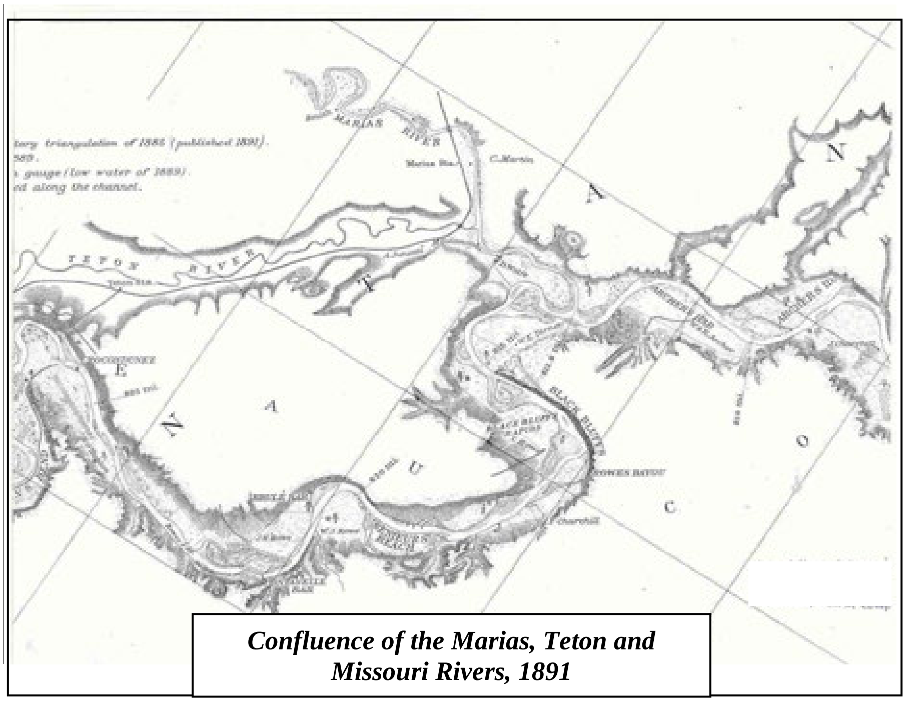
Upper Missouri River Basin Pallid Sturgeon Study
- 2005-10 Final Report -



Confluence of the Marias, Teton and Missouri Rivers, 1891

Montana Fish Wildlife & Parks
and
U. S. Bureau of Reclamation

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April, 2011

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SUMMARY

A five-year study to evaluate varying spring flow releases from Tiber Dam and the effects on pallid sturgeon and other related species was completed in 2010. During the five study years operations of Tiber Reservoir reduced the lower Marias River spring-rise flow (Jun/Jul period) during all years, ranging from a 7% decrease in 2006 to a 65% reduction in 2010. The largest flow accretion in the Missouri River during 2008 occurred at Great Falls with the Sun River increasing the Missouri River flow by 3,616 cfs. Although the Marias/Teton River has a higher average annual flow than the Sun River, the Sun River provided 47% more flow accretion during June compared to the Marias/Teton River, thus demonstrating the potential for increasing Missouri River flows from the Marias River via releases from Tiber Reservoir. During the two years when the lower Marias River experienced high spring-rise flows (2006 and 2008) several of the ecologically important natural fluvial processes occurred including a rise in river stage height of 3.5 feet from the previous base condition, flooding of dry side channels, flooding of islands and general inundation of the floodplain. Missouri River water temperatures at the Morony Station during 2007-2010 were cooler than downstream stations and were the result of cold-water releases from Canyon Ferry Dam, 147 miles upstream. Upstream of Canyon Ferry Reservoir, the average monthly water temperatures of the Missouri River averaged 2.1 F^{o} warmer than water temperatures at the downstream Morony Station during May, June and July. However, the cold water influence of Canyon Ferry Reservoir did not appear to be severe enough to harm the warm-water fish community in the study area. The lower Marias River's water temperatures were generally well within the normal warm-water temperature range and the effects of Tiber Dam did not appear to depress the normal ambient temperatures near the lower river reach.

Radio telemetry monitoring was used for evaluating fish behavior and habitat use preferences relative to varying spring-rise flow scenarios. Additionally, we were interested in locating important habitat areas based on repeated observations of radio tagged fish at specific sites. Pallid sturgeon, shovelnose sturgeon and blue sucker were the three radio tagged species studied because these middle Missouri River species are known to experience extensive spawning migrations. Two male pallid sturgeon spawners appeared to move upriver in response to a doubling of river flows, however, 2006 was a low spring-rise year, so this indicates that pallids will move upriver when spring rise flows are abnormally low. The sub-adult pallids tracked during the five-year study were mostly confined to the lower river between RM 1911.0 and 1929.0. However, three radio pallids were found in the upper reach with radio Code 29 located only three miles downstream from the Marias River Confluence. Adult pallids used the Missouri River extensively and were found throughout 118 miles of the study area. The radio tagged sub-adult pallids were usually found in only a few specific habitats indicating their habitat specificity. Sixty-five percent of the radio-tagged sub-adult pallid sturgeon observations occurred in the channel crossover macro-habitat areas that were located near bluff pool areas (36%) or large islands (31%). The radio-tagged pallid micro-habitat preferences were depths $\geq$ 6 ft (61% occurrence) having substrates of gravel or sand (occurrences of 48 and 40%, respectively). Shovelnose sturgeon movement patterns and spawning habitat use in relation to river flows were also investigated using radio telemetry. This species was considered a good

proxy for inferences made about pallid sturgeon spawning because pallid sturgeon and shovelnose sturgeon are similar species and shovelnose sturgeon and pallid sturgeon are known to hybridize, indicating similar spawning habitat preferences. Fifty-three and 34 percent cent of the radio-tagged shovelnose sturgeon spawner observations, during the spawning season, occurred in the channel crossover or outside bend macro-habitat areas, respectively, that were located near submerged bars (52%) , bluff pool areas (22%) or islands (18%). This indicates that fluvial-dependent features, such as submerged bars and islands, serve as important habitat for shovelnose sturgeon spawning. The radio-tagged shovelnose spawner micro-habitat preferences were depths $\geq$ 6 ft (91% occurrence) in channel areas having substrates of sand (62%) or gravel (29%). This study confirmed that a high spring-rise was essential for attracting shovelnose sturgeon into the Marias River to spawn, however, the magnitude of the spring-rise flow was not determined. Three times as many radio-tagged shovelnose sturgeon spawners entered the lower Marias River during years with a significant spring-rise compared to years when there was no spring–rise flow demonstrating the need for higher flows in the Marias for attracting shovelnose spawners. Blue sucker spawned earlier in the middle Missouri River and tributaries than sturgeon, with a peak average spawning date of 6-May and average water temperatures of 51.6-59.9 F. Radio tagged blue suckers appeared to use the middle Missouri River and tributaries for spawning. Over the years between 25 and 52% of all the radio-tagged blue suckers migrated into the Marias/Teton River during the spawning period, indicating a high preference for these tributaries. Unlike shovelnose sturgeon, blue sucker do not appear to require a rise in base flows to be attracted into the Marias River, however, a stronger run may occur in years when the Marias River has greater April flows. Sturgeon chub were sampled as far upriver as the Marias River Confluence, including a few miles up the Marias, but numbers appeared to be low in the upriver reach. In summary, these results suggest that several improvements for pallid sturgeon habitat and supporting ecosystem can be achieved with an occasional prescribed spring-rise flow from Tiber Dam.

INTRODUCTION

Large dams/reservoirs have significant environmental effects on the physical and chemical conditions of the downstream river. Reservoir operations typically alter the downstream flow regime that in turn will influence the natural channel, floodplain and riparian characteristics, and replace the system with a more static, less diverse condition (Ward and Stanford 1979 and Hesse et al. 1989). The natural sediment transport regime is usually disrupted, further affecting channel morphology and riparian condition (Leopold et al. 1964). Water temperatures of the river below a dam with a hypolimnetic discharge are also altered, and water conditions are usually much cooler than the natural temperature regime. The Upper Missouri River is the most natural free-flowing reach in the entire Missouri River. In spite of this claim, operations of U.S. Bureau of Reclamation (Reclamation) dams/reservoirs have caused significant flow regime changes in this area (Scott et al. 1997).

The 239-mile Missouri River reach between Morony Dam (near Great Falls) and Fort Peck Dam has no dams but, is influenced by the large upstream main stem dam, Canyon Ferry, and two tributary dams, Gibson Dam on the Sun River and Tiber Dam on the Marias River.

Ramey et al. (1993) has reported that the effects of flow regulation by Canyon Ferry Dam have been significant at changing flow patterns at least as far downriver as Fort Benton. For instance, the 2-year recurrence interval flood (28,700 cfs) has been shifted now to occur once every four years, and the 5-year flood (42,900 cfs) has been shifted to occur once every 10 years. The normal flow patterns have also been altered in the Marias River (a large tributary to the Missouri River) as a result of Tiber Dam operations. Here (prior to 1997 when the USBR began providing higher spring flows for fisheries), the 2-year recurrence interval flood (~ 4,000 cfs) had been shifted to occur once every 10 years and the 5-year flood (7,000 cfs) shifted to occur once every 30 years. These alterations in the flow regimes may be affecting the indigenous aquatic fauna, including the endangered pallid sturgeon. Alterations in the temperature and sediment load regimes caused by the operations of Canyon Ferry and Tiber dams may be additional factors affecting the aquatic fauna. The Pallid Sturgeon Recovery Plan (Dryer and Sandvol 1993) lists the 239-mile unaltered reach of upper Missouri River above Fort Peck Reservoir as one of the six recovery-priority management areas (RPMA 1). There has been a continuous history of pallid sturgeon presence in this reach (Gardner 1990), however, losses of habitat and fragmentation from downstream populations caused by the completion of Fort Peck Dam in the late 1930's, probably initiated adverse impacts to the resident pallid sturgeon population. Significant flow and sediment regime alterations occurred in the late 1950's resulting from operations at the newly constructed Canyon Ferry and Tiber Dams and this most likely further reduced the pallid population to the point of near extinction. A report on the biological status of pallid sturgeon for the period 1990-96 concluded that the population was endangered of going extinct within 10-20 years unless immediate actions were taken (Gardner 1996). A preliminary adult population estimate taken during 1995, indicated that only 45 pallid sturgeon remained in this reach. Additionally, the population was found to be senescent and that there had been no significant recruitment in the last 10 years (Gardner 1996). The purpose of this study is to evaluate the present river management of this system and recommend a flow plan that would be most beneficial for pallid sturgeon recovery and for maintaining a healthy fish fauna in the Missouri River. Specific objectives are: 1) Determine if adult pallid sturgeon and other migratory species exhibit an upstream movement response to elevated spring flows. 2) Locate habitat areas (e.g. spawning sites) that are important for pallid sturgeon and other sensitive fish species. 3) Assess migratory fish (including pallid sturgeon) presence in the Marias River in response to variable flow conditions. 4) Assess the "minnow" community populations under variable flow conditions.

STUDY AREA AND PROCEDURES

The study area is a 239-mile reach of the middle Missouri River (MMR) from Great Falls (RM 2106) to the Musselshell River confluence (RM 1867), the present upstream end of Fort Peck Reservoir (Figure 1). The study area also includes 80 miles of the lower Marias River (LMAR) from Tiber Dam (RM 80) to the confluence with the Missouri River (RM 2051). The Marias River is the largest tributary of the Missouri River upstream of the Yellowstone River confluence and has a significant influence on the Missouri River's physical condition and aquatic fauna. Reclamation operates three dams in the Missouri River system that affects flows and other riverine physical/chemical characteristics to varying degrees within the study area. The largest dam on the system is Canyon Ferry Dam, located on the Missouri River near Helena (RM

2253). Total capacity of the reservoir is 1,891,888 acre-ft. at elevation 3,797 ft. (normal full pool). The reservoir covers about 33,500 surface acres at that elevation extending about 19 miles upstream from the dam (USBR 2009). Tiber Dam, located on the Marias River near Chester (RM 80), is the second largest Reclamation dam on the system. Total capacity of the reservoir is 967,319 acre-ft. at elevation 2993 ft. (normal full pool). The reservoir covers about 17,889 surface acres at full pool extending about 23 miles upstream from the dam (USBR 2009). Gibson Dam (RM 101) and associated off-stream storage reservoirs, Pishkun and Willow Creek, are USBR controlled projects located on the Sun River, the second largest tributary to the Missouri River above the Yellowstone River. Total capacity of the reservoir system is 178,100 acre-ft.

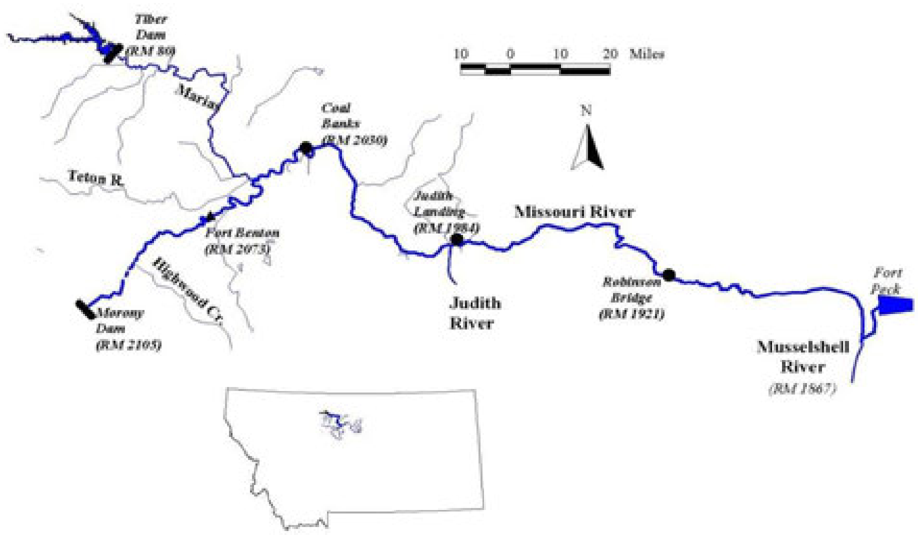

Figure 1. Map of study area

The rivers of interest were the main stem Missouri River where most of the migratory fish reside and the Marias River, a tributary stream that has a major influence on the Missouri River channel condition. Since both of these rivers are regulated by upstream Reclamation reservoirs, there was opportunity to provide varying flow conditions in the study area.

Migratory fish (pallid sturgeon, shovelnose sturgeon and blue sucker) in the study area were monitored using a radio telemetry system so that individual fish could be monitored for habitat selection and behavior responses related to varying flow conditions. The radio transmitters were manufactured by Lotek Wireless, LTD and were of varying sizes and configurations (Appendix 1). The radio transmitters were tuned to three frequencies; Blue sucker were designated a frequency of 149.700 MHz; pallid sturgeon were assigned a frequency of 149.800 MHz and shovelnose sturgeon a frequency of 149.900 MHz. Additionally, all the radios were factory programmed with a unique code allowing for individual identification. Most of this year's radio tags were deployed during the period April 26 through May 20, 2010. After initial capture, the fish were placed in a live well. They were then weighed and either fork length (sturgeon) or total length (blue sucker) was recorded before implantation of the radio tag. All individuals monitored in the study were captured at varying locations depending on species and availability. Three different sites, an upper (RM 2031.4), middle (RM 1984 and 1982.5) and a lower (RM 1928 and 1927) were targeted for capturing and tagging shovelnose sturgeon. One juvenile pallid sturgeon was captured and tagged at a lower (RM 1921) site. Three juvenile pallid sturgeon tagged in the lower (RM 1942-1921) section had previously been tagged and were targeted for re-tagging because their radio's batteries were set to expire and it is desirable to acquire additional data on these individuals. Specific information about fish radio tagged during the period 2006-2009 is reported in previous progress reports (Gardner and Jensen 2007and 2008, and Jensen and Gardner 2009 and 2010).

Transmitters were surgically implanted into the body cavities through a 1-2 inch incision anterior to the pelvic fins offset left from the ventral mid-line. The antenna was threaded through the body wall, posterior of the transmitter, using a shielded needle technique (Ross and Kleiner 1982). The incision was then closed with surgical staples. Sturgeon were sexed, when possible, by direct observation of the gonads through the incision. A small number of eggs (> 10) were removed from most of the female sturgeon at this time to determine stage. The presence (male) or absence (female) of tubercles on the head and body and presence of milt or eggs were used to sex blue suckers. After a short recovery period in the holding tank the fish was released near the area of capture.

The fish telemetry system consisted of ten land-based, continuous recording radio-receiving stations (LBRS) and two different types of transmitters (Appendix 1). In addition to the LBRS, we tracked the radio transmittered fish using two portable SRX- 400 Lotek receivers with two boat mounted four-element yagi antennas. During 2010 we emphasized tracking known shovelnose sturgeon spawners so that more time was spent attempting to locate spawning sites and habitat. Locations were geo-referenced with a boat mounted GPS unit. Macro/meso-habitat and water depth data were additionally collected for approximately one-third of the sturgeon relocations.

In addition to radio telemetry, sampling the LMAR with large trammel nets was also conducted to assess migratory fish presence. Trammel nets used for sampling were 150 ft. long and 6 ft. deep. Three mesh sizes were used: 1- inch inner wall with 10-inch outer walls, 2-inch inner wall with 10-inch outer walls and 1.5-inch inner wall with 4-inch outer walls. Mesh material for both inner and outer walls were light-weight for better fish tangle characteristics and to insure that the net could be retrieved off submerged objects in the event that net material had to be torn free. The trammel nets were set in snag-free areas of the river and allowed to drift along the bottom with the current, typically for 7 minutes. Distances of the drifts varied from 50 to 325 yards. Catch per unit effort for drift netting is expressed as number of fish caught per drift.

Trawling was used to sample the minnow community in the deep-water zones of the study area. The benthic trawl consisted of a 6 ft wide by 1 1/2 ft high rectangular metal frame with skids and an attached 18 ft long outer chafing net with an 11 ft long, 1/8-inch mesh inner liner. The trawl was towed downstream off the bow of the boat usually for a distance of 150-200 yards. A 50 ft rope was attached to each side of the trawl and at the end of the tow the trawl was hand-retrieved by a person at the end of each rope. Catch per unit effort for trawling is expressed as number of fish caught per trawl tow.

RESULTS

River conditions

The study plan was to provide different spring-rise flow conditions in the Missouri and Marias Rivers each year for evaluating sturgeon and migratory fish responses to these conditions over a 5-year period. During these years, 2006-10, the spring-rise flows (June/July) for the combination of the two rivers varied considerably which allowed for distinct comparisons between the years (Figure 2 and Table 1). For instance, in 2006 the Marias River spring-rise flow was high and the Missouri River spring-rise flow was low, whereas, in 2010 just the opposite condition occurred where the spring-rise flow conditions were low Marias River/high Missouri River. The two major reservoirs on the system, Canyon Ferry and Tiber had a significant influence on the downstream river flows during the 5-year study period.

Canyon Ferry Reservoir (CFR) has sufficient storage to significantly alter the Missouri River outflows compared to Missouri River inflows. During the five study years CFR reduced (through storage) the Missouri River spring-rise flow during most years ranging from a 4% decrease to a 28% reduction during 2006 (Table 2). 2007 was a low run-off year and during this year CFR used storage to slightly increase the average spring outflow 9%.
Tiber Reservoir normal spring storage (pool elevation 2976-2993 ft. or 267,994 AF) is 66% of the average May-July inflow (404,193 AF), and therefore, has considerable control over outflow releases to the lower Marias River. During the five study years Tiber Reservoir (through storage) reduced the lower Marias River spring-rise flow(Jun/Jul period) during all years, ranging from a 7% decrease in 2006 to a 65% reduction in 2010 (Table 2).

There are six large tributary streams entering the main stem Missouri River downstream of CFD and these tributaries help restore more natural high spring-rise flow conditions in the Missouri River. The spring-rise flow during 2008 was a more normal condition for the 5-year period and the June average flows at eight gauging stations in the Missouri River were compared from CFD and downstream to depict normal Missouri River flow accretions in a downstream progression (Table 3). The largest accretion in the Missouri River flow occurred at Great Falls with the Sun River increasing the Missouri River flow by 3,616 cfs. Although the Marias River (below Tiber Dam avg. annual flow = 816cfs) has a higher average annual flow than the Sun River (at Simms avg. annual flow = 675cfs), the Sun River added 47% more flow accretion in June 2008 compared to the Marias River. There appears to be a greater potential for increasing Missouri River flows from the Marias River by incorporating greater releases from Tiber Reservoir.

During the two years when the LMAR experienced high spring-rise flows (2006 and 2008) several of the ecologically important natural fluvial processes were observed. For instance during the 2006 spring-rise flow the LMAR river stage height near the confluence rose 3.5 feet from the previous base condition and produced only mild flooding. USGS hydrologists Auble and Bowen (2008) reported that important physical processes including flooding of dry side channels, islands and floodplain had occurred in the LMAR, however, at a much scaled-down version of what occurred naturally. The 2006 flooding produced sediment accretion and spatially distinctive patterns of deposition associated with natural levee formation all of which are important elements for providing and diversifying aquatic habitats. Their follow-up study of LMAR river conditions in 2007when there was no spring-rise flow, recorded unfavorable conditions for aquatic habitat where there was a net channel degradation at the study sites (Auble and Bowen 2009). Clearly, the high spring-rise flow scenario in the LMAR produced a desirable condition for restoring important aquatic habitats.

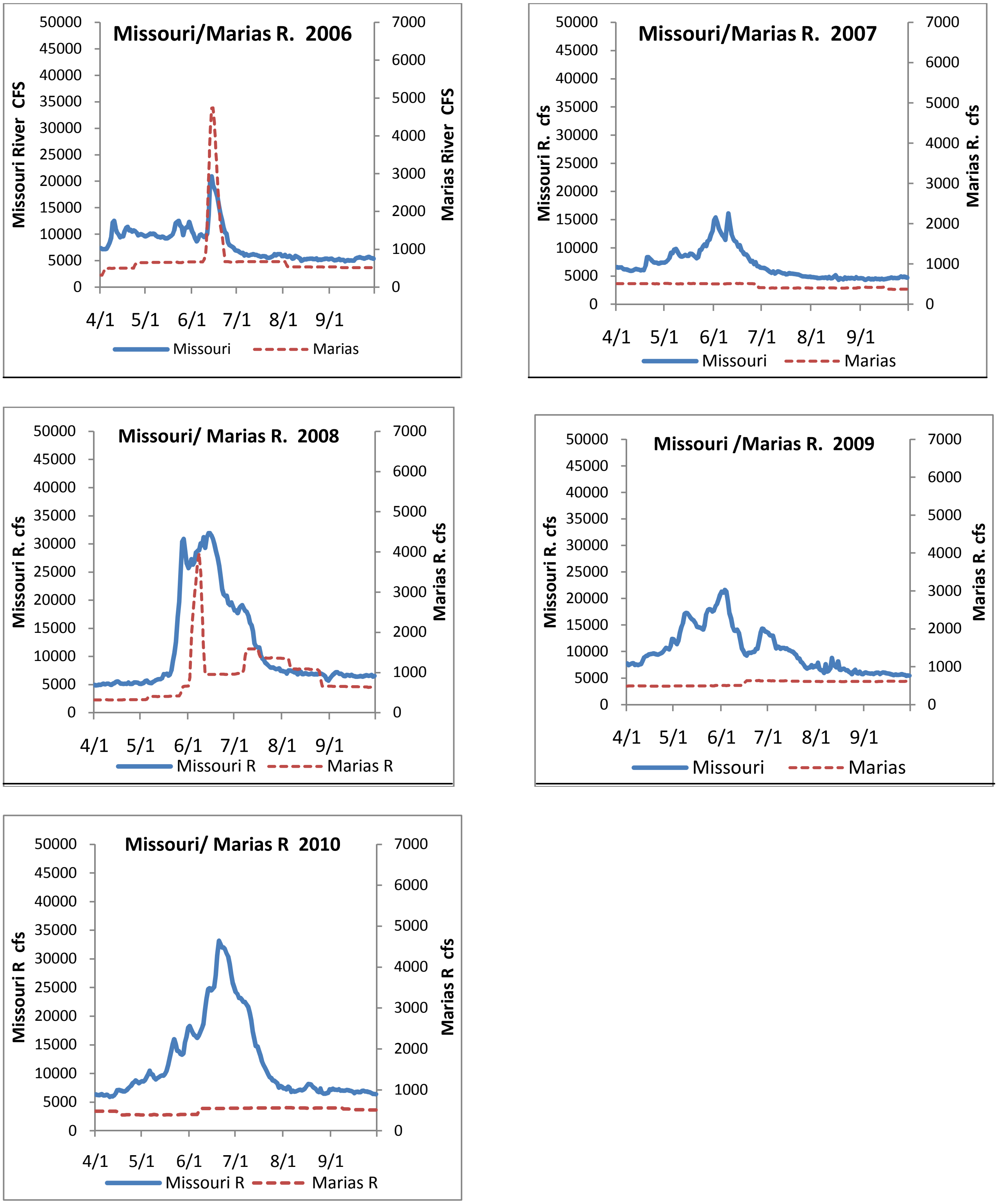

Figure 2. Hydrographs of the Missouri River (@Robinson Brg) and Marias River (@ Tiber Dam) depicting the spring flow conditions for the five study years 2006-2010 (USGS 2011).

Table 1. Average spring-rise (June/July) flow (cfs) for the Missouri River (@ Robinson Brg.) and Marias River (@Tiber Dam) (USGS 2011).

	2006	**2007**	**2008**	**2009**	**2010**
Missouri	8,877	8,053	19,474	11,653	19,603
Marias	1,121	453	1,428	594	538
Flow Scenario	Low Mo. R High Mar. R	Low Mo. R Low Mar. R	High Mo. R High Mar. R	Moderate Mo. R Low Mar. R	High Mo. R Low Mar. R

Table 2. June/July inflow and outflow statistics for the Missouri River at Canyon Ferry Reservoir and Marias River at Tiber Reservoir (USGS 2011).

	2006	**2007**	**2008**	**2009**	**2010**
Missouri River					
Avg. Jun/Jul inflow	5,642	3,675	11,043	8,615	11,612
Avg. Jun/Jul outflow	4,054	3,999	9,602	7,090	11,091
Peak inflow	16,700	10,100	18,900	18,000	21,500
Peak outflow	5,100	5,560	14,900	11,400	18,000
Marias River					
Avg. Jun/Jul inflow	1,207	550	2,229	1,263	1,549
Avg. Jun/Jul outflow	1,121	453	1,428	594	538
Peak inflow	3,460	1,990	5,550	4,120	4,880
Peak outflow	4,740	517	3,970	639	559

Table 3. Average June 2008 flows for eight stream gauging stations on the Missouri River showing flow accretions (or losses) on the main stem Missouri River from immediately upstream of Canyon Ferry Reservoir and on downriver 374 miles to the Robinson Bridge (USGS 2011).

USGS Gauge Station	**RM**	**Reference**	**2008 Avg June Flow**	**Accretion between Sta.**
Toston	2296	Mo. R. inflow	15,423cfs	---
Canyon Ferry Dam	2253	Flow regulation		
Hauser	2237	Outflow from CFD	12,291cfs	-3,132cfs
Holter	2211		12,243cfs	-48cfs
Ulm	2140	Above Grt Falls	15,207cfs	2,964cfs
Morony	2106	Below Sun R.	18,823cfs	3,616cfs
Fort Benton	2073	Below Belt C.	22,080cfs	3,257cfs
Virgelle	2051	Below Marias R.	23,993cfs	1,913cfs
Robinson Brg.	1922		26,463cfs	2,470cfs

Temperature conditions

Missouri River water temperatures at the Morony Station during 2007-2010 were cooler than expected as a result of the cold water releases from Canyon Ferry Dam 147 miles upstream. Upstream of CFR, the average monthly water temperatures of the Missouri River (at the Toston Station) averaged 2.1 F^o warmer than water temperatures at the downstream Morony Station during May, June and July (Table 4). Water releases from CFD generally occur from the hypolimnion with the maximum release capacity of 9,500 cfs. During low run-off years, like 2007, the entire outflow to the Missouri River originates from the cold-water hypolimnion outlet. In spite of the cold water influence of CFD, water temperature conditions recorded for stations in the MMR during the study period 2006 – 2010 appeared to be within the suitable temperature range for warm-water fish species (Table 5). The LMAR water temperatures were generally well within the temperature range for warm-water fisheries and the effects of Tiber Dam did not appear to depress the normal ambient temperatures near the lower river reach (Table 5). This was because Tiber has multiple release outlets including two surface outlets and during periods with high water releases the surface outlets discharge large volumes of warmer water.

Table 4. Seasonal average monthly water temperatures (F) recorded at Toston Dam (RM 2296, USGS 2011) and below Morony Dam (RM 2102, MFWP).

	May	**June**	**July**
2007			
Toston	57.5	64.6	75.4
Morony D	54.4	60.2	69.0
2008			
Toston	53.2	58.3	67.4
Morony D	52.4	56.4	67.5
2009			
Toston	55.2	59.8	68.7
Morony D	53.7	60.9	67.8
2010			
Toston	52.7	58.8	68.1
Morony D	49.4	56.9	66.3

Table 5. Average mean monthly, and range of average monthly water temperatures for stations on the middle Missouri and lower Marias Rivers. Period of record is generally 2002 – 2010, although some stations have less or more years of data.

	APR	MAY	JUN	JUL	AUG	SEP	OCT
Blw.Morony Dam (RM 2102**)**							
Average (4yr)	50.0	52.9	59.0	68.1	67.3	59.6	53.2
Highest Avg	53.2	54.4	60.9	69.3	67.6	63.6	56.9
Lowest Avg	46.4	49.4	56.7	66.3	66.8	58.4	52.3
Loma Bridge (RM 2053)							
Average (9yr)	49.0	56.0	62.9	72.2	69.5	61.2	50.6
Highest Avg	51.0	58.4	66.1	76.0	73.2	65.3	52.2
Lowest Avg	47.1	52.0	59.0	67.6	66.5	58.7	49.5
Judith Landing (RM 1983)							
Average (7yr)	52.3	56.5	64.3	73.0	69.8	60.9	49.8
Highest Avg	56.0	57.4	67.5	77.6	72.3	64.3	54.8
Lowest Avg	48.6	53.6	60.7	69.3	67.5	58.9	45.4
Robinson Bridge (RM 1921)							
Average (9yr)	50.4	57.3	65.4	73.9	70.7	61.6	49.9
Highest Avg	51.8	61.1	69.4	78.8	73.6	64.9	55.0
Lowest Avg	46.9	53.8	61.2	69.6	68.2	58.3	45.9
Marias River (Confl. RM 1)							
Average (12yr)	50.1	58.0	65.4	71.7	68.2	59.3	48.9
Highest Avg	54.0	62.3	69.4	77.8	71.7	62.6	51.4
Lowest Avg	44.3	53.2	60.2	67.3	63.5	57.7	44.4

Pallid sturgeon and other migratory species response to flows as determined by radio telemetry

Over the past five years we monitored radio tagged fish to evaluate the effects (if any) the spring-rise flows might have on fish behavior and habitat use. Additionally, we were interested in locating important habitat areas based on repeated observations of radio-tagged fish at specific sites. Pallid sturgeon, shovelnose sturgeon and blue sucker were the three radio tagged species studied because these MMR species are known to experience extensive spawning migrations (Berg 1981 and Gardner and Berg 1983).

Pallid sturgeon:

There were two different groups of pallid sturgeon that were radio-tagged and monitored during the study period. The first group was the wild adult pallid sturgeon consisting of six individuals. Only in 2006 and 2008 were there radio adult pallids in spawning condition that were tracked. During the 2006 tracking season two adult male spawners (PLS-38 & PLS-39) were monitored, while in 2008 the adult pallid tracked was a female spawner (PLS-45) (Figure 3). All the remaining adult pallids were either non-spawning females or of undetermined status fish. The two male spawners appeared to move upriver in response to a doubling of river flows, however, 2006 was a low spring-rise year, so this observation also indicates that pallids will move upriver when spring rise flows are abnormally low. The other spawner (PLS-45, a mature female) did not show any inclination to move upriver during 2008 when flows were rising and when it was a high spring-rise flow year. Results from this fish may not have been normal because later on during the summer it appeared as if the pallid expelled its radio showing little movement during the remaining seasons. The non-spawning adult pallid sturgeon (PLS-27 and PLS-47) movement patterns were far ranging and fairly consistent over the years (Figure 3). They typically would move up into the middle reach (RM 1970-2020) in early spring and reside in this area until July and then gradually return to the lower reach of the MMR. The radio telemetry tracking for both adult spawners and nonspawners demonstrated that these wild adult pallids were wide ranging and continue to use a considerable length (118 mi) of the MMR (RM 1902.5-2020.9).

The sub-adult group was comprised of 19 pallid sturgeon that were of hatchery origin. These pallids were from the 1997 year-class and were released into the river during 1998, but transmittered periodically during the five-year study duration. The sub-adult pallids were monitored to evaluate if they would exhibit spawning behavior and be influenced by variable spring-rise flows. Additionally we were interested in learning more about their distribution and habitat preferences. Table 6 is a list of the sub-adult pallids tracked over the five-year study duration and the summary results show that these pallids were mostly (70% of the relocations) confined to the lower river between RM 1911.0 and 1929.0. However, three radio pallids were found in the upper with radio Code 29 located only three miles downstream from the Marias River Confluence.

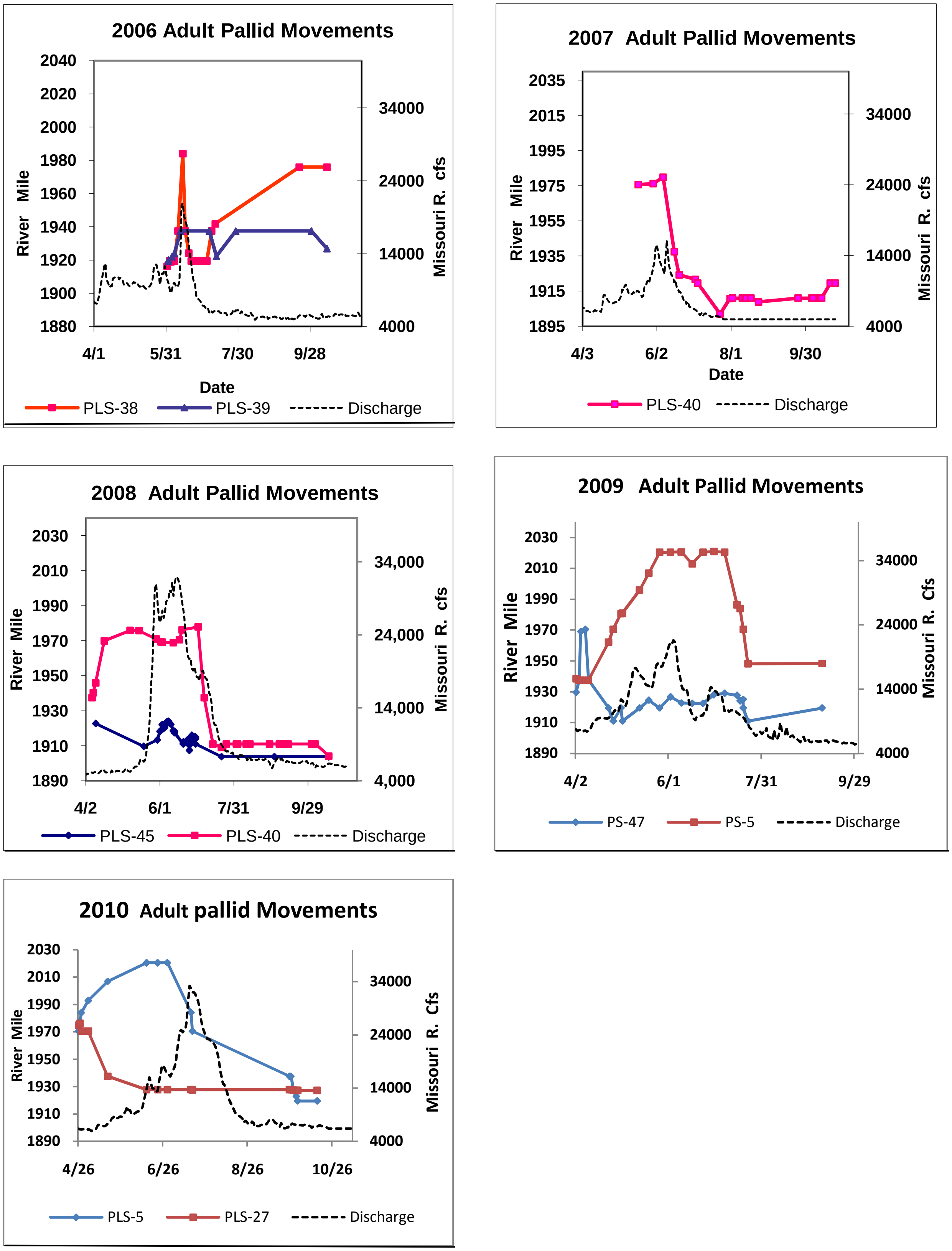

Figure 3. Movement patterns of seven radio tagged pallid sturgeon tracked in the middle Missouri River compared to river conditions (Missouri River @ Robinson Brg hydrograph 2006-2010).

Table 6. A summary of sub-adult pallid sturgeon radio telemetry relocations and distances moved in the Missouri River, 2006-10.

	Code	Downriver Limit	Upriver Limit	Avg RM	Number Contacts
2006	26	1917.5	1922.3	1919.3	31
	27	1892.5	1920.0	1909.4	13
	28	1917.7	1922.0	1919.7	20
	29	1914.6	1927.2	1921.0	23
	30	1911.0	1920.0	1919.3	74
	31	1891.2	1920.0	1904.7	10
	32	1911.0	1923.5	1914.4	19
	33	1917.2	1921.0	1919.1	2
2007	26	1917.0	1925.7	1919.3	19
	27	1892.5	1897.7	1894.7	5
	28	1917.0	1921.8	1919.2	23
	29	1917.3	1927.1	1923.1	15
	30	1916.7	1920.0	1919.4	101
	31	1891.1	1892.8	1892.3	5
	32	1911.0	1915.6	1913.6	10
	33	1911.0	1942.0	1926.4	15
2008	8	1913.5	1946.8	1934.0	15
	9	1977.8	1984.0	1979.8	9
	10	1911.0	2000.6	1960.7	11
	11	1918.8	1923.5	1920.0	63
	12	1926.0	1938.8	1929.4	8
2009	13	1919.5	1929.0	1920.0	61
	17	1923.7	1939.1	1932.5	18
	18	1918.0	1944.6	1933.9	17
2010	17	1925.6	1940.8	1929.6	9
	18	1913.6	1943.3	1934.0	8
	19	1918.8	1923.9	1922.4	14
	22	1916.7	1937.0	1924.8	12
	29	2048.0	2048.7	2048.4	2

The radio tagged sub-adult pallids were usually found in only a few specific habitats indicating their habitat specificity. Preferred macro-habitat was channel crossover areas (CHXO) where the overall average percent of occurrence was 65% (Table7). Preferred meso habitats with high use by the radio pallids were the bluff pool areas (overall average =36%) and large island areas (overall average = 31%). The radio tagged pallid micro habitat preferences were depths $\geq$ 6 ft (61% occurrence) and at areas with substrates of gravel or sand (occurrences of 48 and 40%, respectively).

Table 7. Yearly habitat use by Radio tagged PS-JV sturgeon in the Middle Missouri River expressed as percent of observations. (CHXO = channel crossover; OSB = outside bend; ISB = inside bend; TRM = tributary mouth; SCC = side channel connected; Bluff = bluff pool; Rpds = rapids; SubB = submerged bar; Sm/LgIs =small/large islands; Marg = channel margin; Mid Ch = mid-channel).

	-----------**Macro habitat type** ---------					-----**Number** ---		
	CHXO	OSB	ISB	TRM	SCC	Contacts	Indivds.	
2006	74	17	9	0	0	62	8	
2007	70	10	15	3	0	71	8	
2008	59	23	9	0	7	48	5	
2009	63	13	15	5	2	34	3	
2010	59	19	14	0	6	40	5	
	----------------- **Meso habitat type** --------------------							
	Bluff	Rpds	SubB	SmIs	Lg.Is	Marg	MidCh	
2006	46	0	22	6	9	5	10	
2007	35	0	25	7	18	5	10	
2008	28	2	2	4	50	4	6	
2009	34	0	8	5	38	11	5	
2010	38	0	2	2	41	6	8	
	------ **Depth** (ft) --------				-------- **Substr**. --------			
	1.0– 2.9	3.0-5.9	6 & >		Silt	Sand	Grvl	Cobbl
	3	36	61		0	40	48	12

Shovelnose sturgeon:

Shovelnose sturgeon (SNS) movement patterns and spawning habitat use in relation to river flows were investigated using radio telemetry. This species was considered a suitable proxy for inferences made about pallid sturgeon spawning because pallid sturgeon and SNS are similar species and SNS and pallid sturgeon are known to hybridize, indicating similar habitat preferences. Additionally, by studying SNS spawning aspects, we will be improving on our sampling methodology for future pallid sturgeon research.

SNS are known to migrate considerable distances in the MMR during the spawning season (Jensen and Gardner 2009-10) and it is important to evaluate the influence that the spring-rise flow has on sturgeon migrations. The spawning migration patterns of radio-tagged SNS were studied in depth by Ryan Richards, a MSU graduate student, and he found that the spring-rise flows did not appear to influence SNS spawning migrations in the MMR (Richards 2011). Richards reports more detailed information on the radio-tagged SNS results for the 2008-09 years. It was found that only SNS in spawning condition show extensive spawning migrations. For instance the 2009 radio-tagged SNS in known spawning condition moved an average of 27.6 more miles during June/July than radio-tagged SNS in non-spawning condition (Jensen and Gardner 2010).

We were also interested in investigating SNS spawning locations and spawning habitat conditions, so during the 2010 spawning season we narrowed our focus to tracking 24 radio tagged SNS spawners at two locations, Loma and Robinson areas (Appendices 19-21). We tracked and recorded habitat use on these 24 SNS during the period (June 23 – July 26) when optimal SNS spawning temperatures of 60-70 F(Goodman et al 2011) occurred in the MMR. Table 8 summarizes the habitat conditions where the radio tagged fish were located. There were considerable differences of habitat use between the Loma and Robinson SNS spawner groups. For the Loma group the macro habitat use was variable and spread out fairly even between three main types, whereas, for the Robinson group SNS preferred the CHXO (53% occurrence) and outside bend (OSB) (34%) types (Table 8). The varied habitat use by Loma SNS was also observed for the meso-habitat and micro-habitat categories compared to the more specific habitat use by the Robinson group. We suspect that Loma SNS spawners were in more of a staging mode compared to the Robinson SNS spawners that were more in the actual spawning process. This is supported by two general observations: 1) we did not sample any SNS larva in the Loma area, but did sample 42 SNS larva in the Robinson area (Appendix 22). This supports the idea that there was successful spawning in the Robinson area but there was no evidence of SNS spawning in the Loma area, and 2) approximately 50% of the Loma radio telemetry observations (including 9 individuals) were located within the Marias confluence zone (RM 2049.8 – 2051.6) which probably is a SNS staging area and therefore, more varied habitat use by SNS. We believe that some of the radio SNS were waiting for a higher Marias River flow to motivate them into this important tributary to spawn which did not happen in 2010 due to the abnormally low spring-rise flows due to Tiber Dam operations.

SNS spawning habitat based on the Robinson radio tagged fish observations occurred mostly at CHXO (53%) or OSB (34%) locations. Fifty-two percent of the relocations occurred near submerged bars followed by bluff pool areas (22%) and islands (18%). This indicates that fluvial-dependent features, such as submerged bars and islands, serve as important habitat for SNS spawning. SNS spawners were also mainly (91%) found in depths $\geq$ 6 feet water with channel substrates composed of sand (62%) or gravel (29%).

It is well known that the Marias River is an important tributary for SNS spawning (Berg 1981and Goodman et al 2011). Also, SNS tend to migrate considerable distances upriver during high flow years. Gardner and Berg (1983) sampled fair numbers of SNS in the upper reach nearly up to Tiber Dam (RM 60 - 75) during the 1982 high spring-rise flow year. This study confirmed that a high spring-rise was essential for attracting SNS into the Marias River to spawn, however, the magnitude of the spring flow was not determined. During years when the Marias River had a high spring-rise flows (2006 and 2008) a greater number of SNS spawners entered this tributary as demonstrated by both radio telemetry and drift netting (Table 9 and Figure 4). Low spring-rise years in the Marias attracted very little interest by the SNS spawners.

Table 8. Habitat use by radio tagged shovelnose sturgeon spawners in the Middle Missouri River, 2010. Expressed as percent of observations. A total of 45 and 47 contacts were made on 15 and 9 individuals for Loma and Robinson Brg shovelnose, respectively. (CHXO = channel crossover; OSB = outside bend; ISB = inside bend; TRM = tributary mouth; SCC = side channel connected; Bluff = bluff pool; RipR = rip-rap; Sub/SurfB = submerged/surface bar; Sm/LgIs =small/large islands; Marg = channel margin; Mid Ch = mid-channel

	------------- Macro habitat type -------------							
	CHXO	OSB	ISB	TRM	SCC		Contac	Indiv
Loma SNS	29	33	33	4			45	15
Robinson Brg. SNS	53	34	2	9	2		47	9
	------------------ Meso habitat type -------------------							
	Bluff	RipR.	SubB	SurfB	SmIs	LgIs	Marg	MidCh
Loma SNS	37	17	13	0	5	15	10	3
Robinson Brg. SNS	22	0	52	2	6	12	4	2
	------ Depth (ft) --------				**--------- Substrate ----------**			
	1.0– 2.9	3.0-5.9	6 & >		Silt	Sand	Gravl	Cobbl
Loma SNS	7	44	49		0	10	63	27
Robinson Brg. SNS	0	9	91		0	62	29	9

*Denotes rip rap

Table 9. Yearly Missouri River tributary use by radio shovelnose sturgeon spawners, 2006-2010.

	2006	**2007**	**2008**	**2009**	**2010**
Number of SNS that entered Marias River	6	2	9	5	2
% of all radio SNS spawners that entered the Marias River	33%	9%	20%	12%	4%
Total number of SNS netted in the Marias R.	31	1	332	20	9
Catch rate (No./drift) of SNS sampled in the Marias River	1.0	T	3.9	0.8	0.3
Spring-rise condition of Marias River	High	Low	High	Low	Low
Spring-rise condition of Missouri R.	Low	Low	High	Med.	High

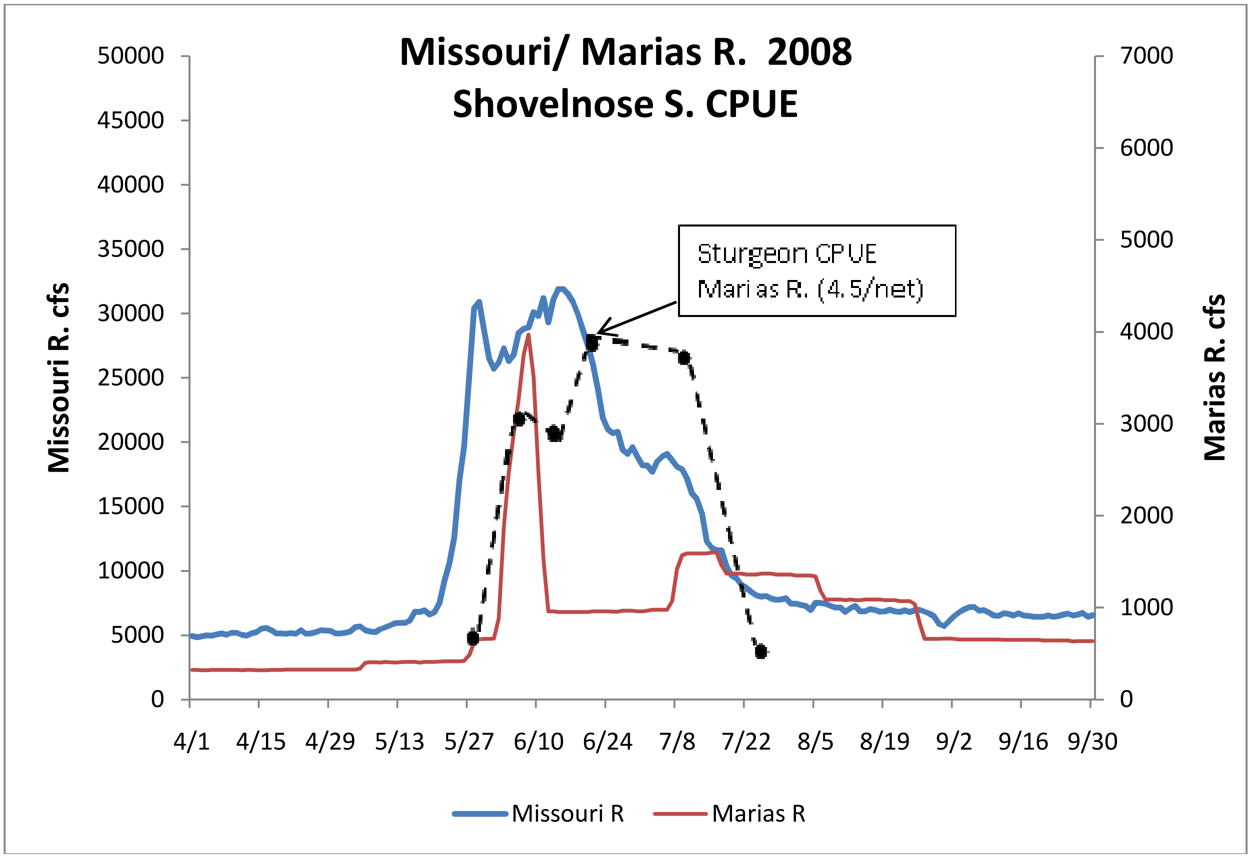

Figure 4. Temporal distribution of shovelnose sturgeon catch rates (no./drift) trammel net sampled in the Marias River during the 2008 spring-rise. Both Marias and Missouri river hydrographs are shown for comparisons of flows vs. sturgeon catch rates.

Blue sucker:

Blue sucker movement patterns in relation to the spring-rise river flows were investigated using radio telemetry. This species was monitored because it is a known migratory species including migrations up the Marias River as far as Tiber Dam (Berg 1981 and Gardner and Berg 1983). Migratory behavior is often associated with spawning, therefore, it is important that migrations are not altered by physical barriers or changes in flow or temperature regimes. The blue sucker spawning period was determined by reviewing the individual radio tracking histories over the four year period. Most of the radio tagged blue suckers exhibited distinct repetitive annual movement patterns showing an extensive migration up or downstream from a home area to the suspected spawning area during April, where they remained for approximately a month. These suspected spawning sites were usually near some type of rocky structure such as bluff pool, rapids or rip-rap site. Specific sites where we observed aggregations of blue suckers surfacing near rocky structure or where we repeatedly located radio fish during April and May were suspected spawning sites. The Missouri River sites were at river miles are listed in Table 10. After spawning in early to mid-June, they would return to their home area and reside here for the remainder of the year. From the tracking histories information we were able to determine that the blue sucker spawning period extended from 9-April to 30-June (average was May 6) when average temperatures ranged from 51.6-58.9 F (Table 11). This range of blue sucker spawning temperatures that we report as suitable for the MMR population are generally in agreement with that reported for the Grand River, MO population, where Vokoun (2003) reported that blue suckers begin spawning when water temperatures exceed 54F.

Radio tagged blue suckers were observed to migrate up into the Marias/Teton rivers and Judith River during April and May. Table 12 shows that between 25 and 52% of all the radio tagged blue suckers migrated into the Marias/Teton River during the spawning period indicating a high preference for these tributaries. Unlike SNS, blue sucker do not appear to require a rise in base flow to be attracted into the Marias River, however, a stronger run may occur in years when the Marias River has greater April flows.

Table 10. Blue sucker spawning sites in the Middle Missouri River and a few main tributaries.

Observed spawning sites (areas that we caught spawning BSU)

Observed Spawning site	**River Mile Location**
Elk Pasture Pool	1914.5
USGS Gauging Station Jetty at Robinson Bridge	1921.5
Old Marias Confluence	2050.0
Marias Bridge at Loma	Marias RM 1.0
Teton River rip-rap	Teton RM 0.1
Old Pump House Riprap	2056.0
Jetty at Fort Benton	2071.0

Spawning sites determined by telemetered blue sucker movements

Spawning area	**River Mile Location**
Big Sandy Island- Robinson Bridge	1908.8-1911
Iron City Islands-McGarry Bar	1968.5-1978.4
Judith Landing	1984-1987.5
Judith River	Judith RM 3.0
Virgelle	2034.0-2040.4
Three Islands	2044.3-2047.0
Marias Confluence	2050.0-2053.4
Marias and Teton Rivers	Marias RM 0.0-1.0; Teton RM 0.25

Table 11. Blue sucker spawning period and average spawning date, average water temperature during spawning period and reach location where spawning occurred for radio tagged fish in the Middle Missouri River, 2007-2010.

			---------- Date ----------			Avg. Temp	Spawn location	
	N	**Sex**	**Min**	**Max**	**Avg.**		**Upper**	**Lower**
2007	12	F	9-Apr	5-Jun	4-May	58.9	9	3
	9	M	12-Apr	15-Jun	1-May	57.0	6	3
2008	13	F	10-Apr	13-Jun	4-May	52.7	8	5
	21	M	14-Apr	22-Jun	11-May	54.1	13	8
2009	16	F	14-Apr	2-Jun	3-May	51.6	14	2
	23	M	12-Apr	8-Jun	6-May	52.9	14	9
2010	11	F	28-Apr	18-May	4-May	52.8	6	5
	17	M	16-Apr	30-Jun	12-May	55.2	12	5

Table 12. Yearly Missouri River tributary use by radio tagged blue sucker spawners, 2006-2010.

	2006	**2007**	**2008**	**2009**	**2010**
No. Entered Marias	10	17	14	30	23
No. of spawners tracked	28	49	55	58	52
% that entered Marias R.	36%	35%	25%	52%	44%
No. Entered Teton R.				2	4
No. Entered Judith R.			1	1	NA

Response of minnow and age-0 fish community to river flows

Pallid sturgeon are carnivorous species dependent on the prey fish abundance including cyprinids. Sturgeon chub are an important diet item for sub-adult pallids in the MMR (Gerrity et al. 2006). This species is distributed in the MMR as far upriver as the LMAR confluence, including the lower Marias and Teton rivers (Gardner 2005). Sturgeon chub appear to be a sensitive species to habitat alterations (Gould 1994) and, therefore, a good indicator of natural habitat conditions. Other cyprinids and non-cyprinids in the main channel river community may also respond to favorable or unfavorable conditions, therefore, the entire benthic fish community was assessed for direct or indirect effects relating to annual flow conditions. Additionally, capture of age-0 sturgeon would indicate successful reproduction and may also be related to specific flow conditions for a given year.

The objective was to assess the minnow community populations under variable flow conditions by comparing years with no spring rise to years with a high spring flow. During the five years of study the minnow communities in three areas of the MMR downstream of the LMAR and the LMAR were sampled by trawling. Sampling with a trawl is an effective method for capturing smaller fish species such as sicklefin and sturgeon chub and age-0 sturgeon in deep water, main channel habitats. Table 13 is a list of the species sampled and their relative abundance. Channel catfish (age-0), longnose dace, shorthead redhorse (age-0), sicklefin chub and sturgeon chub were the five most common species sampled representing eighty-four percent of the catch. The yearly relative abundance of these five common species were compared between years to evaluate the effects of varying flows on fish abundance and results are reported in Table 14. The relationship between flow conditions and trawl catch rates was unclear. The highest catch rates were recorded during the lowest flow year but the lowest trawl catch rates occurred in one of the high water years (2008) but not the other (2010). The abundance of main channel small fish may not be directly related to flow conditions of the year, but effects may be more noticeable a year or two later, especially for the longnose dace, sicklefin and sturgeon chubs where most of the sample was composed of age-1 and older fish. Trawl sampling conducted here, at this intensity appears to be more qualitative and can be used for presence/absence analyses but may be of limited value for relative abundance measurement. The trawl data presented here demonstrates that the MMR benthic minnow community is fairly diverse and includes two state species of special concern (SOC). One of these SOC species, sturgeon chub, appears to have a more extensive distribution reaching as far upriver as the Marias River Confluence, however it is uncommon in the Marias River. More information on distribution and abundance in the Marias River would be beneficial to determine if this important species is being limited in its upriver distribution or the result of a natural progression of habitat attenuation.

Table 13. Average trawling catch rate (number/tow) for fish sampled in the lower Marias and middle Missouri River, 2006-10.

	Marias River	**Coal Banks**	**Judith Landing**	**Robinson Bridge**	**Totals**
Black crappie		T		T	5
Channel catfish-y	4.3	0.4	3.0	1.2	904
Emerald shiner	0.2	T		T	61
Fathead minnow		T			10
Flathead chub	0.5	0.1	0.3	0.4	289
Goldeye-y				T	8
Hybognathus spp.	T	T	T	T	26
Longnose dace	8.3	4.3	2.5	T	1,105
Longnose sucker-jv	T	T	T	T	13
Mottled sculpin	0.2	0.2	T		26
Pallid sturgeon-jv		T	T	0.1	40
River carpsucker y		T	4.1	T	7
Sand shiner	0.1	T			12
Sauger-y				T	8
Shorthead redhorse-y	0.3	8.6	3.5	T	1,363
Shovelnose sturgeon y				T	3
Sicklefin chub				1.0	546
Smallmouth bass-y	0.1	0.2			22
Spottail shiner	T	T		T	7
Stonecat	4.7	0.6	0.6	0.3	328
Sturgeon chub	0.3	0.1	0.6	1.2	713
White sucker y		T			5
Unidentified			0.1	T	15
Total catch	591	1,958	553	2,379	5,516
Total trawl tows	41	135	51	544	771
Avg. depth (ft)	2.9	4.6	5.3	6.6	

Table 14. Average catch rates (no./tow) for common benthic small fish sampled by trawling in the Middle Missouri River.

	2006	**2007**	**2008**	**2009**	**2010**
Channel catfish	1.6	1.7	0.2	0.9	1.2
Longnose dace	3.3	1.2	0.2	0.3	1.2
Shorthead redho.	5.2	1.3	T	T	0.6
Sicklefin chub	1.1	0.3	0.6	0.4	0.9
Sturgeon chub	1.6	1.5	0.5	0.4	0.2
Marias R. spring-rise condition	High	Low	High	Low	Low
Missouri R. spring-rise cond.	Low	Low	High	Med.	High

Discussion:

The LMAR is a very important tributary river of the MMR and presently has a major influence on the MMR physical and biological characteristics downstream. However, the LMAR influences have diminished since construction of Tiber Dam in 1956 compared to conditions before dam construction. Prior to dam construction the Marias River would flood more regularly and the spring-rise flows were of a greater magnitude than present conditions. The 1805 explores Lewis and Clark when arriving at the Marias River Confluence were confused as to which river was the main one to follow because both were of similar size (Moulton 1987). Obviously the Marias River June-flows at the Confluence were much larger back then compared to present times. These changes in the flow regime have decreased sediment to the LMAR and affected sediment transport in the system, thereby altering the natural fluvial dynamics and ultimately reducing fish habitat. We are fairly certain that paddlefish and sturgeon chub have been eliminated or severely reduced in the LMAR because of Tiber Dam and its operations and suspect that pallid sturgeon do not spawn in or near the Marias Confluence area also because of habitat changes associated with the presence and operation of Tiber Dam. Additionally, recruitment of cottonwoods are failing due to river changes associated to Tiber Dam (Rood and Mahoney 1995). Reclamation needs to adjust their operations of Tiber Dam so that more natural flow conditions are provided below the dam especially during good run-off years when water supplies are adequate. This may restrict the amount of water resource development that could potentially occur for Tiber Reservoir, but it is essential that further impacts from Tiber Dam operations be reduced. We believe there is enough flexibility in the operations of Tiber Dam to allow for a more natural spring-rise flow that will improve the aquatic ecosystem in the LMAR. These improvements in turn will be beneficial for pallid sturgeon in the MMR recovery area.

Recommendations:

- A spring-rise flow of 5,000 cfs or greater should be provided every 4-5 years when water supply conditions are adequate. This flow should resemble the 2006 spring-rise with the exception that the descending hydrograph limb should be more gradual and linger through mid-July if possible (similar to the 2008 spring rise). Both the biological and hydrological results reported for these two spring-rise flow years were encouraging.

- Continue with the experimentation of flow scenarios in an adaptive management strategy. Improvements in the habitat conditions will not be detected in a single year or two because of the need for repeated high flows and the unpredictable nature of water supply conditions. Therefore, a long-term monitoring program should be developed that will evaluate the biological and hydrological changes that occur under varying operating conditions and if objectives are being met. Reclamation should provide funding for this program as part of their contribution for pallid sturgeon recovery in RPMA1.

- Reclamation should operate Canyon Ferry and Tiber Dams in the most practical manner as possible that encourages pallid sturgeon recovery in the MMR. Development of an adaptive management plan will be beneficial for achieving this goal.

- The constraints that the US Army Corps of Engineers have on the basin-wide flood control in the area needs to be changed. Reclamation needs more latitude to operate Tiber Dam for providing a spring-rise flow for pallid sturgeon habitat improvements. For instance, Reclamation was required to provide replacement storage in Tiber Reservoir, consequently reducing flows in the LMAR during the 1997 spring-rise flow event. This action provided little flood relief to the system and requires more evaluation regarding overall flood storage efficacy. The cost/benefit values of replacement storage at Tiber Reservoir for US Army Corps of Engineers flood operations needs to be weighed against the value of potential pallid sturgeon habitat improvements in the Marias and Missouri River.

ACKNOWLEDGEMENTS

We would like to thank Sue Camp and Steve Leathe for securing funding for this study, there interest and help was greatly appreciated. Randy Rodencal, Eli McCord and Mike Wente (MFWP) and Ryan Richards and Nick Smith (MSU) assisted with all aspects of fish tracking and data collection. Their efforts are greatly appreciated. US Bureau of Reclamation (Agreement # 06FC602145) and PPL Montana funded this project.

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Appendix Charts

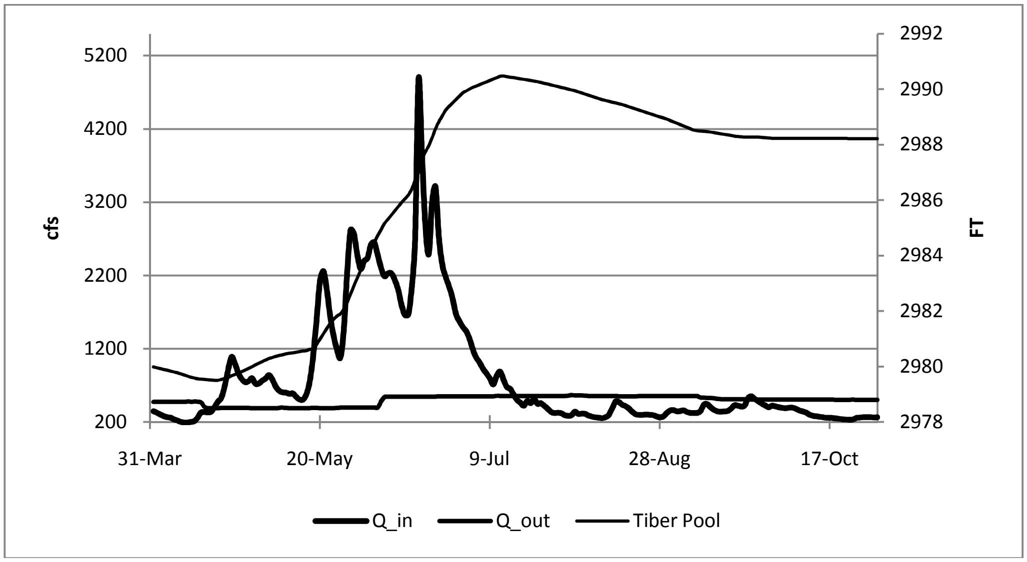
Appendix 1. Model number and type of radio transmitters deployed in 2010. (SNS=shovelnose sturgeon; PS=pallid sturgeon, PS-Jv= juvenile pallid sturgeon).

Model Number	Battery Size (volts)	Warranty Life	Species and/or individual
MCFT-3EM	3	378 days	PS-Jv
MCFT-3L	3	3 years	SNS, PS-26

Appendix 2. Average monthly flow (cfs) and percent of average summaries for the Missouri River near Landusky, MT and Marias River near Chester, MT, 2010 (USGS 2011).

	Missouri River		Marias River	
	cfs	percent [1]	cfs	percent [2]
April average flow	6,992	84%	434	68%
May average flow	11,723	126%	391	52%
June average flow	24,297	175%	517	41%
July average flow	15,061	79%	557	51%
August average flow	7,202	69%	559	68%
September average flow	6,896	106%	527	71%
October average flow	6,351	104%	506	81%
Peak flow and date	33,200	June 20	570	August 2
Estimated bankfull flow	23,466 [3]		3,936 [4]	

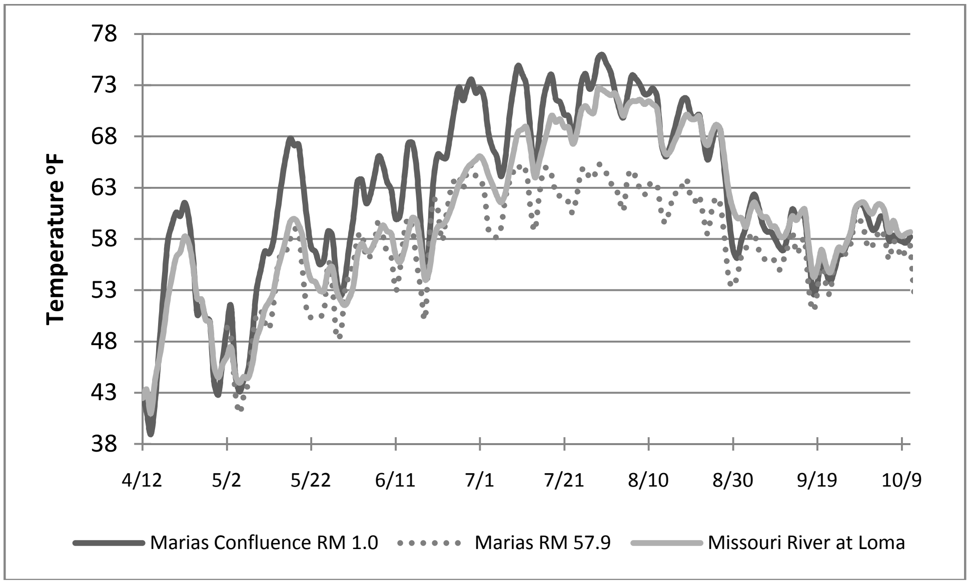
1 Denotes percent of average compared to the record of past 76 years.
2 Denotes percent of average compared to records from 1990-2009.
3 From Gardner and Berg (1982).
4 From Rood and Mahoney (1995).



Appendix 3. Inflow (Shelby), outflow (Tiber) discharge and pool elevation for the Marias River and Tiber Reservoir, 2010 (USBR data records).

Appendix 4. Mean monthly, and range of average monthly (2010) and past mean monthly water temperatures ($^{\circ}$F) for the Lower Marias (1999-2009) and middle Missouri Rivers (2003-2008) near Loma.

	APR	MAY	JUN	JUL	AUG	SEP
Missouri River (Loma)						
Average (6yr)	48.9	56.6	63.6	73.1	69.9	61.1
2010 Avg.	48.2	52.0	59.0	67.6	68.7	58.7
2010 Max.	58.2	60.0	65.7	72.7	72.2	61.6
2010 Min.	41.0	44.0	53.4	61.6	60.0	54.4
Marias River (Loma)						
Average (10yr)	50.2	58.1	64.6	71.0	67.7	59.3
2010 Avg.	48.8	55.7	65.0	71.0	68.9	58.2
2010 Max.	61.5	67.8	73.6	76.0	74.2	62.4
2010 Min.	39.0	43.1	54.2	64.1	56.2	52.7



Appendix 5. Seasonal mean daily water temperature (°F) plots for two stations on the lower Marias River and one station on the middle Missouri River, 2010.

Appendix 6. A list of individual sturgeon radio-tagged in the Missouri River during 2010 and then subsequently monitored during 2010.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	FL (in)	WT (lbs)	Sex	Number of Relocations
Pallid								
149.800	26	MCFT-3L	5/18/10	1921	54.1	33.5	GVDF	3
149.800	29	MCFT-3L	7/29/10	2048	34.5	6.02	UNK	2
149.800	15	MCFT-3FM	9/21/10	MA 1.0	29.3	3.39	UNK	9
149.800	21	MCFT-3EM	9/21/10	MA 1.0	27.1	2.78	UNK	5
149.800	23	MCFT-3EM	9/21/10	MA 1.0	26.7	2.59	UNK	7
149.800	24	MCFT-3EM	9/21/10	MA 1.0	28.3	3.34	UNK	8
149.800	25	MCFT-3EM	9/21/10	MA 1.0	29.2	3.13	UNK	3
Shovelnose								
149.900	126	MCFT-3L	5/7/10	2025.5	34.8	7.78	GVDF[1/]	11
149.900	127	MCFT-3L	5/7/10	2025.5	32.8	6.61	GVDF	16
149.900	128	MCFT-3L	5/7/10	2025.5	31.0	5.33	GVDF	12
149.900	129	MCFT-3L	5/7/10	2034.5	36.8	9.28	GVDF	9
149.900	130	MCFT-3L	5/7/10	2034.5	33.4	6.84	GVDF	14
149.900	131	MCFT-3L	5/7/10	2034.5	29.8	5.71	GVDF	13
149.900	132	MCFT-3L	5/7/10	2034.5	30.3	5.05	GVDF	15
149.900	133	MCFT-3L	5/7/10	2034.5	33.7	7.78	GVDF	6
149.900	134	MCFT-3L	4/26/10	1983	33.5	6.95	GVDF	22
149.900	135	MCFT-3L	4/26/10	1983	31.7	5.64	GVDF	10
149.900	136	MCFT-3L	4/26/10	1983	32.8	6.60	GVDF	21
149.900	137	MCFT-3L	4/26/10	1983	31.0	5.36	GVDF	20
149.900	138	MCFT-3L	4/26/10	1983	33.5	7.95	GVDF	15
149.900	139	MCFT-3L	4/26/10	1983	30.4	5.31	GVDF	49
149.900	140	MCFT-3L	4/26/10	1978.8	33.3	7.15	GVDF	30
149.900	141	MCFT-3L	5/12/10	1970	34.2	7.94	GVDF	23
149.900	142	MCFT-3L	4/27/10	1982.9	31.3	5.61	GVDF	14
149.900	143	MCFT-3L	4/26/10	1978.8	32.5	5.93	GVDF	26
149.900	144	MCFT-3L	5/10/10	1916	36.0	9.58	GVDF	18
149.900	147	MCFT-3L	5/20/10	1921	30.0	5.11	GVDF	38
149.900	148	MCFT-3L	5/20/10	1921	32.1	5.55	GVDF	10
149.900	149	MCFT-3L	5/20/10	1926.7	28.4	4.95	GVDF	31
149.900	150	MCFT-3L	5/20/10	1926.7	32.7	5.92	GVDF	15
149.900	151	MCFT-3L	5/19/10	1925.6	37.9	9.16	GVDF	17
149.900	152	MCFT-3L	5/19/10	1925.6	32.0	7.03	GVDF	19
149.900	153	MCFT-3L	5/20/10	1926.7	29.8	5.14	GVDF	43
149.900	154	MCFT-3L	5/7/10	2034.5	30.9	4.92	GVDF	14
149.900	155	MCFT-3L	5/11/10	2034.1	33.5	7.65	GVDF	19

[1/] These individuals (GVDF) are potentially spawning females with black eggs present during radio implantation (Gravid Female).

Appendix 7. A list of individual sturgeon radio-tagged in the Missouri River during 2009 and then subsequently monitored during 2010.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	FL (in)	WT (lbs)	Sex	Number of Relocations
Pallid								
149.800	22	MCFT-3EM	9/16/09	1921.0	32.3	4.68	UNK	13
Shovelnose								
149.900	96	MCFT-3L	4/14/09	1928.0	32.5	8.10	Female	12
149.900	97	MCFT-3L	4/14/09	1928.0	30.8	5.35	Female	10
149.900	98	MCFT-3L	4/14/09	1928.0	29.6	4.75	Female	19
149.900	99	MCFT-3L	4/14/09	1928.0	30.5	5.80	Female	15
149.900	100	MCFT-3L	4/14/09	1928.0	30.0	6.20	Female	11
149.900	101	MCFT-3L	4/15/09	1928.0	38.0	11.40	Female	3
149.900	102	MCFT-3L	4/15/09	1928.0	35.6	10.45	Female	8
149.900	103	MCFT-3L	4/15/09	1928.0	29.9	5.14	Female	15
149.900	104	MCFT-3L	4/15/09	1928.0	29.1	4.80	Female	14
149.900	105	MCFT-3L	4/15/09	1928.0	27.5	4.70	Female	16
149.900	106	MCFT-3L	4/20/09	2031.4	31.1	5.62	Female	16
149.900	107	MCFT-3L	4/20/09	2031.4	33.8	8.37	Female	8
149.900	108	MCFT-3L	4/20/09	2031.4	30.5	5.84	Female	8
149.900	109	MCFT-3L	4/20/09	2031.4	36.3	9.37	Female	26
149.900	110	MCFT-3L	4/20/09	2031.4	31.1	6.50	Female	0
149.900	111	MCFT-3L	4/20/09	2031.4	33.9	7.39	Female	7
149.900	112	MCFT-3L	4/21/09	2031.4	31.7	6.31	Female	12
149.900	113	MCFT-3L	4/21/09	2031.4	30.7	5.84	Female	7
149.900	114	MCFT-3L	4/13/09	1984.0	29.6	5.60	Female	43
149.900	115	MCFT-3L	4/16/09	1984.0	31.0	5.20	Female	17
149.900	116	MCFT-3L	4/16/09	1984.0	33.6	7.92	Female	15
149.900	117	MCFT-3L	4/16/09	1984.0	30.8	5.60	Female	85
149.900	118	MCFT-3L	4/16/09	1984.0	33.7	7.80	Female	5
149.900	119	MCFT-3L	4/17/09	1982.5	35.0	7.70	Female	20
149.900	120	MCFT-3L	4/17/09	1982.5	34.0	8.00	Female	21
149.900	121	MCFT-3L	4/17/09	1982.5	35.0	8.66	Female	7
149.900	122	MCFT-3L	4/17/09	1982.5	Unk	Unk	Female	5
149.900	123	MCFT-3L	4/17/09	1982.5	32.0	6.20	Female	49
149.900	124	MCFT-3L	4/21/09	2031.4	32.1	6.94	Female	19
149.900	125	MCFT-3L	4/21/09	2031.4	32.9	7.17	Female	29
149.700	87	MCFT-3L	4/20/09	2031.4	31.5	5.51	Female	13
149.700	88	MCFT-3L	4/20/09	2031.4	33.7	6.61	Female	9
149.700	90	MCFT-3L	4/17/09	1982.5	31.0	5.55	Female	19
149.700	92	MCFT-3L	4/17/09	1982.5	31.0	5.56	Female	15
149.700	93	MCFT-3L	4/14/09	1928.0	32.1	5.60	Female	8
149.700	94	MCFT-3L	4/16/09	1928.0	34.2	6.30	Female	62
149.700	95	MCFT-3L	4/17/09	1982.5	33.3	6.40	Female	15
149.700	96	MCFT-3L	4/21/09	2031.4	34.6	7.08	Female	24
149.800	16	MCFT-3L	10/20/09	1927.0	33.2	6.80	Female	25
149.800	20	MCFT-3L	10/20/09	1927.0	37.6	10.72	Female	45

Appendix 8. A list of individual sturgeon radio-tagged in the Missouri River during 2008 and then subsequently monitored during 2009.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	FL (in)	WT (lbs)	Sex	Number of Relocations
Pallid								
149.800	5	MCFT-3FLL[2/]	7/24/08	1921.0	57.0	41.5	Female	16
149.800	19	MCFT-3L	9/10/09	1921.0	30.5	3.70	Unknown	38
149.800	17	MCFT-3L	6/23/09	1925.0	35.7	6.43	Unknown	15
149.900	85	MCFT-3LL	4/24/08	1979.5	44.9	> 15	Female	13
Shovelnose								
149.900	69	MCFT-3LL	9/24/08	1921.0	34.7	7.79	Female	13
149.900	70	MCFT-3LL	5/7/07	2055.5	36.8	9.94	Female	2
149.900	71	MCFT-3LL	5/15/08	1984.0	29.9	4.09	Male	53
149.900	72	MCFT-3LL	5/14/08	1928.5	36.3	11.00	Female	7
149.900	73	MCFT-3LL	5/15/08	1984.0	28.0	4.19	Male	24
149.900	74	MCFT-3LL	5/21/08	1982.5	33.8	7.00	Female	18
149.900	75	MCFT-3LL	5/15/08	1983.5	32.0	6.00	Male	5
149.900	76	MCFT-3LL	5/7/08	2031.2	30.0	4.5	Male	4
149.900	77	MCFT-3LL	4/26/08	2034.0	31.0	5.1	Female	11
149.900	78	MCFT-3LL	4/29/08	1982.5	29.8	4.15	Female	16
149.900	79	MCFT-3LL	4/26/08	2035.0	34.5	7.25	Female	3
149.900	80	MCFT-3LL	4/26/08	2029.1	33.0	8.1	Male	14
149.900	81	MCFT-3LL	4/26/08	2033.0	32.0	5.6	Female	11
149.900	82	MCFT-3LL	4/25/08	1984.0	31.0	5.9	Female	9
149.900	83	MCFT-3LL	4/24/08	1979.5	35.0	7.5	Female	5
149.900	84	MCFT-3LL	4/25/08	1984.0	33.8	6.8	Female	3
149.900	86	MCFT-3LL	4/26/08	2030.0	32.5	6.23	Female	83
149.900	87	MCFT-3LL	4/26/08	2031.0	32.5	6.60	Female	5
149.900	88	MCFT-3LL	4/26/08	2032.0	31.8	5.70	Male	6
149.900	89	MCFT-3L	5/15/08	1983.0	30.1	5.2	Female	5
149.900	90	MCFT-3L	5/15/08	1983.0	34.6	7.84	Female	6
149.900	91	MCFT-3L	4/26/08	2036.0	31.8	5.25	Female	4
149.900	92	MCFT-3L	5/14/08	1928.5	31.2	4.95	Male	15
149.900	93	MCFT-3L	5/21/08	1982.5	30.4	5.18	Male	16
149.900	94	MCFT-3L	5/14/08	1928.5	34.9	9.3	Female	19
149.800	95	MCFT-3L	5/14/08	1928.5	33.5	6.35	Female	14
149.700	48	MCFT-3LL	6/30/08	MA 3.0	32.3	6.18	Male	9
149.700	60	MCFT-3LL	6/30/08	MA 3.7	32.9	5.95	Male	22
149.700	66	MCFT-3LL	4/29/08	1928.5	28.9	4.5	Female	11
149.700	67	MCFT-3LL	4/29/08	1928.5	30.8	5.62	Female	6
149.700	79	MCFT-3LL	4/29/08	1928.5	28.9	4.68	Female	10
149.700	80	MCFT-3LL	6/30/08	MA 4.4	31.4	5.78	Male	12
149.700	81	MCFT-3LL	6/30/08	MA 3.7	30.0	4.56	Male	8
149.700	82	MCFT-3LL	4/29/08	1928.5	30.0	4.70	Female	8
149.800	35	MCFT-3L	5/7/08	2031.2	31.5	4.50	Male	7
149.800	41	MCFT-3L	4/26/08	2028.0	32.0	8.10	Female	8
149.800	42	MCFT-3LL	4/23/08	1921.0	33.6	6.28	Female	28
149.800	43	MCFT-3LL	5/14/08	1928.5	30.8	4.38	Female	11
149.800	44	MCFT-3LL	5/7/08	2031.2	30.5	4.45	Male	8
149.800	46	MCFT-3LL	5/21/08	1982.0	33.8	7.00	Female	3

[2/] Internal loop antenna, tip of antenna bonded to body of radio (any model number with a “LL”)

Appendix 9. A list of individual sturgeon radio-tagged in the Missouri River during 2007 and then subsequently monitored during 2010.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	FL (in)	WT (lbs)	Sex	Number of Relocations
Shovelnose								
149.900	41	MCFT-3L	05/03/07	1921.0	37.2	10.10	Female	18
149.900	42	MCFT-3L	05/03/07	1921.0	41.5	13.65	Female	5
149.900	46	MCFT-3L	05/17/07	1920.0	28.7	3.87	Male	12
149.900	47	MCFT-3L	09/25/07	1914.8	31.0	5.35	Female	16
149.900	48	MCFT-3L	05/07/07	2052.8	34.2	7.30	Male	11
149.900	50	MCFT-3L	05/07/07	2048.0	30.1	6.21	Female	12
149.900	51	MCFT-3L	05/0707	2048.0	32.8	5.75	Male	21
149.900	52	MCFT-3L	05/07/07	2048.0	30.9	5.54	Male	8
149.900	53	MCFT-3L	05/07/07	2052.8	33.5	8.85	Female	9
149.900	54	MCFT-3L	05/07/07	2052.8	37.5	10.64	Female	3
149.900	55	MCFT-3L	05/09/07	1978.5	28.0	4.00	Male	7
149.900	56	MCFT-3L	05/09/07	1978.5	27.8	4.40	Male	12
149.900	57	MCFT-3L	05/09/07	1978.5	27.1	3.65	Male	11
149.900	59	MCFT-3L	05/09/07	1978.5	27.2	3.60	Male	9
149.900	60	MCFT-3L	05/09/07	1983.4	31.3	5.26	Female[2/]	13
149.900	61	MCFT-3LL	05/17/07	1920.0	33.90	5.70	Male	7
149.900	62	MCFT-3LL	05/17/07	1920.0	31.00	4.00	Male	17
149.900	63	MCFT-3LL	05/17/07	1920.0	28.8	4.05	Male	58
149.900	64	MCFT-3LL	05/09/07	1978.5	32.3	6.10	Female	18
149.900	65	MCFT-3LL	05/09/07	1978.5	34.2	7.40	Female	5
149.900	66	MCFT-3LL	09/25/07	1920.5	35.0	7.50	Female	12
149.900	67	MCFT-3LL	09/25/07	1914.8	32.6	5.80	Female	11
149.900	68	MCFT-3LL	05/0707	2048.0	39.40	10.29	Female[2/]	14
149.900	70	MCFT-3LL	05/07/07	2052.8	36.8	9.94	Female	2

Appendix 10. A list of individual sturgeon radio-tagged in the Missouri River during 2006 and then subsequently monitored during 2010.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	FL (in)	WT (lbs)	Sex	Number of Relocations
Pallid								
149.800	4	MCFT-3L	4/17/06	1920.0	43.3	12.20	Male	28
149.800	18	MCFT-3L	4/10/08	1925.5	36.6	6.21	Unknown	8
149.800	27	MCFT-3LL	4/10/08	1945.9	57.3	34.2	Female	23
Shovelnose								
149.900	13	MCFT-3L	5/1/06	1920.0	37.3	9.10	Female	1
149.900	15	MCFT-3L	5/1/06	1920.0	35.7	8.40	Female	3
149.900	17	MCFT-3L	5/1/06	1920.0	26.0	3.20	Female	19
149.900	18	MCFT-3L	5/3/06	1920.0	31.8	6.00	Female	9
149.900	20	MCFT-3L	5/3/06	1920.0	29.4	4.90	Female	15
149.900	21	MCFT-3L	5/3/06	1920.0	30.2	4.70	Male	12
149.900	23	MCFT-3L	5/3/06	1920.0	30.0	4.20	Male	32
149.900	25	MCFT-3L	5/3/06	1920.0	27.8	3.24	Male	26
149.900	26	MCFT-3L	5/8/06	2048.0	29.0	4.23	Male	6
149.900	27	MCFT-3L	5/8/06	2048.0	34.0	8.25	Female	3
149.900	28	MCFT-3L	5/8/06	2048.0	34.3	7.95	Female	3
149.900	29	MCFT-3L	5/8/06	2048.0	32.5	7.60	Female	33
149.900	30	MCFT-3L	5/8/06	2048.0	31.3	6.00	Female	6
149.900	31	MCFT-3L	5/8/06	2048.0	31.1	5.55	Female	4
149.900	33	MCFT-3L	5/8/06	2048.0	28.7	4.70	Male	13
149.900	34	MCFT-3L	5/8/06	2048.0	30.5	5.55	Male	25
149.900	37	MCFT-3L	5/8/06	2048.0	30.0	5.00	Male	12
149.900	38	MCFT-3L	5/8/06	2048.0	30.3	6.25	Female	5
149.900	40	MCFT-3L	9/26/06	1921.0	35.5	9.05	Female	32
149.800	1	MCFT-3L	9/26/06	1921.0	34.5	7.70	Male	27

Appendix 11. A list of individual blue sucker radio-tagged in the Missouri and Marias Rivers during 2009 and then subsequently monitored during 2010.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	TL (in)	WT (lbs)	Sex	Number of Relocations
Blue sucker								
149.700	83	MCFT-3L	5/11/09	MA 0.5	31.9	12.20	Female	11
149.700	84	MCFT-3L	5/11/09	MA 0.5	29.3	9.25	Female	14
149.700	85	MCFT-3L	5/6/09	1982.4	31.6	> 11.0	Female	20
149.700	86	MCFT-3L	5/11/09	MA 0.5	30.4	8.18	Male	18
149.700	91	MCFT-3L	4/17/09	1982.5	32.2	> 11.0	Female	6
149.700	97	MCFT-3L	4/17/09	1982.5	35.7	> 11.0	Female	18

Appendix 12. A list of individual blue sucker radio-tagged in the Missouri River during 2008 and then subsequently monitored during 2010.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	FL (in)	WT (lbs)	Sex	Number of Relocations
Blue sucker								
149.700	58	MCFT-3LL	4/22/08	1919.5	32.2	12.09	Female	5
149.700	72	MCFT-3LL	4/15/08	2050.5	28.5	7.06	Female	5
149.700	73	MCFT-3LL	4/15/08	2050.5	26.7	6.61	Male	4
149.700	75	MCFT-3LL	4/15/08	2050.5	28.2	7.03	Male	5
149.700	76	MCFT-3LL	4/15/08	2050.5	31.2	8.61	Female	5
149.700	77	MCFT-3LL	4/16/08	1979.5	26.9	6.92	Male	2
149.700	78	MCFT-3L	5/6/08	1984.0	30.0	8.27	Female	12

Appendix 13. A list of individual blue sucker radio-tagged in the Missouri River during 2007 and subsequently monitored during 2010.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	FL (in)	WT (lbs)	Sex	Number of Relocations
Blue sucker								
149.700	41	MCFT-3L	4/16/07	1921.0	29.75	7.35	Male	22
149.700	43	MCFT-3L	4/16/07	1921.0	29.90	6.3	Male	31
149.700	44	MCFT-3L	4/16/07	1921.0	31.25	8.35	Male	17
149.700	46	MCFT-3L	4/24/07	1914.5	32.50	11.5	Female	20
149.700	51	MCFT-3L	5/07/07	2052.5	33.80	11.80	Female	12
149.700	52	MCFT-3L	5/07/07	2052.5	30.00	7.25	Male	15
149.700	53	MCFT-3L	5/07/07	2052.5	33.30	12.55	Female	11
149.700	54	MCFT-3L	5/07/07	2052.5	34.70	12.50	Female	14
149.700	55	MCFT-3L	5/07/07	2052.5	31.20	9.95	Male	1
149.700	57	MCFT-3L	5/07/07	2052.5	30.1	8.15	Male	19
149.700	62	MCFT-3LL	4/16/07	1921.0	33.8	~11.5	Female	4
149.700	63	MCFT-3LL	4/16/07	1921.0	32.0	10.35	Male	6
149.700	64	MCFT-3LL	4/25/07	1921.0	31.2	10.4	Female	16
149.700	65	MCFT-3LL	4/25/07	1921.0	28.4	5.85	Male	4
149.700	69	MCFT-3LL	5/07/07	2052.5	33.5	14.85	Female	14
149.700	70	MCFT-3LL	5/07/07	2052.5	30.8	9.25	Male	8

Appendix 14. A list of individual blue sucker radio-tagged in the Missouri River during 2006 and subsequently monitored during 2010.

Frequency	Code	Radio Model Number	Date of Capture	Release Location	FL (in)	WT (lbs)	Sex	Number of Relocations
Blue sucker								
149.700	11	MCFT-3L	5/3/06	1920.0	28.8	6.05	Male	11
149.700	15	MCFT-3L	5/3/06	1920.0	24.6	3.85	Male	2
149.700	16	MCFT-3L	5/9/06	2050.0	29.0	7.00	Male	1
149.700	18	MCFT-3L	5/9/06	2050.0	29.7	7.50	Male	10
149.700	19	MCFT-3L	5/9/06	2050.0	27.5	7.45	Male	10
149.700	20	MCFT-3L	5/9/06	2050.0	28.0	7.10	Male	7
149.700	21	MCFT-3L	5/9/06	2050.0	29.6	8.10	Male	5
149.700	22	MCFT-3L	5/9/06	2050.0	29.0	7.95	Male	6
149.700	23	MCFT-3L	5/9/06	2050.0	30.8	10.50	Female	9
149.700	24	MCFT-3L	5/9/06	2050.0	31.7	10.50	Female	16
149.700	25	MCFT-3L	5/9/06	2051.0	33.2	16.00	Female	1
149.700	26	MCFT-3L	5/9/06	2051.0	29.6	10.50	Female	6
149.700	27	MCFT-3L	5/9/06	2051.0	33.1	13.60	Female	6
149.700	29	MCFT-3L	5/9/06	2051.0	32.0	12.50	Female	7
149.700	30	MCFT-3L	5/9/06	2051.0	30.7	11.80	Female	13
149.700	31	MCFT-3L	5/11/06	1982.0	26.6	4.62	Male	19
149.700	34	MCFT-3L	9/6/06	1984.0	31.3	8.34	Male	5
149.700	35	MCFT-3L	9/6/06	1984.0	33.2	12.00	Female	11
149.700	37	MCFT-3L	9/6/06	1984.0	27.6	6.45	Male	13
149.700	38	MCFT-3L	9/6/06	1984.0	31.6	10.04	Female	4
149.700	39	MCFT-3L	9/6/06	1984.0	32.5	11.00	Female	22
149.700	40	MCFT-3L	9/6/06	1984.0	30.5	8.00	Male	31

Appendix 15. Locations and operating dates of the land-based radio receiving stations and a list of radio contacts recorded by the stations for each species, 2010. (SNS=shovelnose sturgeon; BSU= blue sucker; PS = pallid sturgeon and pallid sturgeon hybrid).

Station Name	**Location** (river mile)	**Start Date**	**Stop Date**	**Number of PS contacts**	**Number of SNS contacts**	**Number of BSU contacts**	**Total contacts**
Big Sandy Island	1911.0	11/1/09	10/15/10	2	45	33	80
King Island	1919.5	11/1/09	10/15/10	27	125	35	187
Power Plant	1937.5	11/1/09	10/15/10	12	66	44	122
Stafford Ferry	1970.5	4/5/10	10/13/10	7	79	61	147
Judith Landing	1984.0	11/1/09	10/13/10	9	466	49	524
Judith River	Jud 3.0	11/1/09	3/23/10	0	0	0	0
Coal Banks Landing	2031.4	11/1/09	10/14/10	9	262	45	316
Marias Confluence	MA 0.5	11/1/09	10/14/10	5	9	96	110
Marias RM 3.0	MA 3.0	11/1/09	10/14/10	0	3	0	3
Teton River	TE 0.25	4/1/10	9/29/10	0	3	4	7
Fort Benton	2074.3	11/1/09	10/14/10	10	15	17	42
Carter Ferry	2089.0	9/29/10	10/14/10	0	0	0	0
			Totals	81	1,073	384	1,538

Appendix 16. Radio telemetry survey dates, locations and number of contacts made while manual tracking for each species, 2010. (SNS = shovelnose sturgeon; BSU = blue sucker; PS = pallid sturgeon and hybrid pallid sturgeon; TE=Teton River and MA = Marias River).

Survey Date	River Mile	Total Mileage	No. of PS Contacts	No. of SNS Contacts	No. of BSU Contacts	Total Contacts
3/24	1941.5-1919.5	22	1	24	2	27
3/25	2074.3-2073.3	1	0	0	0	0
4/1[a]	MA 6.0-1.0	5	0	0	0	0
4/1[a]	TE 6.0-0.0	6	0	0	0	0
4/5-4/6	1984-1899.5	84.5	4	45	20	69
4/12	2031.3-1983	48.3	0	36	14	50
4/16	2053.5-2031.4	22.1	0	27	14	41
4/22-4/23	1934.3-1885.4	48.9	3	21	5	29
5/6[a]	MA 6.0-1.0	5	0	0	0	0
5/10-5/11	1987.8-1897	90.8	4	49	15	68
5/17-5/18	2074.3-1984	90.3	2	74	21	97
5/18[a]	MA 6.0-0.0	6	0	0	0	0
5/26[a]	MA 6.0-0.0	6	0	0	0	0
6/1-6/2	1984-1899.5	84.5	5	66	11	82
6/1-6/2[b]	1928.6-1920.5	23.6	7	46	2	55
6/3[b]	1927.7-1911	16.7	2	5	0	7
6/7[b]	1928-1915.5	25	1	24	0	25
6/8-6/9	2074.3-1984	90.3	1	100	25	126
6/8[b]	2055-2049.7	10.6	0	17	0	17
6/9[b]	2055-2050.3	4.7	0	9	0	9
6/9[a]	1984-1977	11	0	8	0	8
6/10[b]	2054.3-2050.3	8	0	9	0	9
6/11[b]	2054.2-2050.2	4	0	5	0	5
6/14[b]	2031.3-2018.9	24.8	1	8	0	9
6/15[b]	2031.3-2019	24.6	0	15	0	15
6/15	1984-1921	63	6	59	11	76
6/15[b]	1929.3-1919.6	9.7	2	11	0	13
6/16[b]	1923.5-1919.5	8	1	5	1	20
6/21[b]	2054.8-2050.2	9.2	1	16	0	17
6/22[b]	2056.8-2047.6	18.4	0	7	0	7
6/22[b]	1987-1983.3	3.7	0	9	0	9
6/22	2031.4-1984	40.2	1	36	5	42
6/23	2053.5-2040	13.5	0	14	5	19
6/23[b]	2034-2028	12	0	14	0	14
6/28[b]	1988-1977	22	0	13	0	13
6/28-6/29[b]	2054.5-2049.8	18.8	0	23	0	23
6/29[b]	2032.5-2020.5	24	1	15	1	17
6/29[b]	1928-1916	24	3	10	1	14
6/30[b]	1928.7-1917.5	22.2	5	23	0	28
6/30	2054.3-2031.4	22.9	1	27	10	38
7/6[b]	2054.3-2050	8.6	0	15	2	17
7/6[b]	1931.3-1915.5	31.6	2	16	0	18
7/7[b]	1943.3-1913.9	29.4	2	22	1	25
7/8[b]	1930-1915.4	14.6	0	15	0	15
7/13[b]	2054-2049.8	4.2	1	7	1	9
7/13[b]	1928.5-1917.5	11	2	9	0	11
7/14[b]	2054-2045	9	1	15	1	17
7/14[b]	1933.8-1915.3	18.5	1	18	0	19
7/15[b]	2054-2047.3	6.7	1	12	1	14
7/15[b]	1920-1916	4	0	4	0	4
7/26-7/27	2056.8-2045.8	22	0	34	3	37
7/27	1937.8-1911	26.8	4	26	2	32
8/2	2074.3-2068	6.3	0	3	0	3
8/3-8/4	2063-2044	19	1	21	2	24
8/5	2035-2024.5	10.5	0	8	0	8
8/24	1937.7-1915.4	22.3	0	24	2	26
9/27-9/28	2031.3-1926.7	104.6	10	85	31	126
9/29	2089.2-2073	16.2	1	0	1	2
9/30	1926.7-1901	25.7	5	18	1	24
	Totals	**1466**	**83**	**1222**	**211**	**1529**

Appendix 17. A summary of pallid sturgeon radio telemetry relocations and distances moved in the Missouri River, 2010. PS 15, 21,23,24,25 and, 29 were tagged after high water period.

Code	Start RM	End RM	Down river Limit	Up river Limit	Distance @ HiQ [1/]	Direction @ HiQ [1/]	Avg RM	Number Contacts	Spawn Condition
4	2031.4	2075.0	1984.0	2075.0	30.3	Down	2050.5	24	Male
5	1977.7	1922.8	1922.8	2020.5	13.7	Up	1980.4	8	F08[2/]
15	MA 1.0	1923.5	1923.5	MA 1.0	---	---	1973.5	2	IM[3/]
17	1925.6	1937.9	1925.6	1940.8	14.6	Down	1929.6	9	IM
18	1937.5	1913.6	1913.6	1943.3	0.9	Up	1934.0	8	IM
19	1919.4	1919.3	1918.8	1923.9	0	---	1922.4	14	IM
21	MA 1.0	1984.0	1984.0	MA 1.0	---	---	2021.7	6	IM
22	1916.7	1917.8	1916.7	1937.0	4.0	Up	1924.8	12	IM
23	MA 1.0	1937.5	1937.5	MA 1.0	---	---	2002.6	8	IM
24	MA 1.0	1911.0	1911.0	MA 1.0	---	---	1978.6	9	IM
25	MA 1.0	2017.1	2017.1	MA 1.0	---	---	2038.8	4	IM
26	1921.0	1943.6	1921.0	1943.6	---	---	1929.3	3	F10[4/]
27	1911.0	1927.0	1911.0	1976.3	49.2	Down	1925.2	29	F [5/]
29	2048.0	2048.7	2048.0	2048.7	---	---	2048.4	2	IM
85	1921.0	1921.5	1921.0	1921.6	0	---	1921.3	11	F08

[1/] Denotes the maximum miles traveled during high water period May 1 to July 5.
[2/] Female, mature in 2008
[3/] Immature fish
[4/] Spawning female in 2010, taken to Miles City Fish Hatchery during the high water/spawning period and successfully spawned
[5/] Non-Reproducing Female in 2008, recaptured in 2010 no visible gonads

Appendix 18. A summary of shovelnose sturgeon radio telemetry relocations and distances moved in the Missouri River, 2010.

Code	Start RM	End RM	Down river Limit	Up river Limit	Distance @ HiQ [1/]	Direction @ HiQ [1/]	Average RM	Number Contacts	Condition
13	1923.2	1923.2	---	---	---	---	---	1	F06 [2/]
15	2021.7	2022.7	2013.5	2022.7	8.2	Down	2019.3	3	F06
17	1917.0	1916.3	1911.0	1919.5	8.5	Down	1915.5	19	F06
18	1937.5	1935.1	1932.3	1939.5	6.2	Down	1935.5	9	F06
20	2031.4	2031.4	1970.5	2054.5	84	Down	2011.5	15	F06
21	2031.4	1984.0	1911.0	2031.4	4.6	Down	1970.0	12	M06 [3/]
23	1933.9	1933.7	1908.4	1933.9	22.3	Down	1917.0	29	M06
25	1900.4	1902.0	1900.4	2031.4	103.7	Up	1938.9	25	M06
26	2049.0	2048.4	2046.3	2049.0	2.7	Down	2047.4	5	M06
27	2039.0	2038.5	2038.5	2039.0	---	---	2038.8	2	F06
28	2052.7	2059.7	2052.7	2059.7	---	---	2056.2	2	F06
29	2049.9	2050.2	2049.9	2050.2	0.4	Up	2050.2	18	F06
30	2050.0	2046.8	2046.8	2047.0	3.0	Down	2047.8	6	F06
31	2043.4	2026.9	2026.9	2044.5	17.6	Down	2039.2	4	F06
33	1904.3	1927.0	1904.3	1927.7	0.6	Down	1923.5	6	M06
34	2054.2	2053.6	2053.5	2054.3	0	---	2053.9	12	M06
37	2042.8	2036.7	2027.6	2046.0	18.4	Down	2033.5	12	M06
38	2042.0	2033.1	2033.1	2051.6	0	---	2046.0	5	F06
40	1948.5	2045.0	1948.5	2055.0	85.5	Up	2031.6	20	F06
41	1919.5	2020.6	1919.5	2052.6	20.1	Up	1956.1	18	F07
42	1998.3	1997.6	1997.6	1998.3	0.4	Down	1997.9	5	F07
46	1905.3	1904.2	1904.2	1921.7	3.8	Down	1914.7	7	M07
47	1933.5	1907.4	1907.4	1962.6	0.4	Down	1928.6	16	F08 [4/]
48	2049.4	2043.8	2043.0	2054.4	11.4	Down	2049.7	8	M07
50	2049.4	2031.4	1970.5	2049.4	60.9	Down	1992.9	12	F07
51	2041.8	2070.4	2041.8	2070.4	9.5*	Up	2052.5	15	M07
52	2031.4	2059.7	2016.9	2059.7	1.2	Down	2039.4	8	M07
53	2019.4	2019.3	2019.2	2019.4	0.2	Down	2019.2	7	F07
54	2067.1	2048.8	2048.8	2067.1	0.8	Down	2060.7	3	F07
55	1984.8	1993.9	1975.5	1993.9	7.3	Up	1983.1	5	M07
56	1985.6	2001.1	1978.3	2001.1	0	---	1983.6	8	M07
57	1978.4	1978.4	1961.2	1978.4	17.2	Down	1974.2	8	M07
59	2023.3	2013.6	2013.6	2028.8	0.5	Up	2015.7	9	M07
60	2005.1	2010.2	1970.5	2010.2	13.5	Down	1983.6	13	IF07 [5/]
61	2022.4	2024.5	2022.4	2026.3	2.6	Up	2024.6	7	M07
62	1916.7	1916.6	1916.5	1916.8	0	---	1916.7	13	M07
63	1919.3	1930.0	1915.8	1930.0	4.1	Up	1919.9	56	M07
64	2013.3	2020.3	1915.7	2020.3	68.3	Down	1958.6	18	F07
65	1997.0	1999.0	1997.0	2004.3	5.5	Down	2000.8	5	F07
66	2045.4	2057.8	2045.4	2057.8	7.6	Up	2052.2	7	IF10
67	1935.6	1934.9	1928.8	1984.0	44.5	Up	1954.1	12	F08
68	2074.3	2074.3	2051.0	2074.3	0	---	2069.8	14	IF07

Appendix 18. (continued)

Code	Start RM	End RM	Down river Limit	Up river Limit	Distance @ HiQ [1/]	Direction @ HiQ [1/]	Average RM	Number Contacts	Condition
69	1933.4	2058.0	1933.4	2058.0	32.7	Up	1994.0	13	F09
70	2067.5	2046.8	2046.8	2067.5	---	---	2057.2	2	F07
71	1984.0	1984.0	1983.6	1984.9	1.3	Up	1984.0	51	M08
72	2067.5	1928.1	1928.1	2067.5	36.1	Down	1998.0	7	F08
73	1926.3	1919.5	1919.5	1984.0	13.7	Up	1978.8	6	M08
74	1927.0	1927.0	1927.0	1927.0	0	---	1927.0	3	F08
75	1998.7	1998.5	1998.5	1998.8	0.3	Down	1998.7	3	M08
76	2036.2	2036.7	2036.2	2037.0	0.8	Up	2036.6	3	M08
77	1947.3	1995.6	1947.3	1995.6	48.3	Up	1976.0	6	F08
78	1926.4	1921.0	1919.5	1926.4	6.9	Down	1920.7	7	F08
79	2020.9	2007.6	2007.6	2020.9	---	---	2014.3	2	F08
80	2031.4	2017.6	2017.6	2031.4	13.8	Down	2026.9	6	M08
81	2029.5	2028.2	2028.1	2029.6	1.5	Down	2028.9	4	F08
82	1986.9	1985.7	1985.7	1986.9	1.2	Down	1986.2	4	F08
83	2009.5	2009.5	2009.5	2009.5	0	---	2009.5	3	F08
84	2061.6	2061.3	2061.3	2061.6	---	---	2061.5	2	F08
86	2031.4	2031.1	2029.2	2031.4	0	---	2031.2	24	F08
87	1990.7	1990.5	1990.5	1990.7	0.2	Down	1990.6	3	F08
88	2031.4	1995.2	1995.2	2031.4	36.2	Down	2013.6	3	M08
89	1999.2	1998.0	1998.0	1999.2	0	---	1998.6	2	F08
90	2037.0	2038.5	2037.0	2044.6	7.6	Up	2039.9	4	F08
91	1910.2	1911.0	1910.2	1911.0	---	---	1910.6	2	F08
92	2031.4	2024.9	2022.7	2031.4	8.7	Down	2025.7	4	M08
93	1993.2	1970.5	1970.5	1993.2	22.7	Down	1982.6	12	M08
94	1919.5	1970.5	1911.0	1970.5	59.5	Up	1921.9	9	F08
95	1930.8	1932.0	1928.0	1932.0	3.5	Up	1930.0	12	F08
96	2049.3	2022.1	2022.1	2074.3	2.0	Up	2055.6	12	F09
97	1934.0	1936.1	1930.7	1936.1	3.9	Down	1933.8	10	F09
98	1925.0	1924.5	1924.0	1937.5	11.0	Down	1930.7	19	F09
99	1928.5	1926.8	1926.8	1937.5	6.4	Down	1931.1	15	F09
100	1928.5	1919.5	1919.5	1937.4	5.3	Up	1929.5	11	F09
101	2049.6	2062.1	2049.6	2062.1	1.0	Up	2057.6	3	F09
102	2071.2	1926.8	1926.8	2071.3	0.6	Down	2007.9	8	F09
103	1929.0	1929.1	1928.8	1933.2	2.3	Up	1930.3	14	F09
104	1930.0	1936.6	1926.5	1936.6	0.5	Up	1929.2	13	F09
105	1935.5	1937.5	1923.6	1939.9	13.6	Down	1932.2	15	F09
106	2031.4	2024.1	2023.7	2031.4	10.3	Down	2030.2	16	F09
107	2053.4	2031.4	2024.8	2053.4	22.9	Down	2039.0	8	F09
108	2026.3	2011.3	1984.0	2026.3	41.7	Down	2005.3	8	F09
109	2031.4	2031.4	2023.9	2031.4	7.5	Down	2030.0	26	F09
111	2013.2	2012.3	2012.3	2043.8	12.4	Up	2029.0	7	F09
112	2028.1	2024.1	2024.1	2045.0	18.0	Down	2030.7	12	F09
113	2028.6	2024.1	2024.1	2059.5	3.5	Up	2037.6	7	F09
114	1984.0	1972.2	1932.8	1984.0	46.5	Down	1979.9	43	F09
115	1986.0	1987.1	1970.5	1987.1	1.3	Down	1982.5	17	F09
116	1984.0	1987.0	1983.9	1987.1	3.2	Up	1984.7	15	F09

Appendix 18. (continued)

Code	Start RM	End RM	Down river Limit	Up river Limit	Distance @ HiQ [1/]	Direction @ HiQ [1/]	Average RM	Number Contacts	Condition
117	1984.0	1984.4	1982.4	1984.4	0	---	1983.9	85	F09
118	1981.8	1980.0	1978.5	1981.8	0.9	Up	1979.8	5	F09
119	1984.0	1984.0	1937.7	1984.0	12.5	Down	1980.3	20	F09
120	1984.0	1984.0	1975.5	1984.0	2.5	Down	1982.9	21	F09
121	2043.7	1982.5	1982.5	2043.7	14.2	Down	2021.9	7	F09
122	1982.5	1978.3	1978.3	1982.5	0	---	1980.0	5	F09
123	1984.0	1984.3	1939.8	1984.3	39.6	Down	1981.1	49	F09
124	2031.4	2020.3	2020.3	2053.3	21.1	Up	2039.0	19	F09
125	2031.4	2026.2	2026.2	2032.2	2.5	Down	2030.6	26	F09
126	2025.5	2053.6	2019.5	2053.6	23.4	Up	2034.2	10	F10
127	2025.5	2054.0	2031.3	2054.0	22.7	Up	2035.2	14	F10
128	2025.5	2031.4	2025.5	2032.8	7.3	Up	2028.8	10	F10
129	2034.5	2044.0	2019.6	2044.0	14.9	Down	2030.4	10	F10
130	2034.5	2048.0	2003.3	2048.0	40.1	Up	2033.9	12	F10
131	2034.5	2029.7	2029.6	2054.0	19.5	Up	2039.2	9	F10
132	2034.5	2049.2	2020.0	2055.0	35	Up	2038.9	11	F10
133	2034.5	2031.4	2031.4	2046.1	8.2	Up	2039.2	6	F10
134	1983.0	1985.8	1918.6	1985.8	61.4	Down	1954.8	16	F10
135	1983.0	1989.9	1983.0	2004.5	17.5	Up	1988.4	11	F10
136	1983.0	1984.0	1984.0	2010.2	15.9	Up	1986.8	22	F10
137	1983.0	1986.7	1925.9	1986.7	56.3	Down	1960.4	18	F10
138	1983.0	2009.9	1933.0	2009.9	0	---	1960.3	14	F10
139	1983.0	1983.9	1919.5	1984.0	51.0	Down	1967.4	36	F10
140	1978.8	2029.6	1919.5	2029.6	64.5	Up	1954.4	19	F10
141	1970.0	1972.0	1913.6	1972.0	56.9	Down	1937.2	16	F10
142	1982.9	1995.5	1970.5	1995.5	13.5	Down	1982.1	13	F10
143	1978.8	2026.3	1925.0	2026.3	45.5	Up	1972.6	25	F10
144	1916.0	1960.9	1914.7	1960.9	13.3	Up	1919.6	7	F10
147	1921.0	1914.0	1914.0	1923.0	4.7	Down	1920.7	9	F10
148	1921.0	1917.3	1911.0	1921.0	10	Down	1917.4	8	F10
149	1926.7	1944.2	1911	1944.2	15.7	Down	1928.4	13	F10
150	1926.7	1936.5	1936.5	2051.1	124.4	Up	1983.8	14	F10
151	1925.6	2031.4	1922.6	2031.4	47.9	Up	1957.9	11	F10
152	1925.6	2031.4	1925.6	2031.4	63	Up	1963.7	14	F10
153	1926.7	1936.7	1918.5	1936.7	7.4	Down	1922.0	24	F10
154	2034.5	2023.4	2022.2	2053.2	28.9	Up	2033.9	12	F10
155	2031.4	2031.4	2027.6	2032.2	4.6	Up	2030.4	12	F10

Appendix 18. (continued)

Code	Start RM	End RM	Down river Limit	Up river Limit	Distance @ HiQ [1/]	Direction @ HiQ [1/]	Average RM	Number Contacts	Condition
149.7/48	2049.8	2054.2	2049.8	2054.2	1.7	Down	2052.1	7	M08
149.7/60	2050.2	2050.3	2049.3	MA 3.0	6.2*	Up	2051.6	15	M08
149.7/66	1939.0	1926.8	1926.8	1949.8	11.5	Down	1938.0	11	F08
149.7/67	1930.9	1929.3	1939.3	1931.1	---	---	1930.3	5	F08
149.7/79	1933.6	1940.2	1933.6	1940.2	3.9	Up	1937.4	10	F08
149.7/80	2031.4	2048.3	2031.4	2048.3	16.7	Up	2039.2	9	M08
149.7/81	2046.2	2046.1	2046.0	2046.3	0.3	Down	2046.2	8	M08
149.7/82	1929.3	1928.4	1928.3	1929.3	0.5	Down	1928.6	8	F08
149.7/87	2043.0	2031.4	2028.6	2043.0	8.4	Down	2032.3	10	IF09
149.7/88	2029.9	2022.2	2022.2	2034.2	9.2	Down	2030.1	9	IF09
149.7/90	1984.0	1984.2	1918.9	1984.2	51.6	Down	1967.6	19	IF09
149.7/92	1984.0	1982.8	1977.4	1984.0	6.6	Up	1983.0	15	IF09
149.7/93	1932.0	1932.5	1914.3	1932.5	17.1	Down	1927.3	8	IF09
149.7/94	1984.0	1986.8	1981.3	1986.8	2.1	Up	1984.0	60	IF09
149.7/95	1982.3	1996.5	1982.3	1996.5	3.7	Up	1984.5	16	IF09
149.7/96	2021.7	2020.4	2020.4	2053.2	13.7	Up	2041.6	14	IF09
149.8/1	1927.7	1926.7	1926.7	2074.3	31.2	Down	2003.3	25	M06
149.8/2	2055.1	1924.5	1919.5	2055.1	1.4	Down	2012.7	20	F09
149.8/3	1936.9	1935.6	1935.2	1936.9	1.3	Down	1935.9	9	F09
149.8/35	2023.9	2023.5	2023.5	2033.5	10	Up	2025.1	7	M08
149.8/41	2031.4	2024.2	2024.2	2068.2	0.2	Up	2040.2	8	F08
149.8/42	2031.4	2031.4	2031.4	2051.3	1.1	Down	2048.1	16	F08
149.8/43	1929.7	1919.4	1919.2	1930.9	11.7	Down	1926.0	11	F08
149.8/44	2031.4	2001.7	2001.7	2031.4	15.9	Down	2024.3	8	M08
149.8/46	1970.0	1969.8	1969.8	1970.0	---	---	1969.9	3	F08

1/ Denotes the maximum miles traveled during high water period May 1 to July 5.
2/ Female, mature in 2006
3/ Male, mature in 2006
4/ Female mature in 2008
5/ Immature eggs present, may be mature following year
* Entered Marias River or confluence area during high-water period

Appendix 19. A list of radio tagged shovelnose sturgeon spawners monitored during June and July, 2010, in the middle Missouri River.

Code	Location	Period	SEX	Rivermile Range	Numer Contacts
17	Robinson	6-Jul – 15-Jul	M	1915.6-1916.2	5
23	Robinson	13-Jul–14-Jul	M	1924.8-1928.7	2
43	Robinson	29Jun-14-Jul	F	1919.2-1929.2	3
46	Robinson	30Jun - 7-Jul	M	1914.7-1917.9	3
63	Robinson	29Jun-14-Jul	M	1915.8-1930.0	6
147	Robinson	6-Jul – 15-Jul	F	1917.6-1918.5	6
148	Robinson	14-Jul	F	1915.6	1
149	Robinson	29Jun-14-Jul	F	1921.1-1933.3	10
153	Robinson	29Jun-14-Jul	F	1918.7-1919.4	11
7-48	Loma	30-Jun	M	2051.6	1
7-60	Loma	30Jun -15-Jul	M	2049.8-2051.6	5
8-1	Loma	29-Jun	M	2032.2-2032.5	2
8-16	Loma	30Jun - 6-Jul	F	2038.2-2050.2	2
8-20	Loma	28Jun-15-Jul	F	2049.2-2049.8	6
37	Loma	30-Jun	M	2036.7	1
38	Loma	28-Jun	F	2051.6-2051.7	2
40	Loma	28Jun-15-Jul	F	2051.1-2054.5	10
51	Loma	28Jun-6-Jul	M	2050.1-2051.3	5
94	Loma	14Jul-15-Jul	F	2047.6-2047.7	2
126	Loma	30-Jun	F	2042.9	1
128	Loma	29-Jun	F	2027.0	1
130	Loma	30Jun-14-Jul	F	2043.1-2046.0	2
150	Loma	28Jun-30-Jun	F	2044.5-2051.1	2
154	Loma	28Jun-29-Jul	F	2051.1-2053.2	3

Appendix 20. Individual locations and habitat use of Robinson Bridge shovelnose sturgeon monitored during the spawning period, 2010.

DATE	CODE	SEX	RM	Macro habitat	Meso habitat	TEMP	DEP	SUB
7/6	17	M-06	1915.6	OSB-isl	m. isl	62.8		
7/8	17	M-06	1916.2	OSB-isl	sub bar	62.7		
7/13	17	M-06	1916.1	OSB-isl	sub bar	69.5		
7/14	17	M-06	1916.2	OSB-isl	sub bar	65.6		
7/15	17	M-06	1916.0	OSB-isl	sub bar	64.6	12.8	sand
7/13	23	M-06	1924.8	CHXO-isl	s. isl	69.2	4.9	sand
7/14	23	M-06	1928.7	ISB-bar	surf bar	63.9	3.5	gravel
6/29	43	GF-08	1929.2	CHXO-isl	s. isl			
7/6	43	GF-08	1919.2	OSB	BP/sub B	62.8		
7/14	43	GF-08	1926.3	TRM	L. isl	64.2		
7/7	46	M-07	1914.7	OSB	BP	62.1		
6/30	46	M-07	1917.9	CHXO	BP/sub B		14.1	gravel
6/30	46	M-07	1917.9	CHXO	BP/sub B		14.1	gravel
6/29	63	M-07	1923.6	CHXO-isl	BP/m. isl			
6/30	63	M-07	1922.2	OSB	BP			
7/6	63	M-07	1915.8	OSB-isl	m. isl	62.8		
7/8	63	M-07	1916.1	OSB-isl	m. isl	62.7		
7/13	63	M-07	1928.5	SCC	s. isl	68.4	5.0	gravel
7/14	63	M-07	1930.0	CHXO-isl	L. isl	63.9		
7/6	147	GF-10	1918.3	CHXO	sub bar	62.8	9.7	sand
7/7	147	GF-10	1918.5	CHXO	sub bar	61.4	8.5	sand
7/8	147	GF-10	1918.3	CHXO	sub bar	62.7	11.9	sand
7/13	147	GF-10	1917.5	TRM	sub bar	69.5	7.6	gravel
7/14	147	GF-10	1917.4	TRM	sub bar	65.6	8.6	gravel
7/15	147	GF-10	1917.5	TRM	sub bar	64.9	8.3	gravel
7/14	148	GF-10	1915.3	OSB	margin	65.6	12.2	gravel
6/29	149	GF-10	1922.2	OSB	BP		8.5	sand
6/29	149	GF-10	1922.2	OSB	BP		8.5	sand
6/29	149	GF-10	1921.1	OSB	BP		10.3	sand
6/30	149	GF-10	1923.1	CHXO-isl	m. isl		10.3	sand
6/30	149	GF-10	1923.1	CHXO-isl	m. isl		10.3	sand
6/30	149	GF-10	1923.4	CHXO-isl	m. isl		8.4	sand
7/7	149	GF-10	1932.9	CHXO-bar	sub bar	62.2	10	cobble
7/7	149	GF-10	1932.9	CHXO-bar	sub bar	63.5	10	cobble
7/14	149	GF-10	1933.3	CHXO	sub bar	63.9	7	gravel
7/14	149	GF-10	1933.3	CHXO	sub bar	66.7	7	gravel
6/29	153	GF-10	1918.7	CHXO	sub bar		9.6	sand
6/29	153	GF-10	1918.7	CHXO	sub bar		9.6	sand
6/29	153	GF-10	1918.6	CHXO	sub bar		10.1	sand
6/30	153	GF-10	1918.6	CHXO	sub bar		11.0	sand
6/30	153	GF-10	1918.6	CHXO	sub bar		11.0	sand
6/30	153	GF-10	1918.6	CHXO	sub bar		11.6	sand
7/6	153	GF-10	1918.7	CHXO	sub bar	62.8	9.6	sand
7/7	153	GF-10	1918.6	CHXO	sub bar	61.7	9.4	sand
7/8	153	GF-10	1918.5	CHXO	sub bar	62.7	9.8	sand
7/13	153	GF-10	1919.2	OSB	BP	69.5	14.0	sand
7/14	153	GF-10	1919.4	OSB	BP	65.6	7.6	cobble

Appendix 21. Individual locations and habitat use of Loma shovelnose sturgeon monitored during the spawning period, 2010

DATE	CODE	SEX	RM	Macro habitat	Meso-habitat	TEMP	DEP	Substrate
6/30	7-48	M-08	2051.6	OSB	L. isl/sub B	63.2	6.2	sand
7/6	7-60	M-08	2050.2	OSB	Rip Rap	59.9	9.7	gravel/cobble
7/13	7-60	M-08	2049.8	OSB	Rip Rap	64.9	5.3	gravel
7/14	7-60	M-08	2049.8	OSB	Rip Rap	60.3	9.3	gravel
7/14	7-60	M-08	2049.9	OSB	Rip Rap	62.6	5.1	gravel
7/15	7-60	M-08	2050.3	OSB	Rip Rap/m.isl	60.8	2.0	gravel
6/29	8-1	M-06	2032.2	CHXO	margin	65.7	7.6	gravel/cobble
6/29	8-1	M-06	2032.5	CHXO	BP	65.7	7.8	small cobble
6/30	8-16	GF-10	2038.2	TRM	sub b	65.0	10.2	cobble
7/6	8-16	GF-10	2050.2	OSB	Rip Rap/m. isl	59.9	6.7	gravel
6/28	8-20	GF-10	2049.8	ISB	Rip Rap	65.3	6.1	gravel/cobble
6/29	8-20	GF-10	2049.8	ISB	Rip Rap	62.9	3.7	sand/gravel
6/30	8-20	GF-10	2049.2	CHXO	margin	63.2	7.8	large cobble
7/14	8-20	GF-10	2049.3	CHXO	margin	60.4	4.7	gravel
7/14	8-20	GF-10	2049.3	CHXO	margin	62.6	4.4	gravel
7/15	8-20	GF-10	2049.3	CHXO	margin	61.2	4.9	gravel/cobble
6/30	37	M-06	2036.7	TRM	BP	65.0	5.2	gravel/cobble
6/28	38	GF-06	2051.6	OSB	BP/sub b	65.7	5.7	gravel
6/28	38	GF-06	2051.5	OSB	BP/sub b	65.3	6.4	gravel
6/28	40	GF-07	2054.5	ISB	BP/med. Isl	65.0	2.5	gravel/sand
6/28	40	GF-07	2054.5	ISB	BP/med. Isl	65.3	8.8	
6/30	40	GF-07	2053.3	OSB	BP/sm. Isl	63.2	8.3	gravel/cobble
7/6	40	GF-07	2051.3	ISB	BP	59.7	5.3	sand
7/6	40	GF-07	2051.3	ISB	BP	60.3	5.6	sand
7/13	40	GF-07	2051.4	ISB	BP	64.6	4.7	gravel
7/13	40	GF-07	2051.3	ISB	BP	65.3	3.9	gravel
7/14	40	GF-07	2051.2	ISB	BP	60.3	6.0	gravel/cobble
7/14	40	GF-07	2051.4	ISB	BP	62.9	3.5	gravel
7/15	40	GF-07	2051.1	ISB	BP	60.8	2.4	gravel/cobble
6/28	51	M-07	2051.3	ISB	BP	67.1	3.0	gravel
6/29	51	M-07	2051.3	ISB	BP	62.5	3.3	gravel
6/30	51	M-07	2053.2	OSB	BP/s. Isl	63.2	8.3	gravel/cobble
7/6	51	M-07	2050.6	CHXO	sub bar	59.7	7.7	gravel
7/6	51	M-07	2050.1	OSB	Rip Rap /m. isl	60.3	9.3	gravel/cobble
7/14	94	GF-08	2047.7	CHXO	mid chnl	59.7		
7/15	94	GF-08	2047.6	CHXO	mid chnl	61.5		
6/30	126	GF-10	2042.9	CHXO	Rip Rap/m. isl	65.0	6.2	gravel
6/29	128	GF-10	2027.0	CHXO	BP/m. Isl	65.7	6.0	cobble
6/30	130	GF-10	2043.1	CHXO	m. isl/sub bar	64.3	4.7	
7/14	130	GF-10	2046.0	CHXO	margin	60.1	5.8	gravel
6/28	150	GF-10	2051.1	ISB	BP	66.4	11.4	gravel
6/30	150	GF-10	2044.5	OSB	BP	64.3	14.0	
6/28	154	GF-10	2051.1	ISB	BP	66.4	5.5	gravel
6/28	154	GF-10	2051.5	OSB	BP/sub b	65.3	5.7	gravel
6/29	154	GF-10	2053.2	OSB	BP/s. Isl	62.2	6.5	gravel

Appendix 22. Larval fish samples collected with ½ meter nets at sites where radio shovelnose sturgeon spawners were located, middle Missouri River, MT, 2010.

DATE	Location	River Mi.	TIME	Total No Larvae	Ttl Sturg Larvae	Ttl Sturg Eggs
15-Jul	Jones I.	1915.9	850	10	9	0
22-Jul	Jones I.	1915.9	902	8	2	0
14-Jul	Duval Cr.	1917.3	920	16	9	0
15-Jul	Duval Cr.	1917.3	810	4	4	0
22-Jul	Duval Cr.	1917.3	943	3	1	0
7-Jul	King Flat	1918.6	908	0	0	0
14-Jul	2-calf I.	1925.9	1040	3	3	1
13-Jul	2-calf I.	1926.7	2020	3	0	0
22-Jul	2-calf I.	1926.7	1028	2	0	0
8-Jul	2-calf I.	1926.8	954	0	0	1
7-Jul	2-calf I.	1927.0	1920	2	0	0
13-Jul	2-calf I.	1927.2	2048	4	1	0
6-Jul	B.Tree I.	1928.3	2017	1	1	1
7-Jul	B.Tree I.	1928.5	1108	0	0	0
14-Jul	B.Tree I.	1928.6	1145	3	3	0
8-Jul	Grand I.	1930	1037	0	0	0
14-Jul	Grand I.	1930	1230	4	2	0
22-Jul	Grand I.	1930	1059	5	1	0
6-Jul	Grand I.	1930.1	1945	0	0	0
7-Jul	Heller Rpds.	1932.9	2002	0	0	0
14-Jul	Heller Rpds.	1933	2105	0	0	0
22-Jul	Heller Rpds.	1933	1137	1	0	0
14-Jul	Heller Rpds.	1933.6	2040	7	6	0
26-Jul	Red Flame	2047.6	1615	2	0	0
26-Jul	Red Flame	2047.6	1642	1	0	0
13-Jul	Archer I.	2049.7	1630	0	0	0
14-Jul	Archer I.	2050	1150	0	0	0
15-Jul	Archer I.	2050	945	0	0	0
14-Jul	Archer I.	2050.2	1830	0	0	0
27-Jul	Archer I.	2050.2	1148	1	0	0
27-Jul	Archer I.	2050.3		2	0	0
27-Jul	Loma Bridge	2052.6	1218	2	0	0
30-Jun	Woods Bar	2053	910	1	0	0
30-Jun	Woods Bar	2053		0	0	0
30-Jun	Woods Bar	2053		0	0	0
Totals				**85**	**42**	**3**

Appendix 23. Composition, catch rate (number/net) and sizes (inches/pounds) of fish species sampled with trammel nets in the Marias River, 2010.

		Number		Avg.	Length		Avg.	Weight	
	Spp.	**Sampled**	**CPUE**	**Length**	**Min.**	**Max**	**Weight**	**Min.**	**Max.**
6-May	Shorthead redhorse	55	11.0	16.6	13.6	20.0	1.85	0.84	3.43
5 sets	Smallmouth bass	3	0.6	11.0	10.1	12.1	0.72	0.52	0.96
	Mountain whitefish	2	0.4	12.7	12.3	13.1	0.86	0.75	0.97
	Walleye	1	0.2	---	16.5	---	---	1.43	---
	White sucker	15	3.0	15.4	13.5	18.2	1.73	1.10	2.52
26-May	Blue sucker	2	0.5	29.3	28.6	30.0	8.13	7.06	9.19
4 sets	Goldeye	10	2.5	12.5	12.0	13.2	0.58	0.48	0.70
	River carpsucker	75	18.7	20.2	14.2	24.0	4.02	1.91	7.45
	Shorthead redhorse	26	6.5	16.5	14.1	19.3	1.87	1.02	2.88
	Smallmouth bass	1	0.2	---	10.6	---	---	0.68	---
	Smallmouth buffalo	1	0.2	---	24.2	---	---	8.34	---
10-11 June	Bigmouth buffalo	1	0.1	---	32.5	---	---	---	---
6 sets	Channel catfish	3	0.5	16.2	14.0	18.1	1.38	0.89	1.74
	Common carp	1	0.1	---	18.3	---	---	3.80	---
	Goldeye	12	2.0	12.8	12.2	13.4	0.66	0.56	0.84
	Mountain whitefish	2	0.3	13.5	13.4	13.6	1.10	1.06	1.14
	River carpsucker	9	1.5	20.9	16.8	23.4	4.26	2.50	6.42
	Sauger	1	0.1	---	16.8	---	---	1.29	---
	Shorthead redhorse	4	0.6	15.0	14.3	15.9	1.33	1.19	1.57
	Shovelnose sturgeon	4	0.6	31.8	29.2	33.8	6.18	4.66	7.55
14-June	Goldeye	7	2.3	12.4	11.9	13.3	0.58	0.48	0.67
3 sets	Longnose sucker	3	1.0	14.2	13.0	15.2	1.39	1.08	1.59
	River carpsucker	16	5.3	20.3	16.9	22.3	4.54	2.10	6.17
	Shorthead redhorse	8	2.6	16.1	12.5	19.9	1.74	0.70	2.70
21-June	Blue sucker	1	0.3	---	32.4	---	---	15.01	--
3 sets	Goldeye	2	0.6	13.2	13.1	13.2	0.63	0.62	0.64
	Longnose sucker	2	0.6	16.1	15.3	16.9	1.73	1.65	1.80
	River carpsucker	9	3.0	21.1	17.5	23.5	4.83	2.32	7.60
	Sauger	2	0.6	16.8	14.1	19.5	1.37	0.67	2.06
	Shorthead redhorse	12	4.0	15.3	12.8	17.0	1.44	0.87	2.21
	Smallmouth buffalo	1	0.3	---	23.0	---	---	6.42	---

Appendix 23. (continued)

	Spp.	Number Sampled	CPUE	Avg. Length	Length		Avg. Weight	Weight	
					Min.	Max		Min.	Max.
28-29 June	Blue sucker	4	0.8	26.9	23.8	33.6	5.89	3.38	10.50
5 sets	Channel catfish	3	0.6	14.1	12.2	16.9	0.86	0.50	1.50
	Common carp	1	0.2	---	19.7	---	---	3.50	---
	Flathead chub	2	0.4	8.5	7.9	9.0	0.18	0.14	0.22
	Goldeye	5	1.0	11.7	11.2	12.3	0.48	0.40	0.54
	Longnose sucker	1	0.2	---	15.7	---	---	1.68	---
	River carpsucker	20	4.0	19.1	14.8	22.7	3.41	1.50	6.25
	Sauger	5	1.0	11.7	10.3	13.5	0.43	0.30	0.68
	Shorthead redhorse	48	9.6	14.6	10.2	19.1	1.28	0.32	2.80
	Walleye	2	0.4	21.9	15.4	28.3	4.56	0.91	8.21
	White sucker	1	0.2	---	13.8	---	---	1.11	---
27-July	Blue sucker	1	0.2	---	20.0	---	---	1.94	---
5 sets	Channel catfish	7	1.4	13.4	12.0	15.3	0.64	0.52	1.00
	Goldeye	2	0.4	12.6	12.6	12.6	0.56	0.52	0.60
	Mountain whitefish	1	0.2	---	14.3	---	---	1.26	---
	Sauger	11	2.2	11.7	10.3	13.4	0.42	0.29	0.62
	Shorthead redhorse	6	1.2	14.3	10.6	18.3	1.11	0.42	1.91
	Shovelnose sturgeon	5	1.0	31.3	30.7	33.4	5.44	4.88	7.40
	Smallmouth buffalo	1	0.2	---	21.4	---	---	5.10	---
	Walleye	1	0.2	---	9.0	---	---	0.23	---
	White sucker	2	0.4	9.6	9.4	9.8	0.35	0.34	0.36

[a] Vehicle relocations
[b] Searched for pallid and shovelnose sturgeon only (AM/PM movement patterns)

Appendix 24. Average trawling catch rate (number/tow) for fish sampled in the lower Marias and middle Missouri River, 2010.

	Fort Benton	**Marias River**	**Coal Banks**	**Robinson Bridge**	**CK Creek**	**Totals**
Black crappie	---	---	---	T	---	1
Channel catfish-yoy	0.3	---	T	1.1	2.2	181
Channel catfish-jv	---	---	---	T	T	5
Emerald shiner	---	0.4	---	T	T	8
Flathead chub	---	0.7	0.1	0.1	0.7	52
Goldeye-yoy	---	---	---	---	T	2
Longnose dace	3.2	21.5	0.5	---	T	186
Longnose sucker-jv	---	0.1	---	---	---	1
Mottled sculpin	---	---	T	---	---	1
Pallid sturgeon-jv	---	---	---	0.2	T	20
Sauger-yoy	---	---	---	T	---	1
Shorthead redhorse-jv	0.3	---	---	T	---	2
Shorthead redhorse-yoy	7.8	0.1	1.8	T	---	99
Shovelnose sturgeon	---	---	---	---	T	1
Sicklefin chub	---	---	---	1.1	1.2	136
Smallmouth bass-yoy	---	0.1	0.3	---	---	9
Spottail shiner	---	0.1	0.1	T	T	7
Stonecat	0.3	0.2	T	0.1	T	20
Sturgeon chub	---	---	---	0.4	0.1	35
Unidentified	---	---	---	0.1	---	9
Total catch	70	165	78	264	200	776
Total trawl tows	6	7	26	74	43	156
Avg. depth (ft)	4.8	2.4	4.6	7.3	5.9	

Appendix 25. Endangered Species Act Compliance rules.

In brief, to comply with the Endangered Species Act, an evaluation of the affects of any discretionary federal action must be conducted by the action agency in conjunction with informal consultation with the Fish and Wildlife Service. For minor activities, this can be limited to verbal communication. For a larger or more complex action, or for any major construction activity as defined, the action agency is required to prepare a biological assessment. The biological assessment describes the action and evaluates the affect to each species that may be present in the action area by comparing the current condition of the population and habitat to what it is expected to occur during and following the action. A determination is limited to either “no affect,” which equates to no effect at all, positive, negative, or neutral, or to “may affect,” which equates to any effect, positive, negative, or neutral. “May affect” can be further qualified with a determination of ‘likely to adversely affect’ or ‘not likely to adversely affect.’ A “may affect and is likely to adversely affect” determination triggers formal consultation with the Fish and Wildlife Service. A determination of “may affect and not likely to adversely affect” can be addressed with informal consultation with the Fish and Wildlife Service.

Any “may affect” determination triggers formal consultation which may result in either a “not likely to adversely affect” determination or issuance of a biological opinion. Once consultation is requested, the Fish and Wildlife Service has 90 days to render a biological opinion and an additional 45 days to write the biological opinion. The Fish and Wildlife Service usually prepares a draft biological opinion. The period of time that the draft is under review does not count toward the 135 days. Consultation is between the action agency, an applicant if there is one, and the Fish and Wildlife Service. If there is an affect on tribal lands or waters, the tribes must be consulted.

If the Fish and Wildlife Service determines that the proposed action will jeopardize the continued existence of the species by appreciably reducing the likelihood of both survival and recovery of the species in the wild by further reducing its number, reproduction, or distribution (the jeopardy threshold), they prepare a biological opinion which must contain a reasonable and prudent alternative. A reasonable and prudent alternative must be within the jurisdiction of the action agency, technologically and economically feasible, consistent with the original intended purpose of the project, and one that the Fish and Wildlife Service believes will remove jeopardy. The biological opinion must also contain an “incidental take” statement if any take is expected to occur, reasonable and prudent measures, and terms and conditions designed to reduce take and address adverse modification of designated critical habitat. The biological opinion can contain conservation measures, conservation recommendations, and other topics as well. Once the action agency receives the draft biological opinion, they may choose to share the document with other stakeholders (see March 1988 Consultation Handbook, Fish and Wildlife Service).