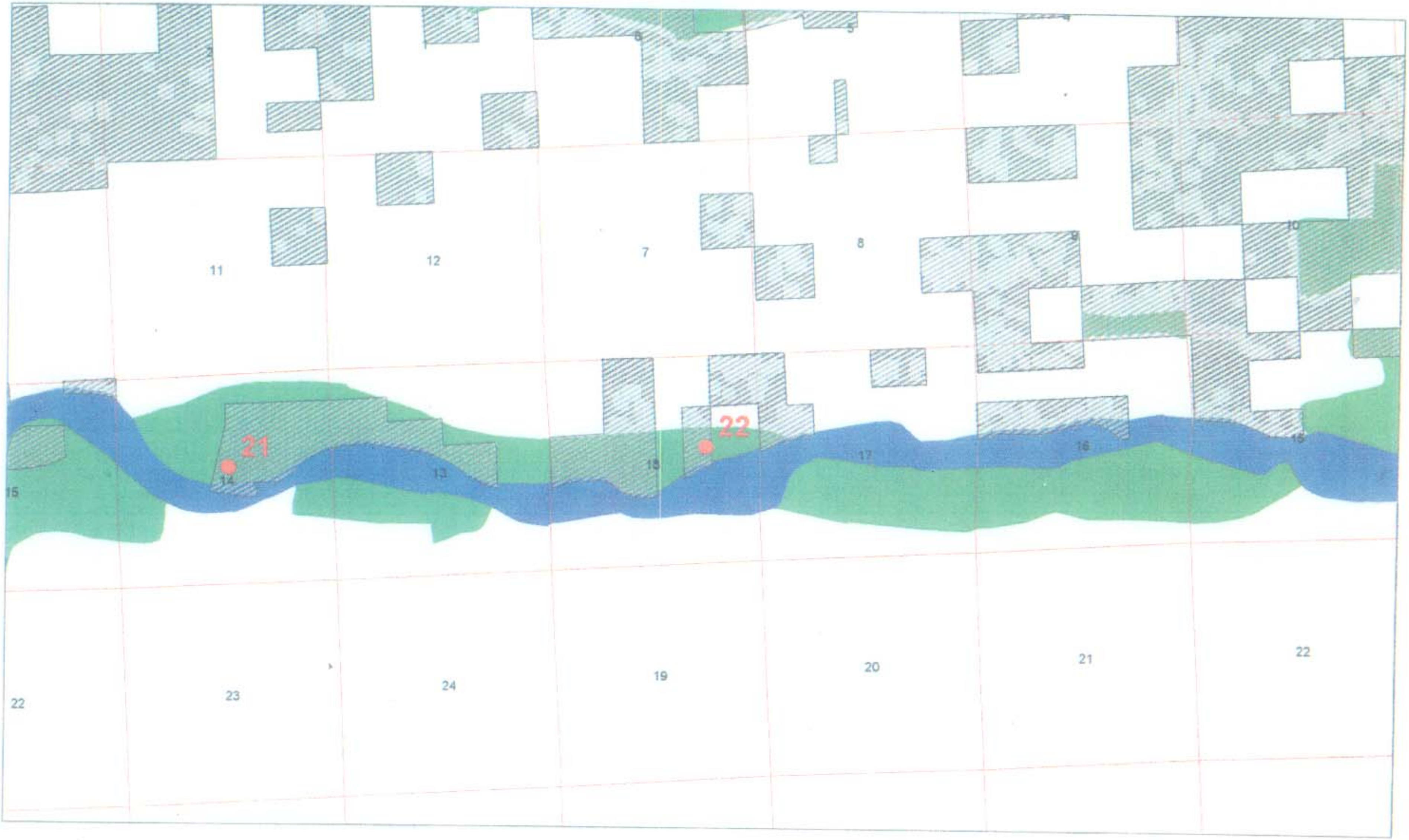
Fort Peck Reservation
Macon, Montana



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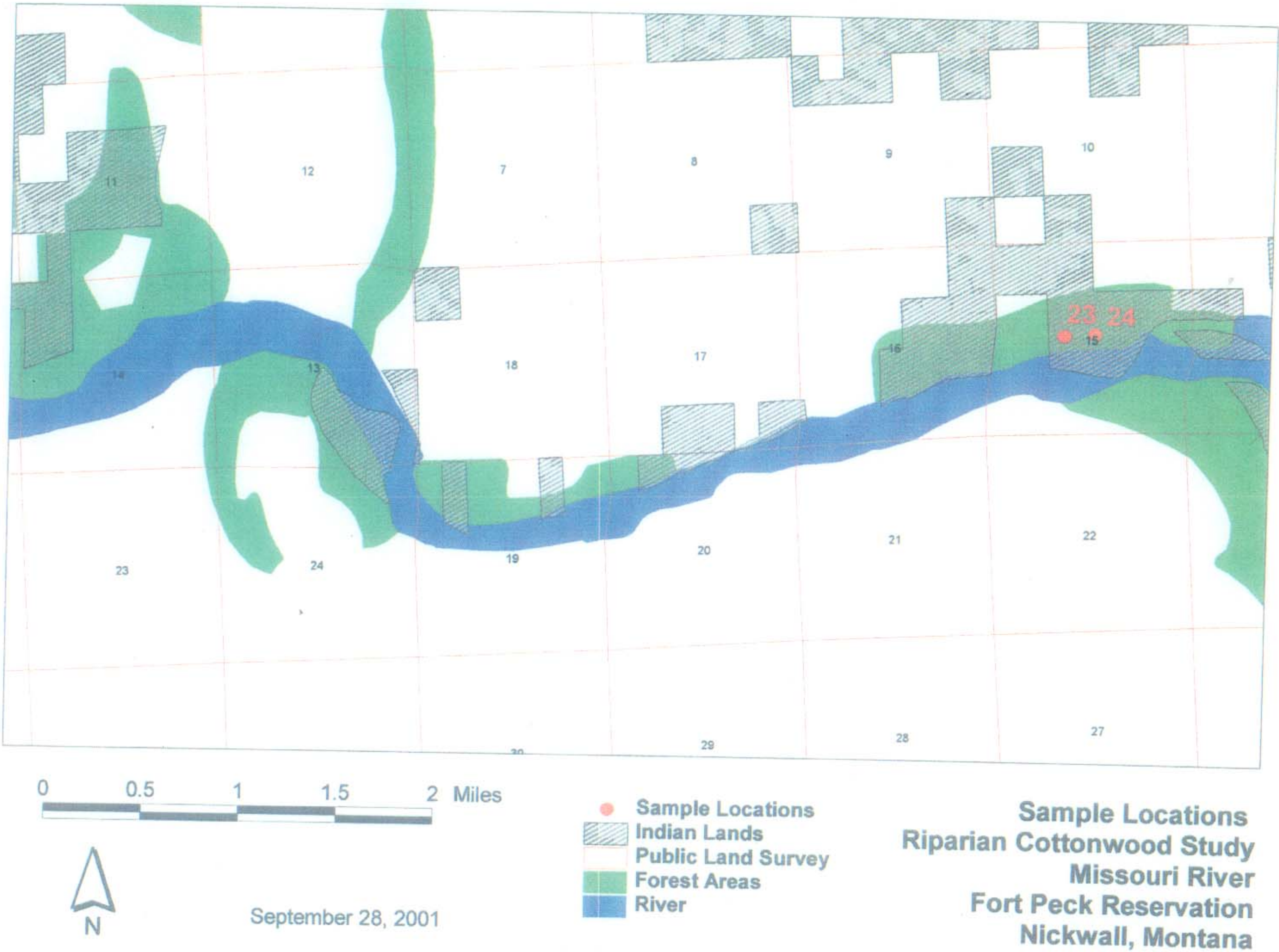
Sample Locations
Indian Lands
Public Land Survey
Forest Areas
River

Sample Locations
Riparian Cottonwood Study
Missouri River
Fort Peck Reservation
Chelsea SW, Montana



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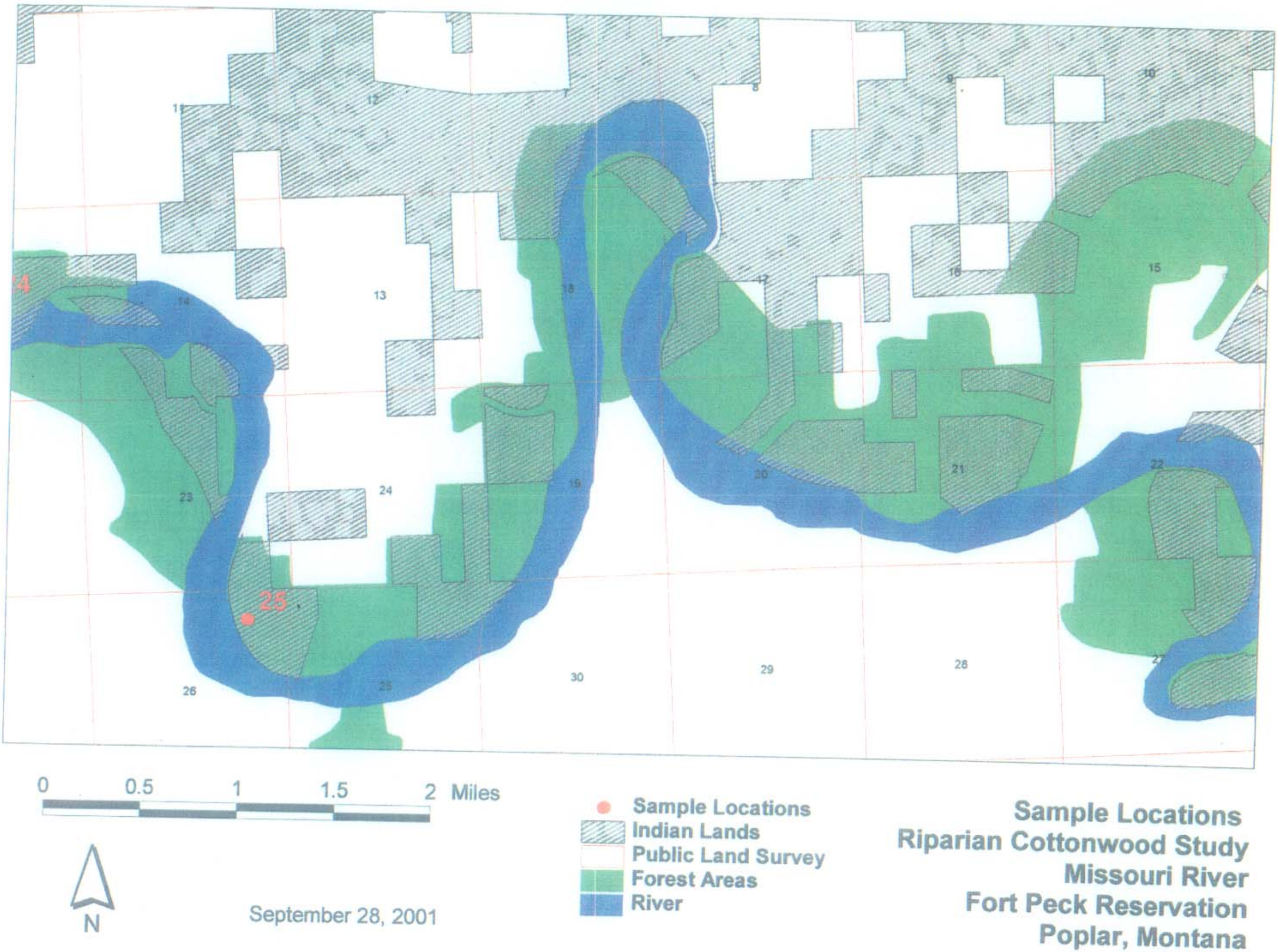
Missouri River
Fort Peck Reservation
Nickwall, Montana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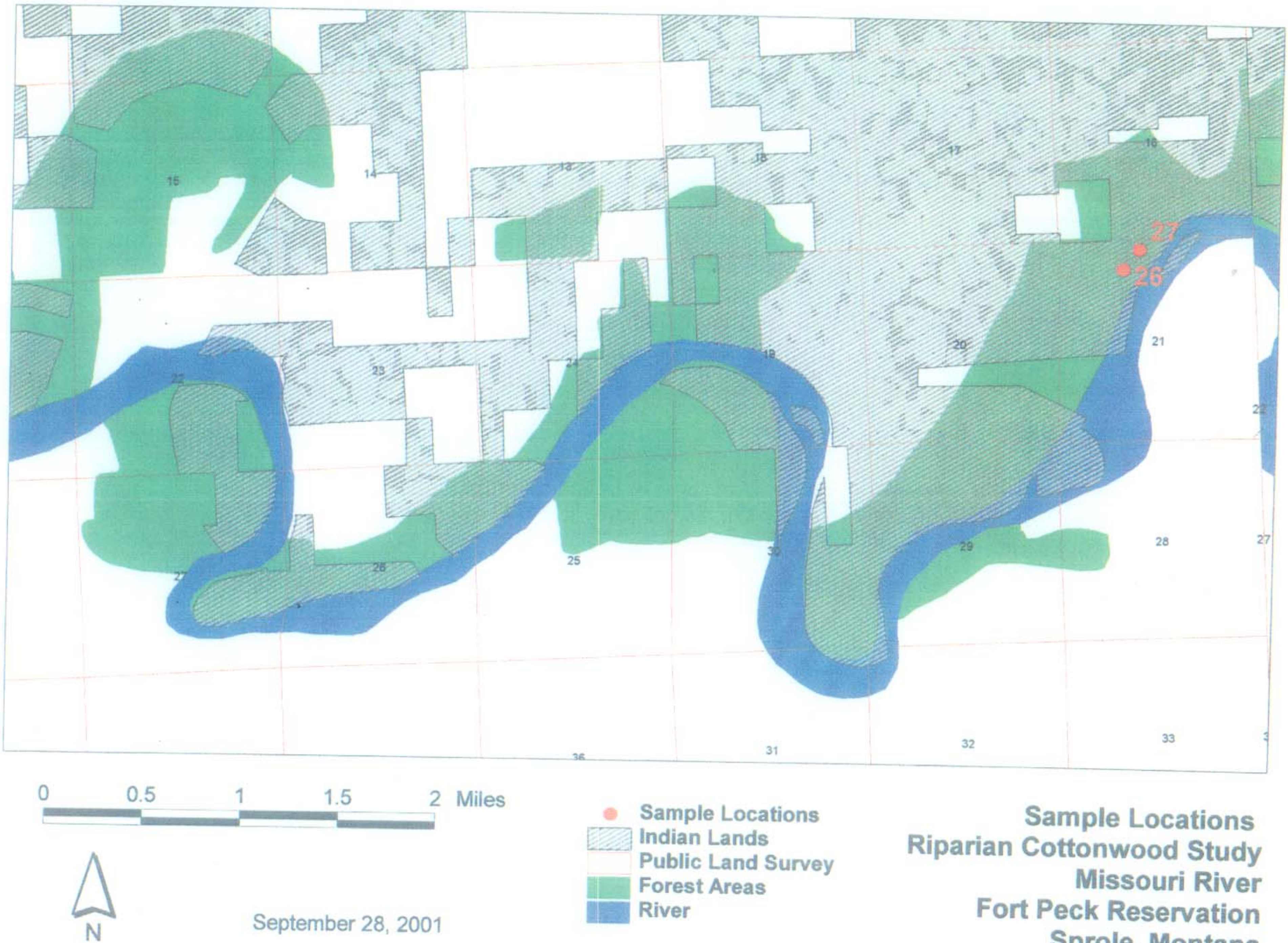
Forest Areas
River
Sample Locations
Riparian Cottonwood Study
Missouri River
Fort Peck Reservation
Poplar, Montana



Sample Locations
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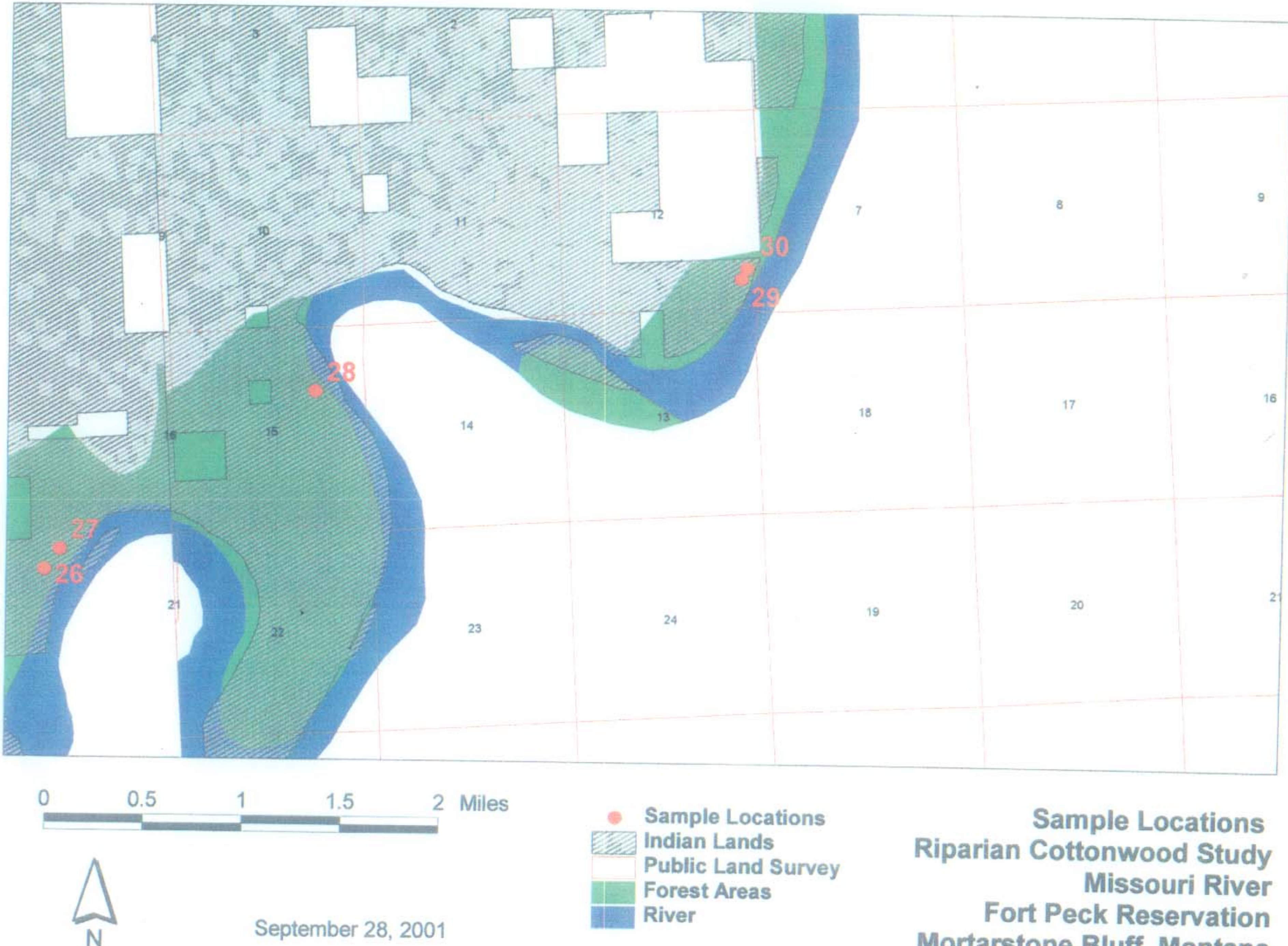
Fort Peck Reservation
Sprole, Montana



September 28, 2001

Sample Locations
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Fort Peck Reservation
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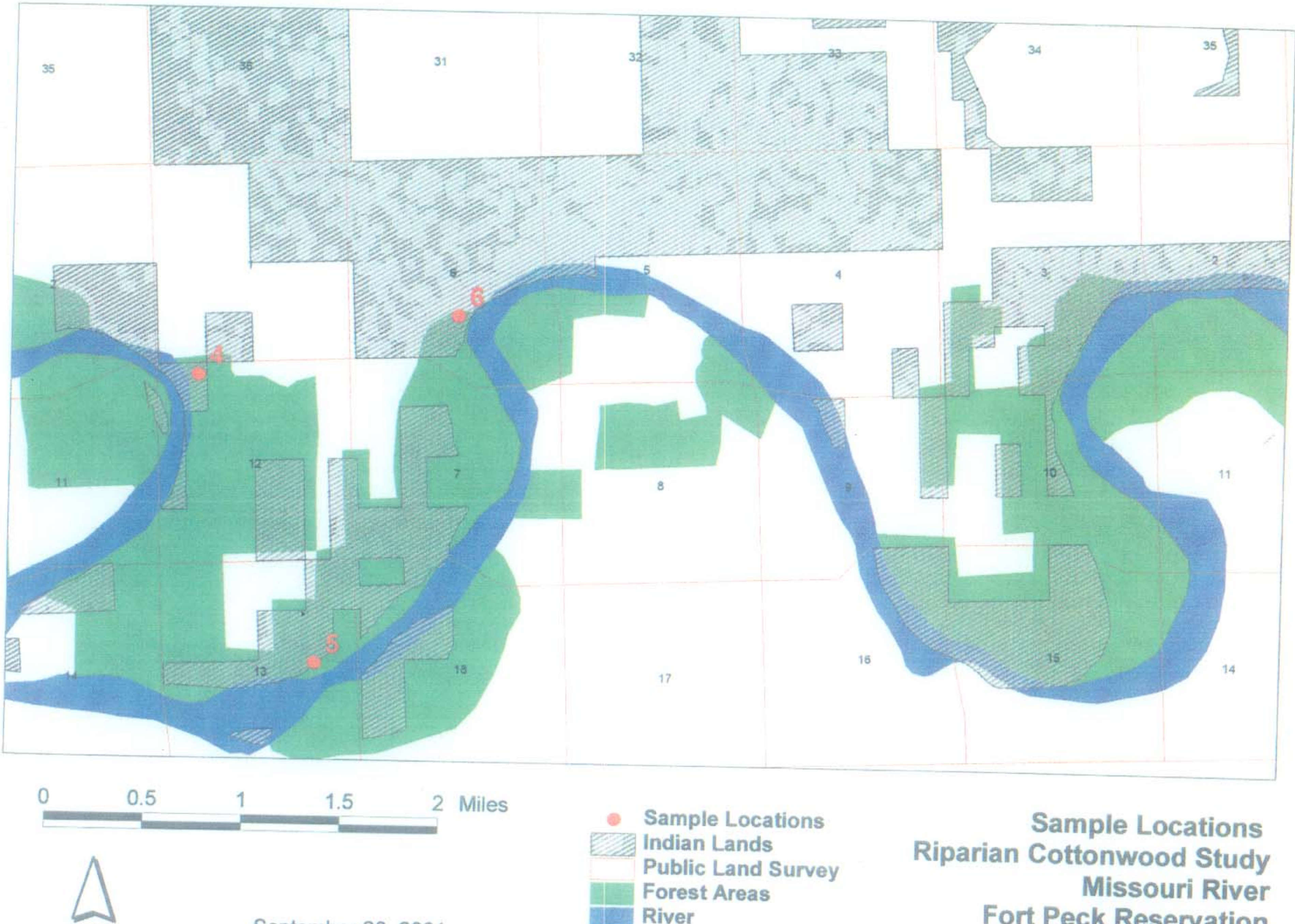
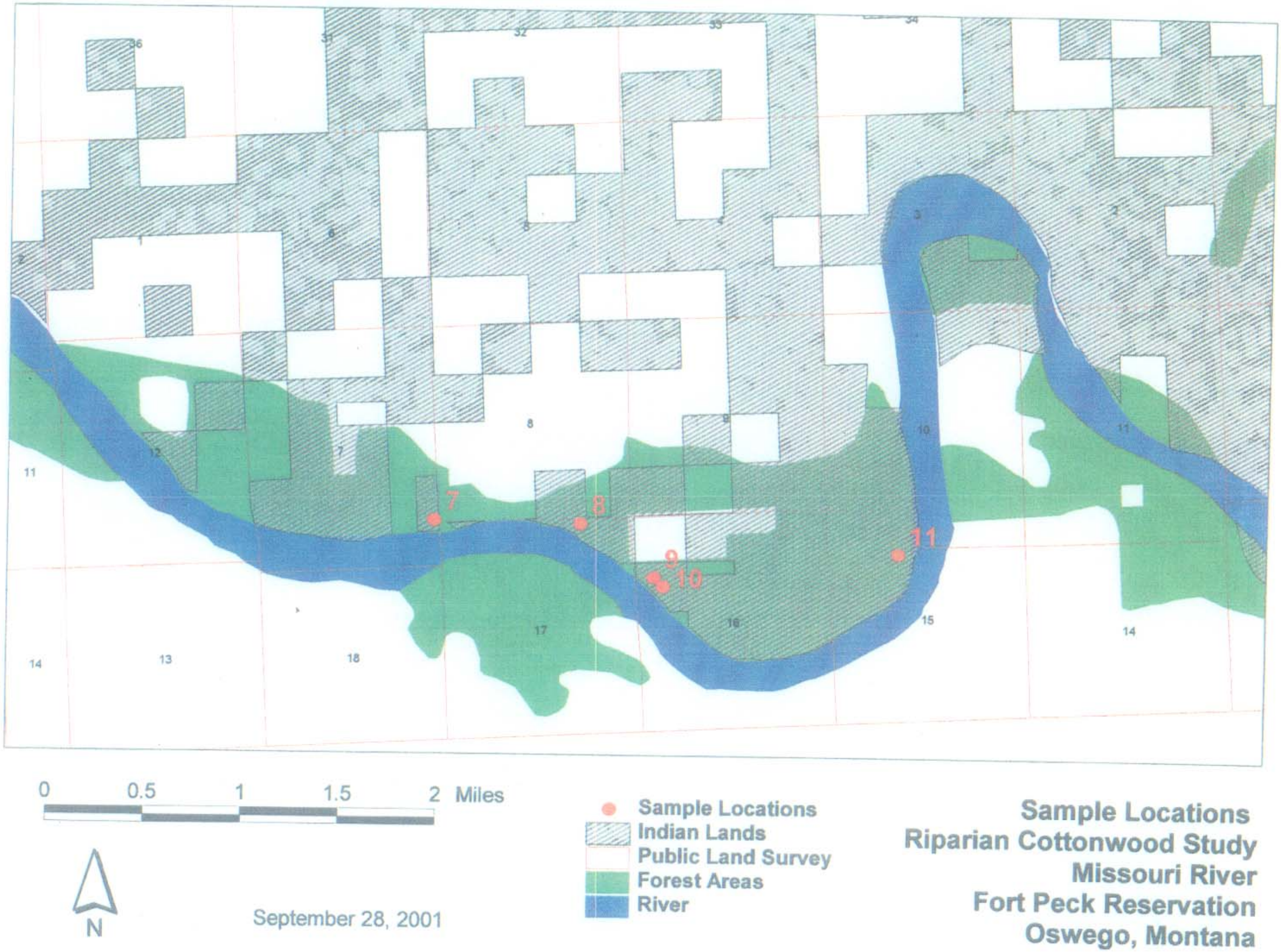


September 28, 2001

Sample Locations
Indian Lands
Public Land Survey
Forest Areas
River

Sample Locations
Riparian Cottonwood Study
Missouri River
Fort Peck Reservation
Frazer, Montana



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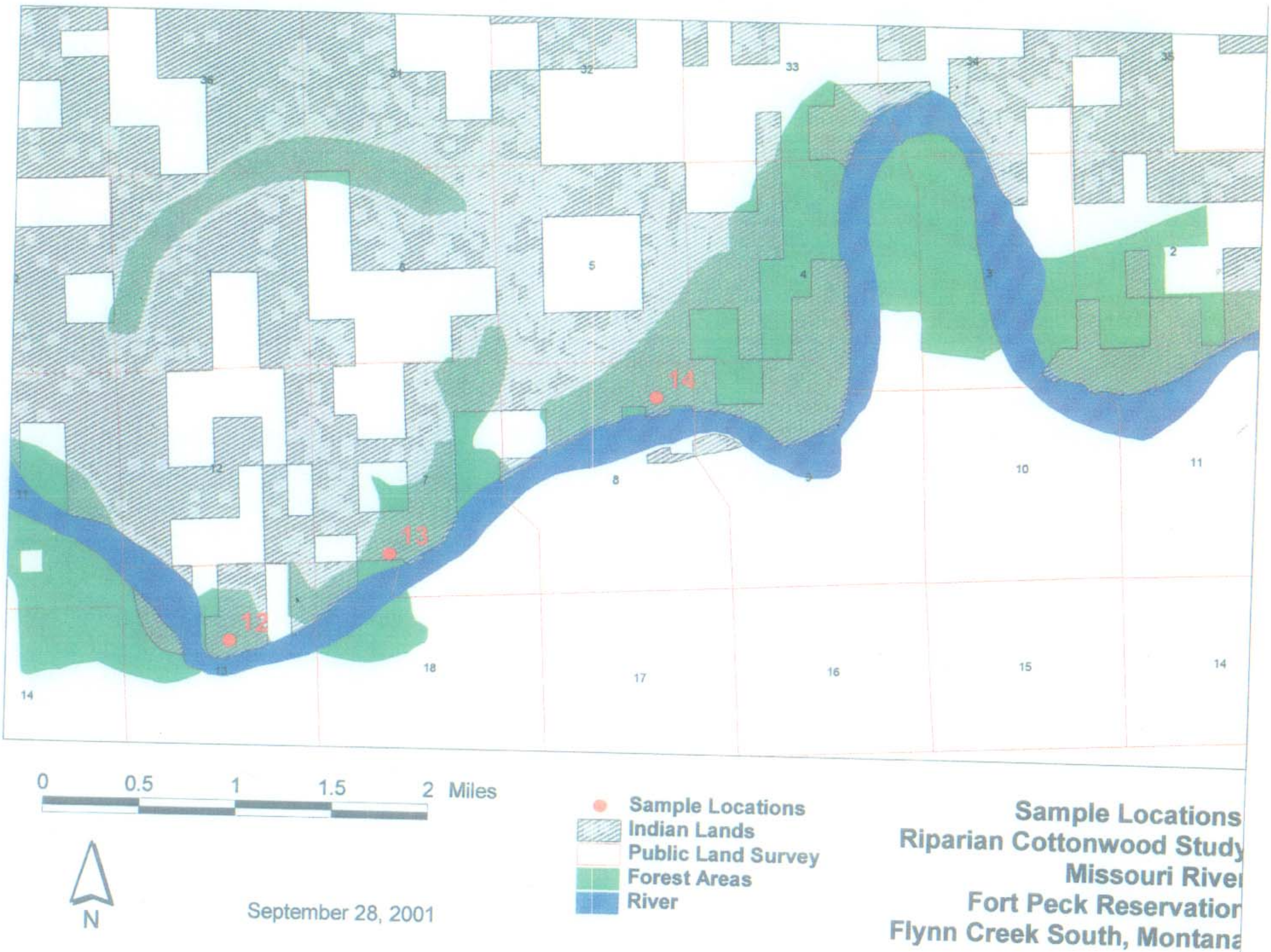
Riparian Cottonwood Study
Missouri River
Fort Peck Reservation
Oswego, Montana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September 28, 2001
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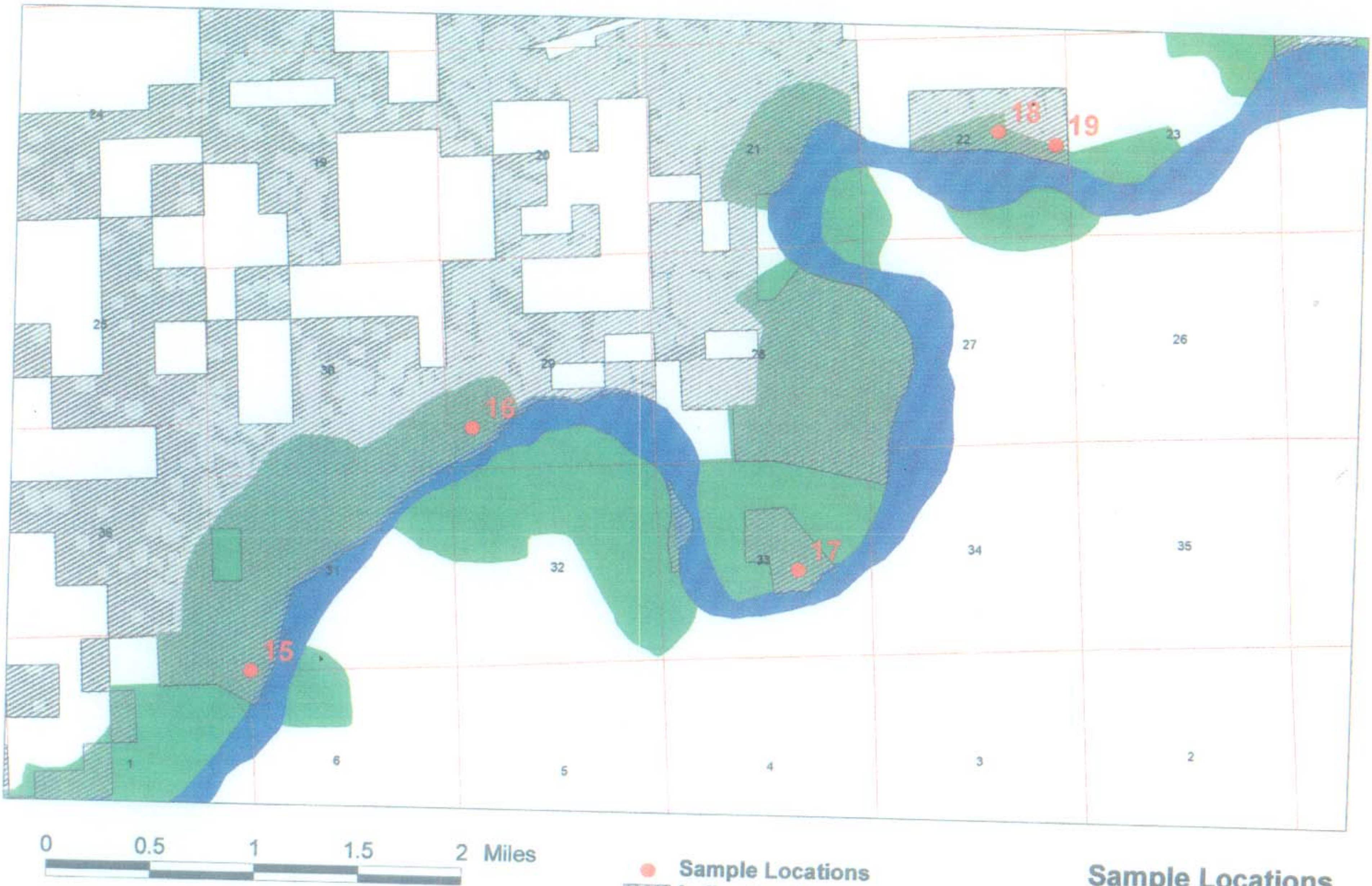
Public Land Survey
Forest Areas
River
Sample Locations
Riparian Cottonwood Study
Missouri River
Fort Peck Reservation
Flynn Creek South, Montana



September 28, 2001

Sample Locations
Riparian Cottonwood Study
Missouri River
Fort Peck Reservation
Wolf Point, Montana

APPENDIX B

DATA FIELD FORMS

Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: #1
Subplot:

Crew: DE/DB

Date: 9/10/01

Subplot Location: GRAZED TERRACE ~15' ABOVE RIVER
STIOCC 15% POAPRA 40% AGRTRA 5 SYMOCC
PHOTO #1 1/10 ACRE PLOT ELYVIR 15% ARTCAN T ROSWOO 2

Forest Type: POP DEL
Percent Slope: 0
Aspect: 0
Physiography: TERRACE

Soil Group:
Soil Texture: SANDY
Soil Erosion: NONE
Litter Depth: 0-2"
Humus Depth:

Stand Structure: 2-STORY
Crown Cover: 40%
Ground Cover: 70%
Browsing Intensity: HIGH
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
FRAPEN	1	5	21	1	22								
FRAPEN	1	6	25	2	—								
FRAPEN	1	5	22	2	—								
POPDEL	1	11	65	2	39								
POPDEL	1	25	65	2	ROT.								
POPDEL	1	33	65	2	ROT.								

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

Rev. 8/25/01

Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: Stand Unit: 2 Subplot:	Crew: JEID B	Date: 9/10/01

Subplot Location: AGRSMI ELYVIR
POAPRA STOCC PHOTO #3 (AFTER GRAVEL BAR W/ CANOE PHOTO
SYMOCC BRDINE

Forest Type: POPDEC	Soil Group: CLAY	Stand Structure: 1 STORY
Percent Slope: 0	Soil Texture: CLAY	Crown Cover: 70%
Aspect: 0	Soil Erosion: 0	Ground Cover: 90%
Physiography: TERRACE 15' ABOVE RIVER	Litter Depth: 2	Browsing Intensity: MODERATE
	Humus Depth:	Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEL	1	9		2									
POPDEL	1	9		2	~40								
POPDEL	1	18		2									
POPDEL	1	17		2									
POPDEL	1	15		2									
POPDEL	1	19		2	ROT.								
POPDEL	1	12		2									
POPDEL	1	19		2									
POPDEL	1	21	71	2	ROT.								
POPDEL	1	13		2									
POPDEL	1	14		2									
POPDEL	1	22		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: Stand Unit: 3 Subplot:	Crew: SE/DB	Date: 9/10/0

Subplot Location: TERRACE ~15' ABOVE RIVER
ELYTOX GLYLEP SYMOCC
BROINE PRUVIR SOLCAN

Forest Type: POP DEL	Soil Group: SANDY LOAM	Stand Structure: 1-STORY
Percent Slope: 0	Soil Texture:	Crown Cover: 60 %
Aspect: 0	Soil Erosion:	Ground Cover: 100 %
Physiography: TERRACE	Litter Depth:	Browsing Intensity: LOW
	Humus Depth:	Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	21	85	2	—								
POPDEL	1	16	80	2	—								
POPDEL	1	28	85	2	ROT.								
POPDEL	1	7	75	1	40								
POPDEL	1	20	80	1	—								
POPDEL	1	19	80	2	—								
POPDEL	1	19	80	2	—								

80

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	3'	—	10					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 4
Subplot:

Crew: JE/DB

Date: 9/11/0

Subplot Location: TERRACE ~15 ABOVE RIVER
SYMOCC PRUVIR GLYCAN
RHUTOX BROINE ROSWOO

Forest Type: POPDEL
Percent Slope: 0
Aspect: 0
Physiography: TERRACE

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2-STORY
Crown Cover: 60
Ground Cover: 98
Browsing Intensity: UNGRAZE
Other Disturbance: BEAVER

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundn
POPDEL	1	38		3		ROTTEN							
POPDEL	2	26	69	5		11							
FRAPEN	1	7		1									
FRAPEN	1	7		1	52								
FRAPEN	1	6		2									
FRAPEN	1	6		2									
FRAPEN	1	6		2									
FRAPEN	1	5		2									
POPDEL	1	35		3									
FRAPEN	1	6		2									
FRAPEN	1	8		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	3	—	2					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 5
Subplot:

Crew: JE/DB

Date: 9/11/01

Subplot Location: TERRACE 12-15 FEET ABOVE RIVER
SYMOCC RHUTOX STIDCC LINPER
ELYCAN POAPRA PARQUI

Forest Type: POPDEL
Percent Slope: 0
Aspect: 0
Physiography: TERRACE

Soil Group: SANDY LOAM
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 1-STORY
Crown Cover: 50%
Ground Cover: 85%
Browsing Intensity: LOW
Other Disturbance: BEAVER

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEL	1	13	69	2									
"	1	15	MULT	2									
"	1	13	TRUNK	2									
"	1	13	MULT	2									
"	1	14	TRUNK	2									
"	1	17	MULT	2									
"	1	15	TRUNK	2									
"	1	17	MULT	2									
"	1	21	TRUNK	2									
"	1	15	MULT	2									
"	1	18	TRUNK	2	70								

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	1.5'	—	3					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 6
Subplot:

Crew: JE/DB

Date: 9/11/01

Subplot Location: TERRACE AMEALN BROINE SYMOCC CORSTO PRUVIR RHUTOX
SPIRITUAL SITE PRAYER FLAGS ON COTTONWOOD
NO PHOTO

Forest Type: POPDEL/FRAPEN
Percent Slope: 0
Aspect: 0
Physiography: TERRACE (10')

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2-STORY
Crown Cover: 50
Ground Cover: 60
Browsing Intensity: NONE
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundne
POPDEL	1	7	58	1	49								
POPDEL	1	18	62	2	—	ROTTEN							
POPDEL	1	12		1	—								
POPDEL	1	18		1	—								
FRAPEN	1	5	25	2	50								
POPDEL	2	18	15	5	—	ROTTEN							
POPDEL	1	19		3	—								
POPDEL	1	17		2	—								
POPDEL	1	10			—								

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
FRAPEN	1	1	10'	1		NONE							
FRAPEN	1	1	8'	1									
FRAPEN	1	1	12'	1									

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: Stand Unit: Subplot: 7	Crew: JE/DB	Date: 9/11/0

Subplot Location: TERRACE 10-15' ABOVE RIVER
SYMOCC ELEANG (1-small tree)
OSMGL
SHEARG RHUTOX

Forest Type: POP DEL	Soil Group:	Stand Structure: 1-STORY
Percent Slope: 0	Soil Texture:	Crown Cover: 50
Aspect: 0	Soil Erosion:	Ground Cover: 90
Physiography: TERRACE	Litter Depth:	Browsing Intensity: NONE
	Humus Depth:	Other Disturbance: DEER

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Deca Soundr
POP DEL	1	23	99	2		ROTTEN							
"	1	14		2									
"	1	17		2									
"	1	11		2									
"	2	14	12	5									
"	1	23		2									
"	2	20	35	5									
"	1	22		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: Stand Unit: 8 Subplot:	Crew: JE/DB	Date: 9/11/01

Subplot Location: TERRACE 12-15'
SYMOCC 60% ELYCAN
RHUTOX SHEARG
NO PHOTO

Forest Type: POPDEL / FRAPEN	Soil Group:	Stand Structure: 2-STORY
Percent Slope: 0	Soil Texture:	Crown Cover: 50
Aspect: 0	Soil Erosion:	Ground Cover: 75
Physiography:	Litter Depth:	Browsing Intensity: NONE
	Humus Depth:	Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	r	26		2		ROTTEN							
POPDEL	1	27		2		"							
POPDEL	1	35	71	3		"							
FRAPEN	1	5	25	1									
FRAPEN	1	8	35	1	60+	ROTTEN							
FRAPEN	1	5		2									
FRAPEN	1	7	25	1									
FRAPEN	1	5	20	1									
FRAPEN	1	5	22	1									
FRAPEN	1	6	22	1									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 9
Subplot:

Crew: JE/DB

Date: 9/11/01

Subplot Location: TERRACE 12-15' ABOVE RIVER
BROINE GLYLEP PRUVIR
SYMOCC SHEARG ELYCAN

Forest Type: POPDEL
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 1-STORY
Crown Cover: 50%
Ground Cover: 95%
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	19	96	1		ROTTEN							
POPDEL	1	14		2									
POPDEL	1	18		2									
POPDEL	1	18		2									
POPDEL	2	19	10	5									
POPDEL	2	16	55	5									
POPDEL	1	18		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
FRAPEN	1	1	12	1									
FRAPEN	1	2	14	1									

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 10
Subplot:

Crew: JE/DB

Date: 9/11/01

Subplot Location: TERRACE ABOVE RIVER
SAME AS #9

Forest Type: POP DEL
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 1-STORY
Crown Cover: 50 %
Ground Cover: 90 %
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	18	82	2									
POPDEL	1	17	MULT.	2									
POPDEL	1	17	TRUNK	2									
POPDEL	1	18		2									
POPDEL	1	16		2									
POPDEL	1	19		2									
POPDEL	1	19		2									
POPDEL	1	19		2									
POPDEL	1	11		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	5		1					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit:
Subplot: 11

Crew: JE DB

Date: 9/11/01

Subplot Location:

TERRACE ABOVE RIVER (10-15')   NO PHOTO

Forest Type: POPDEL
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 1-STORY
Crown Cover: 80
Ground Cover: 40
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundn
POPDEL	1	12		2	~60								
POPDEL	1	12		2									
POPDEL	1	15		1									
POPDEL	1	14	65	1									
POPDEL	1	19		1									
POPDEL	1	7		1									
FRAPEN	1	5	42	1									
POPDEL	1	14	MULT	1									
POPDEL	1	13	TRUNK	1									
POPDEL	1	12		1									
POPDEL	1	11		1									
FRAPEN	1	6		2									
POPDEL	1	17		1									
POPDEL	1	13	MULT	1									
POPDEL	1	17	TRUNK	1									
FRAPEN	1	5		1									
POPDEL	2	7		5									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit:
Subplot: 12

Crew: JE/DB

Date: 9/12/0

Subplot Location: TERRACE
STIOCC ELYCAN RHUTOX
SYMOCC SHEARG

Forest Type: POP DEL
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 1-STORY
Crown Cover: 45%
Ground Cover: 90%
Browsing Intensity: LOW
Other Disturbance:

84
80
6720

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundn
POPDEL	1	18		3		ROTTEN							
POPDEL	1	17	MULT	2									
POPDEL	1	17	TRUNK	2									
POPDEL	1	14		2									
POPDEL	1	19	72	2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit:
Subplot: 13

Crew: JE/JB

Date: 9/12/01

Subplot Location: TERRACE
SYMOCC AMEALN ELYCAN
RHUTOX PRUVIR

Forest Type: POPDEL
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2-STORY
Crown Cover: 70 %
Ground Cover: 60 %
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	2	25	32	5									
FRAPEN	1	7	36	2									
FRAPEN	1	5	35	2									
POPDEL	1	16		2									
POPDEL	1	23		3									
POPDEL	1	5		4									
POPDEL	1	16		2									
FRAPEN	1	5		2									
POPDEL	1	12		2									
POPDEL	1	12		2									
POPDEL	1	43	86	3									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
FRAPEN	1	2	14										

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	2'	—	1					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit:
Subplot: 14

Crew: JE/DB

Date: 9/12/10

Subplot Location: TERRACE
GLYLEP ELYCAN
RHUTOX POAPRA

Forest Type: POPDEL
Percent Slope:
Aspect:
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 1 STORY
Crown Cover: 60
Ground Cover: 70
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEL	1	17		2		ROTTEN							
POPDEL	1	6		3									
POPDEL	1	14		1									
POPDEL	1	11		2									
POPDEL	1	18	78	2									
POPDEL	1	14		2									
POPDEL	1	18		2									
POPDEL	1	20		2									
POPDEL	2	11	17	5									
POPDEL	1	21		2									
POPDEL	1	21											

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	1		1					

Movements and Habitat Preferences of Adult Post Spawn Pallid Sturgeon

2002 Progress Report

March 17, 2003

Wade L. King
Project Biologist

And

Ryan H. Wilson
Project Technician

U.S. Fish and Wildlife Service
Missouri River FWMAO
Bismarck, North Dakota

Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: — Stand Unit: 15 Subplot:	Crew: JE/DB	Date: 9/12/01

Subplot Location: TERRACE 10' ABOVE RIVER

Forest Type: POPDEL Percent Slope: 0 Aspect: 0 Physiography:	Soil Group: Soil Texture: Soil Erosion: Litter Depth: Humus Depth:	Stand Structure: 1 STORY Crown Cover: 60 Ground Cover: 50 Browsing Intensity: HEAVY Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEL	1	16		2									
POPDEL	1	20		2									
POPDEL	1	19		2									
POPDEL	2	9	15	5									
POPDEL	2	11	50	5									
POPDEL	1	8		2									
POPDEL	1	15		2									
POPDEL	1	13		2									
POPDEL	2	6		5									
POPDEL	1	16		1									
POPDEL	1	21		1									
POPDEL	1	29	87	2									
POPDEL	1	23		1									
POPDEL	1	15		1									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 16
Subplot:

Crew: JE/DB

Date: 9/12/01

Subplot Location: TERRACE

Forest Type: POPDEL/FRAPEN
Percent Slope:
Aspect:
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2-STORY
Crown Cover: 50
Ground Cover: 80
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	18		2									
POPDEL	1	16		2									
POPDEL	1	15		2									
POPDEL	1	22	82	2									
POPDEL	1	21		2									
POPDEL	1	15		1									
POPDEL	1	20		2									
FRAPEN	1	5	38	1									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	1		4					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 17
Subplot:

Crew: JE/DB

Date: 9/12/0

Subplot Location: TERRACE ROSWOO SYMOCC PRUVIR PARQUI ELYCAN POAPRA SHEARG RHUTOX

Forest Type: POPDEL
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture: 80
Soil Erosion: 80
Litter Depth: 6660
Humus Depth:

Stand Structure: 1 STORY
Crown Cover: 55
Ground Cover: 50
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	12		2		ROTTEN							
"	1	13	MULT	2									
"	1	14	TRUNK	2									
"	1	15		2									
"	1	12		2									
"	1	15		2									
"	1	13		2									
"	1	10		3									
"	1	17		2									
"	1	14	MULT	1									
"	1	15	TRUNK	1									
"	1	18	75	2		ROTTEN							

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	3		2					

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Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: Stand Unit: 18 Subplot:	Crew: JE/DB	Date: 9/12/01

Subplot Location: TERRACE
ELEANG 30%

Forest Type: POPDEL/ELEANG	Soil Group:	Stand Structure: 2-STORY
Percent Slope: 0	Soil Texture:	Crown Cover: 70
Aspect: 0	Soil Erosion:	Ground Cover: 30
Physiography:	Litter Depth:	Browsing Intensity: LOW
	Humus Depth:	Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	15		2	ROT.	ROT							
POPDEL	1	15		2									
POPDEL	1	7		4									
POPDEL	1	13		2									
POPDEL	1	11		2									
ELEANG	1	5	26	1									
ELEANG	1	5	28	1									
POPDEL	1	16		1									
ELEANG	1	7	27	1	35								
POPDEL	1	19	86	2									
POPDEL	1	16		2									
POPDEL	1	16		2									
POPDEL	1	13		2									
POPDEL	1	15		2									
POPDEL	1	13		2									
POPDEL	1	15		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
ELEANG	1	4	22	1									

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
ELEANG	1	10		4					

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Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: Stand Unit: 19 Subplot:	Crew: JE/DB	Date: 9/12/01

Subplot Location:

RHUTOX
POAPRA

Forest Type: POPDEC/ELEANG Percent Slope: 0 Aspect: 0 Physiography:	Soil Group: Soil Texture: Soil Erosion: Litter Depth: Humus Depth:	Stand Structure: 2 STORY Crown Cover: 85 Ground Cover: 20 Browsing Intensity: LOW Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
ELEANG	1	5	16	1	—								
ELEANG	2	8	22	3									
ELEANG	2	8	16	3									
ELEANG	1	6	14	1									
POPDEC	1	21	88	2									
ELEANG	1	7	16	3									
POPDEC	1	15		2									
POPDEC	1	15		2									
POPDEC	1	14		2									
POPDEC	1	13											
ELEANG	1	5		2									
POPDEC	2	5	60	5									
POPDEC	1	16											

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
ELEANG	1	2	18	1									
ELEANG	1	3	20										
ELEANG	1	3	19										
ELEANG	1	2											
ELEANG	1	3											

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: Stand Unit: Subplot: 20	Crew: JE/DB	Date: 9/13/01

Subplot Location: TERRACE
DENSE SHRUB CANOPY – SALAMG, PRUVIR ROSWOO FRAPEN
RHUTOX ELYCAN GLYLEP

Forest Type: POPDEL/	Soil Group:	Stand Structure: 1– story
Percent Slope: 0	Soil Texture:	Crown Cover: 50
Aspect: 0	Soil Erosion:	Ground Cover: 60
Physiography:	Litter Depth:	Browsing Intensity: LOW
	Humus Depth:	Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	14	—	1									
POPDEL	1	5	30	1									
POPDEL	1	25	85	2									
POPDEL	1	15	—	1									
POPDEL	1	15	—	2									
POPDEL	1	18	—	2									
SALAMG	1	5	18	4									
POPDEL	1	17	—	2									
POPDEL	1	8	—	1									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
SALAMG	1	4	15	3									

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 21
Subplot:
Crew: JE/DB
Date: 9/13/01

Subplot Location: TERRACE 5-10' ABOVE RIVER
UNDERSTORY OF ELEANG YOUNG STAND ON LOWER TERRACE

Forest Type: POPDEL
Percent Slope:
Aspect:
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2 STORY
Crown Cover: 50
Ground Cover: 40
Browsing Intensity: LOW/NONE
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	10		2			POPDEL	1	17		1		
POPDEL	1	15		2			POPDEL	1	20	79	1		
ELEANG	1	5	22	1			POPDEL	1	12				
POPDEL	1	7		1			POPDEL	2	6	—	BEAVER CUT		
POPDEL	1	11		1			POPDEL	2	7	—	BEAVER CUT		
POPDEL	1	7		1			POPDEL	1	10		1		
POPDEL	1	12		1			POPDEL	1	10		4		
POPDEL	1	8		2			POPDEL	1	6		1		
POPDEL	1	12		1	42		POPDEL	1	12		1		
POPDEL	2	8	—	—	BEAVER		POPDEL	1	11		1		
POPDEL	2	5	—	—		CUT	POPDEL	2	8	—	BEAVER CUT		
ELEANG	1	6	24	1	16								
ELEANG	1	5	22	1									
POPDEL	2	7			BEAVER								
POPDEL	2	9				CUT							
POPDEL	2	6											
POPDEL	1	12											
POPDEL	1	13											
POPDEL	1	7			— BEAVER								
POPDEL	1	11				CUT							

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
ELEANG	1	1	8	1									
ELEANG	1	1	8	1									

Seedling Data (trees less than 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
ELEANG	1	2	—	1					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:	Crew:	Date:
Stand Unit: 22	JE/DB	9/13/01
Subplot:		

Subplot Location: TERRACE

ELEANG
FRAPEN

Forest Type: POPDEL	Soil Group:	Stand Structure: 1 STORY
Percent Slope: 0	Soil Texture:	Crown Cover: 60
Aspect: 0	Soil Erosion:	Ground Cover: 75
Physiography:	Litter Depth:	Browsing Intensity: LOW
	Humus Depth:	Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEC	1	16	MULT	2									
"	1	15	TRUNK	2									
"	1	14		2									
"	1	9		2									
"	1	20	MULT	2									
"	1	15	TRUNK	2									
"	1	14		2									
"	1	6		2									
"	1	14	MULT	2									
"	1	16	TRUNK	2									
"	1	16		2									
"	1	10		2									
"	1	10		2									
"	1	15	MULT	2									
"	1	9		2									
"	1	8		2									
"	1	12		2									
"	1	15		2									
ELEANG	1	5		3									
POPDEL	1	12	75	3									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	1		4					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit:
Subplot: 23

Crew: JG/DB

Date: 9/13/01

Subplot Location: TERRACE ~ 5-10' FEET ABOVE RIVER
SHEARD BROING
GLYLEP

Forest Type: POPDEL/ELEANG
Percent Slope: 0
Aspect: 0
Physiography: 0

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2 STORY
Crown Cover: 70
Ground Cover: 80
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	9		1			POPDEL	1	17	1			
"	1	12	} multi	1			"	1	8	2			
"	1	13	} stem	1			"	1	11	2			
"	1	11		1			"	1	12	1			
"	1	8	} multi	1			"	1	10				
"	1	13		1									
"	1	16	72	1									
"	1	6		1									
"	1	12		1									
"	1	5		1									
"	1	7		1									
"	1	11		2									
"	1	14		1									
"	1	8		1									
"	1	12		1									
"	1	16		1									
"	1	6		2									
"	1	13		2									
"	1	10		1									
ELEANG	1	5	28	1									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 24
Subplot:

Crew: JE/DB

Date: 9/13/01

Subplot Location: TERRACE ~ 5-10' ABOVE RIVER

Forest Type: POPDEL/ELEANG
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2 STORY
Crown Cover: 60
Ground Cover: 50
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEL	1	11	MULT.	2			POPDEL	1	9		1		
"	1	7	STEM	2			"	1	9		1		
"	1	12	MULT	1			"	1	10		2		
"	1	12	STEM	1			"	1	8		2		
"	1	11		2									
"	1	7		1									
"	1	5		1									
"	1	5		1									
"	1	13		1									
"	1	5		1									
"	1	12		1									
"	1	5		2									
"	1	12	68	1									
"	1	6		1									
"	1	15		2									
"	1	7		2									
"	2	7		5									
"	1	8		3									
"	1	6		2									
"	1	9											

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
ELEANG	1	1		3					

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit: 25
Subplot:

Crew: JE/DB

Date: 9/14/01

Subplot Location: TERRACE

LOTS OF BROKEN TOPS ON POPDEL

Forest Type: POPDEL/ELEANG
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2 STORY
Crown Cover: 50
Ground Cover: 70
Browsing Intensity: MODERATE
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
ELEANG	1	5	18	1									
POPDEL	1	27		2									
ELEANG	1	5		1									
POPDEL	1	21		2									
POPDEL	1	22		2									
POPDEL	1	20		3									
FRAPEN	1	7	32	1									
POPDEL	1	25		2									
POPDEL	1	27	76	2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count

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Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit:
Subplot: 26 (D)

Crew: JE/DB

Date: 9/14/01

Subplot Location: TERRACE

ROSA SP. 30% RHUTOX
CORSTO GLYLEP

Forest Type: POPDEL
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 1 STORY
Crown Cover: 65
Ground Cover: 80
Browsing Intensity:
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEL	1	21	90	2									
"	1	16		3									
"	1	18		2									
"	1	22		3									
"	1	20		3									
"	1	25		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	10		4					

Rev. 8/25/01

Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit:
Subplot: 27(E)

Crew: SE/DB

Date: 9/14/01

Subplot Location: TERRACE ROSA

Forest Type: POPDEL
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 1 STORY
Crown Cover: 50
Ground Cover: 85
Browsing Intensity: LOW/NONE
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEL	1	14		2									
"	1	19		2									
"	1	21		2									
"	1	20		2									
"	1	23	82	2									
"	1	19		2									
"	1	16		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	4		1					

Rev. 8/25/01

Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID:
Stand Unit:
Subplot: 28 (A)

Crew: JE/DB

Date: 9/14/01

Subplot Location: SYMOCC RHUTOX

Forest Type: POPDEL/FRAPEN
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2 STRATA
Crown Cover: 70
Ground Cover: 50
Browsing Intensity: LOW
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundness
POPDEL	1	20	MULT	2									
POPDEL	1	19	STEM	2									
POPDEL	1	16		2									
POPDEL	1	12	MULT	2									
POPDEL	1	20	STEM	2									
POPDEL	1	21		2									
POPDEL	1	13		2									
POPDEL	1	25	87	2									
FRAPEN	1	5	34	1									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
FRAPEN	1	1	11	1									
FRAPEN	1	4	20										

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	3		1					

Rev 8/25/01

Vegetation Data Collection Sheet
Cottonwood Stand Reconnaissance
Fort Peck Indian Reservation, Montana

Stand ID: 29
Stand Unit: (B)
Subplot:

Crew: JE / DB

Date: 9/14/01

Subplot Location: TERRACE

Forest Type: POPDEL / FRAPEN
Percent Slope: 0
Aspect: 0
Physiography:

Soil Group:
Soil Texture:
Soil Erosion:
Litter Depth:
Humus Depth:

Stand Structure: 2 STORY
Crown Cover:
Ground Cover:
Browsing Intensity:
Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness
POPDEL	1	19		2									
FRAPEN	1	5	36	1									
POPDEL	1	30		3									
POPDEL	1	31	88	2									
POPDEL	1	22		2									
POPDEL	1	25		2									
POPDEL	1	26		2									
FRAPEN	1	6		1									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
FRAPEN	1	2	15	1									
FRAPEN	1	2	15	1									
FRAPEN	1	3	18	1									

Seedling Data (trees less than 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	2		5					

Rev. 8/25/01

Vegetation Data Collection Sheet Cottonwood Stand Reconnaissance Fort Peck Indian Reservation, Montana	Stand ID: Stand Unit: 30 Subplot: (C)	Crew: JE/JB	Date: 9/14/01

Subplot Location: TERRACE

Forest Type: POPDEL/FRAPEN	Soil Group:	Stand Structure: 2 STORY
Percent Slope: 0	Soil Texture:	Crown Cover: 70
Aspect: 0	Soil Erosion:	Ground Cover: 30
Physiography:	Litter Depth:	Browsing Intensity: LOW/MOD.
	Humus Depth:	Other Disturbance:

Tree Data (trees greater than or equal to 5.0" DBH are sampled within a 1/24th acre subplot (24.0 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay / Soundness	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Soundne
POPDEL	1	25	80	2									
"	1	23		2									
"	1	27		2									
FRAPEN	1	6	32	1									
POPDEL	1	18		2									

Sapling Data (trees less than 5.0" DBH and greater than or equal to 1.0" DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class	Spp. Code	Status Code	DBH / DRC	Total Height	Crown Class	Age at Diam.	Decay Class
FRAPEN	1	2	18	1									
FRAPEN	1	1	16	1									
FRAPEN	1	2	16	1									
FRAPEN	7	2	16	1									

Seedling Data (trees less than 1.0"DBH are sampled within a 1/300th acre microplot (6.8 ft. radius))

Spp. Code	Status Code	Average Height	Average Age	Seedling Count	Spp. Code	Status Code	Average Height	Average Age	Seedling Count
FRAPEN	1	4		5					

Rev. 8/25/01

APPENDIX C

PHOTOGRAPHS OF STUDY AREA

Typical stand of Great Plains cottonwood with understory of smooth brome

Typical stand of mature cottonwood

Cottonwood stand on river terrace

Cottonwood stand with understory of green ash

Cottonwood stand with understory of Russian olive

Cottonwoods gnawed by beavers

Cottonwood stand destroyed by fire

Cottonwood seedlings growing on recently formed sand bar

This report submitted to:

Cooperators

Bureau of Reclamation

Garrison Dam National Fish Hatchery

Montana Fish, Wildlife and Parks
Fort Peck Field Office

North Dakota Game and Fish Department

Upper Pallid Sturgeon Workgroup

US Army Corps of Engineers

US Geological Survey
Fort Peck Field Office

Western Area Power Administration

List of Figures

Introduction

This report summarizes the research and field activities conducted in April through October of the 2002 field season. The main goals of this study are to monitor post spawn migrational movements to help identify pallid sturgeon spawning areas, determine pallid sturgeon response to " Spring Test Flows " out of Fort Peck Dam to see if mimicking natural flows will expand pallid use and habitat into the Missouri River above the confluence of the Yellowstone River, and to evaluate reproductive stages of known post spawn females. We also hope telemetered pallid sturgeon will serve as an important tool for future broodstock capture by utilizing and netting possible aggregations in relation to telemetered fish. Netting additional fish and marking them with Passive Integrated Transponder (PIT) tags will also serve to help strengthen current population estimates.

Study Area

The pallid sturgeon study area (See Figure 1, for study area), for the most part, is a semi-confined stretch of approximately 290 river miles encompassing the Missouri River from Fort Peck Dam to the headwaters of Lake Sakakawea and from the Yellowstone River confluence (~ RM 1582.0) up the Yellowstone River to the Intake Diversion Dam, Intake, Montana.

As suggested in the Post Spawn Telemetry Study Plan, datalogging station locations had to be adjusted due to a variety of factors, but eventually all stations were placed in well-suited areas that met the criteria needed to work effectively. Our first station initially was placed up the mouth of the Yellowstone River, a few hundred yards adjacent to or above the confluence on the west riverbank below the high water line. Later in the summer, it was moved to the east bank on private property, due to low water conditions. The second station, which is identified as the Fort Union Station, is approximately 5 river miles up the Missouri River above the confluence, and as its name suggests, lies due east of Fort Union State Park on the north shore of the Missouri River on State-owned land. The third station was located approximately 11 miles down the Missouri River on the Erickson Island State Game Production Area and is located on the north shore of the river.

Two additional logging stations were funded for the 2002 field season by the Bureau of Reclamation (BOR) and the North Dakota Game and Fish Department (NDGFD), which brings the total of stations to five. The BOR station was positioned on Montana Dakota Utilities property outside of Sidney, Montana, (RM 30.1) on the Yellowstone River. The NDGFD funded station was placed downstream of the Ducks Unlimited Pumphouse (RM 1557) on the lower Missouri River. The addition of the two new stations benefited the project, helping to expand the study area into more manageable reaches and providing more movement data.

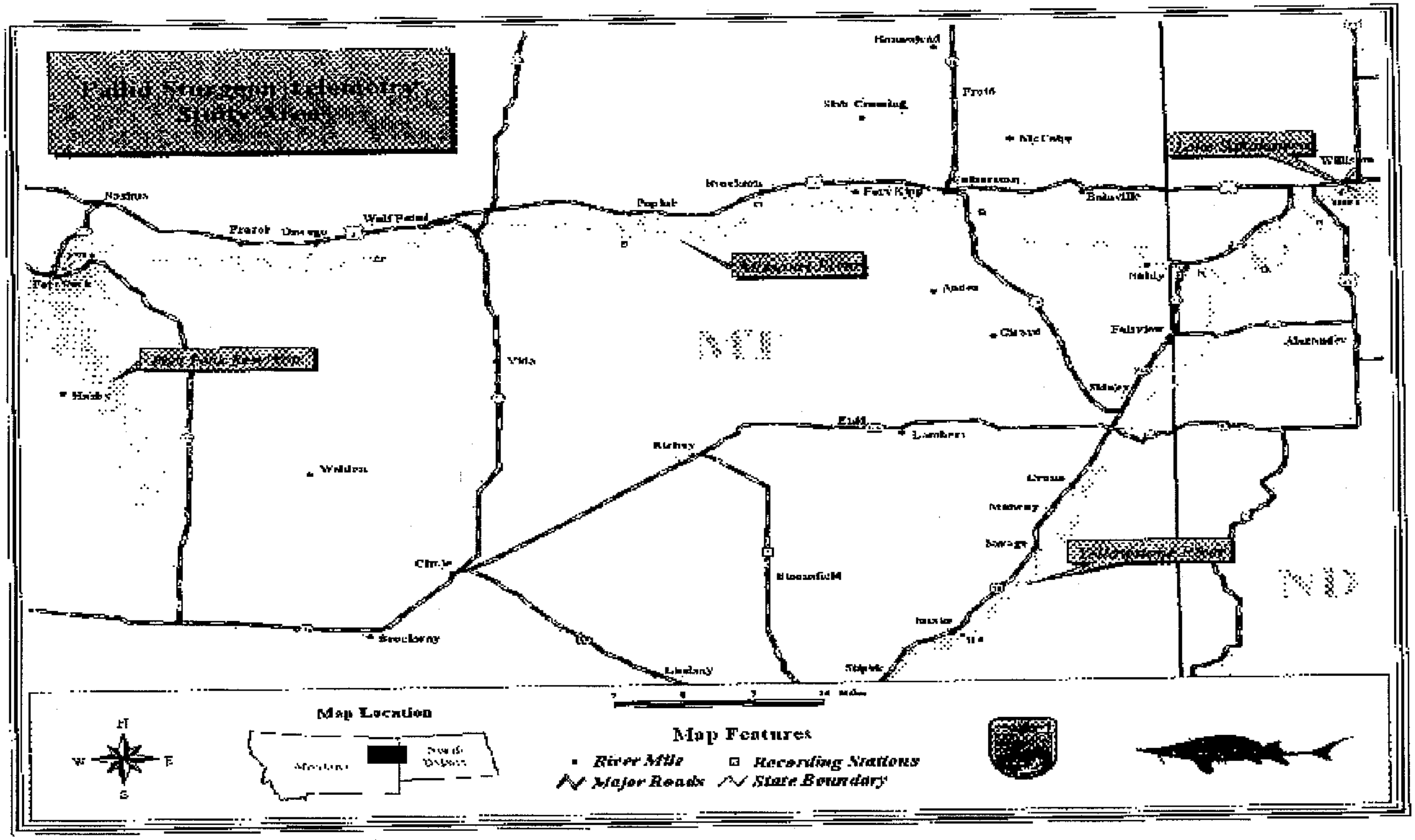

Figure 1: Map of study area

Methods

Pallid sturgeon telemetry tracking started in the second week of May 2002, and manual tracking resumed throughout the month and continued until the end of June. During the month of July, we started a less stringent tracking regime, only tracking every third week, which was continued through October, when fixed datalogging stations were taken out of the river.

Tracking methodology, as well as other methods, has been described in last year's progress report and the USFWS's draft proposal plan, so rather than describe them here, one can refer to the previous year's literature.

One addition utilized in this past field season's tracking, was the implementation of using a cell phone link to the Sidney fixed datalogging station. This system allowed us to download the station data from a hotel or office, with the aid of a computer. The remote system also allowed us to check settings and change them, call the station to see if it is still operating properly, and most importantly, check the data to determine if one of our study fish has moved into another study reach.

Due to the number of paddlefish on the 149.760 pallid frequency, the addition of two more cell phone links and three more W31 receivers will be utilized to ensure data can be downloaded before memory banks fill up and data is lost. This became a problem on a few different occasions in the 2002 tracking season and should be resolved with the upgraded receivers and technology.

No pallid sturgeon were tagged after the spring 2002 spawn, due to a number of mortalities of the broodstock adults in the hatchery. Although only one mortality (which possibly was the result of cumulative stress from spawning, as well as tagging,) has been associated with the telemetry project; surgically implanting telemetry tags was suspended for a year until the mortality issue in the hatchery could be addressed.

For further clarification of tables and figures listed in this report, fish spawned in the spring of 2000 were named starting with the letter "A," and fish spawned in the spring of 2001 were given names with the letter "B." Because no fish were tagged in the spring of 2002, C will be skipped and fish spawned and tagged in 2003 will all be designated with names starting with "D."

Results and Discussion

During the 2002 spring broodstock capture, a male pallid sturgeon with rather suspicious scar tissue was netted. After referencing the pallid sturgeon database for passive integrated transponder (PIT) tag matches, it was conclusive this fish was a previous telemetry study fish. Aaron, fish # 38, had been tracked in the fall of 2000 when he was released back to the river and beginning in the spring of the 2001 field season, was unable to be located till present. His tag incision had healed perfectly and no signs of stress or infection were observed.

Consequently, we saw this happen at least two more times in the 2002 field season. Amber, fish # 62, lost her tag approximately at river mile (RM) 1558 above the Ducks Unlimited Pumphouse. In mid-April, she was observed crossing the Erickson Island Station and staging downstream below the Confluence Station for a brief period of time. She then was located by boat at RM 1567 in May. Somewhere after that time period, she shed her tag in about 7 feet of water adjacent to an island. We continued to pick up here tag throughout the summer at the same location without it ever moving. Attempts were made to net the fish on different occasions, but no movements were ever monitored. Water levels never reached shallow enough depths to attempt retrieval.

Al, fish # 22, also departed from our study this field season. This tag was apparently shed in the early spring of 2002. Montana, Fish, Wildlife and Parks crews' picked up his signal at Big Sky Bend (~RM 17), where it remained for the rest of the year. In late August, attempts to retrieve the tag were conducted. The tag was located in approximately 2 to 3 feet of water and maximum signal output was picked up on our receivers helping us isolate the tag within a couple foot radius, unfortunately after digging for a couple of hours, the tag could not be retrieved.

Bridget, fish # 10, has also been unable to be located since she was returned back to the river. The loss of this fish, as well as Amber, has definitely hurt one of the objectives of the study and has left us with only one female study fish.

Name	Code	Sex	Pit tag #	Weight in Pounds	Weight in Kilograms	Fork Length in Inches	Fork Length in Millimeters
Art	18	M	1F4849755B	33	14982	51	1295
Annie	25	F	1F47715752	55	24970	62	1580
Andre	26	M	7F7B081579	32	14528	56	1444
Alex	34	M	115525534A	36	16344	55	1404
Arnie	44	M	2202236E31	61	27694	60	1542
Archie	46	M	1F4A33194B	45	20340	57	1468
Andrew	50	M	115713555A	28	12712	53	1352

Table 1: List of the class of 2000 remaining in the study, as of October 2002.

Name	Code	Sex	Pit tag #	Weight in Pounds	Weight in Kilograms	Fork Length in Inches	Fork Length in Millimeters
Butch	2	M	1F4A27214F	50	22857	61	1541
Bart	14	M	115631222A	29	13257	52	1340
Bob	116	M	7F7D3C5708	30	13714	55	1405
Ben	144	M	1F4A111C6A	43	19657	55	1394

Table: 2. List of the class of 2001 remaining in the study, as of October 2002.

A primary objective of this study was to establish the time between spawns for adult pallid sturgeon and to learn more about the reproductive physiology of these native river fish. Past spawning records from a female sturgeon suggests they may spawn between 2 and 7 years, as well as physical evidence displayed by two, small pallid/pallid hybrid females at GDNFH. Once a female was identified with gravid eggs, it was hoped that tracking her would lead to pallid sturgeon spawning grounds and give us an idea on the stage periods between spawns.

Fish # 25 was located in the lower Missouri River on April 24th, and subsequent netting drifts were made to capture this female on two different days. Unfortunately, she was located in a deep trough along the shore and was unable to be captured. On two separate occasions (June 19-21 and June 30 to July 8th), she proceeded to migrate up the Missouri River to the USGS's Culbertson datalogging station (RM 1619). Unfortunately, we were unaware of her location and she eluded us until mid-August, when she was found in the lower Missouri River around RM 1556.5.

Upon relocation of the Annie on August 22 at RM 1664.7, Garrison Dam National Fish Hatchery Manager, Rob Holm, was contacted immediately and met us at the highway 85 boatramp 3 hours later. We then drift-netted for the female and captured her on the third drift, at which time we went to shore and prepared to tube her. Rob used a ¼-inch diameter, 30-inch section of clear, plastic tubing to perform the procedure.

Upon tubing the female, no small white eggs or black shriveled, larger eggs were found. Two subsequent attempts were made to extract eggs off the ovary, but no eggs were present. Annie was released and remained present in the lower Missouri throughout the rest of the summer and into the end of the tracking season. Although we can't be positive, due to the lack of any eggs present, two possible scenarios could exist. One, she spawned her eggs in the spring of 2002 and is in the process of regeneration; and, if this theory is true, she should have small, white eggs present on her ovaries in the spring of 2003. Two, if no sign of eggs are found on the ovary in the spring of 2003, it will be safe to assume that it will take a longer duration for her to attempt another spawn.

Diel movements were also recorded and compared for the 2002 fish by using data from individual fish passing fixed datalogging stations. The stations list the time the fish enters and leaves the range of station hydrophones. Times from boat relocations were not considered.

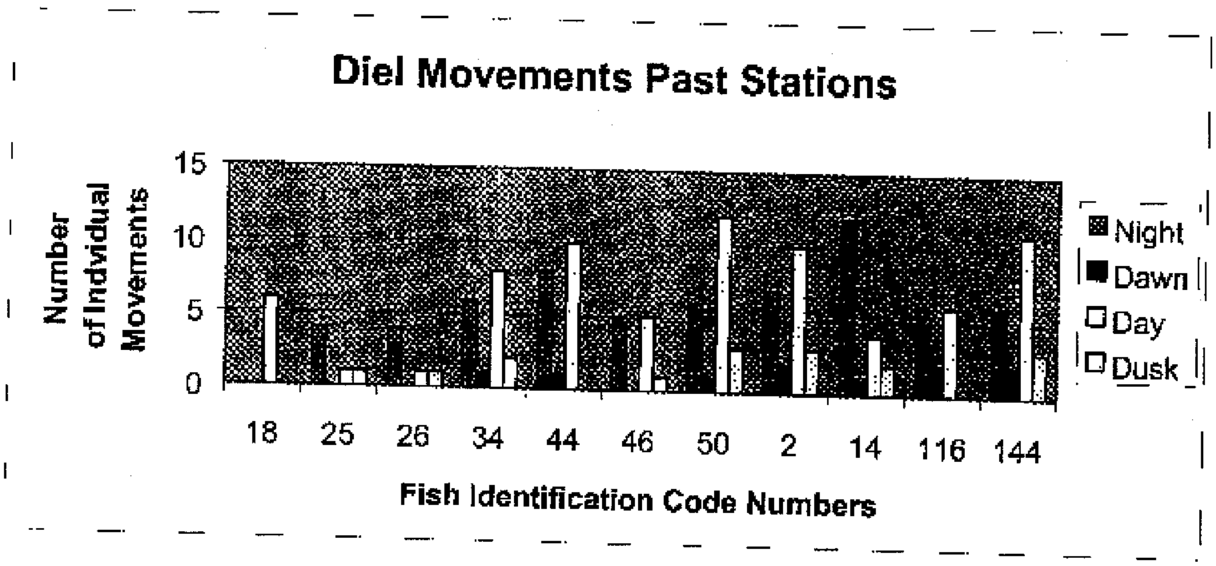

Table 3: Diel movements of the11fish remaining in study for the 2002 field season.
Night = 1 hour after sundown to 1 hour before sunrise.
Dawn = 1 hour before sunrise to 1 hour after sunrise.
Day = 1 hour after sunrise to 1 hour before sunset.
Dusk = 1 hour before sundown to 1 hour after sundown.

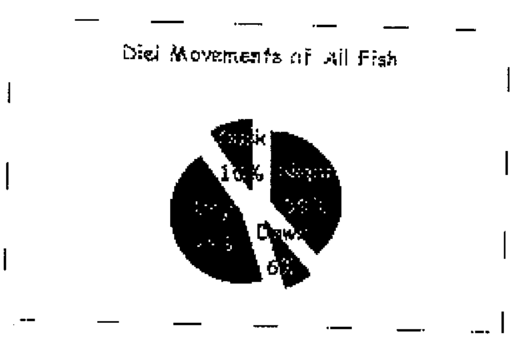

Figure 2: Diel movements for all fish in 2002.

Although diel movements differed significantly between some fish, there seems to be only a marginal difference between the higher percentages of daytime movements from the nighttime movements recorded.

A total of 331 observations were recorded in the 2002 field season, with 139 of them coming from boat relocations. A portion of the boat relocations came from Montana Fish, Wildlife and Park's fishery crews tracking paddlefish in the same confines of the river. This added information helped fill the gaps in data when fish sometimes slipped past stations and were not recorded.

With the addition of the USFWS's two stations and the deployment of the Montana based USGS stations on the upper Missouri River to Fort Peck Dam, fish movement was recorded both higher in terms of RM's traveled up in the upper Missouri and Yellowstone Rivers. Fish # 144 traveled up the Missouri River to the Wolf Point, Montana, Station (RM 1717), from May 20 to June 8 and ranged as low as RM 1555.4 in the lower Missouri in mid-July to the last boat relocation on November 8, 2002. From lower to upper river reaches, he spanned over 161 river miles in the Missouri and also made a couple of appearances 4 to 5 miles up the Yellowstone. In the Yellowstone River, a male pallid sturgeon was relocated 50 miles above the confluence, marking it as the highest a fish has been observed in that reach.

Although we saw greater distances traveled from a few individual pallids, overall fish movement seemed to decrease in 2002 compared to 2001. In 2001, only three fixed datalogging stations were active in the study and they recorded a total of 165 observations of fish passing them. For the 2002 field season, the USFWS deployed five stations and the USGS deployed at least five additional stations from Culbertson, MT, to Fort Peck Dam, Montana. In all, there were over three times the stations deployed and activated, and they accounted for 192 station observations, only 27 more than last year.

A large proportion of movement mimicked behavior from last year's observations. In April, May, and June, fish reacted to the rising and falling hydrographs daily; later in the summer to early fall, response was usually limited.

The study pallids are definitely exhibiting some unique behavior that has carried over from 2001 to 2002. Two males, Art (18) and Andre (26), have consecutively passed the Yellowstone Station and have spent almost the entire summer around or above Sidney, Montana. Andre passed the Yellowstone Station on May 19 in 2001 and on May 17 in 2002 to spend most of the summer above Sidney, and then returned in August and September. Art basically followed the same behavior and traveled up the Yellowstone on May 25 and also spent his summer ranging above the Highway 200, Fairview Bridge to about 10 miles above Sidney, MT.

For 2 consecutive years, Annie, the sole female left in the telemetry study has selected to stay in the Missouri River, this past year ranging from RM 1557 in the lower Missouri to RM 1619, at Culbertson, MT, on the upper Missouri. Although on both years she was recorded staging around the Yellowstone Station, she has never been relocated by boat up the Yellowstone River.

This was also the case for Butch, a male from the class of the 2001 spawners. He was captured four times in one week during the broodstock capture in mid-April at the confluence, and finally dropped down into the lower Missouri, where he stayed for the rest of the summer. This fish didn't seem to exhibit any urge to follow the hydrograph and spent most of the season between the Erickson Island and the Williston Stations. In fact, he never did migrate up to the confluence or show up on the Yellowstone Station. Although, I suspect some of his behavior may have stemmed from the stress induced with being caught four times in April, it's possible his home range may be that small considering all the movement he displayed within the small area.

As mentioned above, many of the telemetry study fish were either captured or monitored in the confluence area during the April broodstock capture. Besides Butch, Arnie was captured three times and three other fish were at least captured once. Radio-transmittered fish aided in the capture of non-tagged sturgeon on a couple different occasions, including a large female caught up the Yellowstone River adjacent to where Archie, fish # 46, was netted previously.

On three occasions during the field season, we relocated pallid sturgeon using slow, shallow side channels, which was interesting, considering we did not see this happen in 2001. In two of the cases, the side channel was shallow, with about 3 feet of water and we saw the pallids moving around continually, possibly feeding.

Plans for the 2003 field season include the same tracking schedule and protocol, hopefully with the addition of more study fish in the spring. Baseline data will continue to be taken to compare against fish movement associated with USACE proposed test flows slated for the future.

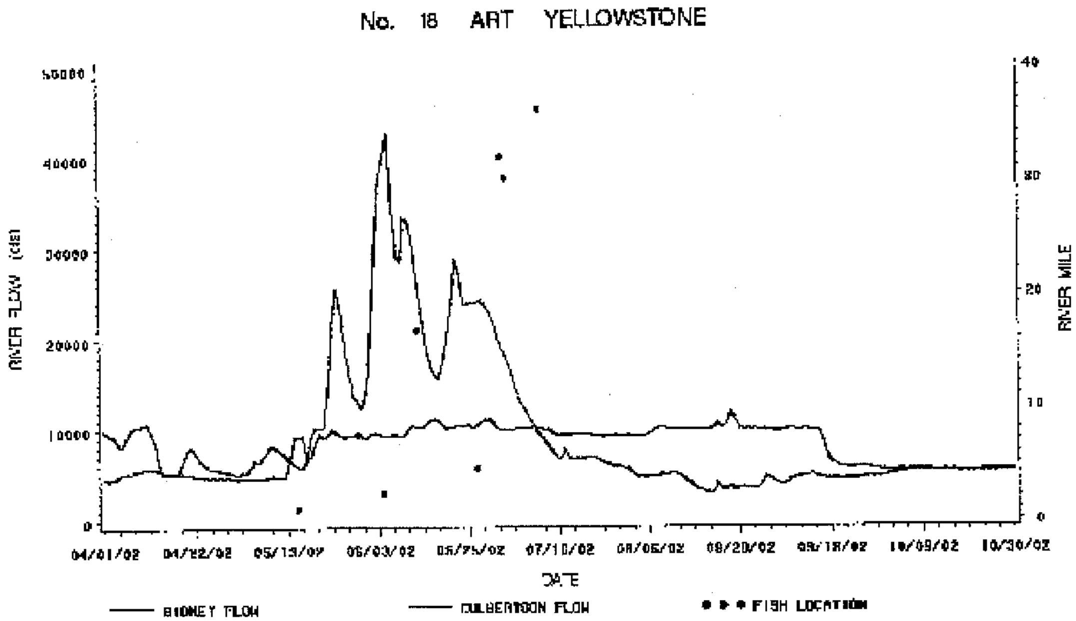

Figure 3: Relocations for Art, fish # 18, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

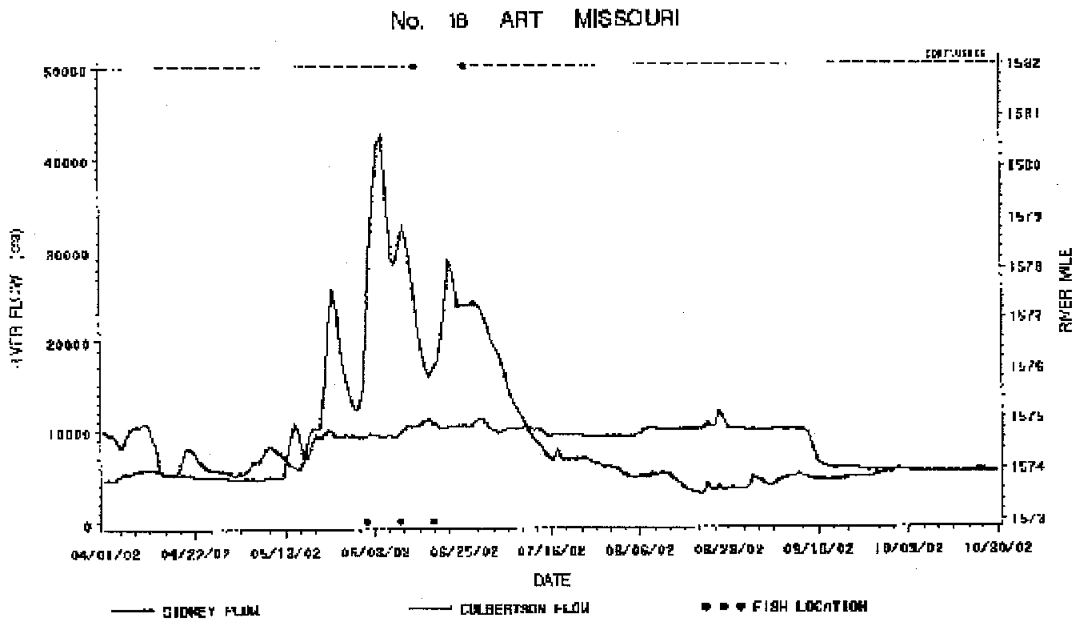

Figure 4: Relocations for Art, fish # 18, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

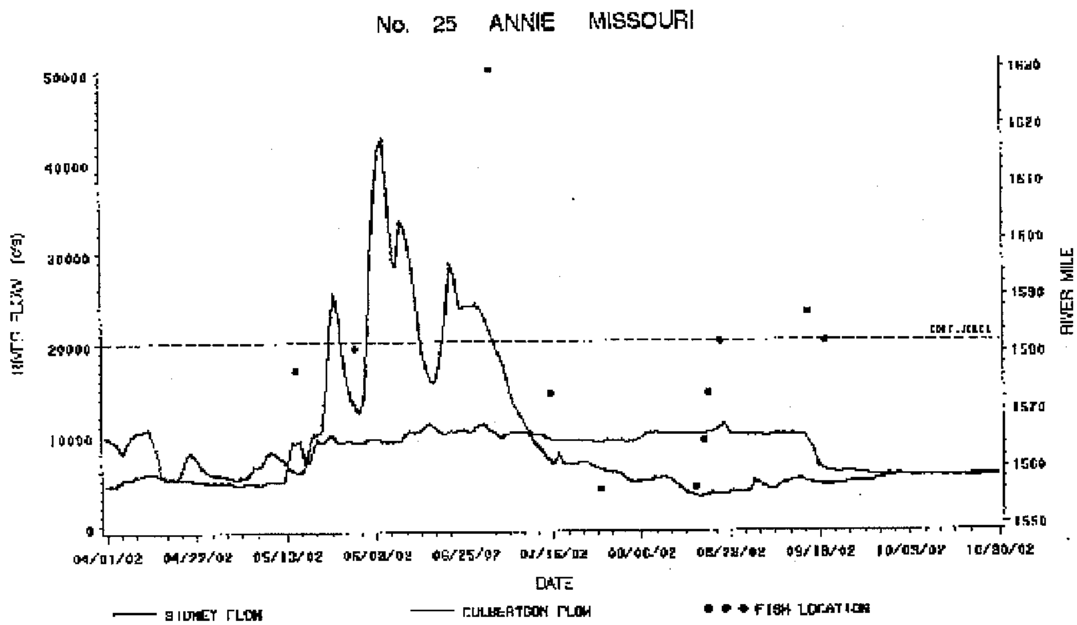

Figure 5: Relocations for Annie, fish # 25, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

No. 26 ANDRE YELLOWSTONE

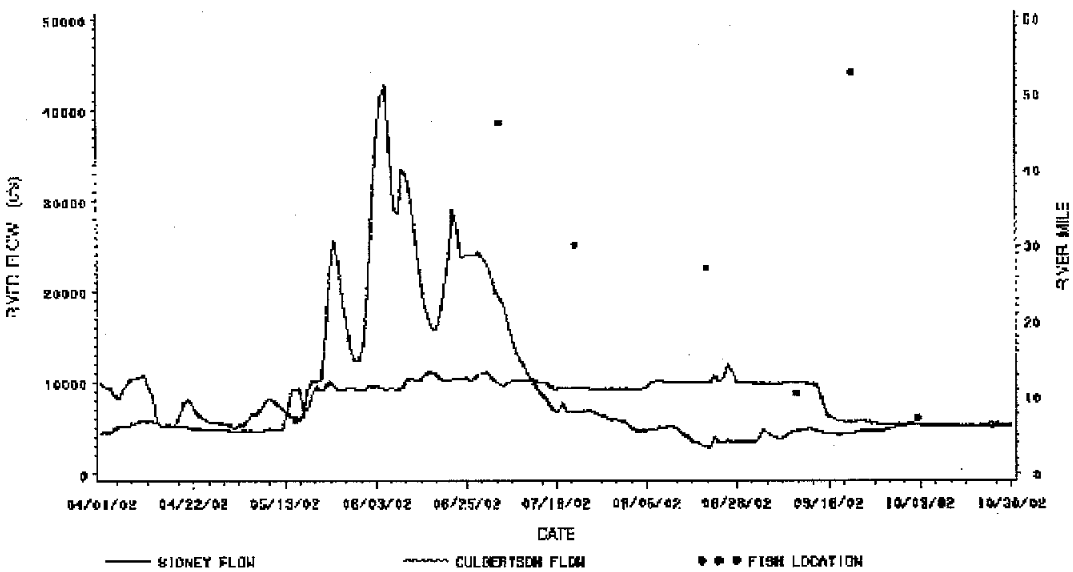

Figure 6: Relocations for Andre, fish # 26, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

No. 26 ANDRE MISSOURI

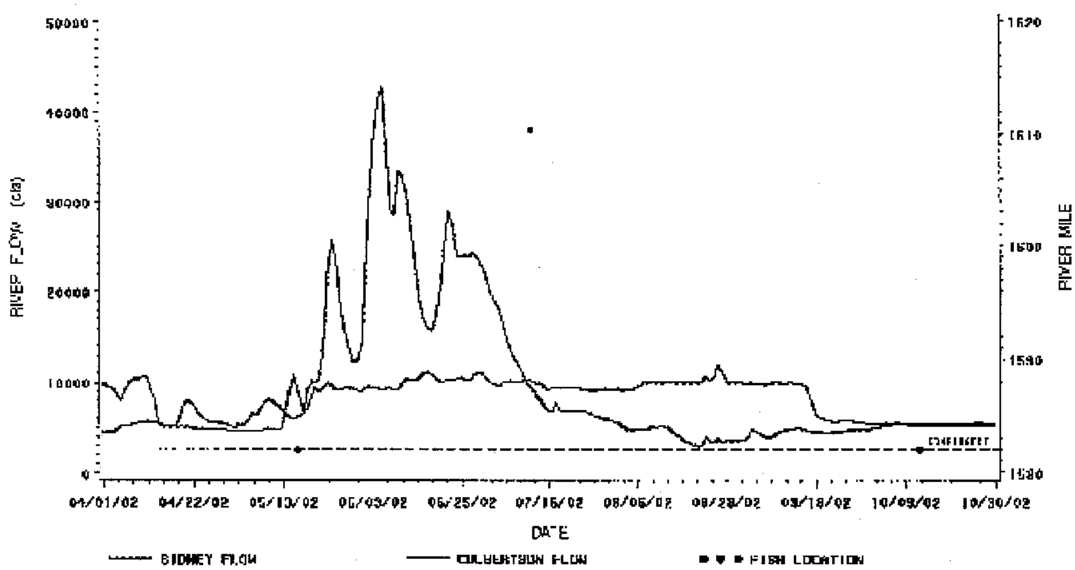

Figure 7: Relocations for Andre, fish # 26, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

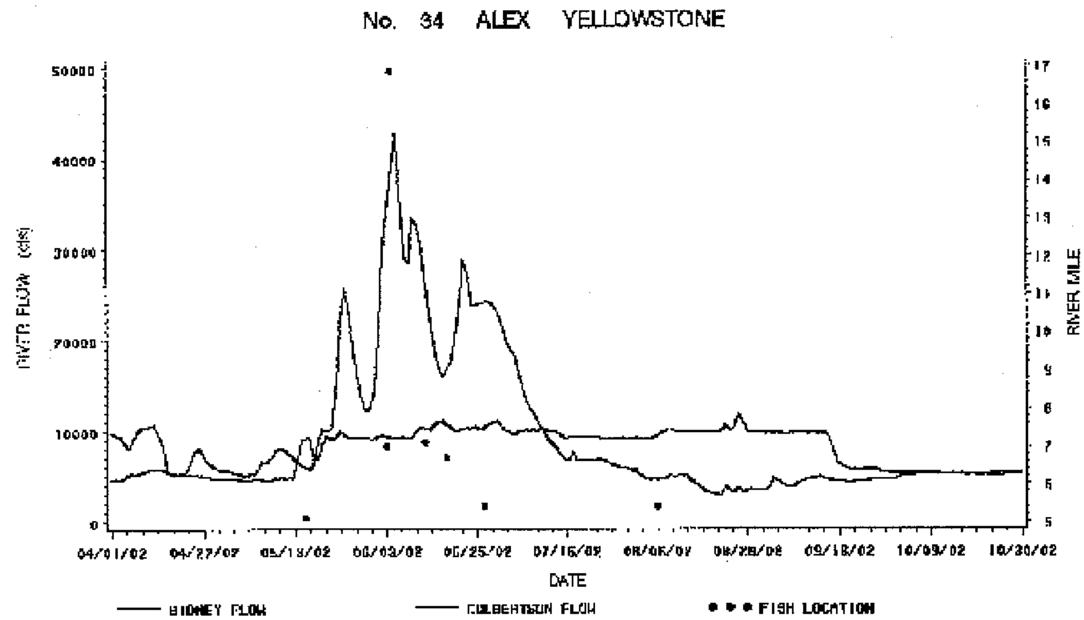

Figure 8: Relocations for Alex, fish # 34, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

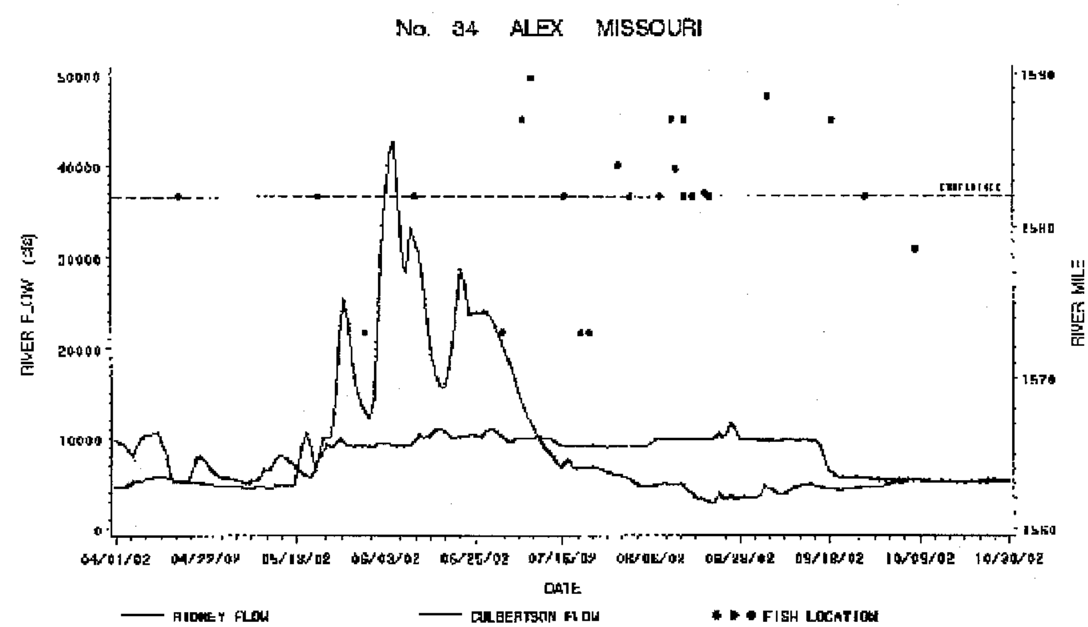

Figure 9: Relocations for Alex, fish # 34, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

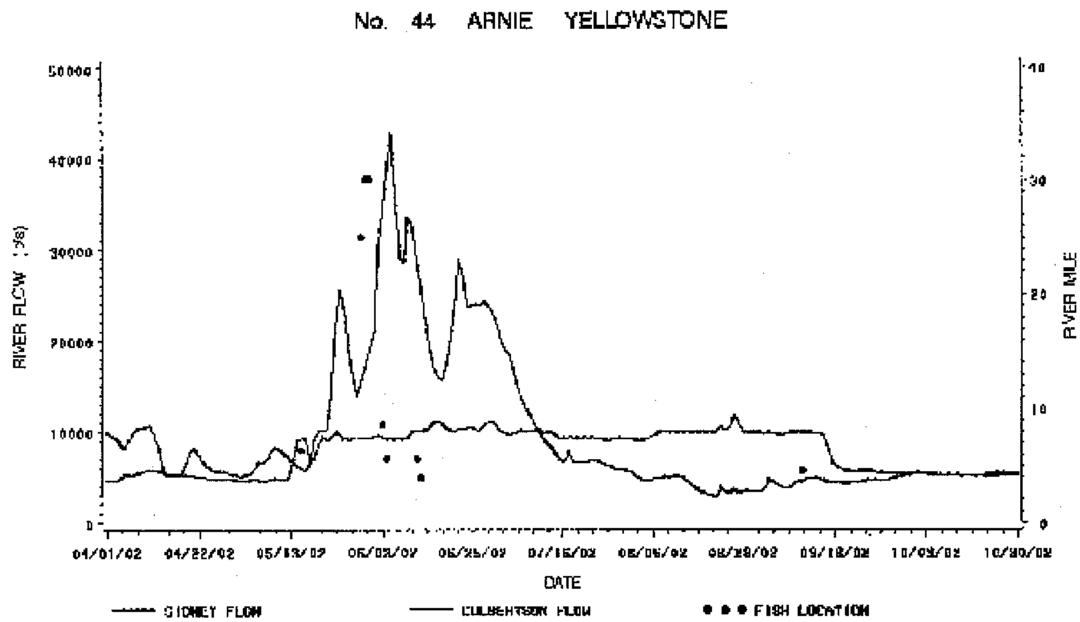

Figure 10: Relocations for Arnie, fish # 44, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

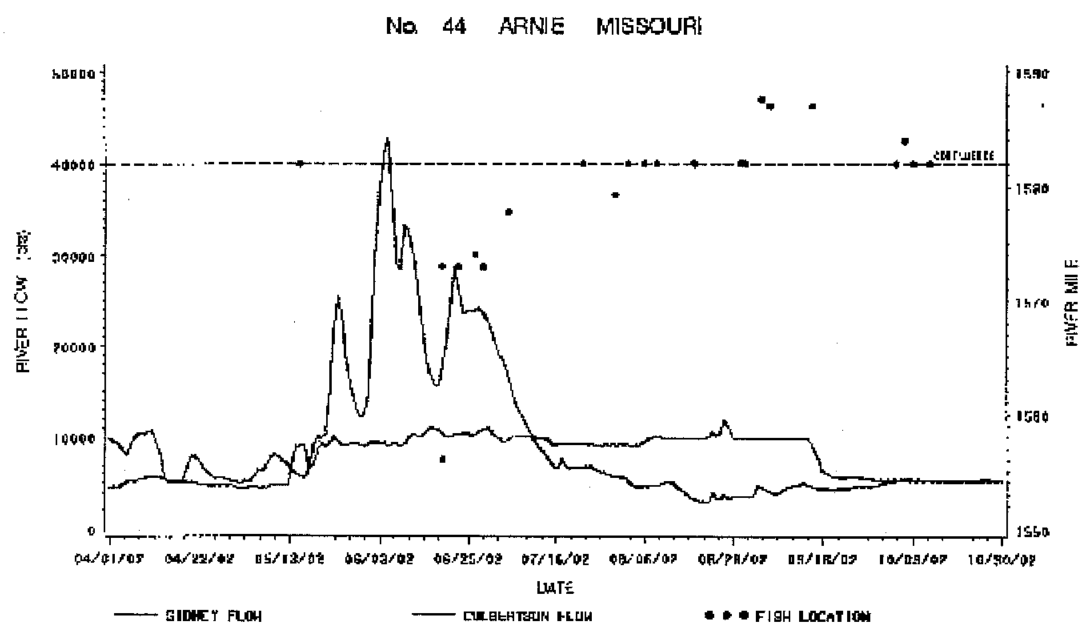

Figure 11: Relocations for Arnie, fish # 44, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

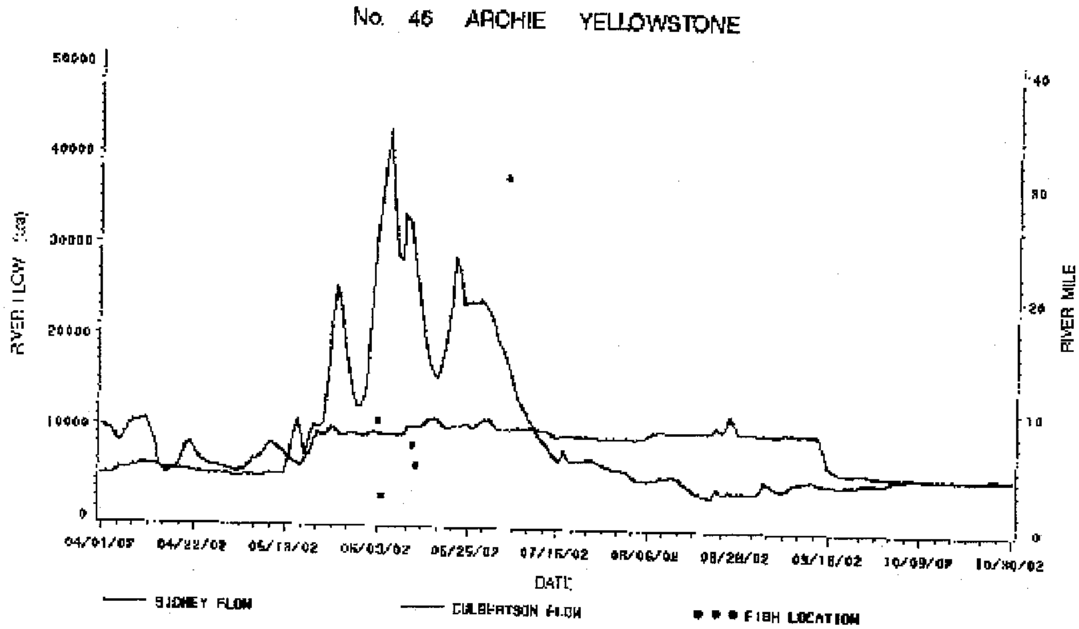

Figure 12: Relocations for Archie, fish # 46, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

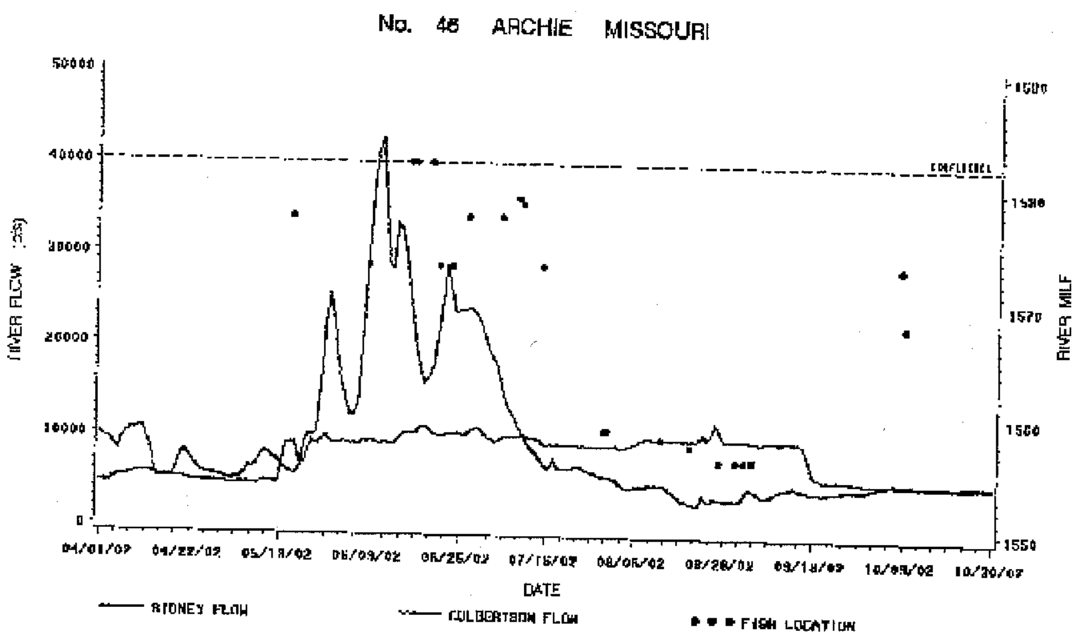

Figure 13: Relocations for Archie, fish # 46, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

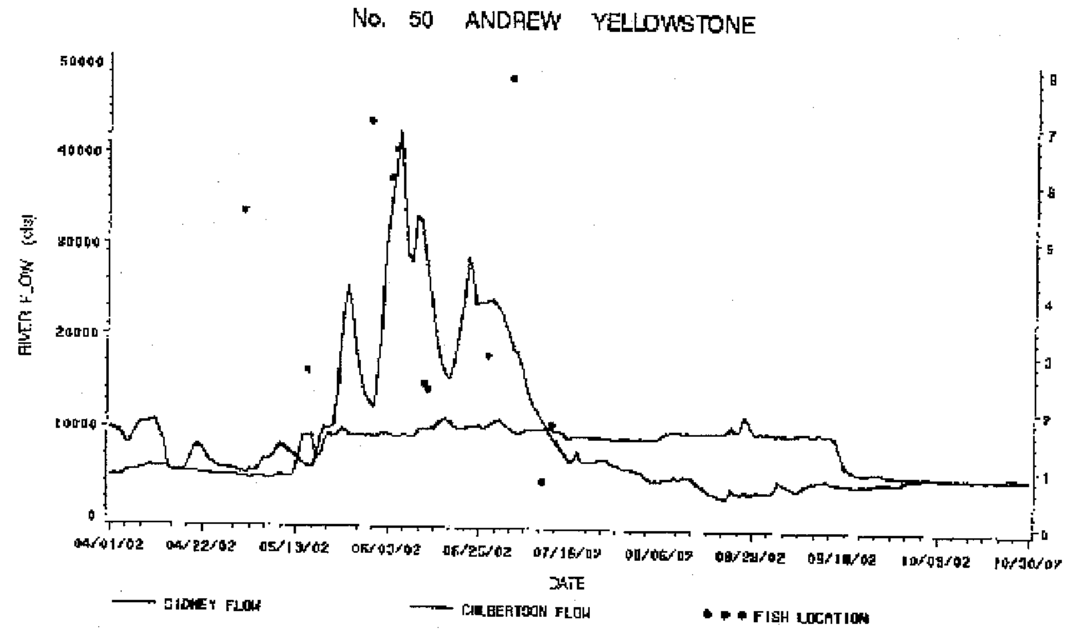

Figure 14: Relocations for Andrew, fish # 50, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

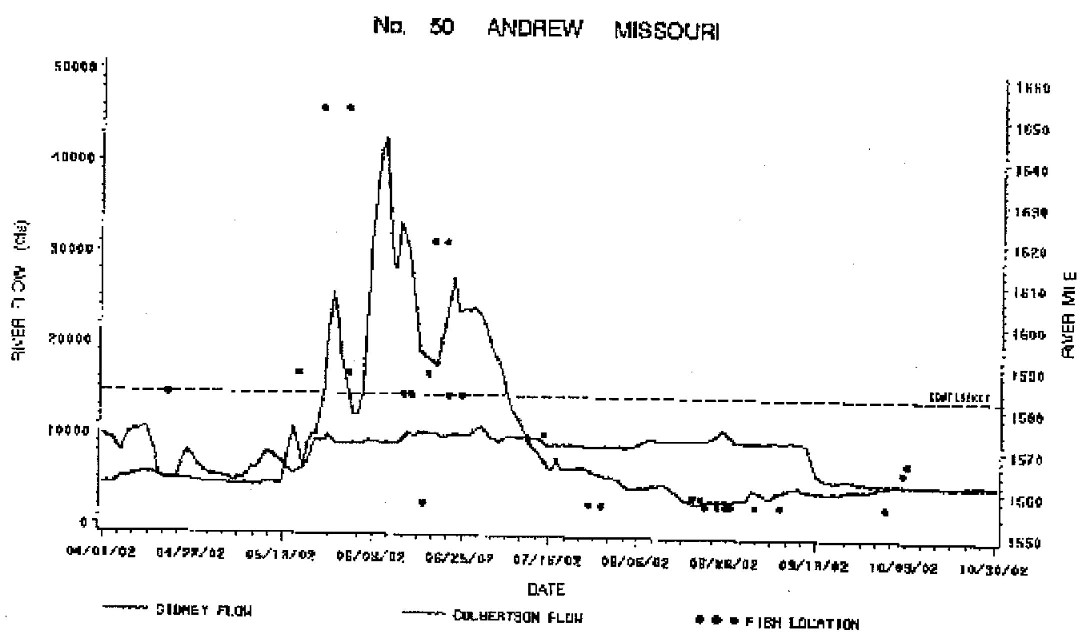

Figure 15: Relocations for Andrew, fish # 50, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

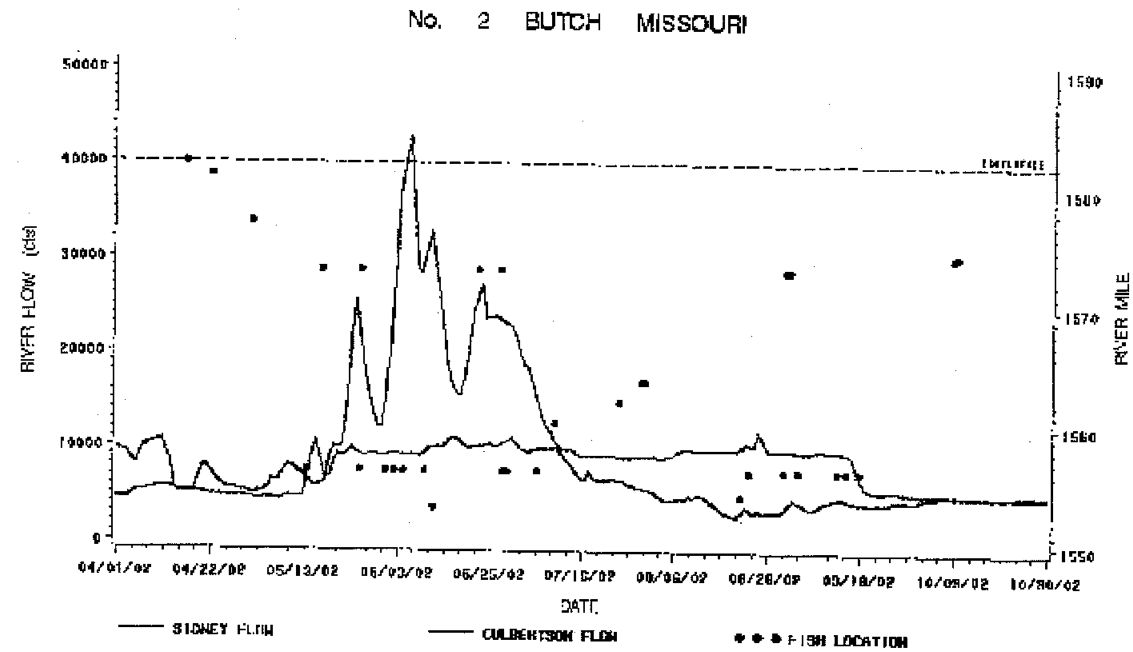

Figure 16: Relocations for Butch, fish # 2, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

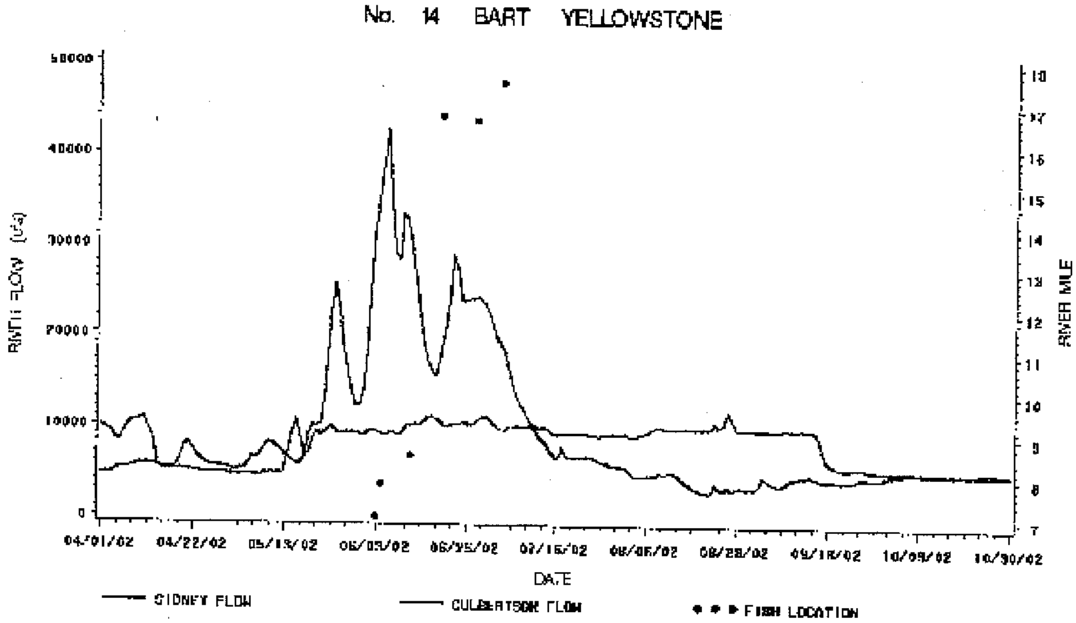

Figure 17: Relocations for Bart, fish # 14, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

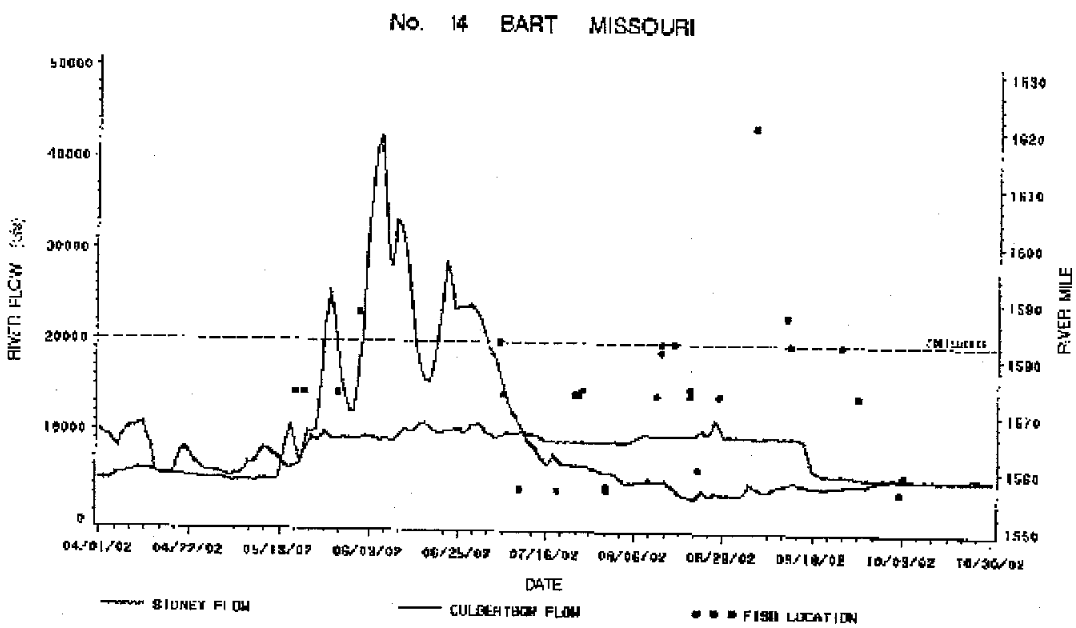

Figure 18: Relocations for Bart, fish # 14, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

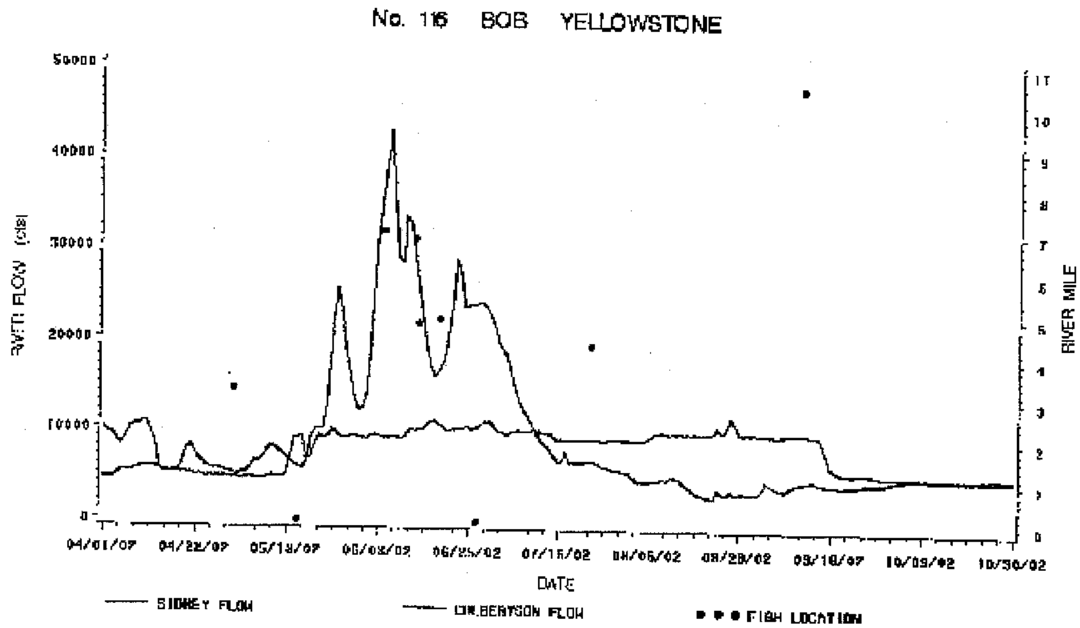

Figure 19: Relocations for Bob, fish # 116, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

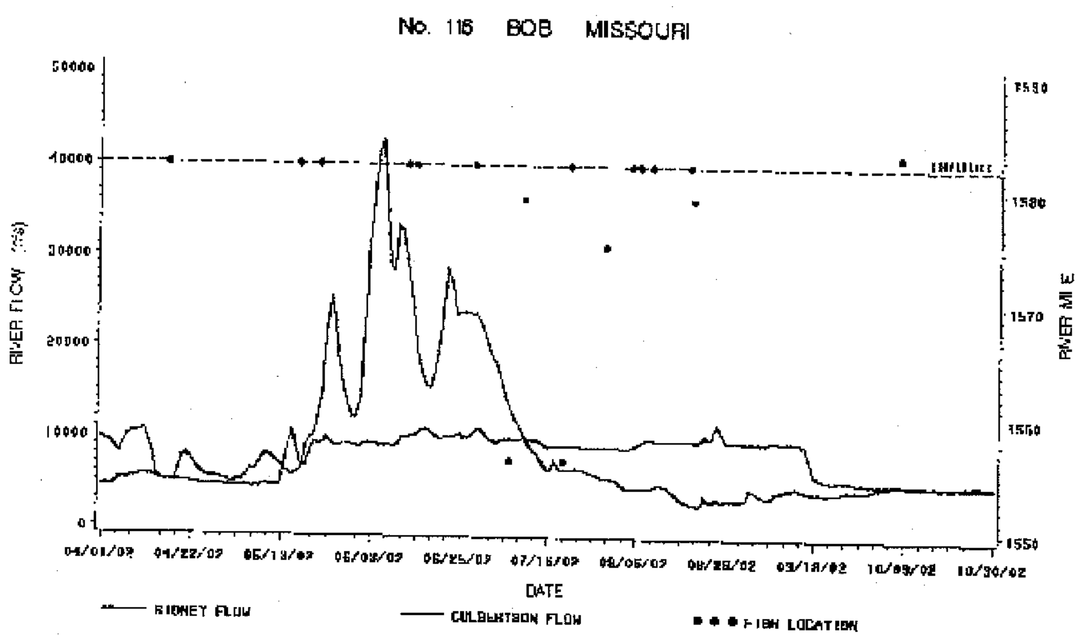

Figure 20: Relocations for Bob, fish # 116, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

No. 144 BEN YELLOWSTONE

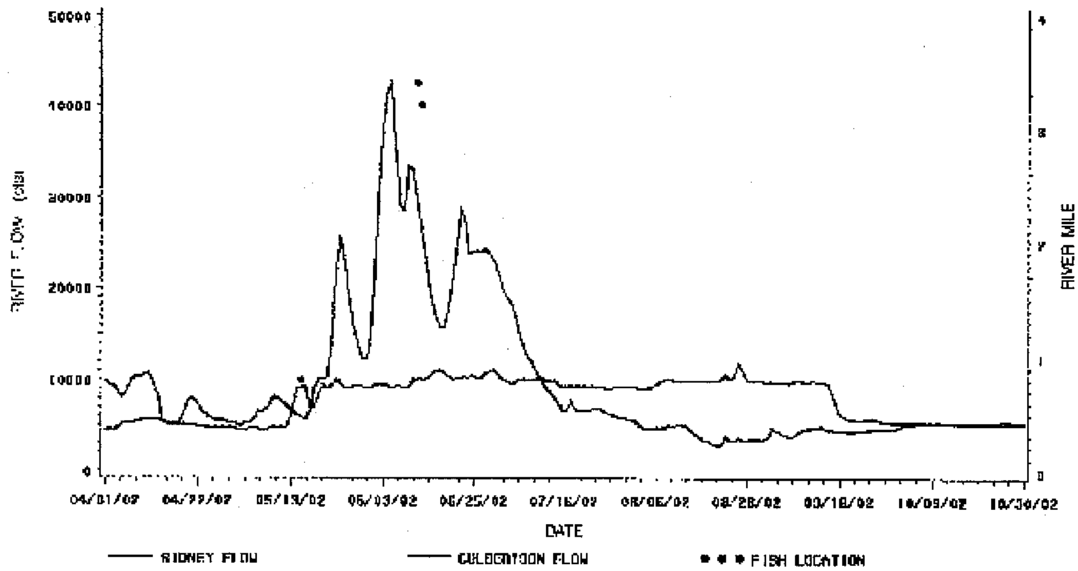

Figure 21: Relocations for Ben, fish # 144, by river mile in the Yellowstone River plotted against flows from the Sidney and Culbertson gauging stations.

No. 144 BEN MISSOURI

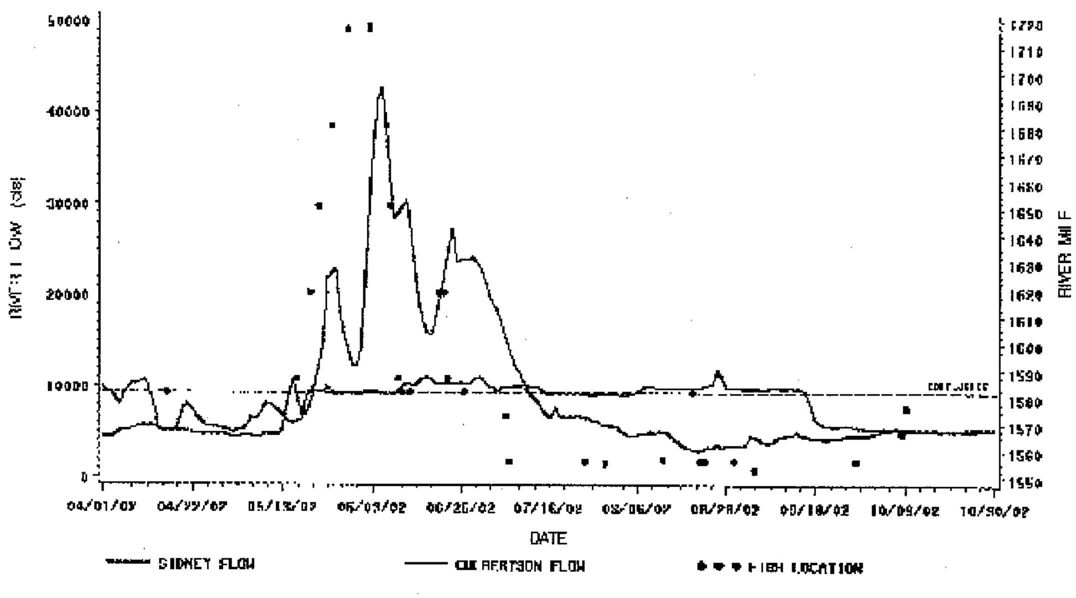

Figure 22: Relocations for Ben, fish # 144, by river mile in the Missouri River plotted against flows from the Sidney and Culbertson gauging stations.

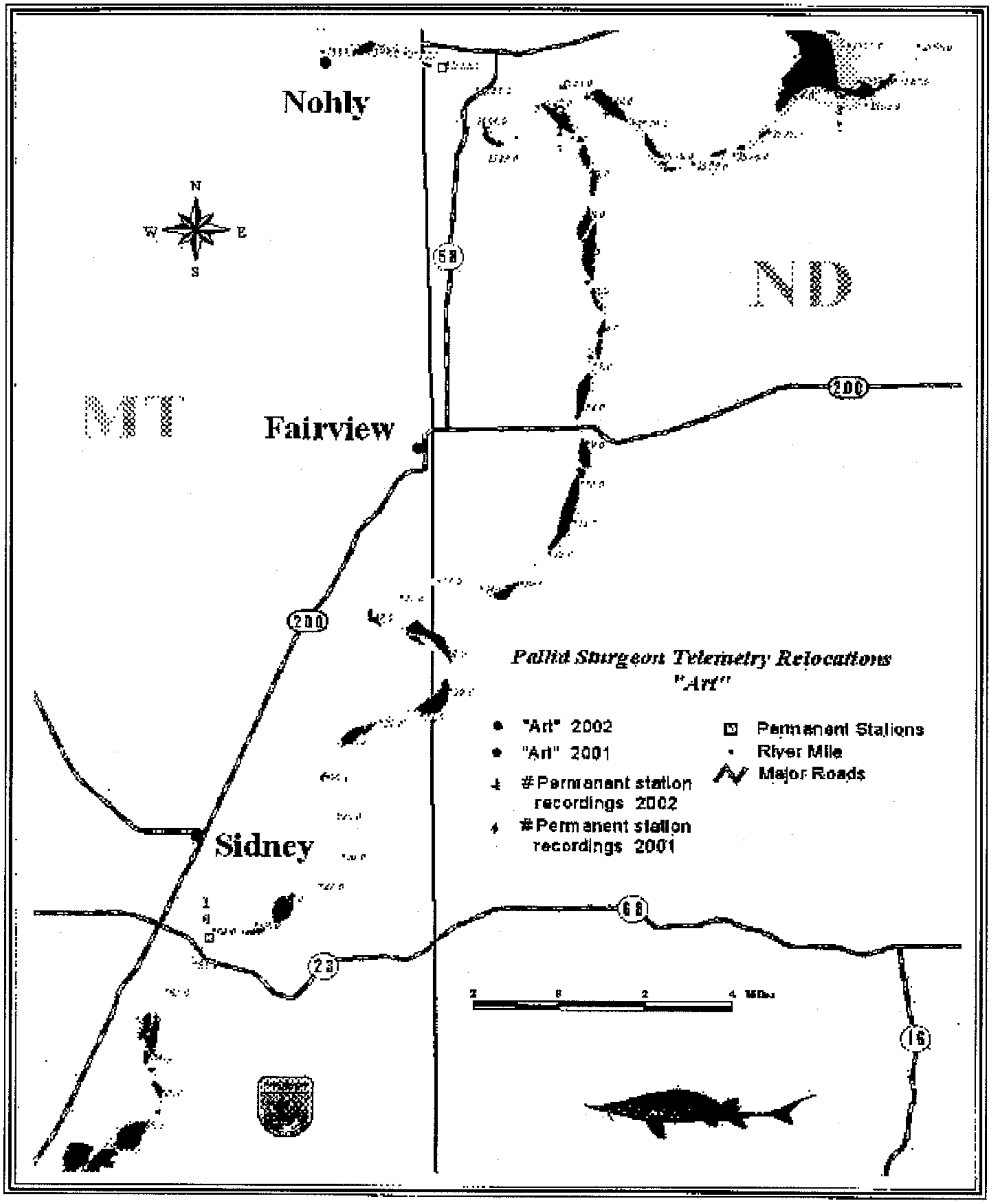

Figure 23: Map of boat relocations and movement frequencies registered for Art passing various fixed datalogging stations for 2001 and 2002.

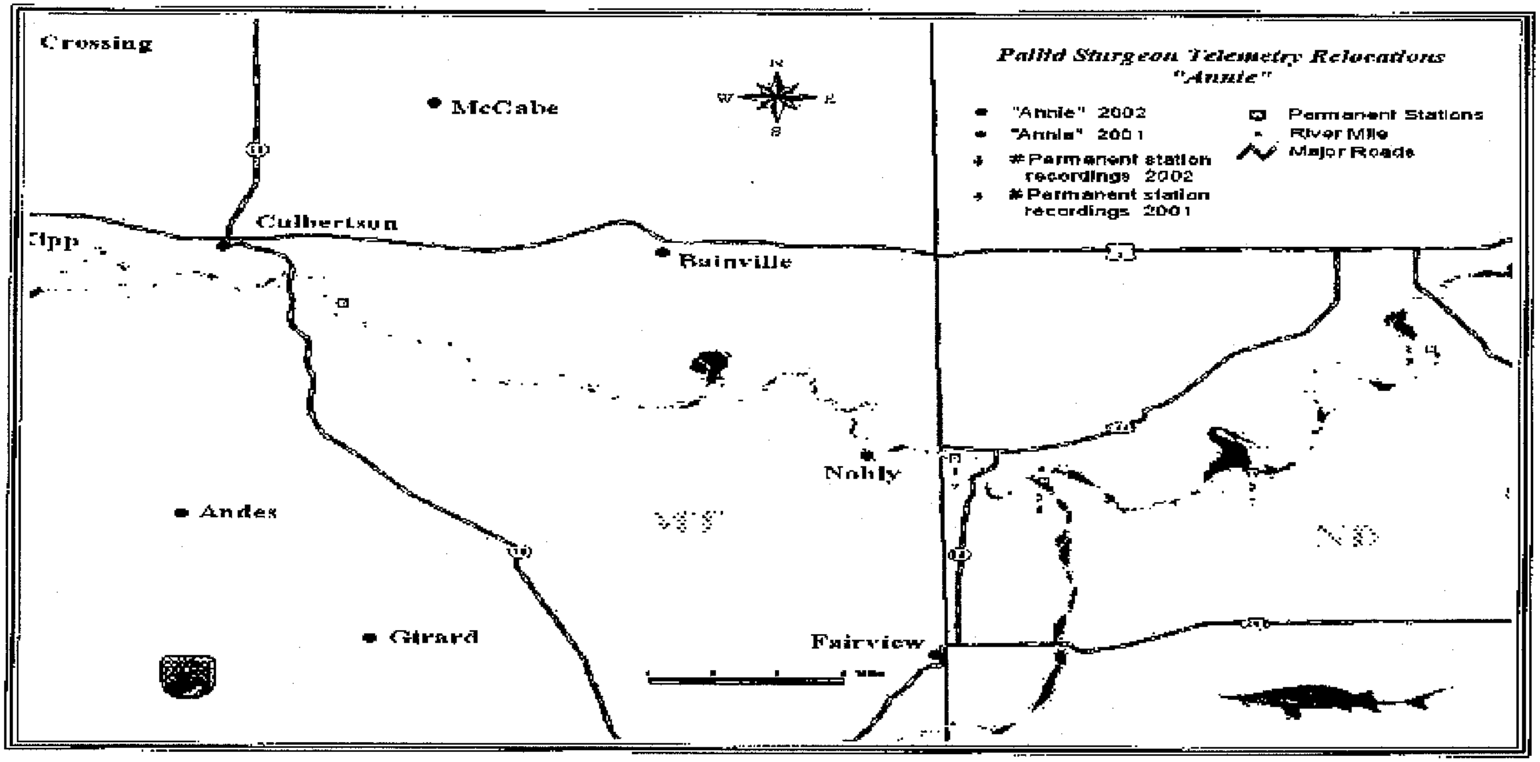

Figure 24: Map of boat relocations and movement frequencies registered for Annie passing various fixed datalogging stations for 2001 and 2002

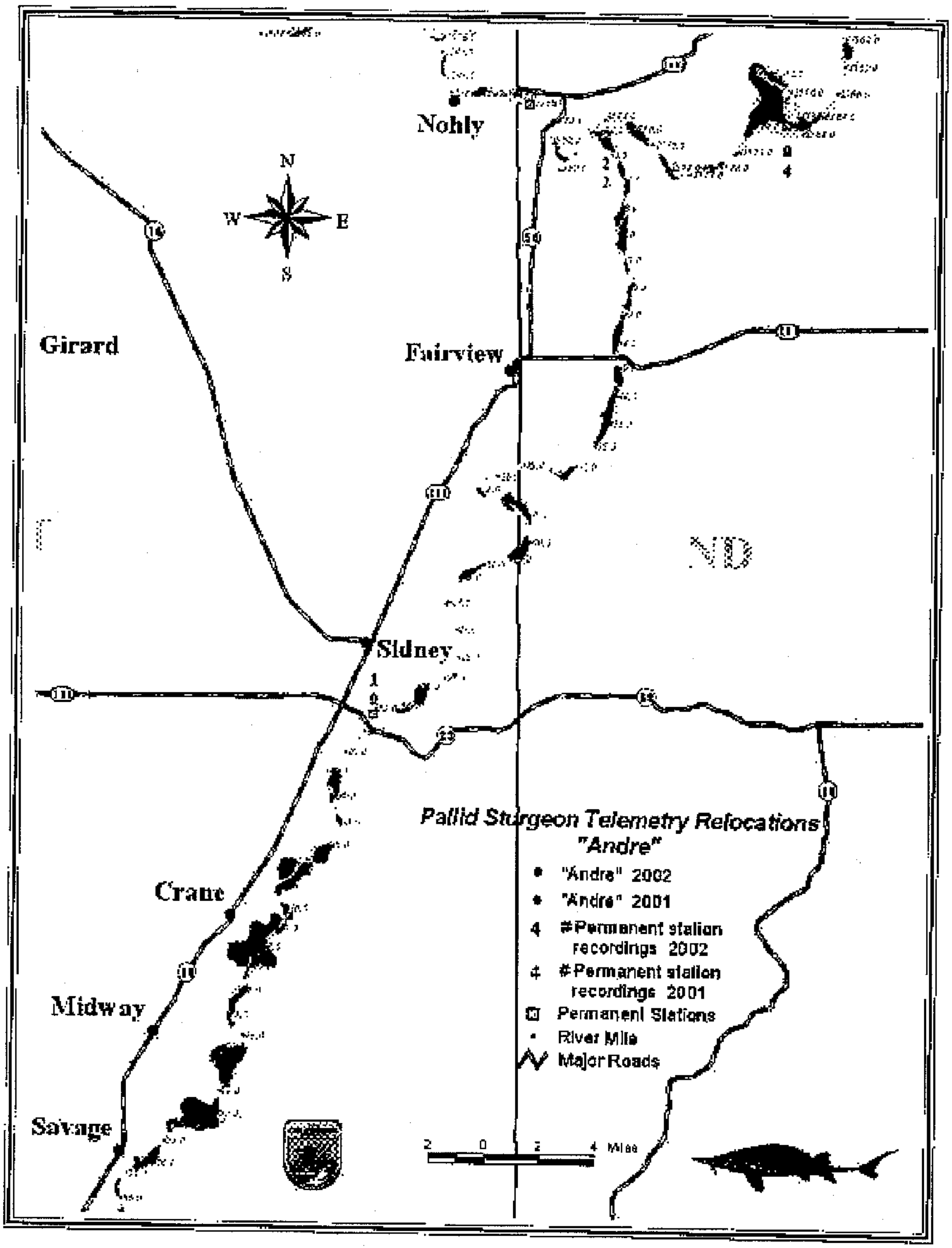

Figure 25: Map of boat relocations and movement frequencies registered for Andre passing various fixed datalogging stations for 2001 and 2002.

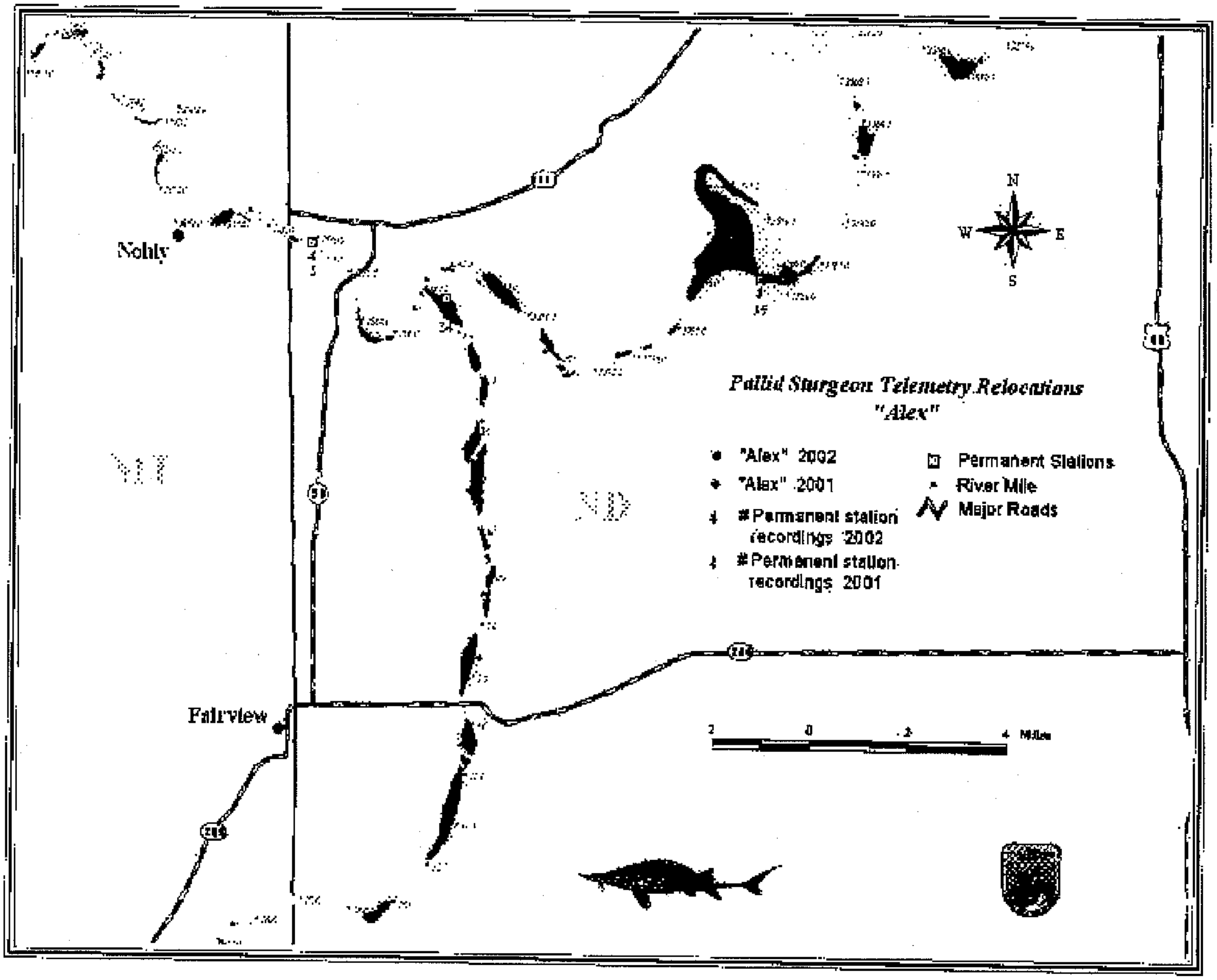

Figure 26: Map of boat relocations and movement frequencies registered for Alex passing various fixed datalogging stations for 2001 and 2002.

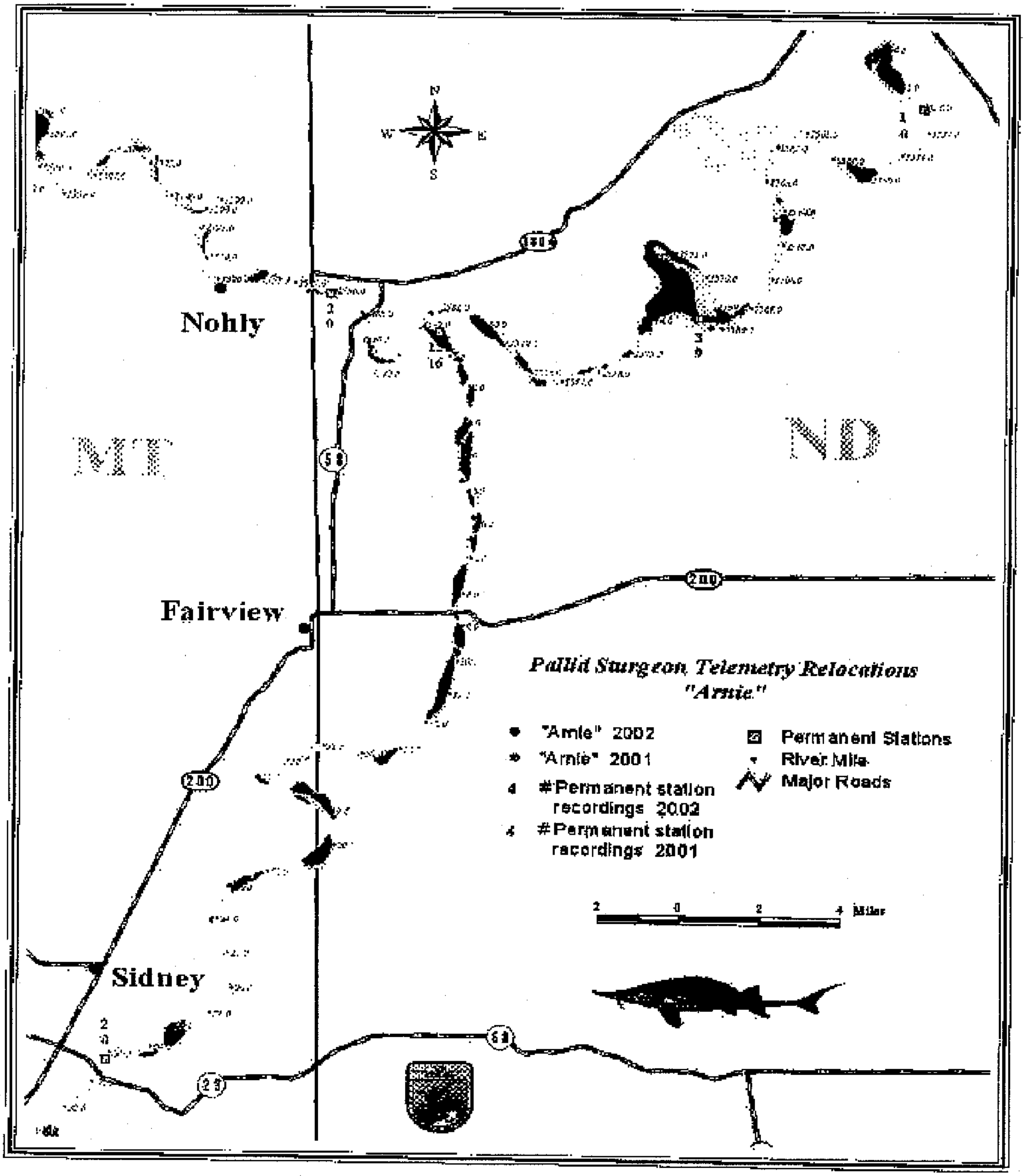

Figure 27: Map of boat relocations and movement frequencies registered for Arnie passing various fixed datalogging stations for 2001 and 2002.

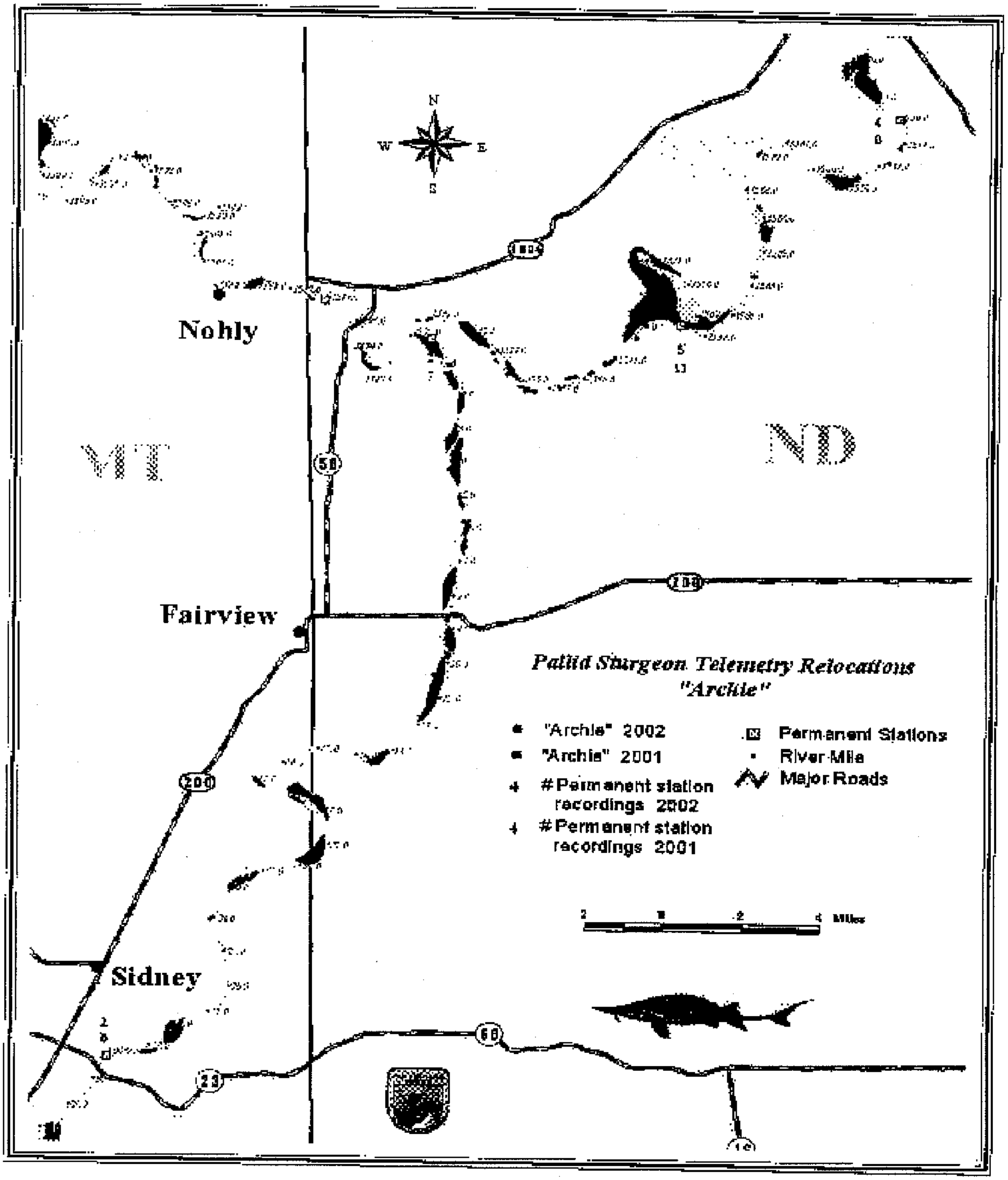

Figure 28: Map of boat relocations and movement frequencies registered for Archie passing various fixed datalogging stations for 2001 and 2002.

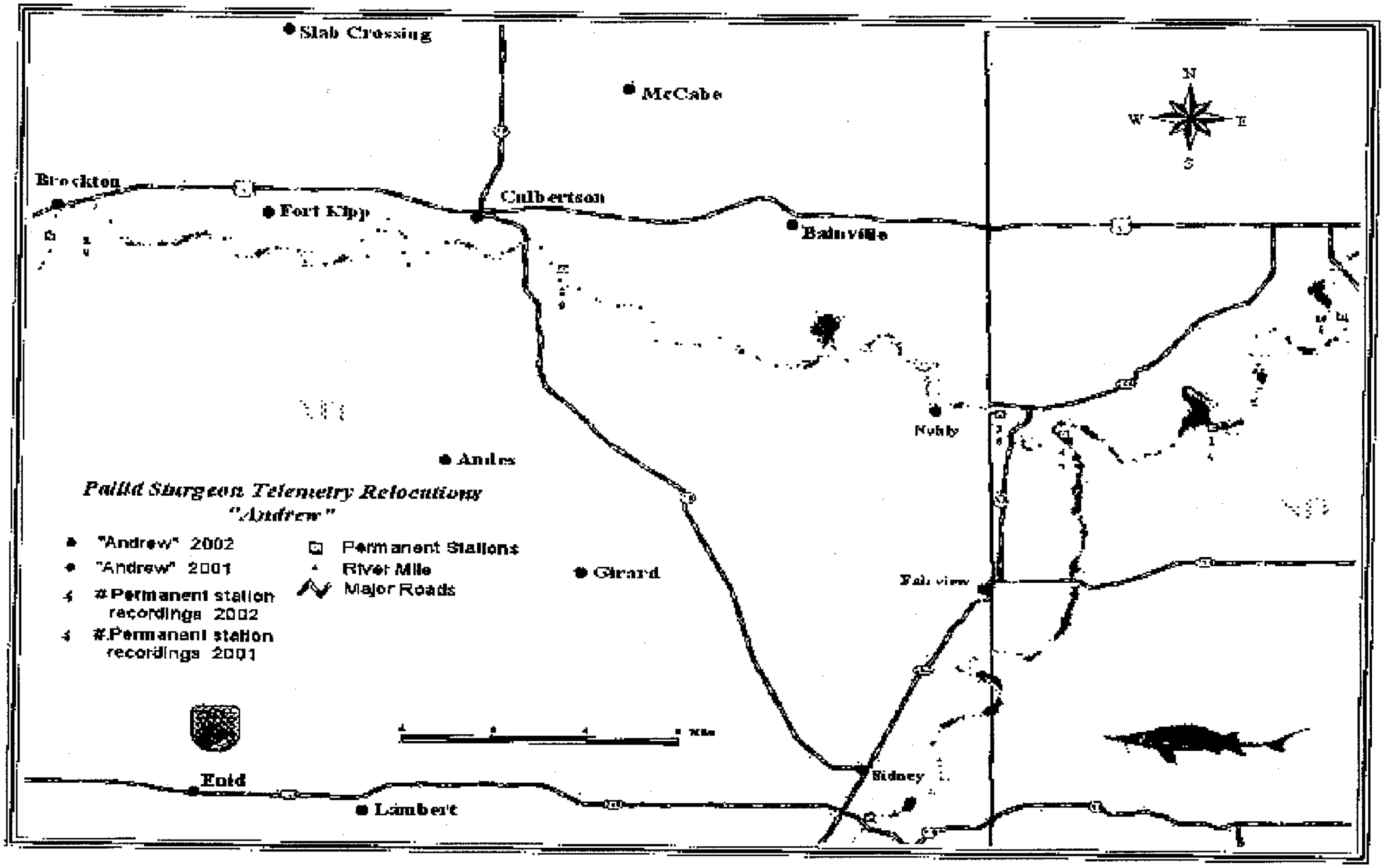

Figure 29: Map of boat relocations and movement frequencies registered for Andrew passing various fixed datalogging stations for 2001 and 2002.

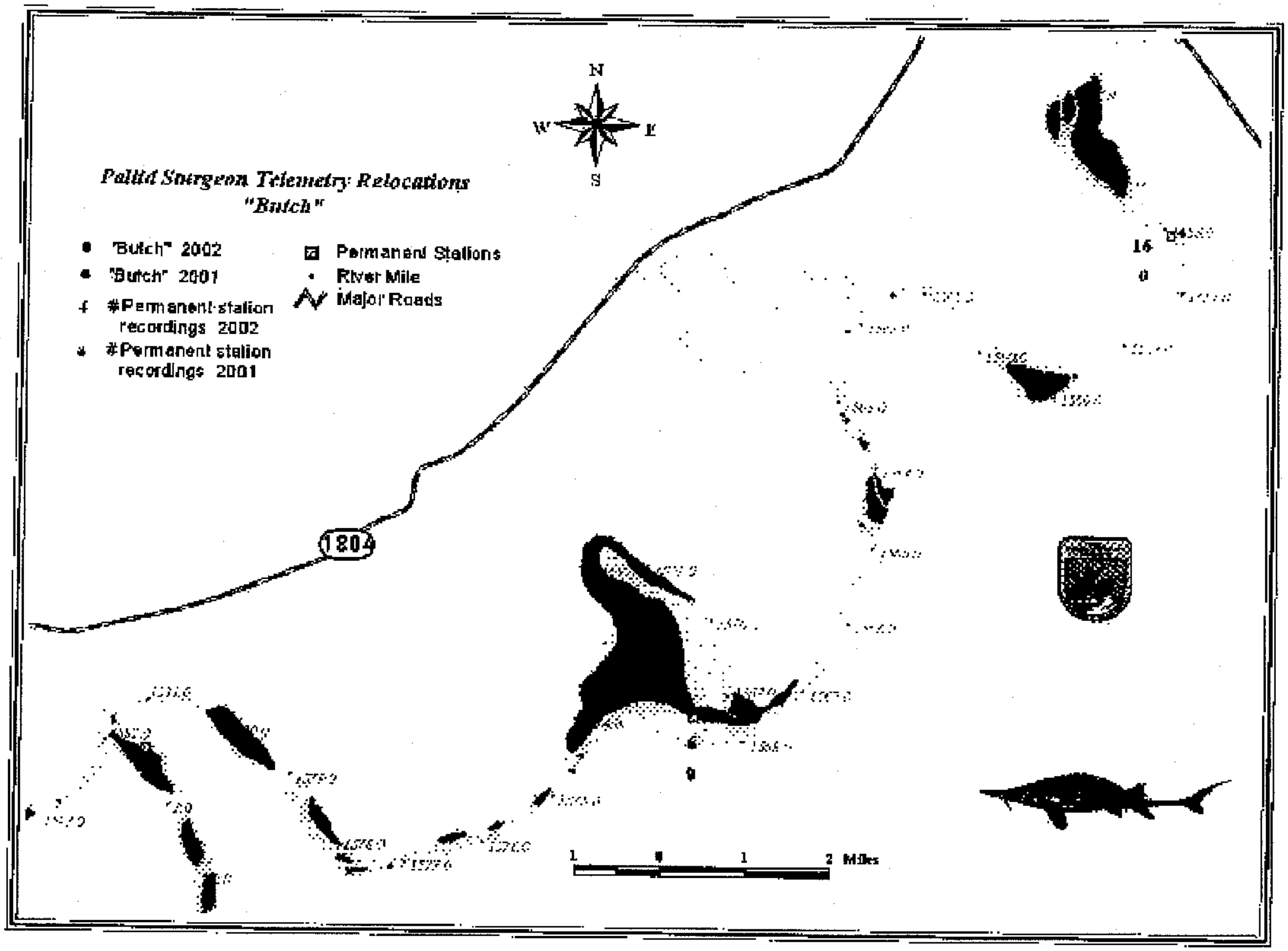

Figure 30: Map of boat relocations and movement frequencies registered for Butch passing various fixed datalogging stations for 2001 and 2002.

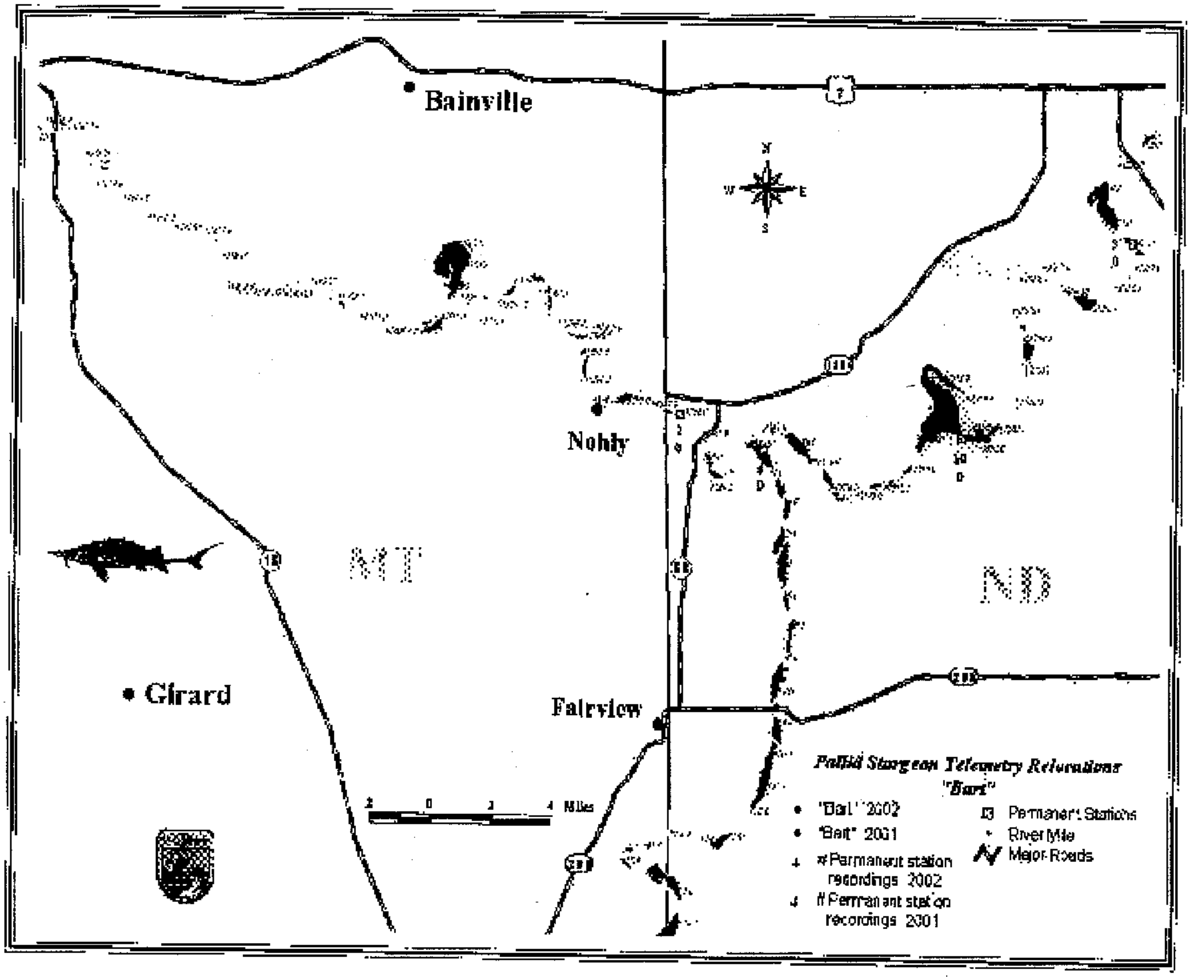

Figure 31: Map of boat relocations and movement frequencies registered for Bart passing various fixed datalogging stations for 2001 and 2002.

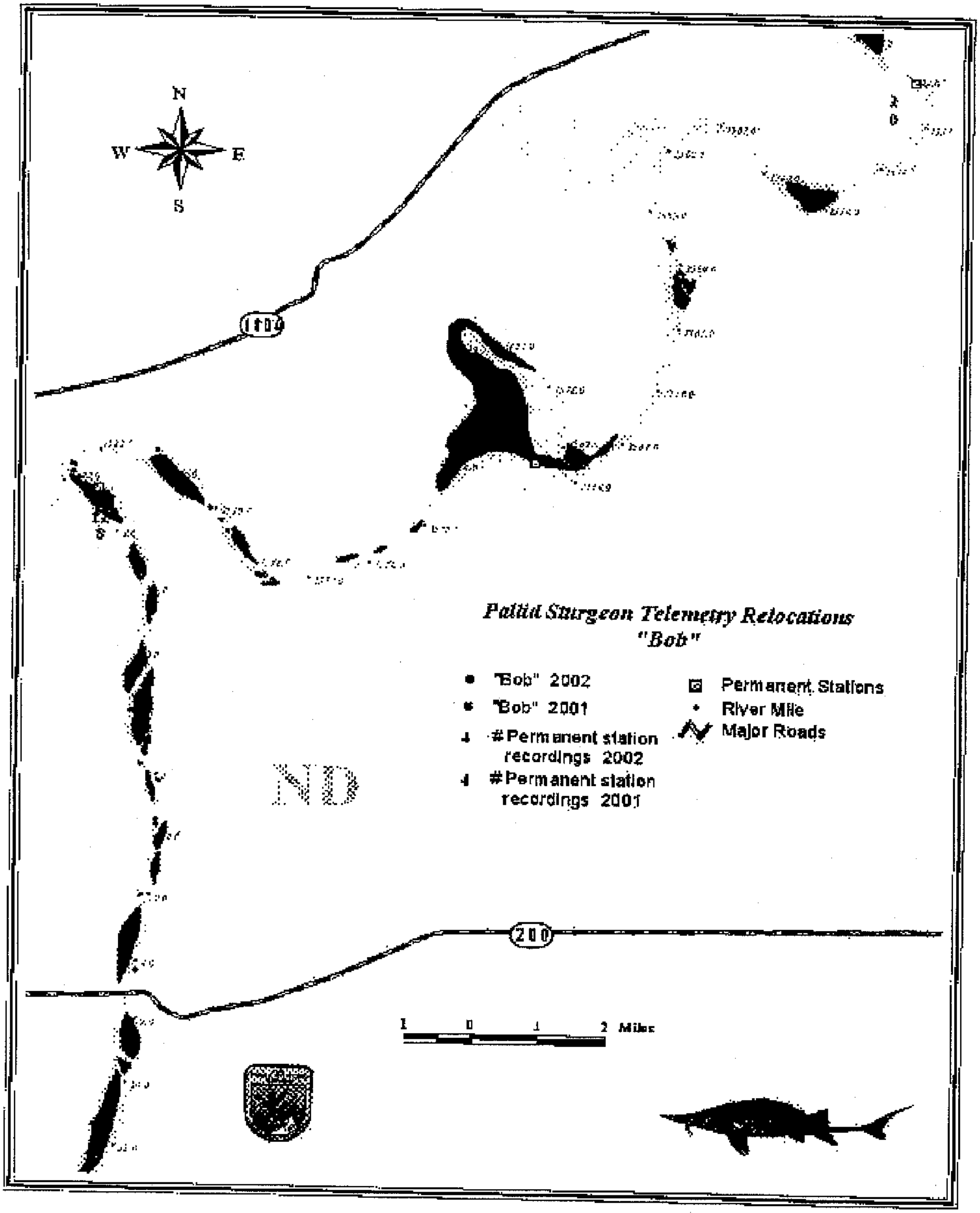

Figure 32: Map of boat relocations and movement frequencies registered for Bob passing various fixed datalogging stations for 2001 and 2002.

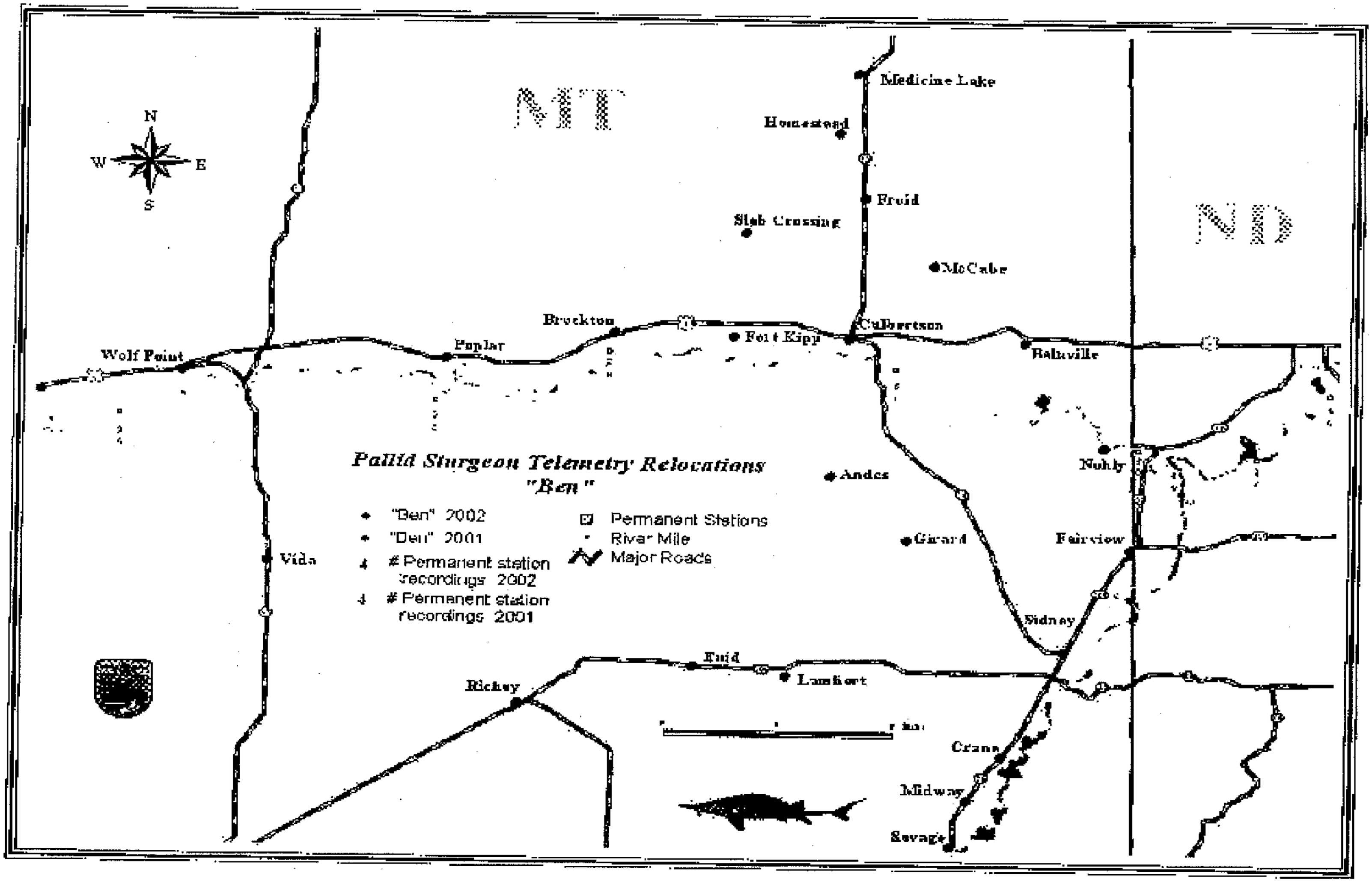

Figure 33: Map of boat relocations and movement frequencies registered for Ben passing various fixed datalogging stations for 2001 and 2002.

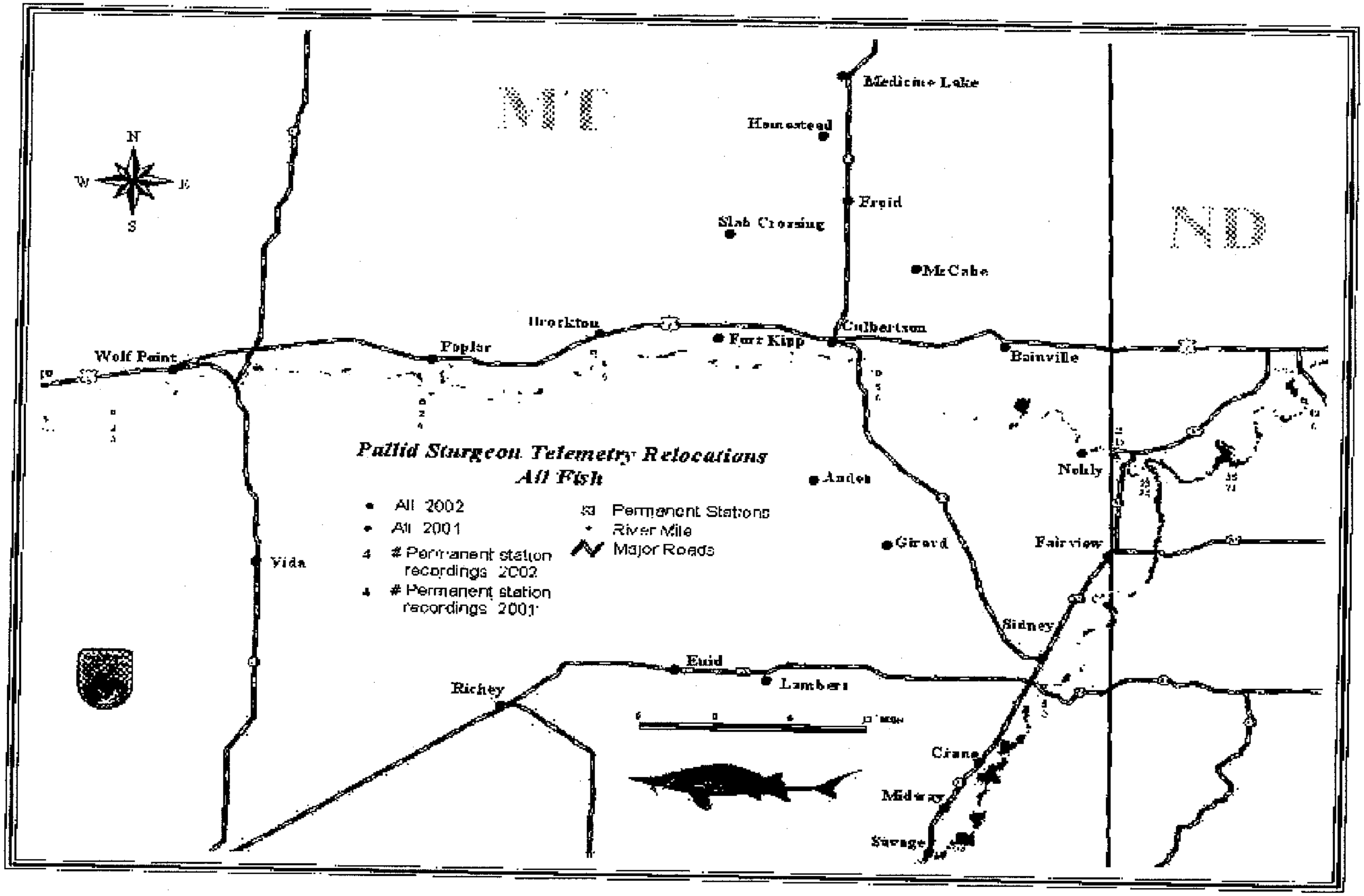

Figure 34: Map of boat relocations and movement frequencies registered for all fish passing various fixed datalogging stations for 2001 and 2002.

Fort Peck Flow Modification Biological Data Collection Plan

Summary of 2002 Activities

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Prepared for:
U. S. Army Corps of Engineers
Contract Number 00-UGPR-34

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Abstract

The Missouri River Biological Opinion developed by the U. S. Fish and Wildlife Service formally identified that seasonally atypical discharge and water temperature regimes resulting from operations of Fort Peck Dam have precluded successful spawning and recruitment of pallid sturgeon *Scaphirhynchus albus* in the Missouri River below Fort Peck Dam. In response, the U. S. Army Corps of Engineers (USACE) proposes to modify operations of Fort Peck Dam to enhance environmental conditions for spawning and recruitment of pallid sturgeon. The Fort Peck Flow Modification Biological Data Collection Plan (hereafter Fort Peck Data Collection Plan) was implemented in 2001 to evaluate the influence of proposed flow and temperature modifications on physical habitat and biological response of pallid sturgeon and other native fishes. Activities continued during 2002, and are summarized below. The multi-year Fort Peck Data Collection Plan is comprised of five monitoring components: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements by pallid sturgeon that inhabit areas immediately downstream from Fort Peck Dam, 3) examining flow- and temperature-related movements of paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus*, 4) quantifying larval fish distribution and abundance, and 5) examining food habits of piscivorous fishes. The Fort Peck Data Collection Plan is supported by the USACE, and implemented by the Montana Department of Fish, Wildlife, and Parks (MTFWP) and the U. S. Geological Survey Columbia Environmental Research Center.

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

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

Introduction

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

The original schedule of events for conducting the flow modifications called for conducting the mini-test during 2001 and conducting the full-test in 2002. However, insufficient water levels in Fort Peck Reservoir during spring 2001 and 2002 precluded conducting the mini-test and full-test. Thus, pending favorable precipitation and adequate reservoir water levels in early spring 2003, the mini-test may be conducted in 2003 and the full-test conducted in 2004.

The Fort Peck Flow Modification Biological Data Collection Plan (hereafter referred to as the Fort Peck Data Collection Plan) is a monitoring program designed to examine the influence of proposed flow modifications from Fort Peck Dam on physical habitat and biological response of pallid sturgeon and other native fishes. Components of the monitoring program include: 1) measuring water temperature and turbidity at several locations downstream from Fort Peck Dam, 2) examining movements by pallid sturgeon that inhabit areas immediately downstream from Fort Peck Dam, 3) examining flow- and temperature-related movements of paddlefish *Polyodon spathula*, blue suckers *Cycleptus elongatus*, and shovelnose sturgeon *Scaphirhynchus platorynchus*, 4) quantifying larval fish distribution and abundance, and 5) examining food habits of piscivorous fishes. The Fort Peck Data Collection Plan is supported by the USACE, and implemented by the Montana Department of Fish, Wildlife, and Parks (MTFWP) and the U. S. Geological Survey Columbia Environmental Research Center – Fort Peck Project Office. Western Area Power Administration serves as the contractual liaison between the USACE and MTFWP.

Study Area

The Missouri River study area extends from Fort Peck Dam located at river kilometer (rkm) 2,850 (river mile, RM 1,770) to the headwaters of Lake Sakakawea near rkm 2,496 (RM 1,550; Figure 1). The study area also includes the lower 113 rkm (70 miles) of the Yellowstone River (Figure 1). See Gardner and Stewart (1987), White and Bramblett (1993), Tews (1994), and Bramblett and White (2001) for a complete description of physical and hydrological characteristics of the study area.

Methods

Monitoring Component 1 - Water temperature and turbidity.

Water temperature logger deployment. Water temperature loggers (Optic StowAway, -5°C – +37°C, 4 min response time, accuracy ± 0.2°C from 0 - 21°C) were deployed during early May at sites in the Missouri River, Yellowstone River, selected tributaries, and off-channel areas (Table 1). Duplicate loggers were secured adjacent to the north and south bank lines at sites in the Missouri River to assess lateral variations in water temperature. Water temperature loggers were positioned near the bottom of the river channel. An additional logger was stratified in the water column at selected sites to assess vertical variations in water temperature. Stratified water temperature loggers were secured to either the north or south bank locations. Water temperature loggers were programmed to record water temperature at 1-hr intervals, and periodically downloaded during the deployment period.

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

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

Statistical analysis of water temperature logger precision. Pre- and post-deployment precision of loggers for each water bath treatment was evaluated with univariate statistics (mean, standard deviation, minimum, maximum, and range) computed over all loggers. The mean, minimum, maximum, and range were screened for precision. If precision was low (e.g., broad range of temperature for an individual water bath trial), logger data were scrutinized to determine which logger(s) was contributing to the extreme values. After identifying and deleting the "suspect" logger(s), univarite statistics were computed again to assess precision. In addition to univariate statistics, a two-way analysis of variance was used to compare precision (i.e., temperature range) of water temperature loggers between pre- and post-deployment test and among the three water temperature treatments.

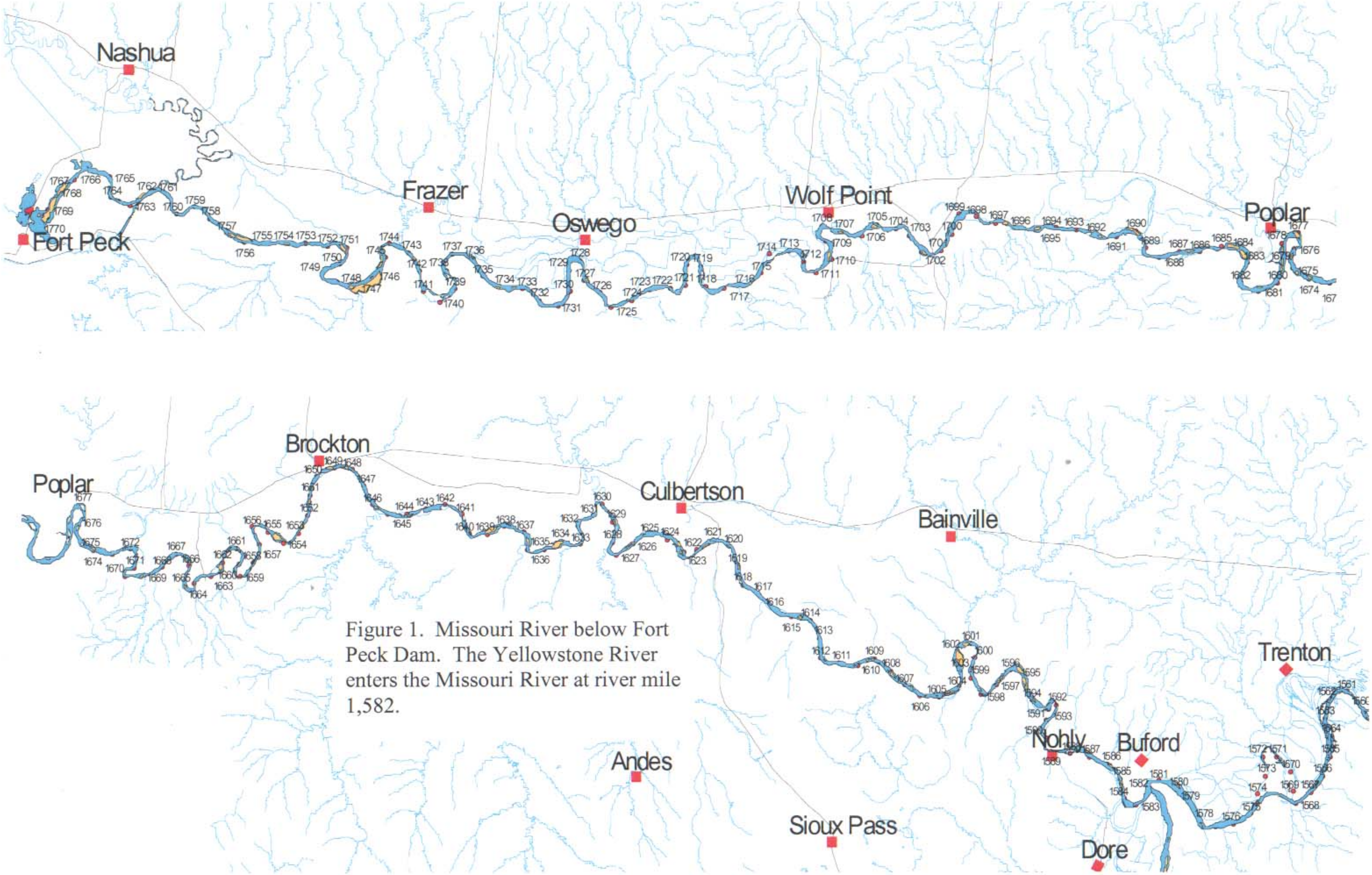

Figure 1. Missouri River below Fort Peck Dam. The Yellowstone River enters the Missouri River at river mile 1,582.

Table 1. Sites, approximate river mile (RM; distance upstream from the Missouri River-Mississippi River confluence or distance upstream in a specified tributary), bank locations (north, south, strat = stratified in the water column), serial numbers, and dates of deployment for water temperature loggers deployed in the Missouri River and adjacent areas during 2002. NR = not recovered at the end of the season.

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

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

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

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

Monitoring Component 2 – Movements by pallid sturgeon.

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

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

Transmitter implantation.-Sampling for paddlefish, blue suckers, and shovelnose sturgeon for transmitter implantation was conducted in September 2002. Species were sampled using drifted trammel nets, hoop nets (primarily targeting blue suckers), and surface-drifted gill nets (primarily targeting paddlefish). A minimum of 20 suitable-sized individuals of each species were targeted for transmitter implantation. Our goal was to extend flow- and temperature-related movement inferences to all areas of the Missouri River below Fort Peck

Dam. Therefore, species were collected in several areas between rkm 2,842 (RM 1,765) and rkm 2,547 (RM 1,582; Figure 1).

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

Surgical implantation of transmitters was conducted after 1-6 individuals were captured at a sampling location. After being sampled, fish were placed in streamside live cars. Individuals were placed in a partially submerged V-shaped trough during surgical implantation of transmitters, and water was continually flushed over the gills using a bilge pump apparatus. After making an abdominal incision about midway between the pectoral fin and pelvic fin, a shielded needle technique (Ross and Kleiner 1982) was used to extrude the transmitter antennae through the body cavity. The transmitter was then inserted into the body cavity, and the incision was closed with silk sutures. Most blue suckers and shovelnose sturgeon were held overnight in streamside live cars, and released the following morning. A 5-10 minute period of facilitated acclimation following surgical procedures was used to stabilize paddlefish prior to release. Surgical implantation of transmitters was conducted at water temperatures between 10.3°C and 16.4°C.

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

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

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

Monitoring Component 4 – Larval Fish

Sampling protocols. Larval fish were sampled at about 3-4 day intervals from late May through early August at six sites (Table 2). Similar to 2001, sites on the mainstem Missouri River were located just downstream from Fort Peck Dam, near Wolf Point, and near Nohly. Sites located off the mainstem Missouri River included the spillway channel, the Milk River, and the Yellowstone River. Larval fish at all sites were sampled with 0.5-m-diameter nets (750 μm mesh) fitted with a General Oceanics Model 2030R velocity meter.

Table 2. Larval fish sampling locations, number of replicates, samples, and net locations for 2002. Abbreviations for net location are as follows: B = bottom, M = mid-water column, S = surface (0.5 - 1.0 m below the surface).

Site	Approximate river mile	Replicates	Samples per replicate	Net location
Missouri River below Fort Peck Dam	1,763.5-1,765.3	3	4	B/M
Spillway	1,762.8	2	4	S
Milk River	0.5-4.0	5	4	S
Missouri River near Wolf Point	1,701.0-1,708.0	5	4	B/M
Missouri River near Nohly	1,584-1,592	5	4	B/M
Yellowstone River	0.1-3.0	5	4	B/M

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

Larval fish were sampled at the same replicate and subsample locations throughout the sampling period except when changes in discharge necessitated minor adjustments in the sampling location. For example, an attempt was made to sample larval fish at total water column depths between 1.5 m and 3.0 m. This protocol was used to minimize variations in larval fish density associated with vertical stratification of larvae in the water column. When river discharge decreased (or increased), water depth in a previously sampled location exceeded the required range. Therefore, the specific sampling location changed but was always near ($\pm$ 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. Damaged individuals that could not be identified were classified as unknown.

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

Monitoring Component 5 – Food habits of piscivorous fishes

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

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

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

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

Results and Discussion

Monitoring Component 1 - Water temperature and turbidity

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

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

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

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

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

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

Table 4. Summary statistics and probability values (P, from ANOVA or t-tests) for comparisons of mean daily water temperature (°C) among water temperature loggers located on the north bank and south bank, and stratified in the water column during 2002. Means with the same superscript within sites are not significantly different (P > 0.05). Inclusive dates for comparisons at all sites are 5/11/02-10/20/02 (163 days).

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

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

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

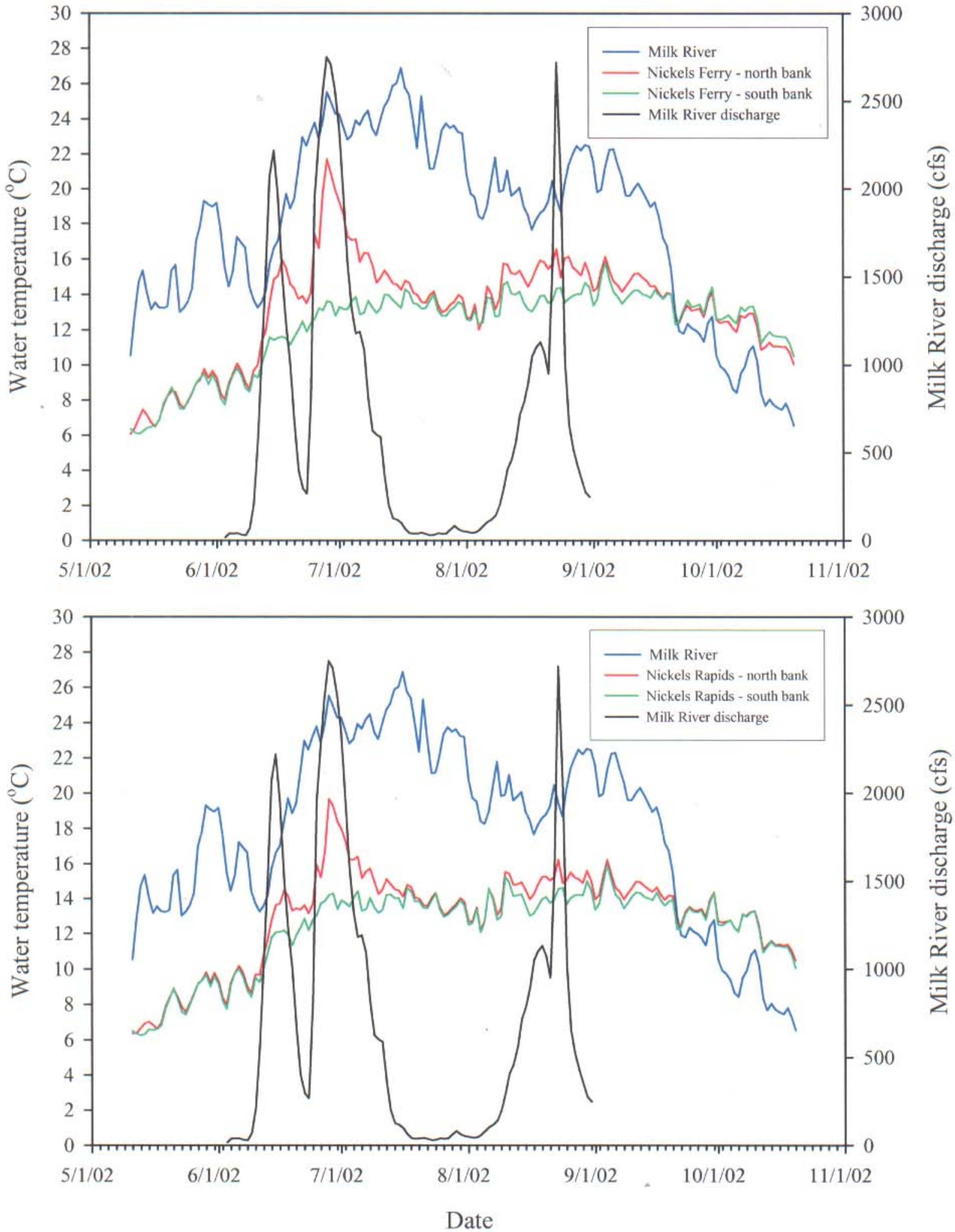

Figure 2. Water temperature profiles and discharge for the Milk River, and water temperatures profiles for the Missouri River at Nickels Ferry and Nickels Rapids during 2002.

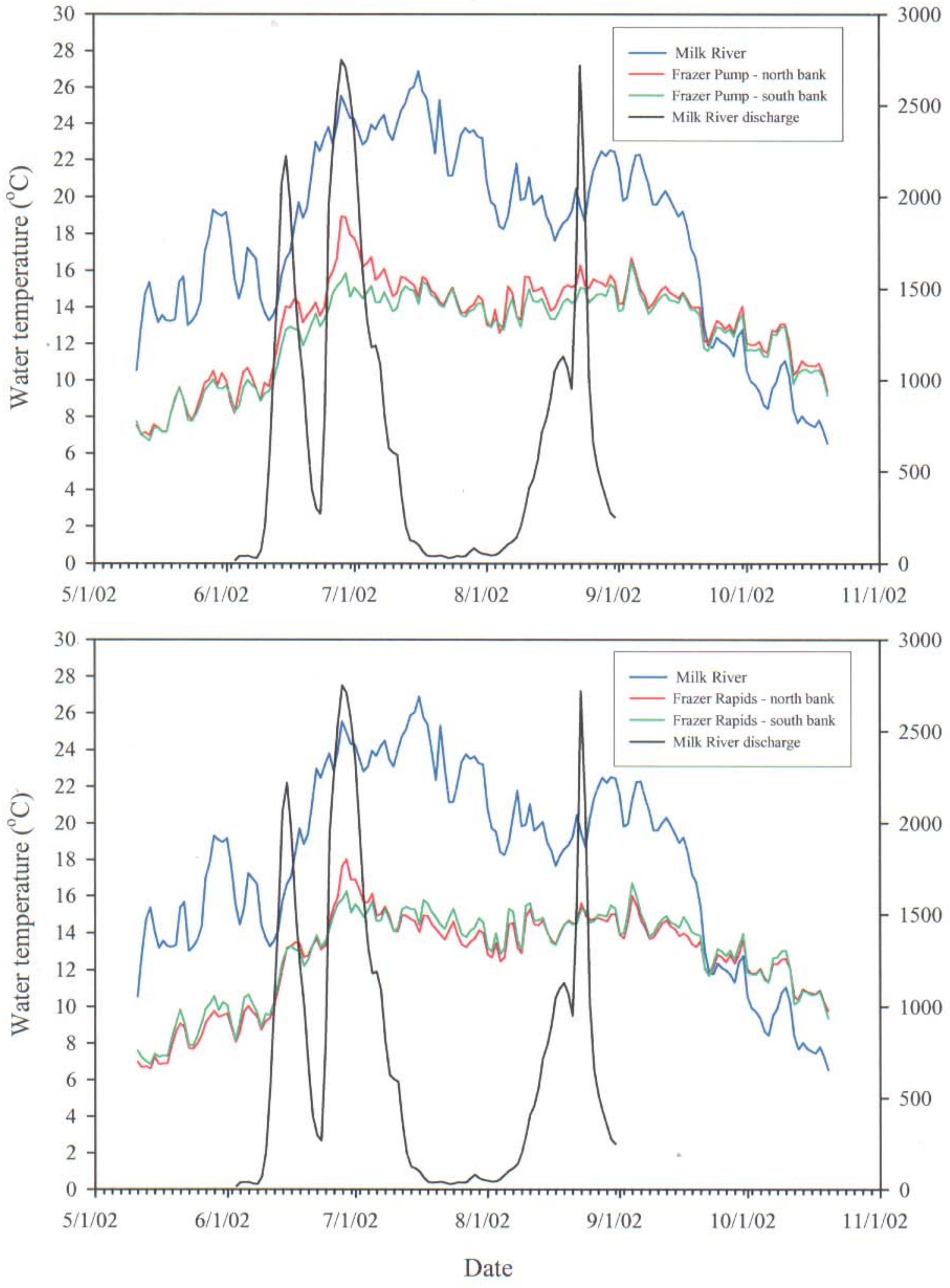

Figure 3. Water temperature profiles and discharge for the Milk River, and water temperatures profiles for the Missouri River at Frazer Pump and Frazer Rapids during 2002.

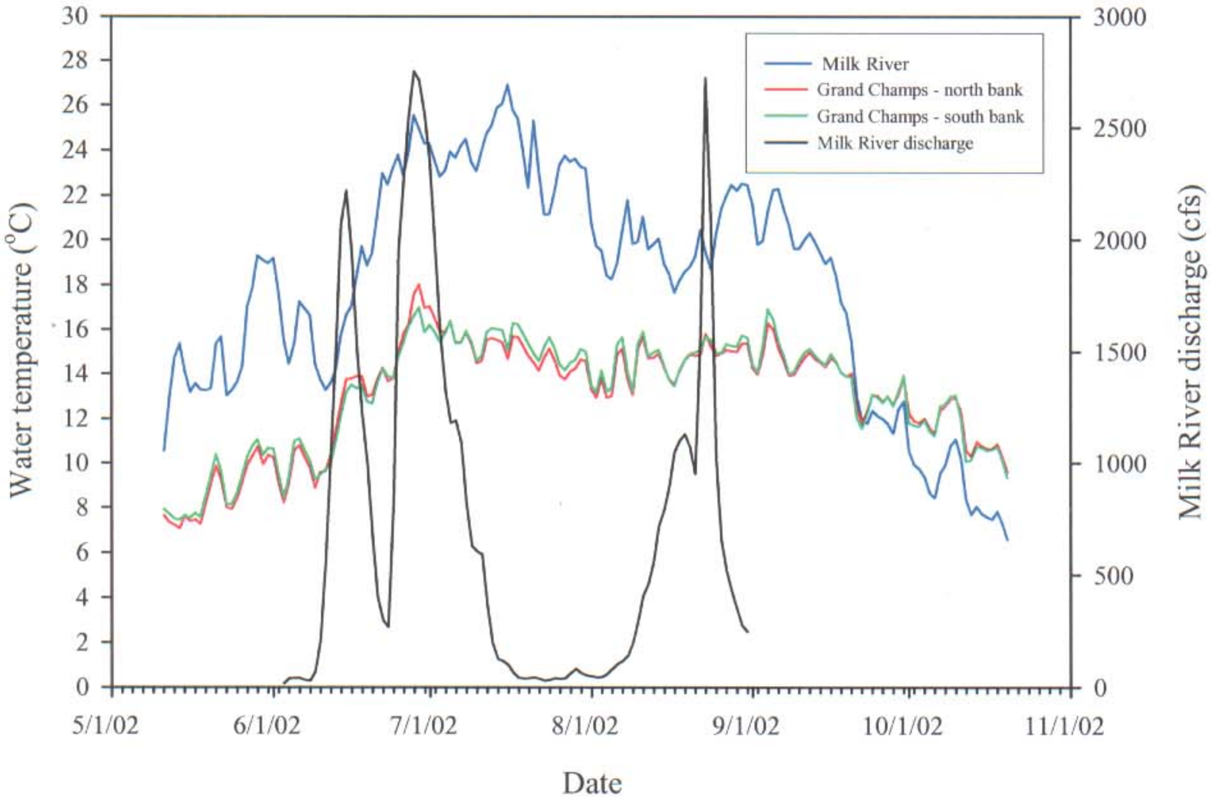

Figure 4. Water temperature profiles and discharge for the Milk River, and water temperatures profiles for the Missouri River at Grand Champs during 2002.

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

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

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

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

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

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

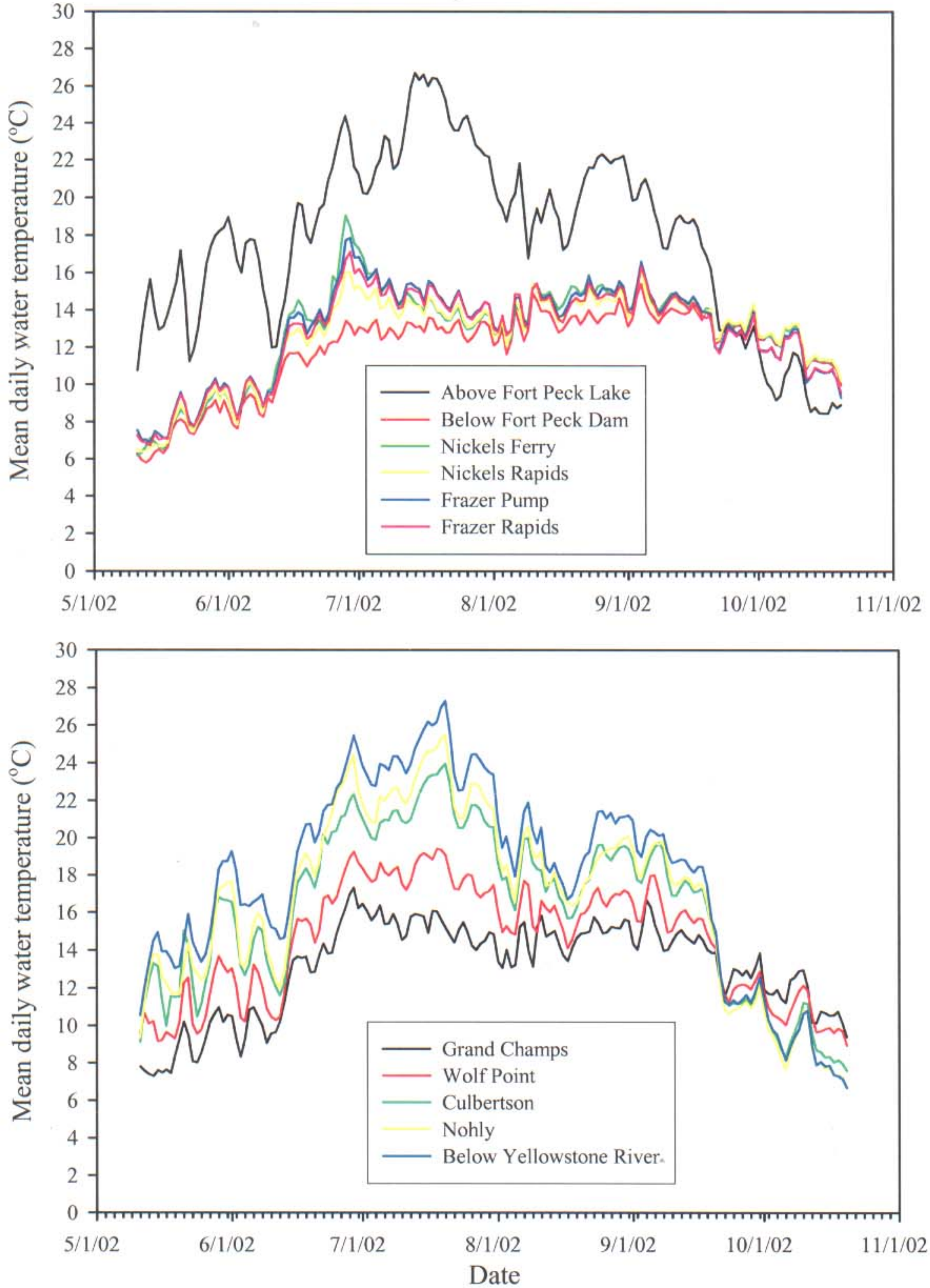

Figure 5. Mean daily water temperature (°C) at 11 sites on the mainstem Missouri River during 2002.

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

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

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

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

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

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

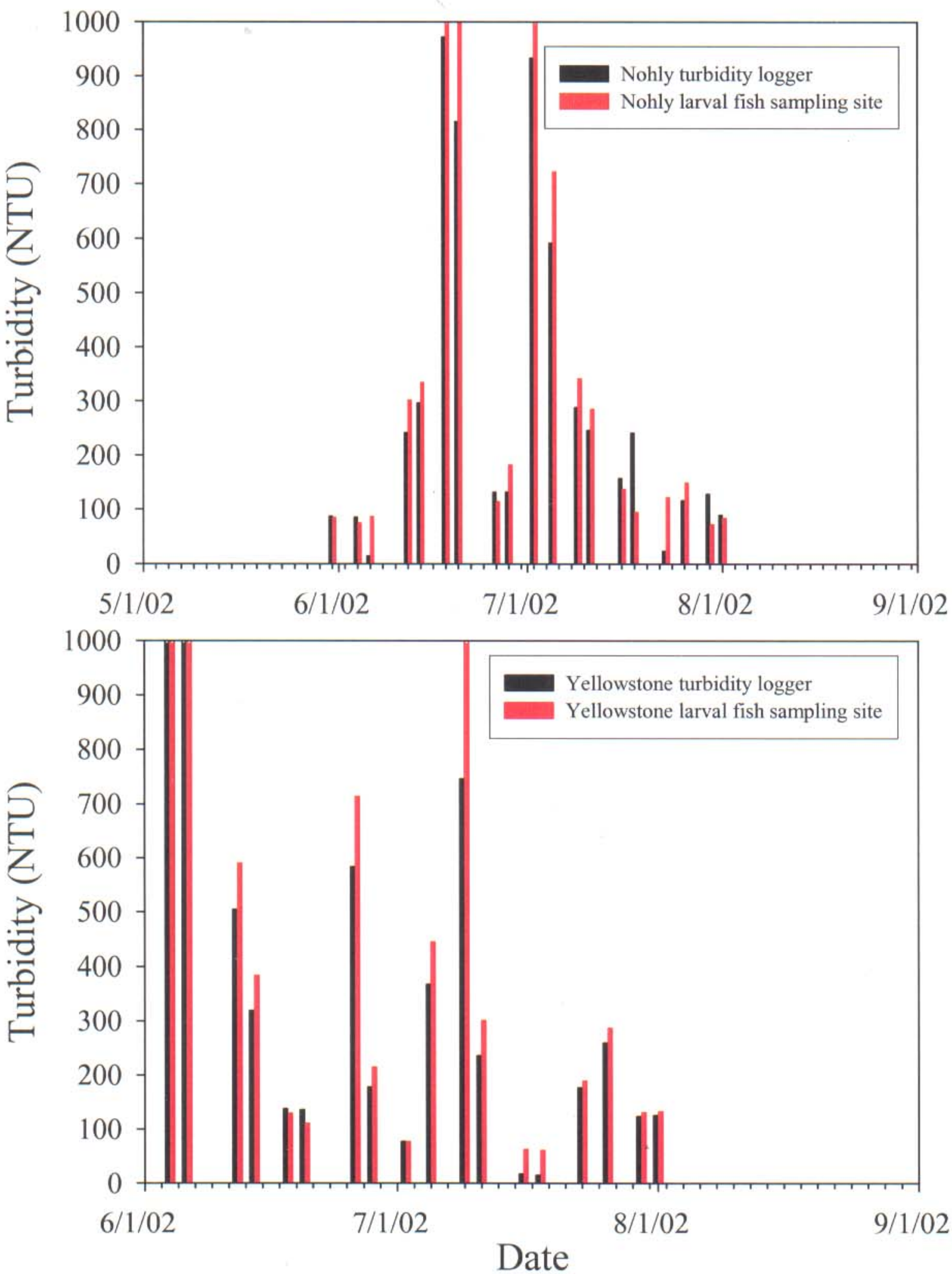

Figure 6. Mean daily turbidity (NTU) by date for Nohly (upper panel) and the Yellowstone River (lower panel).

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

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

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

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

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

Monitoring Component 2 – Movements by pallid sturgeon

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

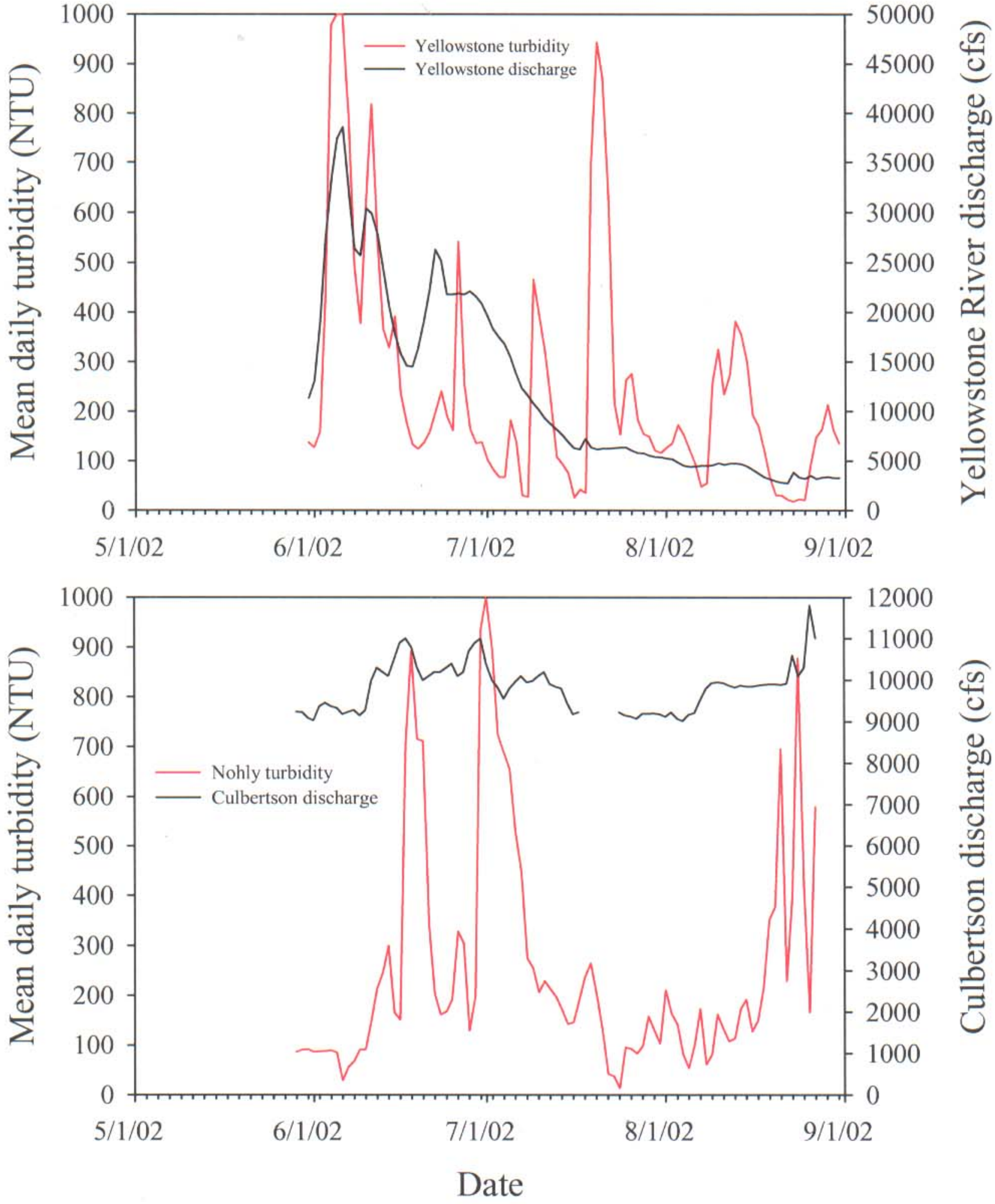

Figure 7. Mean daily turbidity (NTU; solid line) from turbidity loggers and discharge (cfs; dashed line) in the Yellowstone River (upper panel) in the Missouri River at Nohly (lower panel) during 2002.

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

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

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

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

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

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

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

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

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

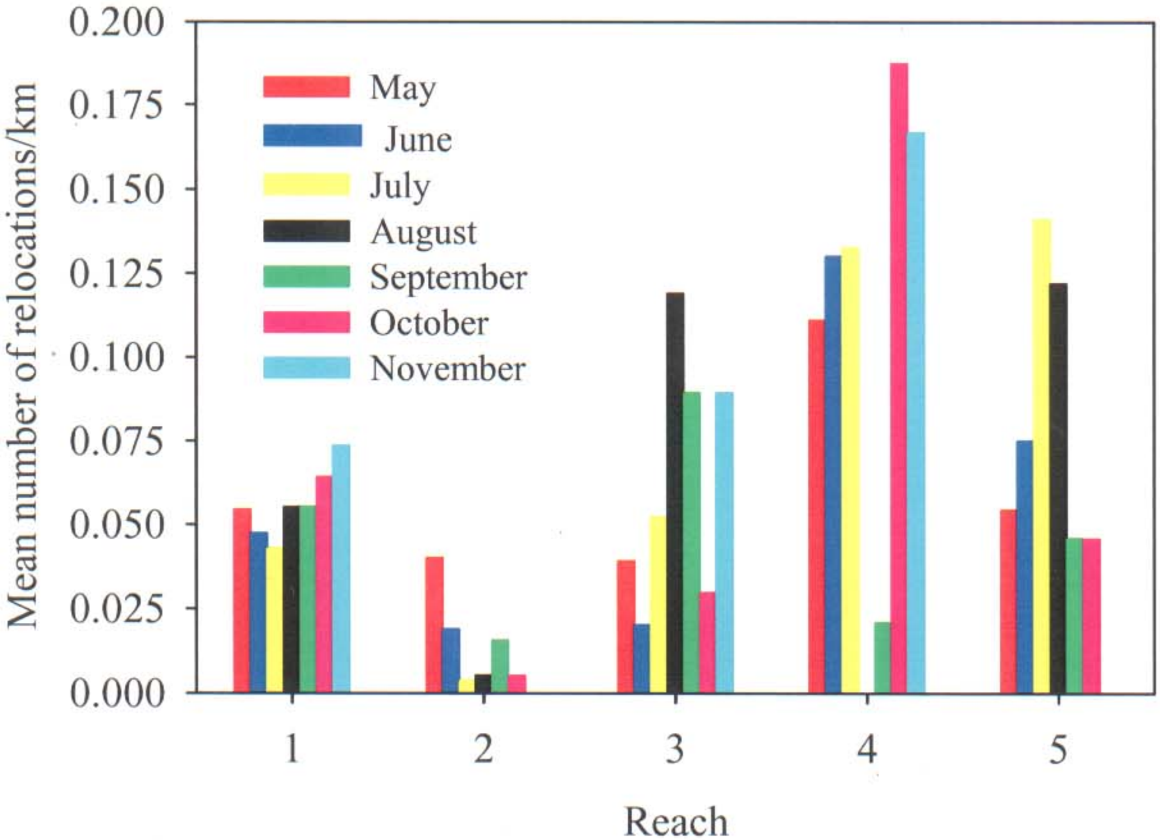

Figure 8. Mean number of shovelnose sturgeon relocations per km by month in five riverine reaches (Reach 1 = Missouri River between Fort Peck Dam and Wolf Point, Reach 2 = Missouri River between Wolf Point and the Yellowstone River confluence, Reach 3 = Missouri River from the Yellowstone River confluence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

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

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

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

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

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

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

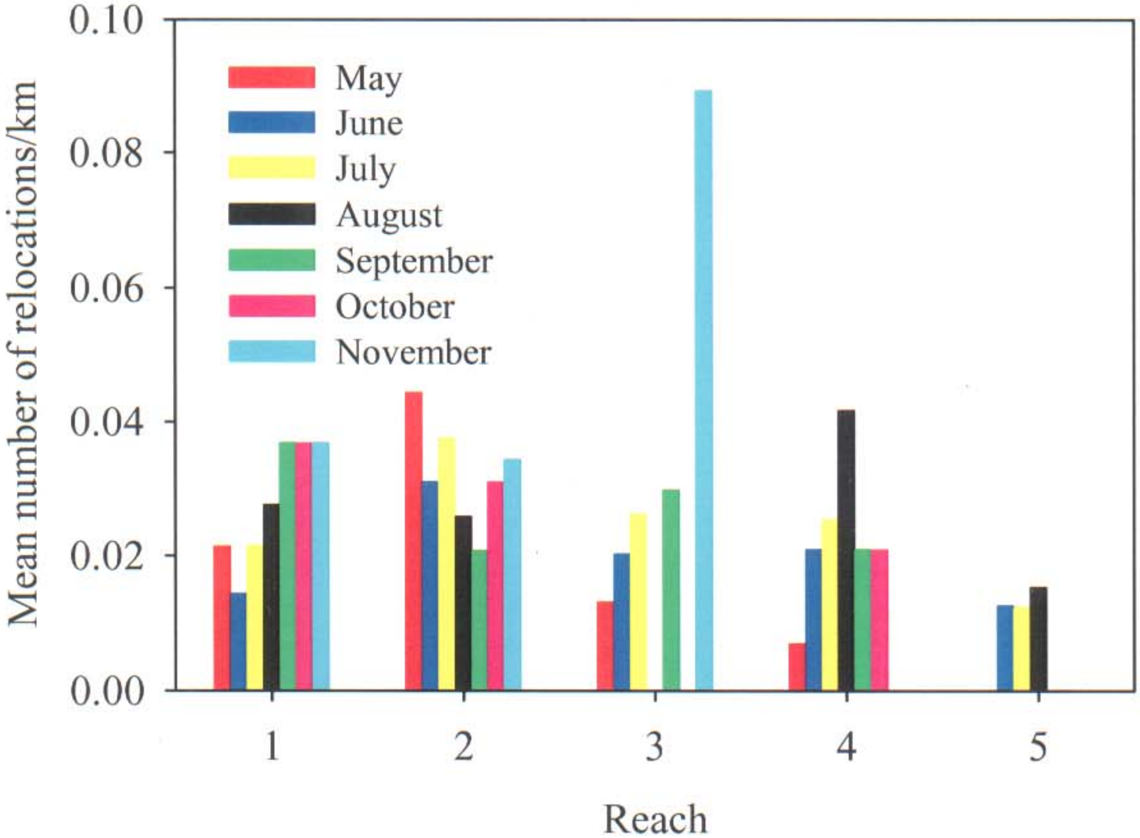

Figure 9. Mean number of blue sucker relocations per km by month in five riverine reaches (Reach 1 = Missouri River between Fort Peck Dam and Wolf Point, Reach 2 = Missouri River between Wolf Point and the Yellowstone River confluence, Reach 3 = Missouri River from the Yellowstone River confluence to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

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

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

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

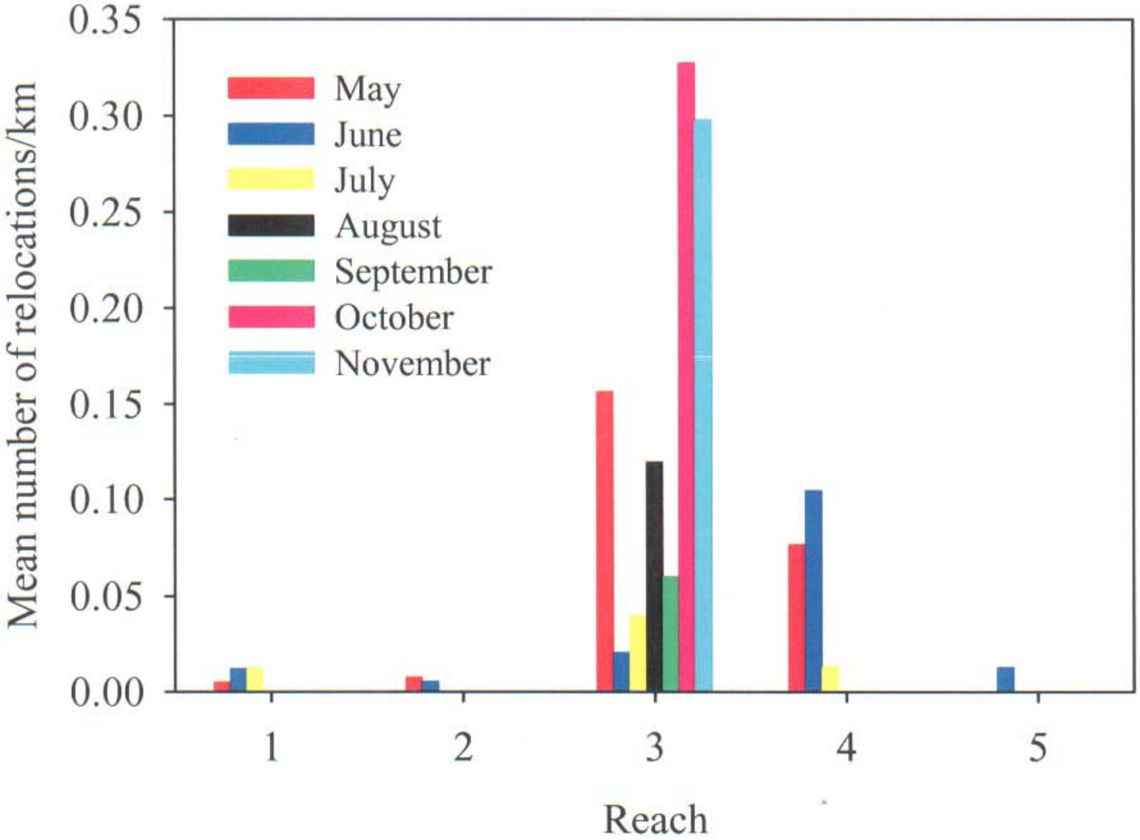

Figure 10. Mean number of paddlefish relocations per km by month in five riverine reaches (Reach 1 = Missouri River between Fort Peck Dam and Wolf Point, Reach 2 = Missouri River between Wolf Point and the Yellowstone River confluence, Reach 3 = Missouri River from the Yellowstone River confluence to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

Monitoring Component 4 – Larval Fish

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

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

Table 11. Number (N) and frequency (%) of larval fishes, and numbers of juveniles, adults, and eggs sampled at six sites during 2002. T = less than 0.1%.

	Below Fort Peck Dam		Spillway		Milk River		Wolf Point		Nohly		Yellowstone River	
Taxon	N	%	N	%	N	%	N	%	N	%	N	%
Acipenseridae							5	T			9	0.7
Catostomidae	158	93.5	291	87.9	25,601	79.9	5915	87.8	476	43.1	605	44.0
Centrarchidae									2	0.2		
Cyprinidae	4	2.4	12	3.6	4,447	13.9	363	5.4	118	10.7	469	34.1
Hiodontidae			3	0.9	818	2.6	67	1.0	101	9.1	175	12.7
Ictaluridae					8	T					3	0.2
Percidae			2	0.6	1	T	240	3.6	326	29.5	22	1.6
Polyodontidae					7	T	27	0.4	14	1.3	34	2.5
Salmonidae	3	1.8					14	0.2	35	3.2		
Sciaenidae			4	1.2	1,142	3.6	93	1.4	23	2.1		
Unknown	4	2.4	19	5.7	27	T	13	0.2	9	0.8	59	4.3
Total larvae	169		331		32,051		6,737		1,104		1,376	
Juveniles			3		413				12		5	
Adults	4		9		347		2		2		1	
Sturgeon/ paddlefish eggs							1					4
Unknown eggs	333		33		4,461		2,425		1,965			5,838

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

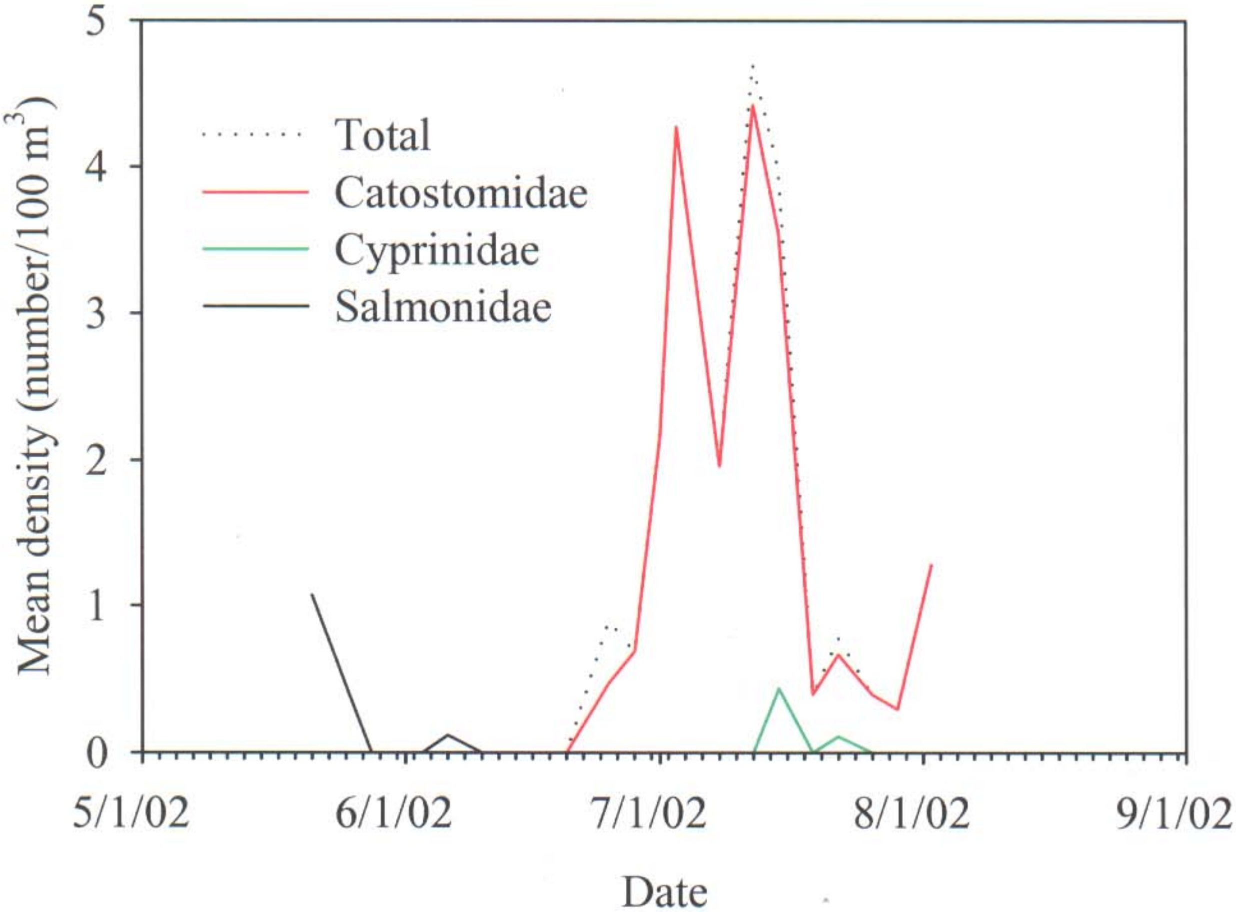

Figure 11. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, and Salmonidae sampled in the Missouri River at the site downstream from Fort Peck Dam during 2002.

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

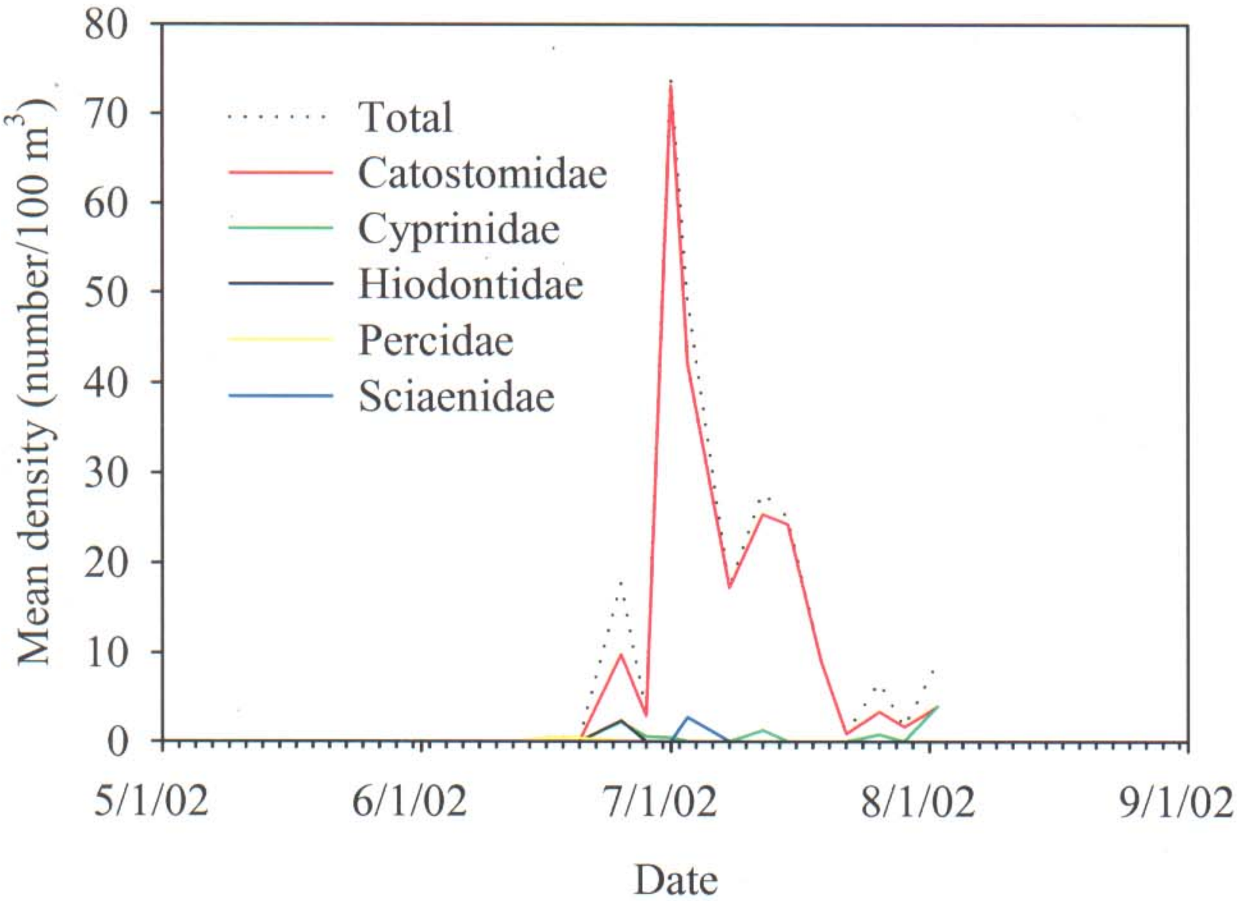

Figure 12. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, and Sciaenidae sampled in the Fort Peck spillway channel during 2002.

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

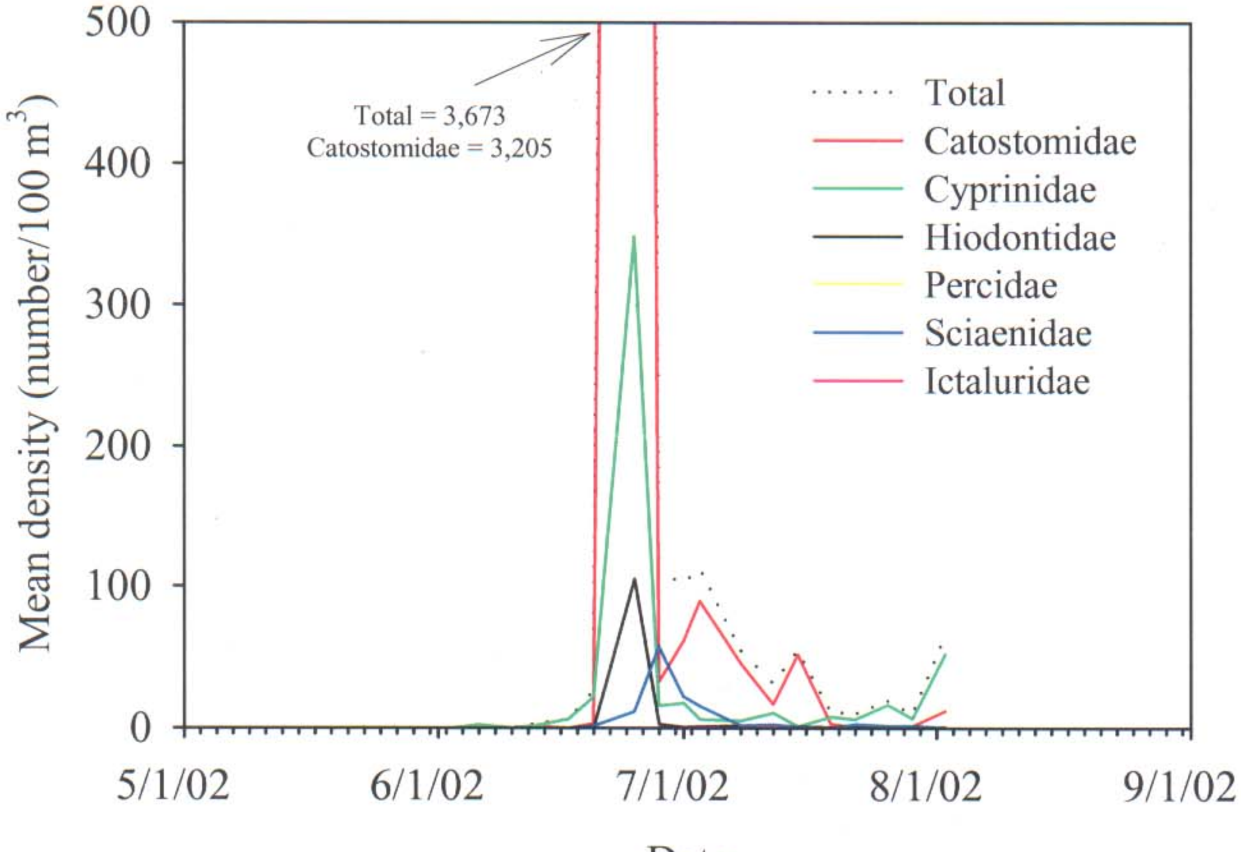

Figure 13. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Sciaenidae, and Ictaluridae sampled in the Milk River during 2002.

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

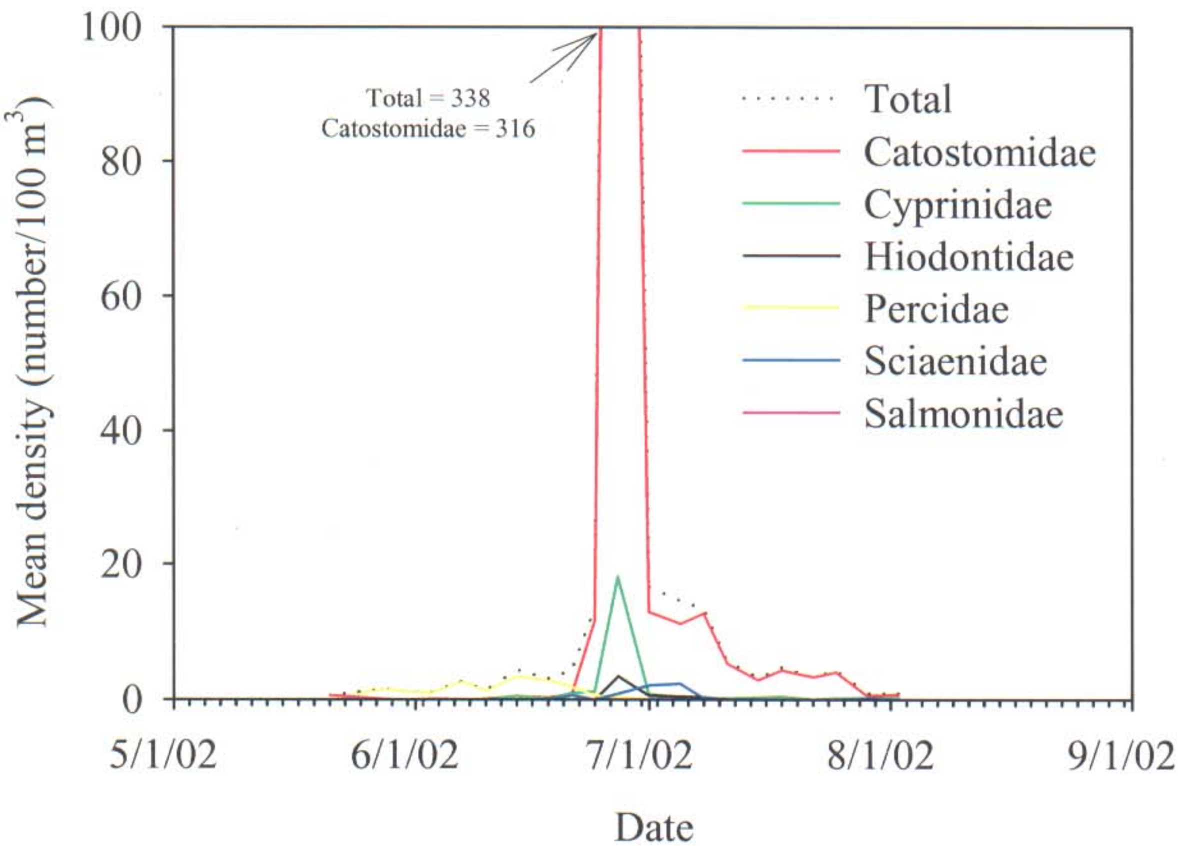

Figure 14. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Sciaenidae, and Salmonidae sampled in the Missouri River at Wolf Point during 2002.

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

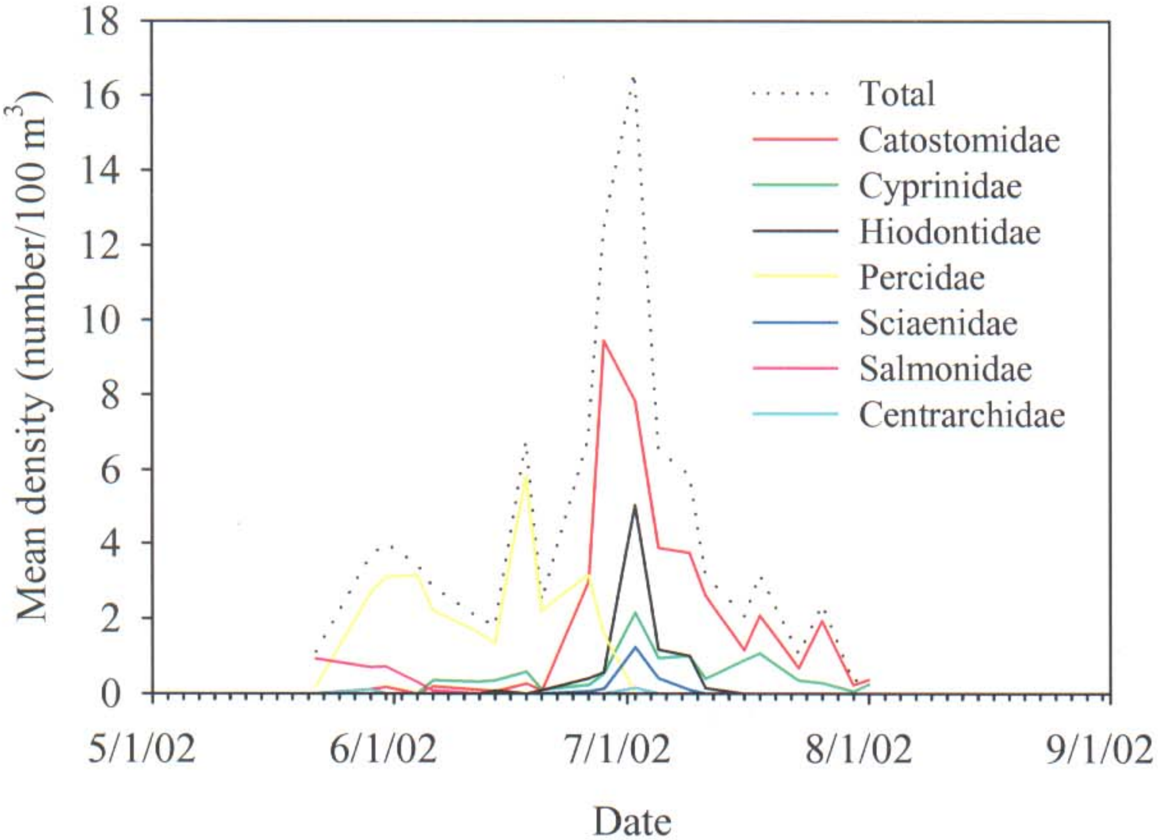

Figure 15. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, Sciaenidae, Salmonidae, and Centrarchidae sampled in the Missouri River near Nohly during 2002.

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

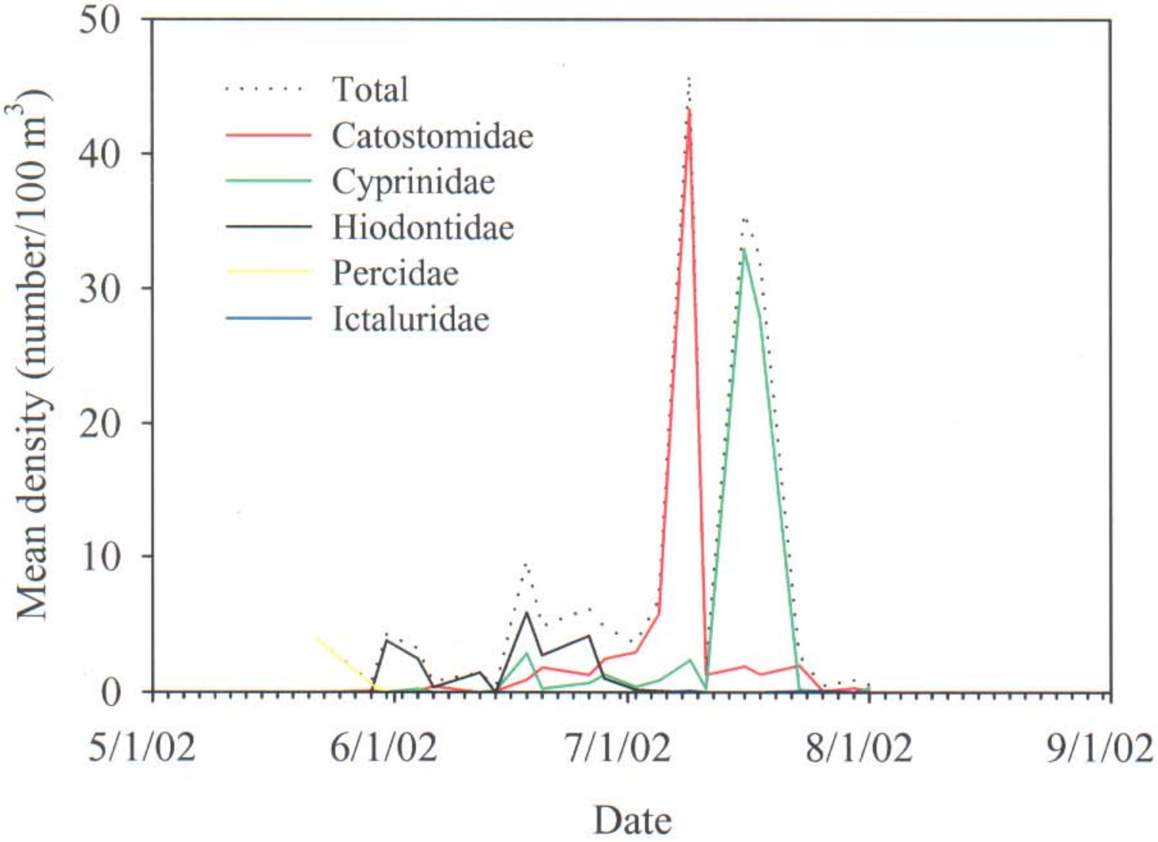

Figure 16. Mean density (number/100 m^3) by date of all larval fishes (Total), Catostomidae, Cyprinidae, Hiodontidae, Percidae, and Ictaluridae sampled in the Yellowstone River during 2002.

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

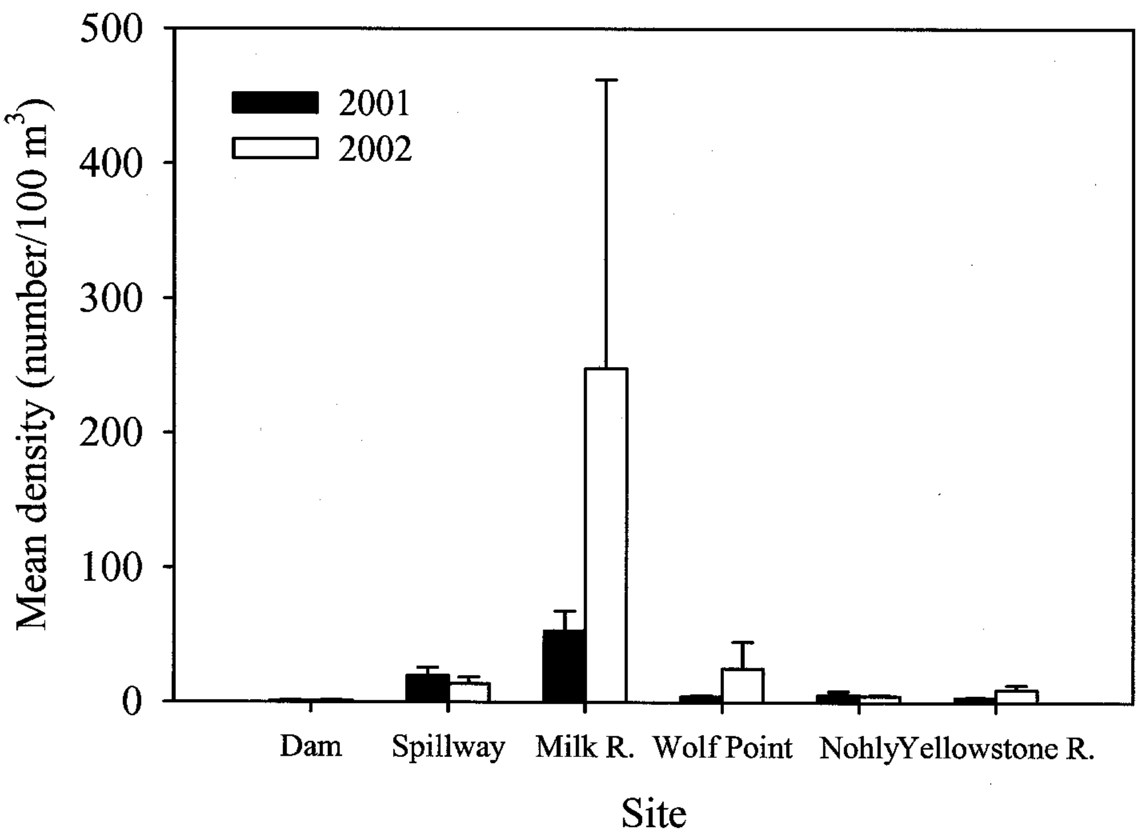

Figure 17. Mean total density (number/100 m^3; lines denote 1 standard error) of larval fishes sampled at six sites in 2001 and 2002.

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

Monitoring Component 5 – Food habits of piscivorous fishes

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Related Activities

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

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

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

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

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

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

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

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

Activities for 2003

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

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