Examination of pallid sturgeon use, migrations and spawning in Milk River and Missouri River below Fort Peck Dam during 2011

Prepared by:

David B. Fuller and Tyler M. Haddix

Montana Department of Fish, Wildlife and Parks

East Kansas Street

Fort Peck, MT 59223

Prepared for:

U. S. Geological Survey

And

U. S. Army Corps of Engineers

February 2012

Background

The lower Yellowstone River and Missouri River between Fort Peck Dam and Lake Sakakawea is inhabited by a wild adult population of federally endangered pallid sturgeon (*Scaphirhynchus albus*). Over the last two decades, pallid sturgeon in this section of the upper Missouri River basin have been the focus of several studies examining movements, migrations and habitat use (e.g., Bramblett and White 2001; Fuller et al. 2008). Pallid sturgeon primarily use the Yellowstone River during the spawning season, and successful spawning has been documented in lower reaches of the Yellowstone River (Fuller et al. 2008). Conversely, pallid sturgeon spawning has not been documented in the Missouri River downstream of Fort Peck Dam. Suppression of the thermal regime in association with regulated flows through Fort Peck Dam have been implicated as major factors impeding spawning and recruitment of pallid sturgeon in the Missouri River downstream from the dam (USFWS 2000). Subsequently, the U.S. Army Corps of Engineers (USACE) proposed to modify operations of Fort Peck Dam following specifications outlined in the Missouri River Biological Opinion (USFWS 2000). Modified dam operations were proposed to increase discharge and water temperature during late May through 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, surface water from Fort Peck Reservoir would be released over the spillway during flow modifications to increase water temperature conditions. The USFWS (2000) recommended that a minimum water temperature of 18^{o}C be established and maintained at Frazer Rapids (RM 1,746) via the spillway releases. The USACE proposed to conduct a mini-test to evaluate the structural integrity of the spillway. A full-test of the flow modifications would occur when a maximum of 19,000 ft^3/s would be routed through the spillway. Spillway releases would be accompanied by an additional 4,000 ft^3/s released through the powerhouse. Pending results from the full-test, modified flow releases from Fort Peck Dam in subsequent years would be implemented in an adaptive management framework. All proposed flows were dependent on adequate inflows to Fort Peck Reservoir and adequate water levels in the reservoir. The original schedule of events for conducting the flow modifications called for conducting the mini-test during 2001 and conducting the full-test in 2002. However, insufficient water levels in Fort Peck Reservoir during 2001 through 2010 precluded conducting the mini and full-test.

In 2011, record setting snowfall coupled with record spring rains resulted in rapid filling of Fort Peck Reservoir above full pool and subsequent, releasing water over the Fort Peck Spillway. The hydrologic regime in the Missouri River downstream Fort Peck Dam during 2011 was unique among the last several years due to these spillway releases, increased discharge from the Fort Peck Powerhouses and elevated discharge conditions during spring and early summer from the Milk River. Given the unique hydrologic conditions of 2011 and the potential for improved pallid sturgeon spawning conditions, this study focused on evaluating use, migrations, and spawning of pallid sturgeon in the Missouri River downstream from Fort Peck Dam and the Milk River.

Scope and Objectives

The Objectives of this work were to (1) assess pallid sturgeon migrations and use of the Milk River and Missouri River between Fort Peck Dam and the Yellowstone River confluence; (2) quantify reproductive products (eggs, free embryos, larvae) and potential spawning reaches in the Milk River and Missouri River below Fort Peck Dam; and (3) assess and quantify settlement of pallid sturgeon larvae from the drift based on collections of young-of-year pallid sturgeon in lower reaches of the Missouri River.

Study Area

The Missouri River study area extended from Fort Peck Dam located at river mile (RM)1770 (rkm 2,850) downstream to RM 1553.5 (rkm 2,500) (near Williston, North Dakota; Figure 1). The study area also included the lower 115 miles of the Milk River from Vandalia Dam to its confluence with the Missouri River.

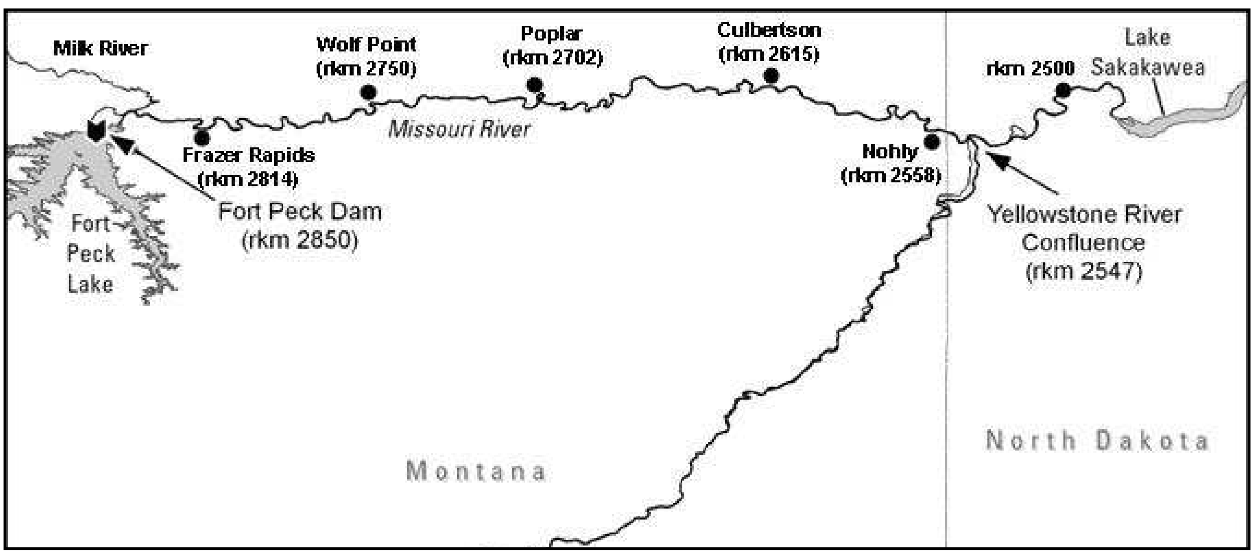


Figure 1. Study area of the Missouri River, Milk River and lower Yellowstone River.

Methods

Pallid sturgeon were sampled using drifted trammel nets and were implanted with radio tags (MCFT-3L tags, 16 mm x 73 mm, air weight = 26 g, 1,624-day longevity, 5-second pulse interval, 149.760 Mhz, Lotek Wireless Incorporated, New Market, Ontario). The coded signal emitted by each tag is unique to facilitate identification of individual fish. Surgical procedures followed methods outlined in Braaten and Fuller (2005). Most fish were collected in prior years during brood stock collection near the confluence of the Missouri and Yellowstone rivers.

Manual tracking of fish by boat during 2011 was initiated in April. The Missouri River between Fort Peck Dam and Wolf Point (70 m) and the Milk River from its confluence with the Missouri River to various upstream areas were tracked from April through October. Two radio frequencies (149.760 MHz, 149.620 MHz) were simultaneously monitored during the boat-tracking run using two 4-element Yagi antennae. Several variables (e.g, radio frequency, fish code, latitude, longitude, time-of-day) were recorded at fish locations.

Stationary telemetry logging stations were deployed in April 2011 at four sites on the Missouri River (Nickels, rm 1,760; near Wolf Point, rm 1,720; near Culbertson, rm 1,620; at rm 1,584 just upstream from the Yellowstone River confluence) and one site on the Milk River (rm 2.5). The logging stations were placed on shore with two 4-element Yagi antennae. Each logging station was equipped with a battery powered receiver (Lotek SRX- 400), solar panel, an environmental enclosure kit containing dual 12-volt batteries, and an antenna switchbox. Data recorded by the logging stations were downloaded to a laptop computer two times per month between April and October. Coupled with manual tracking efforts, the array of telemetry logging stations facilitated detection of dates and times of movement events between and within rivers and river reaches.

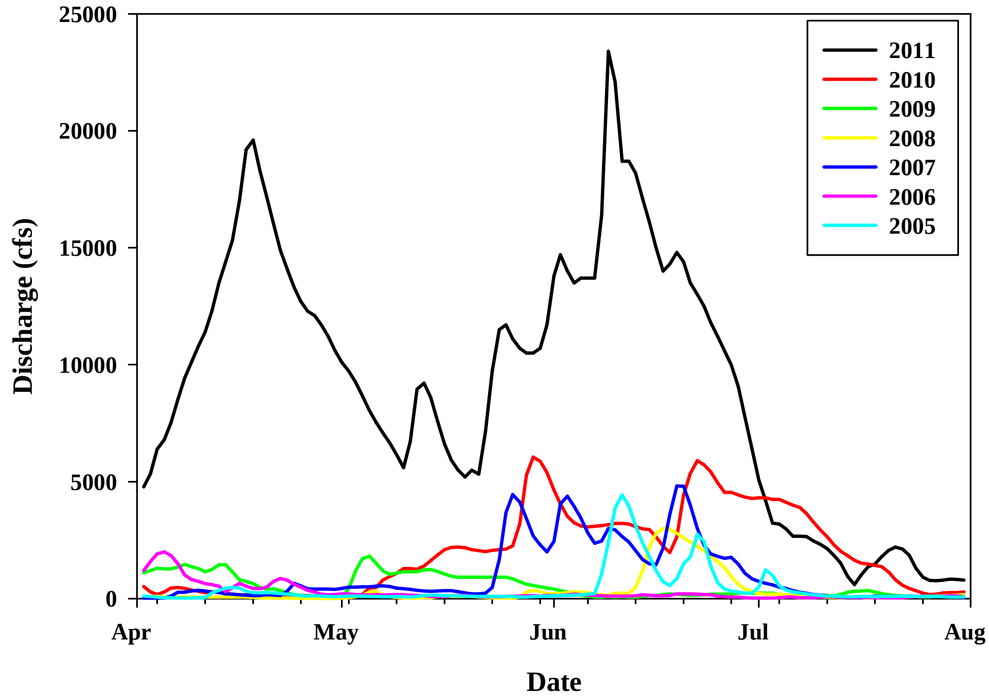
Sampling for free embryos and larvae was conducted in the lower Milk River and Missouri River near Wolf Point following methods outlined in Braaten et al. (2010). However, high flows made it difficult to sample on the bottom in the thalweg. Therefore, to maintain contact with the bottom, sampling location was generally closer to inside bend rather than the thalweg. Sampling was conducted two times per week at multiple replicate locations when flows allowed. After sampling was completed, net contents were transferred to black rubber trays where Acipenseriformes larvae (sturgeon and paddlefish) were extracted from the detritus. Extracted Acipenseriformes larvae were placed immediately in 95% non-denatured ethanol for genetic analysis. After extracting these larvae, the remaining sample was placed in a 10% formalin solution containing phloxine-B dye and contents were separated and identified in the lab.

Targeted sampling for young-of-year pallid sturgeon followed trawling methods outlined in Braaten and Fuller (2007) and was conducted every week from mid-July through August. Sampling for young-of-year sturgeon (*Scaphirhynchus* spp.) was conducted with a benthic (beam) trawl in the Missouri River above the Yellowstone River confluence (i.e., ATC) and Missouri River below the Yellowstone River confluence (i.e., BTC). Four replicate sampling locations were established at each site where each replicate was comprised of an inside bend, outside bend, and channel crossover habitat complex (IOCX) associated with a river bend. Fin clips were obtained for all *Scaphirhynchus* spp. collected, stored in 95% ethanol, and genetically processed by Ed Heist at Southern Illinois University to distinguish individuals as pallid sturgeon or shovelnose sturgeon. If identified as a pallid sturgeon, further analysis to determine parentage was performed.

Results

The Milk River exhibited two periods of elevated flow conditions in 2011 as flood stage conditions occurred on 18-April and 9-June with peaks of 19,600 ft^3/s and 23,400 ft^3/s, respectively (Figure 2). The melting of local snow caused the first peak of elevated discharge followed by rain fall and mountain snow melt creating the high discharge in June. Most of the year, the Milk River was at an all time high and flooding occurred in nearby communities.

Discharge of the Missouri River at Wolf Point (cumulatively reflecting Fort Peck Powerhouse and Spillway releases as well as contributions from the Milk River) increased from 14,000 ft^3/s to 29,000 ft^3/s from 1-April through 15-April, primarily due to elevated flows from the Milk River and declined throughout the remainder of April. The greatest peak occurred on 14-June when flows reached a maximum of 90,600 ft^3/s. The majority of the discharge was from water being released over the spillway (52,000 ft^3/s). Discharge then declined throughout the remainder of June and July, and remained relatively stable between 25,000 and 30,000 ft^3/s through August and September. The spillway was closed on 1-October and flows dropped to approximately 10,000 ft^3/s for the remainder of the year. This was the first time the spillway had been extensively used since 1997. It was initially opened from 6-May 2011 through 23-May and averaged 7,000 ft^3/s, was reopened from 2-June through 30-September, averaged 24,000 ft^3/s and reached a maximum of 52,211 ft^3/s on 16-June. In 2011, the Missouri River downstream of Fort Peck Dam had the highest monthly mean discharge from May – August since records have been kept in 1942. Discharge was higher in the Missouri River than in the Yellowstone River through 10-May and then the Yellowstone had two large pulses in mid and late May (Figure 6).



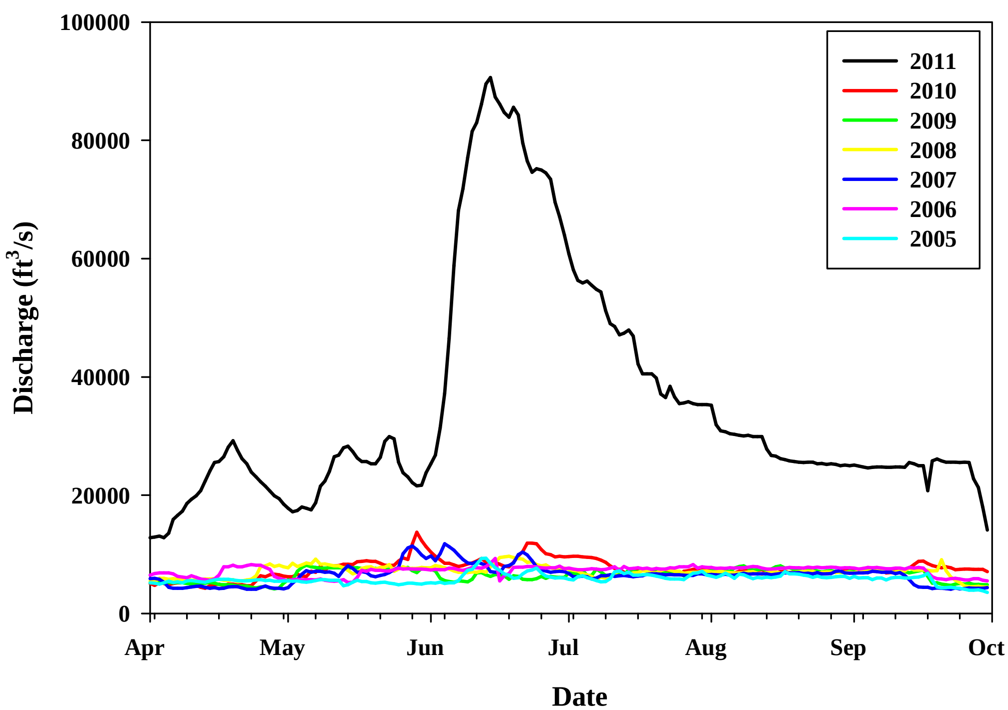


Figure 2. Mean daily discharge (ft^3/s) in the Milk River at Nashua, Montana (top panel) (gage 06174500) and Missouri River at Wolf Point, Montana (bottom panel) (06177000),

Water temperature loggers (Onset Computer Corporation, HOBO Water Temp Pro v2, operation range -20 to 70°C, 5 min response time, accuracy ± 0.2°C) were deployed at several locations in the Missouri River, tributaries, and in the spillway bay of Fort Peck Reservoir in mid-April through early May. Water temperature in the spillway bay averaged 6-8°C cooler than in past years during May through mid-June (Figure 3). Hypolimnetic released water temperature below the powerhouse was very similar to spillway released temperature during this time. Water temperature in Milk River did not vary appreciably from past years (Figure 4). Despite the surface released water from the spillway and large contribution from the Milk River, water temperature in the Missouri River near Wolf Point (fully mixed water from powerhouse, Milk River and spillway) were actually cooler than previous years throughout May and June (Figure 5). After the reservoir warmed in July, water temperature in the Missouri River was similar to previous years. As wild pallid sturgeon began their upstream migration, temperature averaged 1°C cooler in the Missouri River ATC than in the Yellowstone River in April and May (Figure 6). This is similar to other years where mean seasonal temperatures ranged from 0.4-1.9°C cooler in the Missouri River than in the Yellowstone River (Braaten et al., 2009).

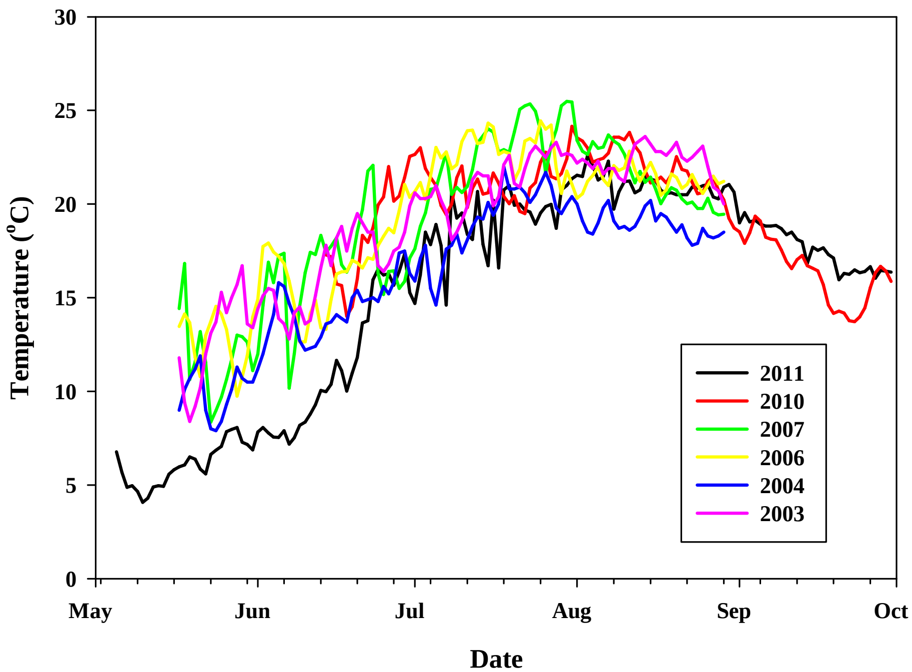


Figure 3. Mean daily water temperature (°C) in spillway bay of Fort Peck Reservoir .

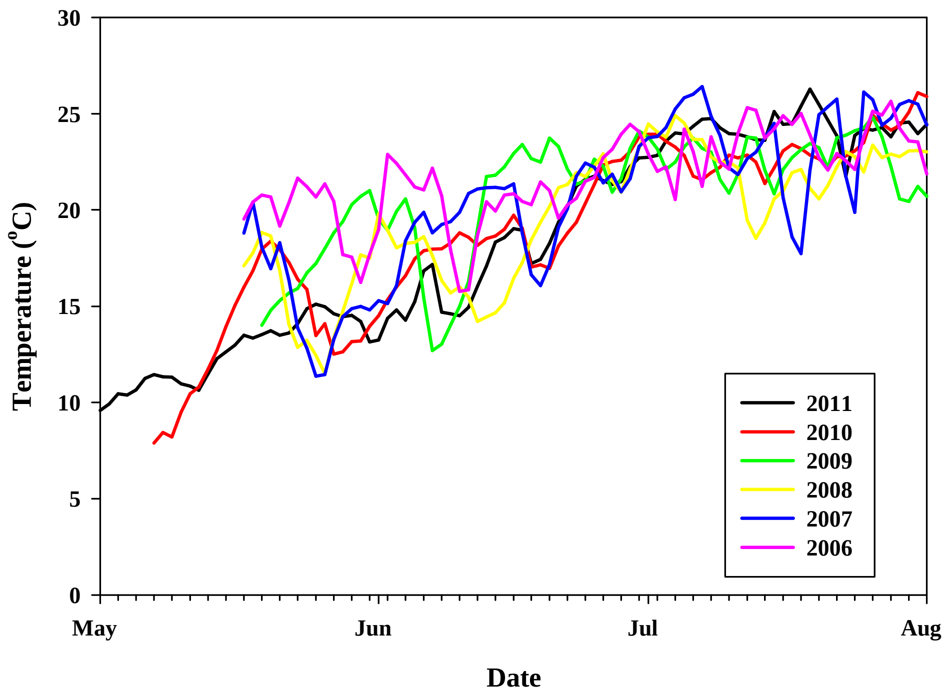


Figure 4. Mean daily water temperature (°C) in the Milk River.

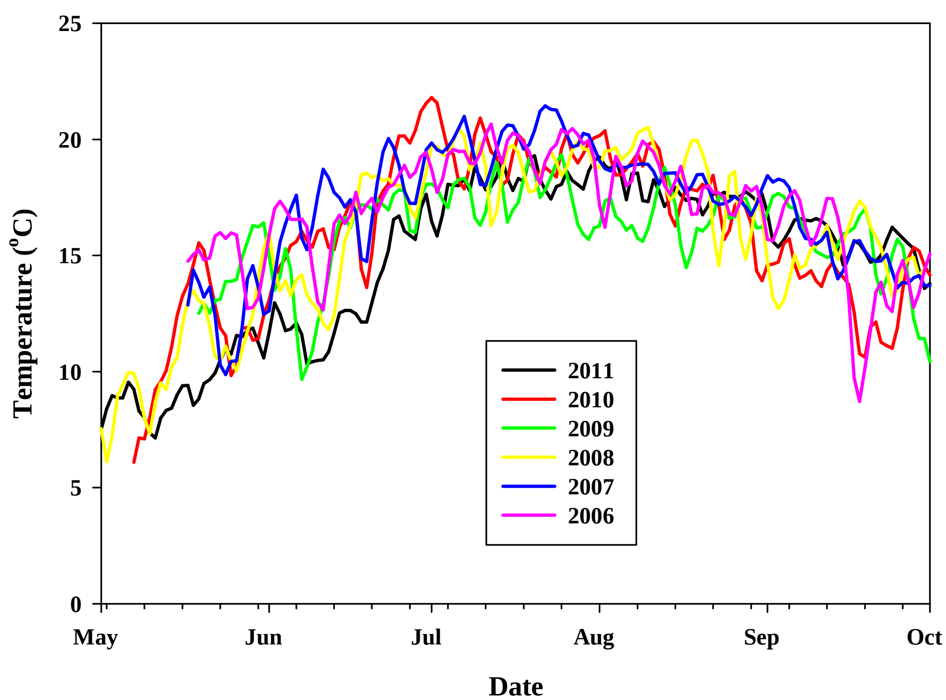


Figure 5. Mean daily water temperature (°C) at Wolf Point (rm 1699) on the Missouri River.

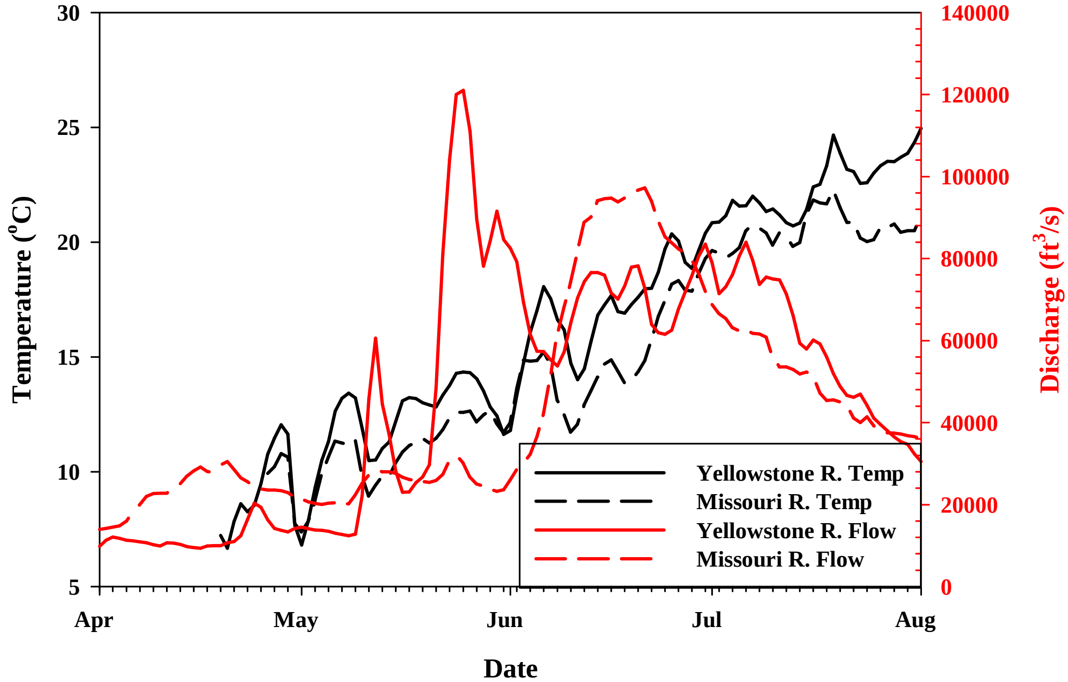


Figure 6. Water temperature and discharge of the Yellowstone River and Missouri River (ATC) in 2011.

For task 1, telemetered wild adult pallid sturgeon (n=31) were manually tracked in the Missouri River ATC to Fort Peck Dam and in the Milk River from its mouth to areas below Vandalia Dam. During 2011, a total of thirteen different individuals used the Missouri River ATC during the spawning season. Detection of fish was very difficult due to increased depths and elevated conductivities associated with the high run-off. Of these thirteen fish that used the Missouri River, manual relocations ranged from 0-5 (average 1.67) per fish and ground-based telemetry station detections ranged from 2-13 (average 5.6) per fish.

As evidenced by lower Missouri River ground-based telemetry stations, adult pallid sturgeon began migrating into the Missouri River ATC in mid-April following a large pulse of water created by prairie run-off into the Milk River. By mid-May, nearly 40% (n=12) of telemetered pallid sturgeon, including a potentially gravid female (code 66) were in the Missouri River (Figure 7) above the Wolf Point ground station (rm 1720). A gonadal biopsy was not performed on this particular female since this fish could not be manually located. Most female pallid sturgeon in the upper Missouri River basin spawn every two years (Fuller et al. 2008). This fish was spawned in the hatchery in 2009 and was most likely in spawning condition in 2011. On 6-July, an aggregation of four males (codes 15, 22, 43 and 92) was located at river mile 1760, just downstream of the Milk River. This occurred on the descending limb of the hydrograph (52,000 cfs) and when water temperature was 18°C. This aggregation could not be relocated the following day. Approximately 35% (n=11) of all telemetered pallid sturgeon remained in the upper Missouri River through early August and then began emigrating out of the upper Missouri River to downstream areas as indicated by ground-based telemetry stations. These results are in stark contrast from the previous six years when Missouri River ATC use declined throughout the spring to approximately 0-5% during the June/July spawning season (Figure 7).

A majority of the pallid sturgeon that used the Missouri River during 2011 entered the river when the Missouri River's discharge was higher than the discharge of the Yellowstone River (Figure 6). However, some fish did exit the Yellowstone River and migrate up the Missouri River in late May when discharge was greater in the Yellowstone River. Temperature was similar between the two rivers during this time. The remaining 60-65% of telemetered pallid sturgeon remained in the Yellowstone River during the spawning season.

From 18-May through 31-May, four males and female code 66 entered the Milk River as evidenced by the ground-based station at the mouth of the Milk River for an undetermined amount of time. The furthest confirmed upstream location of pallid sturgeon in the Milk River was at river mile 36. Several tracking runs were terminated on the Milk River due to hazardous conditions (e.g., low power lines, log jams, or debris). During the previous nine years combined, only two telemetered adult pallid sturgeon have been detected in the Milk River, one in 2004 and one in 2010.

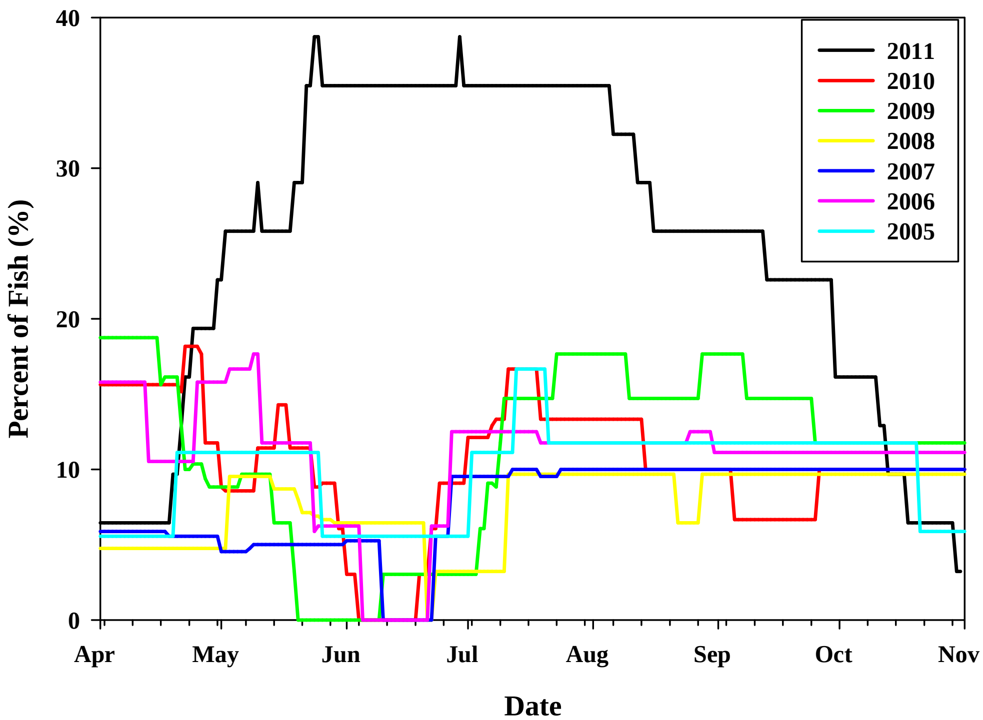


Figure 7. Pallid sturgeon use in the Upper Missouri River including the Milk River.

For task 2, no sturgeon larvae were collected from the Milk River. A total of 53 paddlefish larvae was collected from the Milk River with a peak occurring on 17-June (Table 1). These larvae were identified by FWP personnel in the lab. No larval sampling was conducted during most of the month of June and early July in the Missouri River due to high flows. A total of 64 Acipenseriform larvae was collected in the Missouri River near Wolf Point (Table 2). All specimens were analyzed by Southern Illinois University Carbondale, Fisheries and Illinois Aquaculture Center as most were in poor condition and identification by our lab was difficult. Results indicated that there were 39 paddlefish (*Polyodon spathula*), 24 shovelnose sturgeon (*S. platyorhynchus*) and **one unambiguous pallid sturgeon larvae** (Edward Heist, Southern Illinois University, Carbondale, Illinois, written communication, 2011). This pallid sturgeon larva was a wild-produced fish, as there were no larval stockings in 2011. This larva was approximately 7 mm in length and collected at river mile 1707 on 12-July. This is the first documentation of pallid sturgeon spawning and successful reproduction in the Missouri River below Fort Peck Dam and the first genetically confirmed pallid sturgeon larva in the Missouri River Basin. Parentage analysis conducted by Jeff Kalie & Meredith Bartron, Northeast Fishery Center, Lamar, PA linked the larvae to a telemetered male (code 23; 1F4A3E1445) and a non-telemetered female (40636B2945). Code 23 was located several times in the upper Missouri River during the study but was not relocated after 24 June therefore, exact location of this spawning event is uncertain. The female was spawned at Garrison Dam National Fish Hatchery in 2007 and several progeny were stocked in RPMA 2 including 44,000 larvae for the Missouri River mainstem drift study conducted by Braaten et al. (2012). There were an additional 19 Acipenseriformes larvae collected that were missed when initially picked in the field. These fish were added to the table below and distinguishing between pallid and shovelnose is not feasible since samples were stored in formalin.

Table 1. Sampling dates and paddlefish (Pdfh) larvae collected in the Milk River in 2011.

Date	5-18	5-26	5-31	6-3	6-6	6-15	6-17	6-21	6-23	6-27	6-30	7-6	7-11	7-13
Pdfh	0	0	0	0	0	7	26	6	9	2	3	0	0	0

Table 2. Sampling dates and paddlefish (Pdfh), shovelnose sturgeon (Snsg), pallid sturgeon (Pdsg), and unknown Acipenseriformes (Acip) larvae collected in the Missouri River near Wolf Point in 2011.

Date	5-18	5-24	6-1	7-12	7-14	7-18	7-21	7-25	7-28	8-1	8-4	8-8	8-11
Pdfh	0	0	0	4	18	1	2	4	4	3	3	0	0
Snsg	0	0	0	3	7	0	2	3	2	6	1	0	0
Pdsg	0	0	0	**1**	0	0	0	0	0	0	0	0	0
Acip.	0	0	0	2	5	2	1	4	0	0	3	1	1

For task 3, a total of 172 trawls were conducted during seven sampling events from 20-July through 31-Aug. Sturgeon chub (*Macrohybopsis gelida*) and channel catfish (*Ictaluris punctatus*) made up 48% and 32% of the catch, respectively (Table 3). Only three young-of-year sturgeon were collected (all BTC) and they were determined to be shovelnose sturgeon through genetic analysis.

Table 3. Total catch of fish by the benthic trawl in the Missouri River ATC and BTC from 20-July to 31-Aug, 2011.

Species	Above the Confluence (ATC)	Below the Confluence (BTC)	Total
Bigmouth buffalo	7	3	10
Burbot	30	15	45
Blue sucker	1	0	1
Common carp	16	6	22
Channel catfish	4	428	432
Cisco	0	1	1
Emerald shiner	1	1	2
Flathead chub	7	15	22
Fathead minnow	1	2	3
Freshwater drum	0	3	3
Goldeye	3	2	5
Hybognathus spp.	0	9	9
Longnose dace	1	6	7
No fish	17	8	25
Pallid sturgeon (Hatchery-reared)	3	6	9
River carpsucker	0	3	3
Sicklefin chub	38	23	61
Sturgeon chub	124	539	663
Sauger	3	6	9
Shovelnose sturgeon	5	5	10
Shovelnose sturgeon (YOY)	0	3	3
Stonecat	10	36	46
Unidentified Cyprinid	0	4	4
Walleye	1	0	1

Discussion

The response of wild adult pallid sturgeon to the mid-April through May run-off in the Missouri River is very intriguing. Discharge increased from 14,000 ft^3/s to 29,000 ft^3/s from 1-April through 15-April, primarily due to elevated flows from the Milk River. Pallid sturgeon began migrating into the Missouri River after this pulse and continued to migrate into the Missouri River through May when discharges ranged between 20,000-30,000 ft^3/s. This is similar to flows requested in the 2000 Biological Opinion (total 23,000 ft^3/s). However, the increase in discharge may need to occur sooner than previously stated in the Biological Opinion (mid-April rather than late May) to cue pallid sturgeon migration from areas below the confluence of the Yellowstone River.

The 6-July aggregation of sexually mature male pallid sturgeon observed during 2011 downstream of Fort Peck Dam is the first documented aggregation of wild pallid sturgeon in the Upper Missouri River. Tracking data from this study indicate that even though the species is extremely rare, reproductive adults can find one another at the appropriate time given the appropriate environmental cues. The origin of the pallid sturgeon larva that was collected on 12-July is uncertain since there were no locations of the telemetered male parent during the spawning window. It may have come from the area associated with the 6 July aggregation or other nearby reaches in the Missouri River at a similar time. This fish was likely produced on 6-July for the following reasons; First, this 7mm larva was likely one day post hatch (dph) since larvae are 7-9 mm at hatch (Rob Holm personal communication). Secondly, the embryo would have needed approximately 5 days of incubation at 18-19^{o}C before hatching (Webb et al., 2007). Finally, the larva would have needed several hours to drift before it was collected at the downstream larval sampling site on 12-July depending on where this larva was produced (Braaten et al. 2012) .

Successful spawning of shovelnose sturgeon has been documented in the Missouri River below Fort Peck Dam every year since 2001 (Braaten and Fuller 2010). This spawning and recruitment could be from a population that resides year-round in areas of the Missouri River above Wolf Point. Therefore, traditional migration cues are not required to draw these fish to upstream spawning reaches. In 2010, contributions of warm Milk River water resulted in flows of 14,000 ft^3/s in early June and 12,000 ft^3/s in the Missouri River during late June. Flows of this magnitude during this time lead to shovelnose sturgeon recruitment that was at a ten-year high. These young-of-year fish were likely produced from upper reaches of the Missouri River since most were collected in the Missouri River ATC of the Yellowstone River. However, there was not an increase in discharge early enough to trigger adult pallid sturgeon to migrate into the Missouri River in 2010 (Figure 7). Thus, no larvae or young-of-year pallid sturgeon were detected. Therefore, an April pulse of approximately 20,000 ft^3/s appears to be needed to cue this population of wild adults into the Missouri River based on the last ten years of data. Fuller et al. (2008) documented pallid sturgeon spawning in the Yellowstone River with a maximum flow of only 40,000 ft^3/s; therefore, it is unlikely that flows of the magnitude observed in 2011 are needed to cue pallid sturgeon to spawn. Further studies on trigger flows required to cue pallid sturgeon to migrate into the Missouri River and to spawn are essential. Since very few sexually mature adult pallid sturgeon have been observed in the Missouri River prior to 2011, limited data exists that details the flow parameters required to stimulate wild pallid sturgeon migrations and spawning.

The documentation of use, spawning and reproduction in the Missouri River indicates that the Missouri River is used by pallid sturgeon when flow regimes are suitable. Results of the 2011 study added substantial new information on pallid sturgeon movement, river use, and behavior. Verification of successful reproduction by wild pallid sturgeon has provided information that shows spawning, fertilization, egg survival, and hatch can occur in the Missouri River when flows deviate from baseline operations.

These findings lend further evidence to the leading hypothesis that the bottleneck of recruitment is the lack of distance for drifting larvae in this fragmented river reach. Braaten et al. (2012) estimated that 160-230 river miles are needed for the slowest 25% of drifting larvae to settle out when subjected to an average water velocity of 0.7 m/s and water temperature of 20^oC. Although there were approximately 200 river miles available from the location of the aggregation to headwater areas of Lake Sakakawea and average water velocities may have been greater than 0.7m/s, lower velocities along channel margins and inundated lateral floodplain habitat may have decreased total drift distance as these areas exhibit substantiually lower water velocities than the main channel. Therefore, there is some likelihood that wild produced pallid sturgeon larvae may have settled out prior to reaching lentic habitat of Lake Sakakawea. It remains uncertain at this time if this rare spawning event and the flow conditions of 2011 that produced the event will lead to successful pallid sturgeon recruitment. Current monitoring programs are in place to examine this in future years.

References

Braaten, P. J., and D. B. Fuller. 2005. Fort Peck Flow Modification Biological Data Collection Plan – Summary of 2004 Activities. Report prepared for the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Fort Peck.

Braaten, P. J., and D. B. Fuller. 2007. Growth rates of young-of-year shovelnose sturgeon in the upper Missouri River. Journal of Applied Ichthyology 23: 506-515.

Braaten, P. J., D. B. Fuller., and R. D. Lott 2009. Fort Peck Flow Modification Biological Data Collection Plan – Summary of 2008 Activities. Report prepared for the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Fort Peck.

Braaten, P. J., D. B. Fuller, R. D. Lott, M. P. Ruggles, and R. J. Holm. 2010. Spatial distribution of drifting pallid sturgeon larvae in the Missouri River inferred from two net designs and multiple sampling locations. North American Journal of Fisheries Management 30:1062-1074.

Braaten, P. J., and D. B. Fuller. 2010. Fort Peck Flow Modification Biological Data Collection Plan – Summary of 2009 Activities. Report prepared for the U. S. Army Corps of Engineers. Montana Department of Fish, Wildlife and Parks, Fort Peck.

Braaten, P. J., D. B. Fuller, R. D. Lott, M. P. Ruggles, T. F. Brandt, R. G. Legare, R. J. Holm. An experimental test and models of drift and dispersal processes of pallid sturgeon free embryos in the Missouri River. 2012. Environmental Biology of Fishes 93:377-392.

Bramblett, R. G., and R. G. White. 2001. Habitat use and movements of pallid and shovelnose sturgeon in the Yellowstone and Missouri Rivers in Montana and North Dakota. Transactions of the American Fisheries Society 130:1006-1025.

Fuller, D. B., M. E. Jaeger, and M. A. Webb. 2008. Spawning and associated movement patterns of pallid sturgeon in the lower Yellowstone River. Report submitted to the Western Area Power Administration, Upper Basin Pallid Sturgeon Work Group, and U. S. Army Corps of Engineers. Montana Fish, Wildlife and Parks, Fort Peck, Montana.

USFWS (U.S. Fish and Wildlife Service). 2000. Biological Opinion on the operation of the Missouri River main stem reservoir system, operation and maintenance of the Missouri River bank stabilization and navigation project, and operation of the Kansas River reservoir system US Fish and Wildlife Service, Region 3 (Fort Snelling, MN) and Region 6 (Denver, CO).

Webb, M. A., K. Kappenman, C. Guy. 2007. Investigations to improve larval pallid sturgeon survival during the onset of exogenous feeding. Report submitted the Upper Basin Pallid Sturgeon Workgroup.