Progress Report
MIDDLE MISSOURI RIVER FISHERIES MONITORING, MITIGATION AND ENHANCEMENT STUDIES 2016
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ABSTRACT

This report includes information for 2016 fisheries monitoring on the 239-mile reach of the Missouri River between Great Falls, Montana and Fort Peck Reservoir. Spring run-off reached 14,000 cfs but a peak flow of 17,000 cfs was recorded in October. Sampling conditions were generally good and flows were usually below the median. In 2016, 20,101 fish were sampled in five survey sections representing 43 of the 50 fish species known to occur in this area. The study design relied on five sampling techniques; electrofishing, seining, trammel netting, set lining and trawling to sample a variety of Missouri River fish communities. Age information from 2014 – 2016 for Sauger and Walleye and from 2016 for Smallmouth Bass is included in this report.

During electrofishing surveys, 10,079 fish were captured. Channel catfish (*Ictalurus punctatus),* Sauger *(Sander canadense)* and Smallmouth Bass *(Micropterus dolomieu)* were the most abundant game fish with more than 400 individuals captured. A total of 206 walleye *(Sander vitreus)* were caught. Smallmouth Bass and Walleye catch rates (CPUE) were at near record highs. Black Crappie *(Pomoxis nigromaculatus)* and Northern Pike *(Esox lucius)* had above average catch rates that were similar to those observed in 2015. Shorthead Redhorse (*Moxostoma macrolepidotum)* and Goldeye (*Hiodon alosoides)* continued to be the most common non-game fish in the study area. Shorthead Redhorse were 41% and Goldeye, 21% of the catch. In the early 2000's, many native species experienced declines associated with low water conditions. River Carpsucker, Goldeye and Freshwater Drum were at record lows in 2007 – 2008 but rebounded to record highs in 2015 - 2016.

In 2016, standardized trammel netting was completed in the Fort Benton, Coal Banks and Robinson Sections. A Shovelnose Sturgeon population estimate was conducted near Coal Banks. Standard and estimate drift nets captured 2,775 fish representing 17 species. There were 1,174 Shovelnose Sturgeon (9.9/drift) sampled during the Coal Banks estimate. The Shovelnose Sturgeon population has declined near Coal Banks since the mid-2000's. The Schnabel estimate was 604/mile in 2016 compared with 1,242 and 1,310 per mile in 1995 and 2005. Pallid Sturgeon were not caught during the previous Coal Banks estimates but 0.3 per drift were caught in 2016. In the Robinson Section, Pallid Sturgeon CPUE declined and Shovelnose Sturgeon CPUE was the highest observed since 2013.

Setlines captured 435 fish in 2016. Pallid Sturgeon, a federal Endangered Species, had the highest CPUE at 1.2/set, followed by Goldeye. Seines captured 5,467 fish, which was about 50% of the 2015 catch. Emerald Shiner *(Notropis atherinoides)* at 27%, and White Sucker *(Catostomus commersoni)* at 19%, were the most common species. Western Silvery Minnow *(Hybognathus argyritis)* had the lowest catch rates observed since 1999. An Iowa Darter *(Etheostoma exile)* was captured in the Fort Benton Section. This was the first specimen caught in over a decade. Most fish species captured in seines exhibited strong longitudinal trends along the river corridor. *Catostomid sp*. and Smallmouth Bass were most common in the upstream sections, while Flathead Chub *(Platygobio gracilis)* increased in abundance downstream. Channel Catfish, Stonecat (*Noturus flavus)* and Sturgeon Chub *(Macrhybopsis gelida)* were the most common species sampled with the beam trawl in the Robinson Section in 2016. Four YOY Shovelnose Sturgeon were caught during trawling. This is the highest number captured since the 2011 flood.

In 2016, endangered fish species and Montana Species of Special Concern captured included, 58 Blue Sucker (*Cycleptus elongatus*), 224 Pallid Sturgeon, 663 Sauger, 107 Sturgeon Chub and 31 Sicklefin Chub *(Macrhybopsis meeki).*

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ACKNOWLEDGMENTS

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INTRODUCTION

The middle Missouri River supports a diverse warm water fishery and is relatively unaltered compared to the Missouri River downstream. This reach still has a spring pulse, most of the riparian/area and shoreline is protected by special designation and temperatures are adequate for native fish. However, the spring freshet is much smaller and fish migration has been blocked by dams. Water and irrigation management also reduce tributary run-off. The native fish species that historically occurred here are still found in this reach, including the federally listed endangered Pallid Sturgeon (Tews and Gardner 2014). Berg (1981) conducted a baseline inventory of fish populations in the Middle Missouri River over 30 years ago, and concluded the fishery had exceptional aesthetic and recreational values. Today, most of the reach is a Wild and Scenic River, a National Monument or a National Wildlife Refuge. In 2000, PPL was re-issued a 40-year operating license by the Federal Energy Regulatory Commission (FERC) for the company's Great Falls hydroelectric dams located on the Missouri River just upstream of the study area. PPL was required by FERC to develop and implement a comprehensive fish monitoring and evaluation program for the protection, mitigation and enhancement of the fisheries resources in this reach of the Missouri River. PPL contracted with MFWP to conduct this work starting in 2001, to help meet the requirements of PPL's federal operating license (FERC Project 2188) for five dams on the Missouri River in the Great Falls area. The objectives for this project are detailed in five-year fisheries protection, mitigation and enhancement plans which were developed by PPL in cooperation with state and federal resource agencies and approved by FERC. The current agreement is in effect until 2018. The hydroelectric dams were purchased by Northwestern Company (NWE) in 2014. NWE is following the fisheries monitoring and evaluation program previously contracted by PPL. NWE also provides funds for radio telemetry and additional Pallid Sturgeon work in this reach.

OBJECTIVES

1. Monitor the relative abundance of the most common fish species in the Missouri River downstream of Morony Dam.
2. Implement adaptive management practices to mitigate fisheries impacts associated with the operation of the Great Falls dams.
3. Protect and provide for the recovery of threatened and endangered species, and other aquatic species of special concern in the Missouri River below Morony Dam.
4. Provide assistance to the USFWS and MFWP for ongoing evaluation of Pallid Sturgeon in the Missouri downstream of Morony Dam.

DESCRIPTION OF STUDY AREA

The middle Missouri River study area is a 239-mile reach between Great Falls, Montana and Fort Peck Reservoir (Figure 1). The U.S. Bureau of Land Management manages the 148 miles within the Wild and Scenic Missouri River and the Upper Missouri River Breaks National Monument. In addition, 54 miles of the study area are bordered by the CMR National Wildlife Refuge, administered by the USFWS. Four major tributaries enter the Missouri in the study area; the Marias River/Teton River, Judith and Musselshell. The present flow regimen is modified by regulation and storage at several upriver dams (Brummond 2015). For study purposes, the river was divided into five sections (Appendix 1, Appendix 2). Fisheries

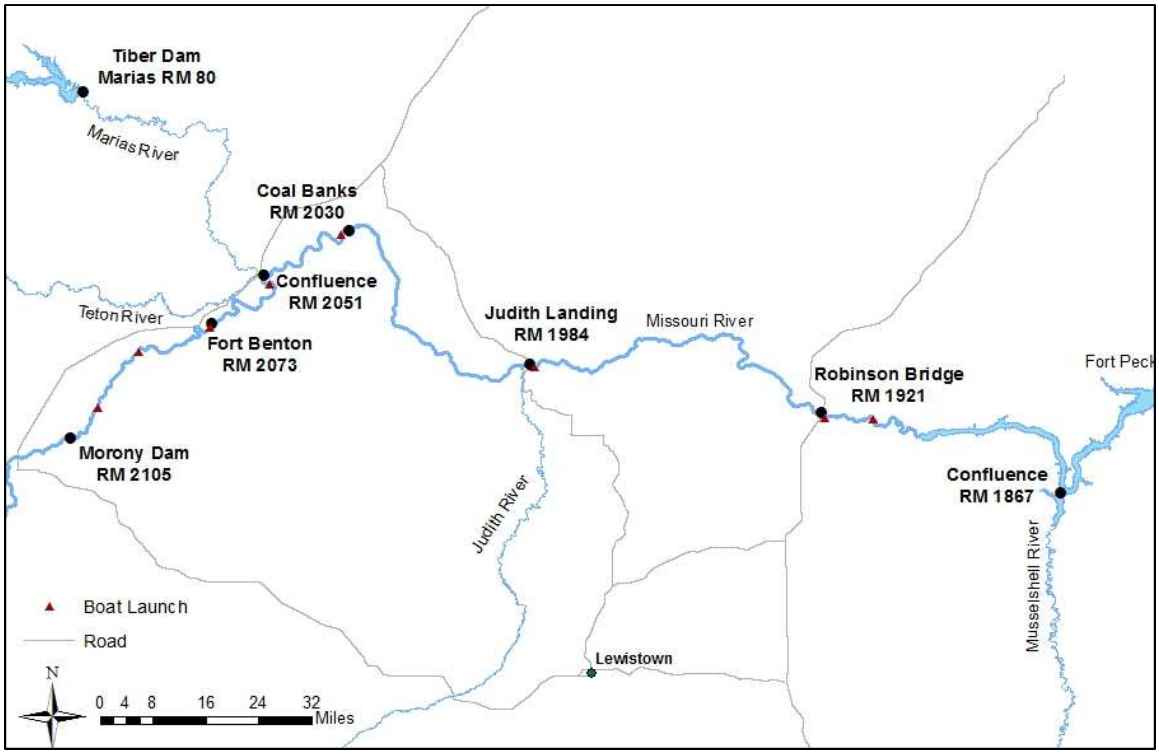

Figure 1. Map of the Middle Missouri study area.

information collected from the 80 miles of the lower Marias River downstream from Tiber Dam is included in this report due to its importance for migratory fish in the Missouri River. The middle Missouri River is generally entrenched within the Missouri River Breaks topography and is contained in a moderate to narrow valley. Habitat characteristics of the study sections are described in Appendix 2.

PROCEDURES

Target fish species were chosen to represent of a variety of habitat and trophic guilds. Game and non-game fish species were used as biological indicators as part of the comprehensive fisheries monitoring and evaluation program for the protection, mitigation and enhancement of the fisheries resources in the middle Missouri River. Twenty target species were divided into groups based on life cycle guilds and sampling method (Table 1). These groups were; shallow water game fish, shallow water non-game fish, deep water large fish, deep water small fish and shallow water small fish. Small fish consisted of minnows and age-0 fish. Five sampling methods were used to sample these fish communities (Table 2). Fall electrofishing sampling was completed in 6-mile trend areas to evaluate adult fish populations in shallow water habitats (Appendix 1). Trammel drift netting was used to sample sturgeon in deep water habitats. Long lines (set lines) were used to sample fish near large woody debris. Summer seining was used in the shallow river habitats to evaluate the juvenile fish and the cyprinid portion of the fish communities. The seining protocol was revised in 2013 to provide from comparable sampling between years and staff (Appendix 3). Finally, small fish in deep-water habitats were sampled with a benthic trawl. To facilitate data analysis, only information from the more common target species was analyzed in detail and over time to determine if any environmental changes could be tied to these observations.

In 2016, a Shovelnose Sturgeon population estimate, using trammel nets, was conducted between RM 2032.5 and 2039 near Coal Banks Landing. This reach was chosen to match estimates completed in 1995 (Gardner 1996) and 2005 (Gardner 2008). During the first week, sampling locations were chosen to cover the entire section using professional judgment. Random sampling, of 0.1 mile increments with left or right bank, was completed the next two weeks. Selection was without replacement and sub-sampled for upper and lower reaches. Shovelnose Sturgeon were tagged with individually numbered orange cinch up tags. Most Shovelnose Sturgeon were also tagged with 23mm 134.2 kHz HDX PIT tags for a future pilot study to evaluate Shovelnose Sturgeon movements with PIT tag arrays. All Pallid Sturgeon were injected with 125 kHz PIT tags following the standard UFWS protocol (USFWS 2012). August sampling was chosen because Shovelnose Sturgeon are less motile during this period which helped us to meet the assumption of emigration/immigration so a closed population estimate model could be used. All standard drifts completed at Coal Banks in 2016 were done as part of the Shovelnose Sturgeon estimate.

Fish were measured to the nearest 1 mm (fork length for sturgeon and total length for other species), and weighed to the nearest gram. Blue Suckers and Pallid Sturgeon were checked for 125 kHz PIT tags. New PIT 125 kHz tags were installed as needed. A spiny dorsal fin ray was extracted from Sauger *(Sander canadense)*, Walleye *(Sander vitreus)* and Smallmouth Bass *(Micropterus dolomieu)* for aging. See Tews and Gardner 2014 for detailed aging procedures. Sauger age frequency distribution for 20 mm intervals followed the methods of Quist et. al (2012). The black stripe/dot in the caudal peduncle was used to differentiate Sicklefin Chub *(Macrhybopsis meeki)* and Sturgeon Chub *(Macrhybopsis gelida)* in the field. Western Silvery Minnows *(Hybognathus argyritis)* and Plains Minnows *(H. placitus)* were delineated in the field by eye size and body shape (Bramblett 2017). These species were combined as *Hybognathus spp.* during surveys conducted prior to 2012, so long-term comparisons in this report do not separate the two species. Nearly 100% *Hybognathus spp.* from 2012 – 2016 have been identified as Western Silvery Minnow; it is very likely that the vast majority of this genus have consistently been that species. Equations from Neuman et al. (2012) were used to calculate relative weight (Wr). Neely et al. (2008) was used to calculate Blue Sucker Wr. MFWP collected temperature data at four locations on the Missouri, at RM 3.0 on the Marias and at RM 2.3 on the Teton.

RESULTS

In 2016, flows were generally below the daily median and at times were much below the median at the Landusky USGS station just downstream for the Robinson Bridge (Figure 2). In 2016, the maximum discharge occurred in October during fall rains (Figure 2). Discharge in the Marias River was well below the daily median after May 1 (Figure 3) and did not meet MFWP flow recommendations of 550 cfs for most of the year (MFWP 1989). MFWP (1989) developed flow recommendations for four different seasons on the Missouri. In 2016, the recommended high spring discharge was not reached for the first time since 2004. The recommended side channel flow was achieved 38% of the time and base flow from fall through early spring 100% of the time (Figure 4). Daily mean, maximum and minimum temperature data collected by MFWP is listed in Appendix 4. Average monthly water temperatures were generally above average from mid-April – July 2016 with mean August – September temperatures close to average (Appendices 5 – 7). The Robinson Section had a record high June average temperature (Appendix 6).

Electrofishing (shallow water large-fish group)

A total of 10,769 fish of 33 species were sampled by electrofishing in the Middle Missouri River during fall, 2016. See Table 3 and Appendices 8 – 12 for catch rates and size statistics by section. Table 4 compares catch from 2007 – 2016. Table 5 compares average CPUE, length, weight and Wr for 2001 – 2016 with 2016. Overall trends for the Middle Missouri River for nine common species are shown in Figure 5. Long term trends by section including catch rate, average length and Wr of Sauger and Walleye are shown in Figure 6. In 2016, Channel Catfish (*Ictalurus punctatus)* was the most common game species, followed by Sauger and Smallmouth Bass (Table 4). Channel Catfish CPUE was the highest observed since 2013 and the second highest on record (Figure 5) and was above the long-term average in the three upstream sections (Table 5). Channel Catfish had excellent condition with a Wr near 100 in all sections. Mean Channel Catfish total length was similar to the long-term mean.

Sauger

Sauger are a popular native game fish and a Montana Species of Concern. In 2016, the legal harvest was doubled to two fish. Therefore, further analysis of the abundance and ecology of this species is warranted. There appeared to be no immediate impact from the regulation change. In 2016, overall Sauger electrofishing CPUE was well above average and increased or was unchanged from 2015 in all sections. The long-term Sauger CPUE was below average at Robinson, close to average at Morony and above average in the other sections (Table 5). Sauger Wr was above 90 in the Morony Section but below 85 in the other sections. Average, minimum and maximum Sauger length at age are summarized by section in Appendix 13. The oldest Sauger were 10 years old. From 2014 – 2016, age 0 Sauger were only captured in the Judith Landing and Robinson Sections (Appendix 13). This distribution followed the 21st century trend for age 0 Sauger (Tews and Gardner 2014). Average size at age was usually similar throughout the river (Appendix 13), so sections were combined for age frequency analysis (Table 6). Captured Sauger were primarily old fish; from 2012 – 2016 at least 40% of the August – October captures were at least 5 years old (Table 6). Small fish often have low capture efficiency, so it is likely the percentage of small fish listed in Table 6 is much less than in the actual population. Average length of fish at age was usually similar for most years; age 0 fish averaged less than 170 mm, Age 3 about 315 mm and Age 4 about 350 mm. Good reproduction occurred in 2012, 2014 (Table 6) and 2009 (Tews and Gardner 2014). Year class evaluations are confounded by inaccurate age class assignments which may be off by at least a year (Tews and Gardner 2014, Iserman et al. 2007). However, the assigned age classes indicate recruitment of the 2009, 2012 and maybe the 2014, year classes was good. Age 1 Sauger were rarely caught so it takes several years to evaluate Sauger recruitment. This makes it difficult to quickly evaluate harvest and other impacts on the Sauger population.

Non-native game species

Catch rates of non-native shallow water game species have increased in recent years. Walleye CPUE has increased steadily over the last decade (Figure 5) and in 2016 CPUE was above average in all five sections (Table 5). Average total length and Wr declined in all sections from 2015 (Figure 6). Walleye CPUE was a record high in the Fort Benton Section in 2016 (Figure 6). Walleye typically had better condition (Wr) than Sauger (Figure 6). Walleye length at age by section is shown in Appendix 14. Age 0 Walleye were captured in the Coal Banks, Judith Landing and Robinson Sections. The oldest Walleye was 19 years old and 723 mm long. Average Walleye length at age (Appendix 14) was similar to Sauger (Appendix 13) through age 5.

Northern Pike *(Esox lucius)* and Black Crappie *(Pomoxis nigromaculatus)* declined from record highs in 2014 but were still above the long-term average in 2016 (Table 4, Figure 5). Northern Pike were caught at low rates in all sections (Table 3). Smallmouth Bass CPUE from 2014 – 2016 was more than twice that of any previous year (Figure 5). In 2016, Smallmouth Bass CPUE was well above average in the two upstream sections and close to average in the other sections (Table 5). Smallmouth Bass CPUE exhibited a strong linear trend with the highest CPUE in the upstream Morony Section and zero catch at Robinson (Tables 3 and 5). Smallmouth Bass Wr was about average at 120 (Table 5). Smallmouth Bass length at age by section for 2016 is summarized in Appendix 15. The oldest Smallmouth Bass was 8 years old. Fish from age 0 – 5 were caught as far downstream as Judith Landing. Age 0 – 1 fish were typically longer in the Morony and Fort Benton Sections than in the Coal Banks and Judith Landing Sections. Length at age was generally less in 2016 than from 2006 – 2013 (Tews and Gardner 2014).

Native non-game shallow water species

Shorthead Redhorse (*Moxostoma macrolepidotum)* and Goldeye (*Hiodon alosoides)* continued to be the most common non-game fish sampled in the study area (Table 4). Shorthead Redhorse were 41% of the total catch and Goldeye, 21% of the catch. Shorthead Redhorse CPUE was highest in the upstream sections (Table 5). Other common non-game fish were Freshwater Drum *(Aplodinotus grunniens)*, Common Carp *(Cyprinus carpio)*, River Carpsucker *(Carpiodes carpio)*, Longnose Sucker *(Catostomus Catostomus)* and White Sucker *(C. commersoni)*. Minnow species, such as Emerald Shiner *(Notropis atherinoides)* and *Hybognathus sp.* continued to have low catch rates in 2016 (Table 4). In the early 2000's, during a major drought (Figure 4), many native species experienced declines. Fort Peck water level was also low during the drought but filled into the flood pool in 2011 (Figure 4). River Carpsucker, Freshwater Drum and Goldeye had record low CPUE in 2007 – 2008 but rebounded to record highs in recent years (Figure 5). These species had above average CPUE in nearly all sections in 2016 (Table 5).

Trammel net drifting (deep water large fish group).

Trammel net drift sampling was used to evaluate Pallid and Shovelnose Sturgeon population trends. Standard drift netting captured 895 fish representing 17 species (Table 7). Size statistics by section are listed for the Fort Benton and Robinson Sections in Appendices 16 - 17. An additional 786 fish were captured during the Shovelnose Sturgeon population estimate at Coal Banks (Appendix 18). Shovelnose Sturgeon CPUE in the Middle Missouri River, has consistently been highest in the Coal Banks Section and, in 2016, CPUE was the highest observed since 2006 (Figure 7). The high catch rate in 2016, was likely due to only sampling the 6.5 mile population estimate reach near Coal Banks. This reach is known to have a high-density Shovelnose Sturgeon population. During most years, random trammel net sites are chosen throughout the entire 48 mile section (Appendix 2). Shovelnose Sturgeon Wr, was excellent and exceeded 100 in all sections (Figure 7). For the last 15 years, average Shovelnose Sturgeon fork length has consistently been about 50 – 100 mm shorter in the Robinson Section than in the other river sections (Figure 7). In 2016, average fork length followed this trend and was 846 mm long in the Fort Benton Section (Appendix 16), 805 mm in the Coal Banks Section (Appendix 18) and only 713 mm in the Robinson Section (Appendix 17). During standard sampling at Robinson, CPUE for Pallid Sturgeon decreased slightly in 2016 from 1.3 to 1.2 per drift and Shovelnose Sturgeon CPUE increased from 2.2 to 3.1 per drift. Shovelnose CPUE was slightly below average of 3.9 per drift but the highest observed since 2013 (Figure 8).

Table 1. A list of 20 monitored species and their life history status and sampling method used. (Revised from Galat et al. 2005 and Bergsted et al. 2004).

Species	Origin	Habitat use Guild	Trophic Status	Life stage	Monitoring Method	Monitoring Group
Blue Sucker	Native	Fluvial Specialist	Invertivore	Adult	Electrofish/ Trammel net	Deep water
Common Carp	Non-native	Macrohabitat generalist	Invertivore/ Detritivore	Adult	Electrofish	Non game Shallow
Channel Catfish	Native	Macrohabitat generalist	Invertivore/ Carnivore	Age-0/ Adult	Electrofish/ Trawl/Setline	Game fish Shallow
Emerald Shiner	Native	Macrohabitat generalist	Planktivore	Age-0/ Adult	Seine	Non game Shallow
Flathead Chub	Native	Fluvial Specialist	Invertivore	Age-0/ Adult	Seine	Non game Shallow
Goldeye	Native	Fluvial Dependent	Invertivore	Age-0/ Adult	Electrofish/ Seine	Non game Shallow
Hybognathus spp.	Native	Fluvial Dependent	Detritivore	Age-0/ Adult	Seine	Non game shallow.
Longnose Sucker	Native	Fluvial Dependent	Invertivore	Adult	Electrofish	Non game Shallow
Mountain Whitefish	Native	Fluvial Specialist	Invertivore	Adult	Electrofish	Game fish Shallow
Pallid Sturgeon	Native	Fluvial Specialist	Carnivore/ Invertivore	All	Trammel net/ set line	Deep water
River Carpsucker	Native	Fluvial Dependent	Planktivore/ Detritivore	Adult	Electrofish	Non game Shallow
Sauger	Native	Macrohabitat generalist	Carnivore	Age-0/ Adult	Electrofish/ Seine	Game fish Shallow
Shovelnose Sturgeon	Native	Fluvial Specialist	Invertivore	All	Trammel net/ Trawl/set line	Deep water
Shorthead Redhorse	Native	Fluvial generalist	Invertivore	Adult	Electrofish	Non game Shallow
Sicklefin Chub	Native	Fluvial Specialist	Invertivore	Age-0/ Adult	Benthic trawl	Deep water
Smallmouth Bass	Non-native	Macrohabitat generalist	Carnivore	Age-0/ Adult	Seine/ Electrofish	Game fish Shallow
Smallmouth Buffalo	Native	Macrohabitat generalist	Invertivore/ Herbivore	Adult	Electrofish/ Trammel net	Deep water
Sturgeon Chub	Native	Fluvial Specialist	Invertivore	Age-0/ Adult	Benthic trawl	Deep water
Walleye	Non-native	Macrohabitat generalist	Carnivore	Adult	Electrofish	Game fish Shallow
White Sucker	Native	Fluvial Dependent	Invertivore/ Detritivore	Adult	Electrofish	Non game Shallow

Table 2. Annual standard monitoring protocol for the study area. See Tews and Gardner (2014) for details.

	Electrofishing	Trammel netting	Set line	Seining	Beam Trawl
Fish life history (Table 1)	Large shallow water	Large deep water	Large fish near debris such as submerged logs	Small shallow water	Small deep water
Target species	Large species except Sturgeon. All game and 100 non-game fish of each species measured.	Sturgeon	Sturgeon, Channel Catfish	Cyprinids Age 0 fish	Sicklefin Chub Sturgeon Chub
Equipment Details	Smith Root VVP 15 with pulsed CPS or straight DC at 8 – 10 amps; using the 300 or 600 volt setting. Honda 5,000 or 6,500-watt generator; 3/8 in mesh dip net. Metal boat served as the negative. The positive set up consisted of 2 fiberglass booms with 4, 18 in droppers.	150 x 6 ft nets; 1 – 2 inch inner mesh, 10 inch outer mesh; Large floats attached by long ropes at each end.	100 ft lines with 20, 18 inch heavy mono-filament leaders with one hook attached by trotline clips. Hook sizes 3/0l, 2/0 and 1//0. Large weights attached at each end and one float on the inner end.	Beach seine with bag; 50 ft long x 4 feet high with ¼ inch mesh.	Benthic trawl; 6 ft wide x 1.5 ft high rectangular metal frame on skids with an 18 ft long outer chafing net with a 1/8 in inner mesh liner. Boat backed downstream with net off the front of the boat on the bottom.
Sampling Sections	5 sections sampled in fall; alternated sides every mile.	Robinson Section and two other sections	Robinson Section	5 sections; See Appendix 3.	Robinson Section
Site selection	Standard Sites (Appendix 1)	Robinson – Random sites selected RM 1925.3 -1907 with 20 sites from Pallid Sturgeon "hot spots." Other sections; 5 drifts at four random locations, including inside bend, outside bend, and channel crossovers. (Appendix 2)	Random sites selected and stratified by reach (RM 1913.5 – 1930); (RM 1896.9 - 1913.4); (RM 1880-1896.8). 50% were chosen from Pallid Sturgeon "hot spots."	See Appendix 3.	Robinson Section; Random sites chosen from RM1913 – 1883 with 50% upstream of 1899.
Sampling intensity	Sites were about 6 miles long sampled about 10 hours each for 50 hours of VVP time.	50 drifts at Robinson 20 Drifts at other sites. Nets drifted for about 7 minutes; typically 50 – 400 yards.	90 set lines; set for 12 – 20 hours.	100 seine hauls. 20 in each river section for thirty yds each.	100, 2 minute hauls; 3 hauls (left, right and center) at each random location. Typically 150 to 200 yds at 2000 RPMs.
Catch rate	# of fish/hr	# fish/net	# fish/set	# fish/haul	#fish/haul

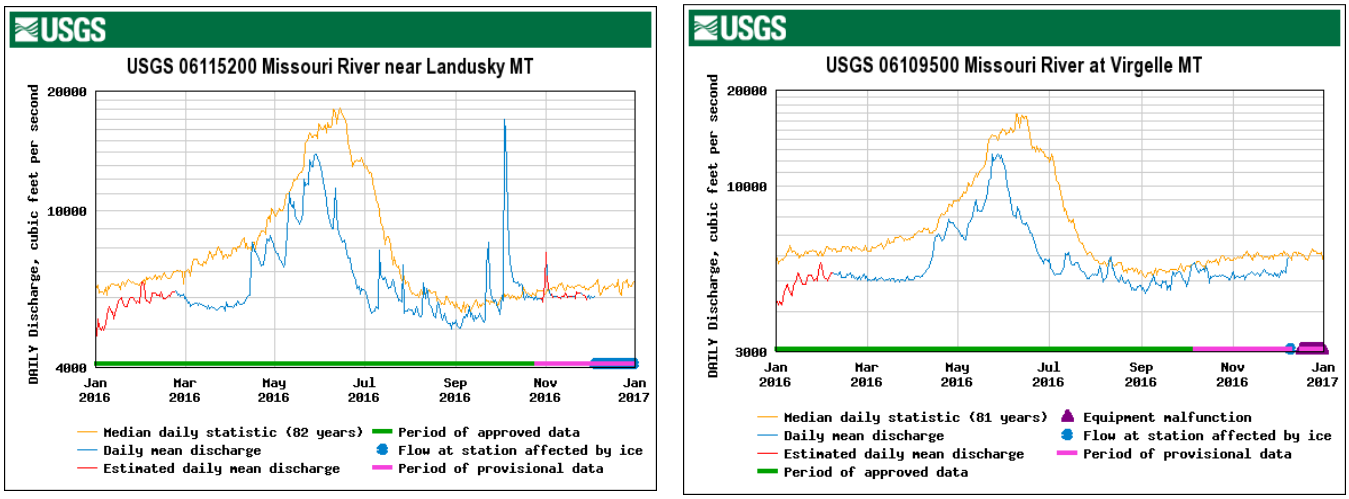

Figure 2. Mean daily flow statistics for 2016 for two locations in the Middle Missouri River compared with median flows, USGS Web interface, 2017.

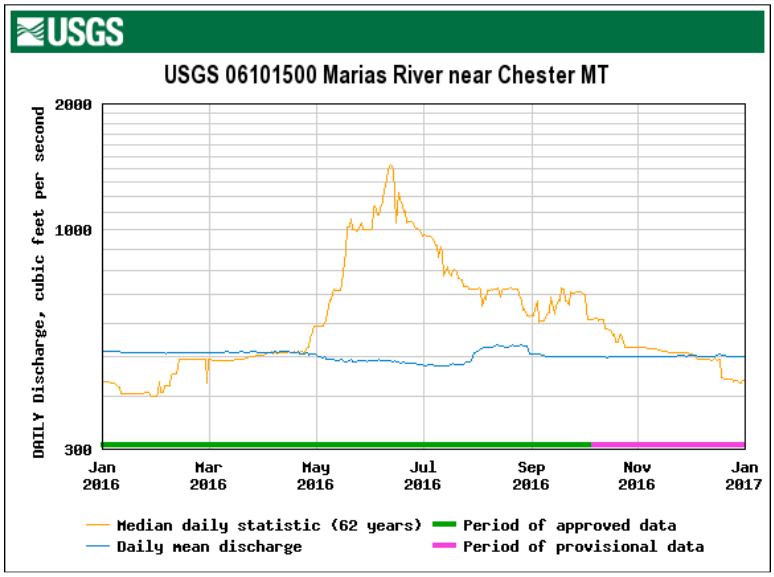

Figure 3. Mean daily flow statistics on the Marias River in 2016 compared with median flows, USGS Web interface, 2017.

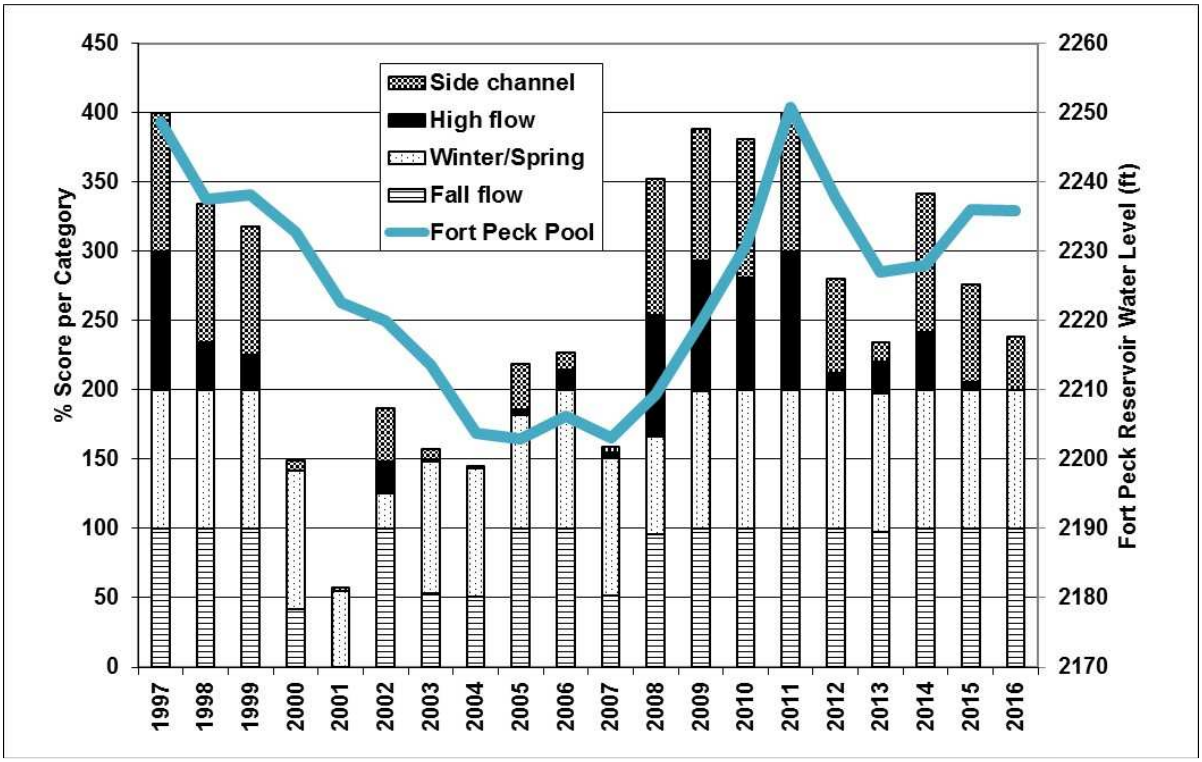

Figure 4. Percent of time Landusky discharge met or exceeded the MFWP requested minimum instream flows, compared with Fort Peck Pool level. Methods described in Tews and Gardner (2014).

Table 3. Average fish catch rates (#/hr) for electrofishing at trend areas in the Middle Missouri River, MT, fall 2016. For fish ≥150 mm. [1]Includes fish <150mm.

Species	Morony	Fort Benton	Coal Banks	Judith Landing	Robinson
Bigmouth Buffalo	0.2		0.1	0.4	0.2
Black Crappie[1]				0.4	3.8
Blue Sucker		0.1	0.1	0.5	0.2
Bluegill				0.2	
Brown Trout	1.4	0.3			
Burbot		0.1		0.2	0.5
Channel catfish	19.2	17.2	5.7	3.5	7.9
Cisco				0.2	3.0
Common Carp	13.6	8.8	5.9	3.9	3.4
Common Carp <150			0.2	0.2	
Emerald Shiner[1]				3.3	0.5
Flathead Chub[1]			0.2	6.7	5.6
Freshwater Drum	11.5	9.4	3.4	3.3	6.8
Goldeye[1]	23.9	37.2	29.2	65.0	45.9
Longnose Sucker	18.1	13.3	2.4	2.3	0.2
Longnose Sucker < 150		0.1	0.1	0.2	
Mountain Sucker[1]	0.3				
Mountain Whitefish	0.3	0.5	0.6		
Mountain Whitefish <150		0.2	0.1		
Northern Pike	0.4	0.8	0.6	0.7	0.4
Pallid Sturgeon				0.1	
Rainbow Trout	2.2				0.1
Pumpkinseed			0.1		
River Carpsucker	3.1	3.6	14.0	11.9	11.8
River Carpsucker<150				0.4	0.1
Rocky Mtn Sculpin[1]	0.2	0.1		0.1	
Sauger	2.8	12.6	8.5	12.7	8.8
Sauger <150					0.1
Shorthead Redhorse	164.3	140.9	45.8	46.8	16.1
Shorthead Redhorse <150		0.2	2.7	15.8	1.0
Shovelnose Sturgeon			0.3	0.1	0.1
Smallmouth Bass	27.1	11.3	2.8	0.7	
Smallmouth Bass <150	0.9	0.4	2.1	1.7	
Smallmouth Buffalo	2.4	0.6	0.4	0.4	0.2
Stonecat[1]	0.6				0.6
Walleye	4.7	5.2	2.6	3.3	3.5
Walleye <150					
Western Silvery Minnow				3.2	0.3
White Crappie			0.1		
White Sucker	8.2	20.1	1.7	0.9	
White Sucker <150	0.1	0.2	0.2		
Yellow perch[1]			0.3	0.1	
Total Fish	2,760	2,765	1,664	2,077	1,503
Hours	9	9.8	12.8	11	12.4

Table 4. Fall electrofishing catch (number of fish) for the 5 combined sections on the Middle Missouri River, 2007 - 2016. [1]Includes fish <150mm.

Species	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Bigmouth buffalo		1		8	1	2	1	17	46	9
Black crappie[1]		5		3	61	131	38	229	42	51
Bluegill[1]					3	1	1	0		2
Blue sucker	1	4	7	9	13	7	8	8	3	10
Brook stickleback		1								
Brown trout	19	11	6	20	8	21	14	13	7	16
Burbot	2	1	7	7	9	4	1	5	4	9
Channel catfish	114	60	77	236	267	265	578	446	445	550
Cisco							10	9	1	39
Common carp[1]	237	177	221	295	420	266	291	229	234	375
Emerald shiner [1]	349	660	769	1236	1146	2492	1040	765	338	42
Fathead minnow	2									
Flathead chub [1]	151	117	578	176	225	254	74	134	114	145
Freshwater drum	88	61	104	275	269	224	314	290	353	361
Goldeye[1]	550	526	565	856	1244	957	1587	1354	1143	2237
Green sunfish							4			
Hybognathus spp. [1]	214	755	230	730	392	519	754	275	95	39
Lake chub[1]								1		
Longnose dace	2	1	2			1	5	1		
Longnose sucker	153	73	89	246	154	371	363	258	435	356
Mtn whitefish[1]	37	92	13	10	33	22	13	4	17	19
Mountain sucker						5	7	22	1	3
Northern pike	15	8	9	17	28	69	52	115	53	33
Pallid sturgeon					1		2			1
Pumpkinseed	5					1	1		2	1
Rainbow trout	73	32	10	56	25	19	16	10	23	21
River carpsucker	133	71	141	199	181	291	293	244	343	524
Rocky Mtn.	2	6		10	7	19	8	16	6	4
Sculpin[1]			19							
Sand shiner	1	2								
Sauger	489	376	340	610	410	464	450	429	376	505
Sauger <150	2	0	37	2	0	39	3	29	1	1
Shorthead	2687	2306		4560	4192	4042	4152	4448	4666	4381
redhorse[1]			2194							
Shovelnose	8	9		14	13	6	13	19	11	6
sturgeon			9							
Sicklefin chub		2		1				1		
Smallmouth bass	109	114	114	188	133	114	135	375	388	399
S. bass <150	106	11	57	41	19	260	159	89	52	58
Smallmouth	36	40		66	70	39	30	44	13	40
buffalo			53							
Spottail shiner[1]		1	13		384	46	4	1		
Stonecat [1]	19	12	3	10	12	7	7	11	4	12
Sturgeon chub[1]		7	7			3				
Walleye	71	70	68	95	128	161	134	180	181	206
Walleye <150	0	2	4	0	0	9	2	31	2	
White crappie				1	1					1
White sucker	249	106	63	254	264	285	327	267	232	308
Yellow perch[1]	3		6	2	16	24	3	2	7	5
Total fish	5,927	5,720	5,815	10,233	10,129	11,440	10,894	10, 370	9,638	10,769
Total hours	50	48.6	51.7	51.6	48.9	51	51.3	50.1	51.3	55.0

Table 5. Fall electrofishing statistics for 11 species of interest on five sections of the Middle Missouri River 2016 compared with averages for the period 2001 - 2016.

		Average	2001 to	2016			2016		
Section	Species	CPUE	Length (mm)	weight (g)	Wr	CPUE	Length (mm)	weight (g)	Wr
Morony	Channel Catfish	5.9	577	2508	109.2	19.2	564	2045	107.8
	Common Carp	9.8	647	3976	101.5	13.7	663	4143	101.8
	Freshwater Drum	6.8	400	988	107.6	11.6	395	945	107.2
	Goldeye	22.7	324	326		24	322	306	
	Longnose Sucker	15.1	308	446		18.1	351	531	
	River Carpsucker	1.9	494	1862	109.8	3.1	446	1379	107.7
	Sauger	3.0	356	458	87.7	2.8	376	530	92.1
	Shorthead Redhorse	120.0	428	1022	105.4	164.9	438	1059	104.2
	Smallmouth Bass	11.0	271	393	119.1	27.2	280	422	119.0
	Smallmouth Buffalo	1.5	612	4597	93.0	2.4	568	3365	87.0
	Walleye	2.5	403	836	93.8	4.7	345	390	89.2
Fort Benton	Channel Catfish	6.0	576	2396	107.5	17.1	571	2253	108.7
	Common Carp	5.9	631	3607	101.4	8.8	642	3695	98.8
	Freshwater Drum	4.3	386	841	106.0	9.4	364	696	103.1
	Goldeye	19.7	326	334		37	332	324	
	Longnose Sucker	6.8	347	593		13.3	371	640	
	River Carpsucker	2.5	470	1510	103.6	3.6	451	1324	100.5
	Sauger	6.6	394	563	84.7	12.6	387	517	83.0
	Shorthead Redhorse	100.8	423	969	101.6	140.3	426	938	96.2
	Smallmouth Bass	3.4	283	461	121.9	11.2	305	563	118.7
	Smallmouth Buffalo	0.7	611	4341	92.5	0.6	517	2551	90.5
	Walleye	2.4	394	654	90.2	5.2	359	420	85.4
Coal Banks	Channel Catfish	3.1	570	2283	104.6	5.7	555	2094	108.1
	Common Carp	4.1	564	2459	94.6	5.9	529	2470	99.5
	Freshwater Drum	3.9	356	623	104.3	3.5	353	589	102.4
	Goldeye	23.5	317	299		29.1	313	268	
	Longnose Sucker	3.0	328	466		2.4	291	340	
	River Carpsucker	5.8	453	1277	98.2	14	427	1146	104.2
	Sauger	6.8	369	417	78.9	8.4	373	439	80.4
	Shorthead Redhorse	62.1	349	565	92.8	45.7	314	473	91.7
	Smallmouth Bass	2.0	282	474	121.1	2.8	253	365	115.8
	Smallmouth Buffalo	1.1	580	3437	87.3	0.4	534	2573	82.3
	Walleye	2.0	370	536	85.4	2.6	330	322	85.8

Table 5. continued. Fall electrofishing statistics for 11 species of interest on five sections of the Middle Missouri River 2016 compared with averages for the period 2001 - 2016.

		Average	2001 -	2016			2016		
Section	Species	CPUE	Length (mm)	weight (g)	Wr	CPUE	Length (mm)	weight (g)	Wr
Judith Landing	Channel Catfish	3.9	587	2549	104.5	3.5	584	2354	98.5
	Common Carp	3.9	529	2171	95.5	3.9	383	1136	97.3
	Freshwater Drum	2.8	352	595	103.5	3.3	334	477	102.8
	Goldeye	22.3	309	280		65.0	310	237	
	Longnose Sucker	2.2	303	352		0.44	272	268	
	River Carpsucker	5.0	463	1421	100.7	11.9	435	1239	104.0
	Sauger	11.3	354	388	79.0	12.7	348	345	78.7
	Shorthead Redhorse	44.9	332	511	93.2	46.8	286	354	90.1
	Smallmouth Bass	0.9	290	565	124.4	0.7	256	433	112.4
	Smallmouth Buffalo	0.8	643	4688	87.9	0.4	647	5175	93.1
	Walleye	2.6	377	565	84.6	3.3	347	425	85.2
Fred Robinson	Channel Catfish	4.3	534	1799	95.8	7.9	483	1034	85.2
	Common Carp	2.8	504	1843	93.9	3.4	413	1227	95.4
	Freshwater Drum	3.4	321	464	104.7	6.8	309	382	101.3
	Goldeye	21.4	298	251		41.8	304	222	
	Longnose Sucker	0.3	164	132		0.2	340	457	
	River Carpsucker	5.8	481	1623	101.4	11.8	450	1375	103.6
	Sauger	11.5	331	330	78.0	8.8	344	345	78.2
	Shorthead Redhorse	21.9	307	388	92.3	16.1	338	487	97.7
	Smallmouth Bass	0.1	113	262	133.5	0			
	Smallmouth Buffalo	0.4	605	3044	83.6	0.2	540	2923	86.4
	Walleye	1.7	375	702	85.9	3.5	349	543	81.8

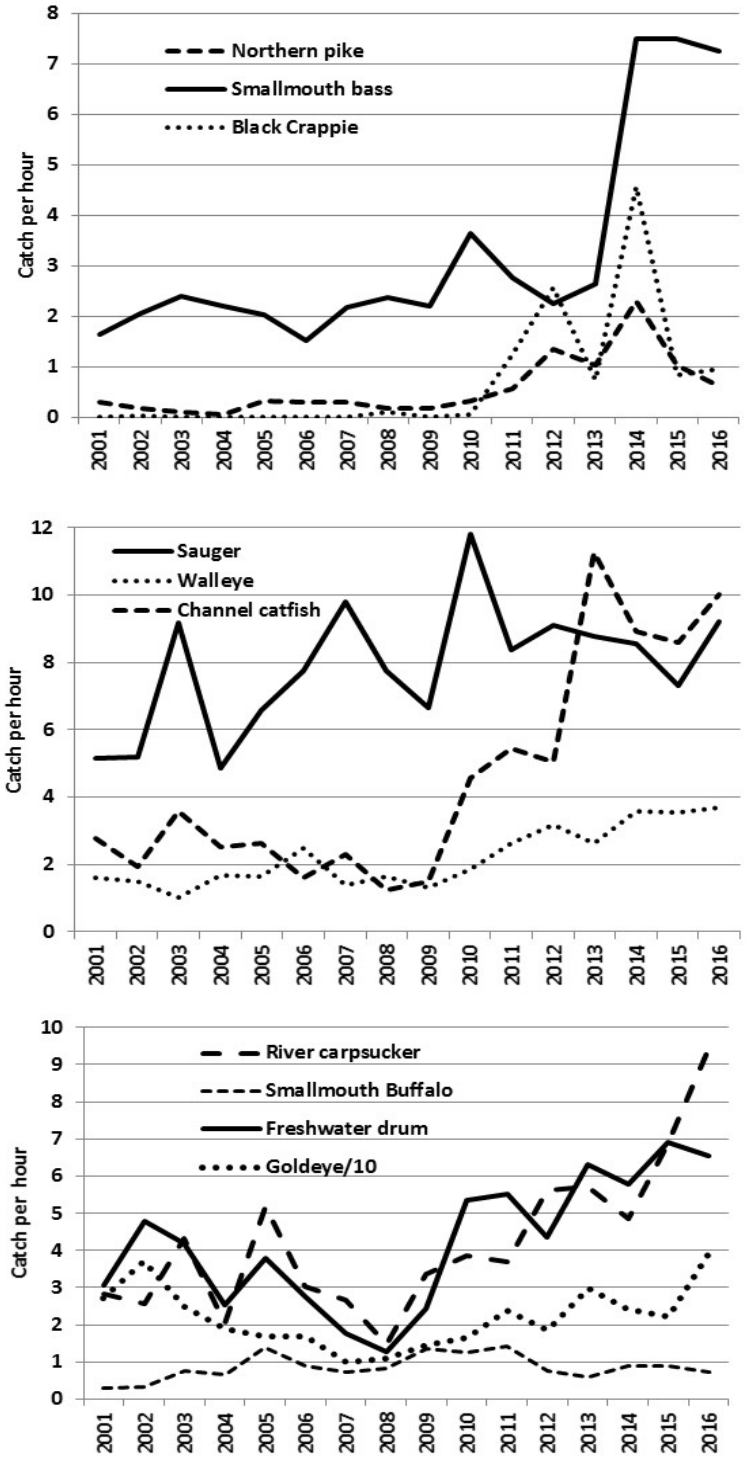

Figure 5. Electrofishing catch per hour summaries for all sections combined for nine common Middle Missouri River species, 2001 – 2016.

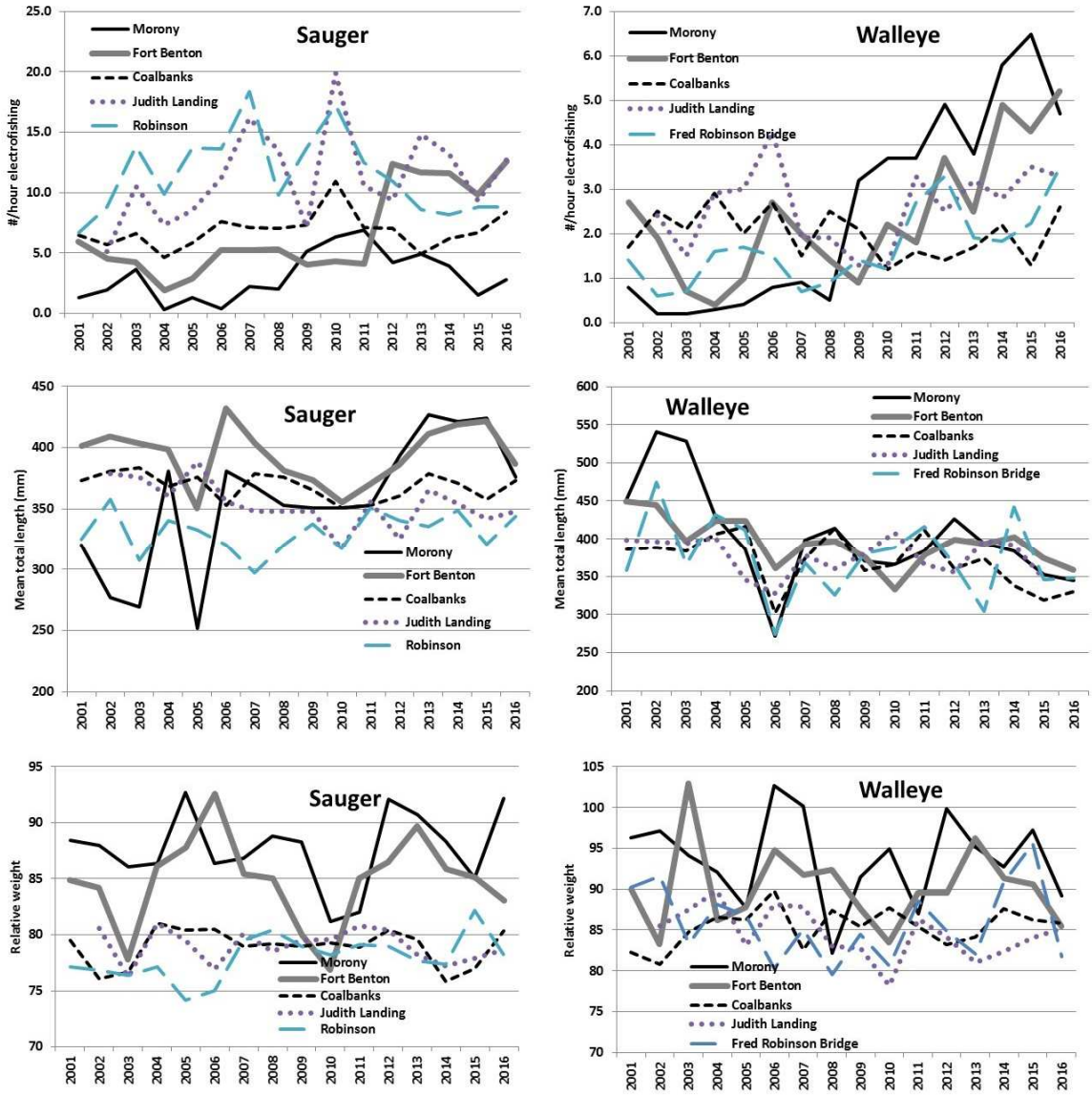

Figure 6. Electrofishing summaries for Sauger and Walleye, for CPUE, total length and Wr trends from 2001 – 2016, Middle Missouri River, Montana. Note different scales.

Table 6. Sauger age distribution and average length for August – October captures, 2012 – 2016, throughout the study area. Number sampled was based on size frequency at age.

Year	Description	Age 0	Age1	Age 2	Age 3	Age 4	Age 5	Age 6+	Total N
2012	N sampled	48	22	72	38	31	69	244	524
	N Aged	16	10	36	12	7	16	91	188
	% of age	9.2	4.2	13.7	7.3	5.9	13.2	46.6	
	Mean mm of aged fish	152	187	284	318	354	367	414	
2013	N sampled	17	17	26	92	146	88	108	494
	N Aged	8	13	14	45	55	41	54	230
	% of age	3.4	3.4	5.3	18.6	29.6	17.8	21.9	
	Mean mm of aged fish	155	200	277	332	380	475	472	
2014	N sampled	47	9	44	46	65	91	200	502
	N Aged	14	6	31	28	34	45	110	268
	% of age	9.4	1.8	8.8	9.2	12.9	18.1	39.8	
	Mean mm of aged fish	141	240	276	318	349	398	435	
2015	N sampled	9	4	52	59	52	127	107	410
	N Aged	7	5	26	24	19	45	55	181
	% of age	2.2	1.0	12.7	14.4	12.7	31.0	26.1	
	Mean mm of aged fish	168	189	253	314	353	395	445	
2016	N sampled	5	9	37	144	115	83	156	549
	N Aged	4	3	17	37	34	34	71	200
	% of age	0.9	1.6	6.7	26.2	20.9	15.1	28.4	
	Mean mm of aged fish	164	224	276	319	358	415	443	

Shovelnose Sturgeon Population Estimate –Coal Banks Section.

Population estimates are challenging in large river systems but use actual fish numbers instead of catch rates to evaluate population trends. Relative abundance, evaluated as CPUE, is influenced by fish catchability and habitat conditions (Hubert and Fabrizo 2007). In 2016, 1,174 Shovelnose Sturgeon (9.9/drift) were sampled during the Coal Banks estimate. The Schnabel estimate was 3,925 (3,294 – 4,852) in the 6.5 mile section or 604/mile (Table 8). The 1995 and 2005 estimates on this section were 1,242 and 1,310 per mile (Gardner 1996, Gardner 2008). All estimates were similar using the population estimate program Mark (Table 8, White and Burnham 2009). See Appendix 19 for estimate calculations. Shovelnose Sturgeon CPUE appears to represent relative abundance at Coal Banks, when environmental conditions are considered. CPUE was much higher in 2005 than in 2016 under similar flow conditions at the time of the estimates (Table 8). CPUE was lowest in 1995, likely due to less efficient netting during higher flows. Average Shovelnose Sturgeon length was within 10 mm for all three years (Table 8). Mode length was also similar, but in 1995 and 2005 there were more Shovelnose Sturgeon <650 mm long (Figure 9). Several Shovelnose Sturgeon with old external tags deployed as far back as 1979 were recaptured. These fish grew on average 2 mm per year (Tews 2016a). Two hatchery raised Shovelnose Sturgeon were recaptured during the 2016 Coal Banks population estimate. Those fish displayed fin curl on the pectoral fins (Figure 10). They were part of a 1,000 fish lot from the Bozeman Fish Tech Center that was known to have had fin curl when stocked in 2002 at Robinson Bridge (MFWP Lewistown data files). Fin curl is often a concern for fish raised at the Bozeman Tech Center, but can also occur in wild fish (Deslauriers et al. 2016). The two stocked fish averaged 624 mm long in 2016, and had grown 360 mm in 14 years. Brood stock for these hatchery raised Shovelnose Sturgeon was from Coal Banks. A few of these fish were initially recaptured near the release site at Robinson Bridge, but recent recaptures have been near Coal Banks. Deslauriers et al. (2016) found that swimming performance was reduced in Shovelnose Sturgeon with fin curl, but these fish survived for at least 14 years and swam over 100 miles upstream from the original stocking location. In contrast to Shovelnose Sturgeon, hatchery raised Pallid Sturgeon (HRPS) with fin curl died within 10 years of stocking in the Middle Missouri River (Rotella 2012).

Shovelnose Sturgeon numbers near Coal Banks Landing have declined since the mid-2000's; the 90% confidence intervals from the 2016 estimate do not overlap with the 1995 and 2005 estimates (Table 8). Three potential causes of this decline, are fishing pressure, changes in fish species composition and Missouri River flows during drought. It is unlikely that fishing pressure is responsible for the decline. Creel surveys conducted in 2003, 2007, 2011 and 2015 indicate Shovelnose Sturgeon harvest has likely declined over the last 15 years and Shovelnose Sturgeon catch rates have been consistently low (Tews 2016b). Species composition was similar during all three estimates. Trammel net CPUE for Goldeye, Shorthead Redhorse, Smallmouth Bass and Sauger was higher in 2016 than during the earlier estimates (Appendices 18, 20, 21). These increases also show up in electrofishing surveys (Figure 5). Blue Sucker catch rates were similar for all three years and are further discussed in the Species of Concern section of this report. The main change in species composition is due to Pallid Sturgeon stocking. Numbers of Pallid Sturgeon living upstream of Fort Peck increased from about 50 wild fish in 1995 (Gardner 1996) to several thousand HRPS by 2013 (Rotella 2015). Pallid Sturgeon were only caught during 2016 estimate (Table 8). Stocking impacts of Pallid Sturgeon on Shovelnose Sturgeon have not been studied. Pallid Sturgeon are closely related to, and even rarely hybridize with Shovelnose Sturgeon in the study area, but there is insufficient information to understand interactions between these two *Scaphirhynchus* sp. One study found little diet overlap between them (Gerrity et al. 2006). The Middle Missouri had a major drought from 2000 – 2007, during which, MFWP high flow and side channel flow recommendations were rarely observed (Figure 4). Proportional stock density

indicates there was little recruitment in the Robinson Section from 2006 – 2011 (Tews and Gardner 2014). The Robinson Section appears to be a rearing area for many native species and is likely important for Shovelnose Sturgeon throughout the entire system. Long-term monitoring will help determine if the population decline observed between 2005 and 2016 is a concern, or if occasional juvenile recruitment events are sufficient to maintain the Shovelnose Sturgeon population over decades.

Set lines

In 2016, 435 fish were caught with 90 standard set lines (Table 9, Appendix 22). Sauger and Walleye CPUE were record highs. Pallid Sturgeon, Shovelnose Sturgeon and Channel Catfish CPUE were well below average (Figure 11, Table 9). Fourteen set lines set upstream of the standard monitoring section, between RM 1931.5 and 1942.2, captured 39 fish of 8 species (Appendix 23). Channel Catfish, Goldeye and Shovelnose Sturgeon were the most common species.

Seining

Seining surveys were conducted to assess cyprinid populations and game fish reproduction in shallow water habitats. In 2016, seining captured 5,467 individuals of 23 species (Table 10). Size statistics are presented in Appendix 24. Species diversity was average at 23 species and the CPUE of 55 fish/haul was close to the average of 58/haul with the 2013 seining protocol (Appendix 3). Diversity has increased since the protocol was developed during the 2012 season. In 2016, Emerald Shiner (28%), White Sucker (19%), Shorthead Redhorse (11%) and Flathead Chub (10%) were the most common species. *Hybognathus sp.* were at record low levels since the study began in 2000 (Table 10, Gardner 2008, Gardner 2006, Gardner 2005, Gardner 2004). Overall seine catch was highest in the Fort Benton Section, followed by the Coal Banks Section (Table 11). In 2016, Emerald Shiner and Shorthead Redhorse were sampled in all sections. Most other species exhibited a longitudinal distribution, consistent with past years; suckers and Smallmouth Bass were most common in the upstream sections with Flathead Chub most abundant in the lower sections (Table 11). An Iowa Darter *(Etheostoma exile)* was captured in the Fort Benton section. This was the first specimen caught in over a decade, but the species was reported by Gardner and Berg (1982). Iowa Darters are too small to be effectively captured with the ¼ inch mesh seine used in the seine protocol (Appendix 3); the 2016 specimen was found on the bank and had gone through the seine mesh. A 1/8 inch mesh seine was used in 1979 and 1980 during the Gardner and Berg (1982) study.

Trawling

A beam trawl is the primary method to capture Sicklefin and Sturgeon Chub, two Montana Species of Special Concern. Age 0 Channel Catfish, age 0 Shovelnose Sturgeon, juvenile Pallid Sturgeon and Flathead Chub are often captured by this method. In 2016, 342 fish of 12 species were sampled with the trawl (Table 12). Channel Catfish (1.1/haul), Sturgeon Chub (1.0/haul) and Stonecat (0.4/haul) had the highest catch rates. Sturgeon Chub CPUE was the highest observed since 2007 (Figure 12). Sicklefin Chub CPUE increased slightly from 2015 but remained below average. Flathead Chub continued their downward trend. YOY Shovelnose Sturgeon catch was the highest observed since 2011 and was well above average (Figure 13). HRPS catch was below average (Figure 13).

Table 7. Average CPUE (number/drift) and total number of fish sampled by standard trammel nets in the middle Missouri River, 2016.

	CPUE		
Species	Fort Benton	Coal Banks	Robinson
Blue Sucker	0	0.2	0.0
Channel Catfish	0	0.6	0.4
Common Carp	0.15	0.1	0.2
Freshwater Drum	0	0.2	<0.1
Flathead Chub	0	0	<0.1
Goldeye	0.9	0.8	0.3
Longnose Sucker	1.9	2.0	0
Pallid Sturgeon	0	0.3	1.2
River Carpsucker	0.05	0.1	0.2
Sauger	0.15	0.3	<0.1
Shorthead Redhorse	4.1	5.9	0.6
Shovelnose Sturgeon	1.45	8.9	3.1
Smallmouth Bass	0.1	0.5	0
Smallmouth Buffalo	0.15	0	0
Stonecat	0	0	<0.1
Walleye	0	0	0.1
White Sucker	0.55	0.1	0
Total Fish	190	388	317
Total Drifts	20	20	50
Mean Depth (ft)	5.3	4.2	6.1
Mean Distance (yds)	522	297	311

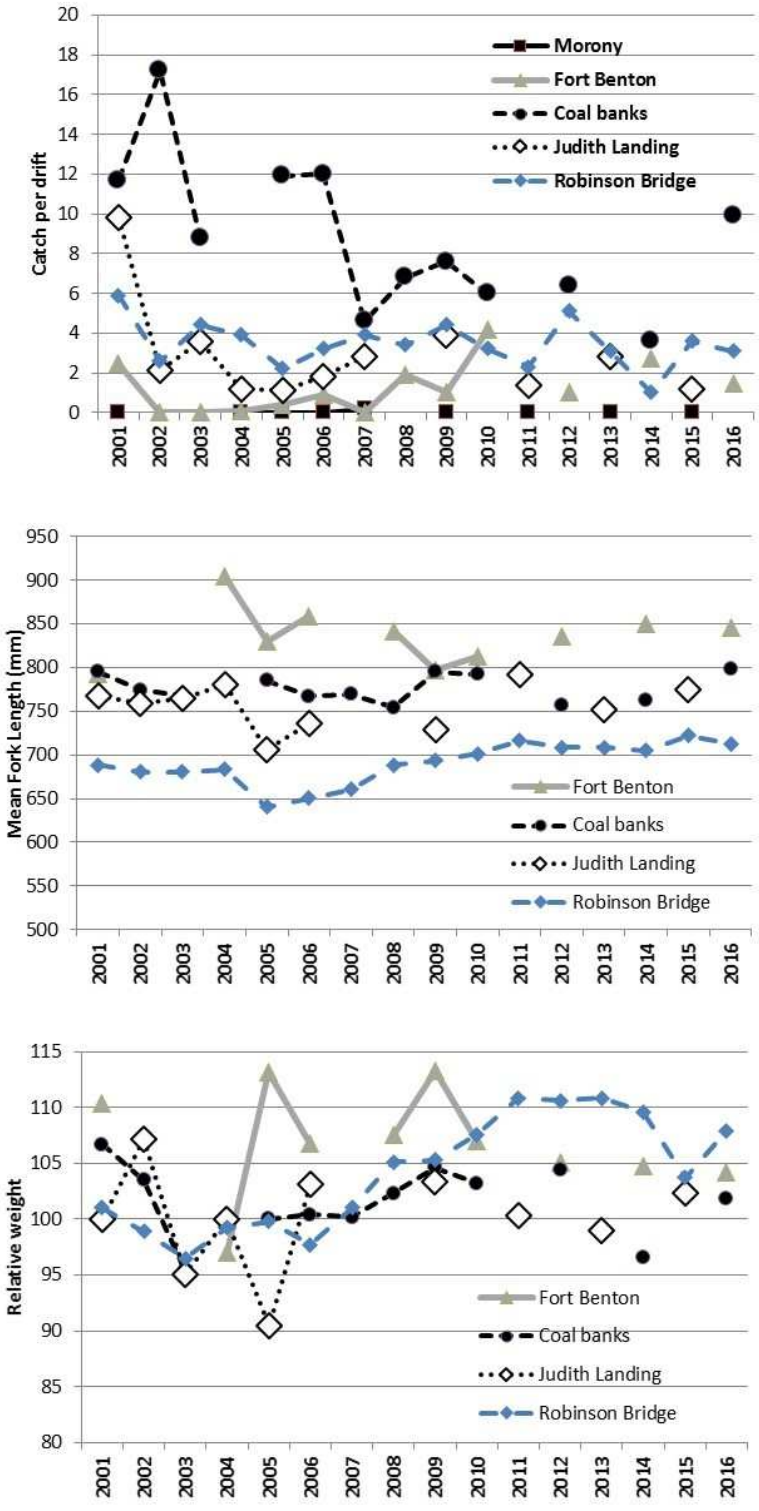

Figure 7. Shovelnose Sturgeon catch rates, mean fork length and Wr from trammel net drifts completed in five sections of the Middle Missouri River in summer/fall 2001 – 2016; some sections sampled on alternate years.

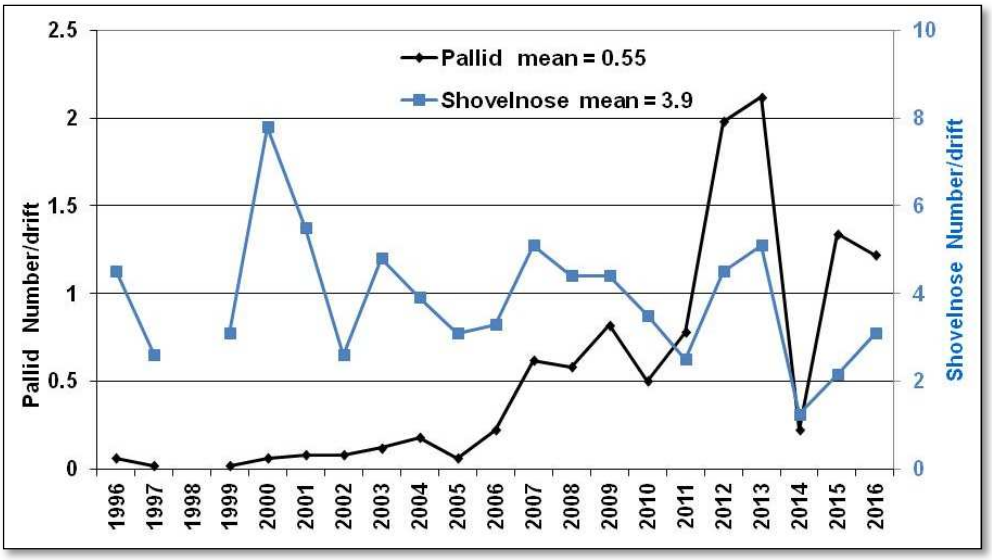

Figure 8. Pallid Sturgeon and Shovelnose Sturgeon catch rate trend for fall trammel netting surveys conducted in the Robinson Section (RM 1925 – 1907), 1996 – 2016.

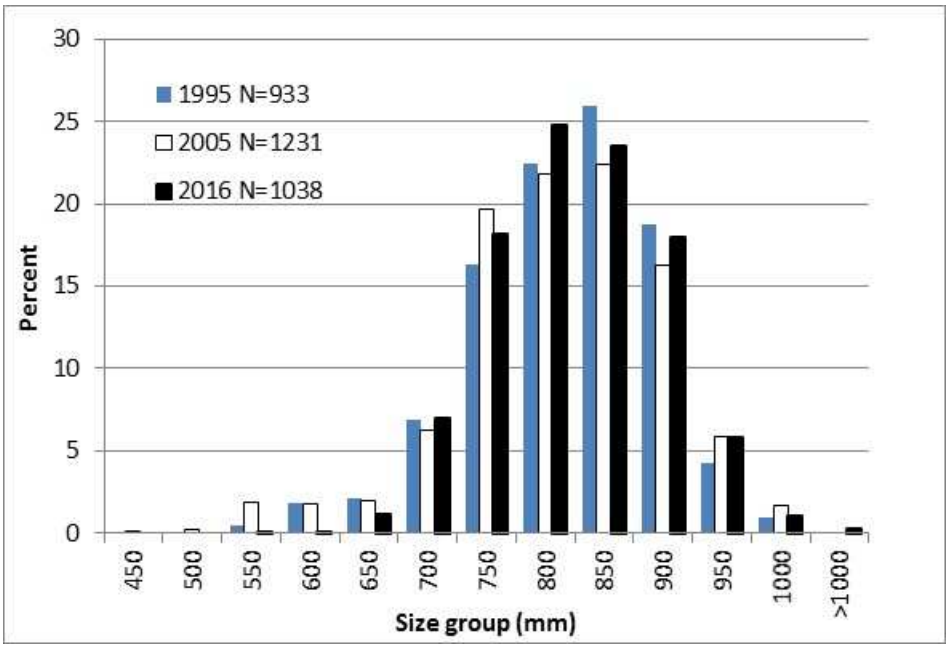

Figure 9. Shovelnose Sturgeon size structure during three population estimates near Coal Banks Landing 1995, 2005 and 2016.

Table 8. Shovelnose Sturgeon estimates for the Coal Banks area (RM 2031.5 – 2039) during 1995, 2005 and 2016.

Year	Drifts	N SNS	N recaps	SNS/ Drift	Pallid/ Drift	Mean FL SNS	Estimate (95%) Mark	Estimate (95%) Schnabel	CFS
2016	118	1041	105	9.3	0.3	798	4386 (3683-5275)	3925 (3294 – 4852)	5643
2005	108	1240	71	12.2	0.0	785	8518 (6412-11434)	8514 (6909-11095)	5367
1995	126	933	42	7.7	0.0	792	8700 (7057 – 10861)	8073 (6211-11494)	8417

Figure 10. A Shovelnose Sturgeon stocked in 2002 at Robinson Bridge and recaptured 2016 near Coal Banks. Note fin curl.

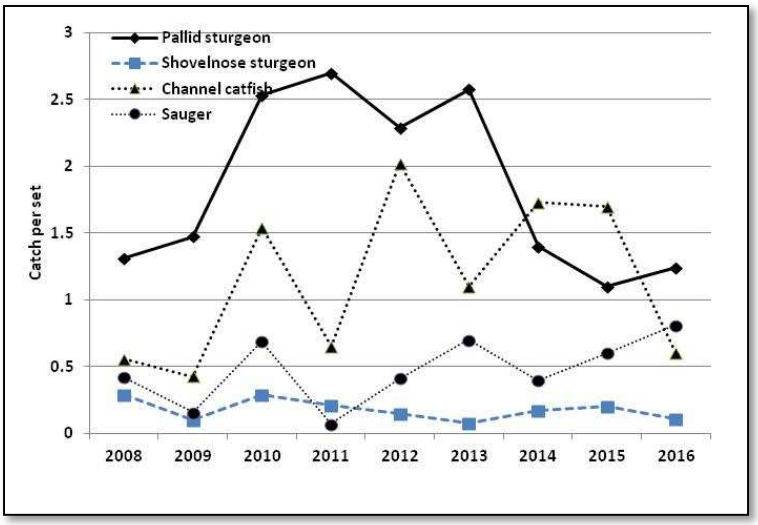

Figure 11. Catch rate of frequently caught species during standardized spring set lining, Robinson Section 2008 – 2016.

Threatened, endangered and species of special concern

A plan to protect and provide for the recovery of threatened and endangered fish species, as required by FERC, Articles 417 and 421, has been completed. The number of Montana Species of Special Concern sampled from 2007 – 2016 is provided in Table 12. Sauger, Sicklefin Chub and Sturgeon Chub trends have been previously discussed. Paddlefish catch was low because that species is evaluated in other studies and is best sampled with other gear types.

For Pallid Sturgeon, a federally listed endangered species, the plan includes monitoring dispersal, survival and distribution of HRPS. Formal population estimates of HRPS survival in RPMA 1 (this project area) have been conducted since 2007 (Rotella 2012). The most recent estimate, for 2013, was 7,935 (95 CI 6,231-9,630) HRPS (Rotella 2015). The estimate was 9,139 (6397 – 11853) HRPS in 2010 (Rotella 2012). Dr. Rotella will be updating the HRPS survival estimates in 2017. Pallid Sturgeon catch has declined in recent years (Table 13). This is likely due, in part, to a reduction in stocking rates starting in 2011. Pallid Sturgeon stocking is now done to maximize genetic variability (Heist et al. 2013). In 2017, 329 yearlings from each family were stocked, a reduction from recent years. The 2017 stocking rate was established based on past yearling stocking history and to maximize the effective population size. This stocking strategy is founded on the premise that wild Pallid Sturgeon recruitment will eventually occur. In 2016, three wild adult male Pallid Sturgeon were taken from RPMA1 to the Miles City State fish hatchery and their genetics were incorporated into the brood stock program.

Active radio telemetry has been used to monitor Pallid Sturgeon in the study area since 1992 (Gardner 1994). The study expanded to include remote passive receivers and a telemetry system using codes instead of individual frequencies that supported monitoring of many more fish in 2006 (Gardner and Jensen 2007). In 2016, 10 wild Pallid Sturgeon, 61 PS-97, 3 PS-05 and 1 PS-09 HRPS had active radios. One wild fish was last relocated in April 2016, so it has likely lost its radio or has died. In 2016, MFWP obtained 449 Pallid Sturgeon relocations during 1730 miles of boat travel and 1587 Pallid Sturgeon relocations from the 13 remote land based stations. Individual Pallid Sturgeon were relocated between 2 and 130 different times in 2016, with the average Pallid Sturgeon was relocated on 26 days. The re-locations in 2016 indicated that Pallid Sturgeon occupy the Middle Missouri from Fort Peck Reservoir to the Marias River. Pallid Sturgeon radio telemetry information was last summarized in Tews et al. 2016. Pallid Sturgeon telemetry information for 2016 will be summarized in a future report.

In 2016, 58 Blue Suckers were captured. They averaged 770 mm with a size distribution similar to 2007 – 2015 (Figure 14). One fish had a floy tag installed on 7/18/2001 at RM 2037.3 when it was 767 mm and 4286 g. It was recaptured at RM 2035.8 on 8/24/16 at 804 mm long and 4485 g, indicating extremely slow growth of 2.5 mm and 3.5 g/year over the 15-year period. A second 863 mm fish had an unreadable floy tag, likely installed the same year. In 2016, most of the Blue Suckers were caught during the Coal Banks Shovelnose Sturgeon population estimate. Blue Sucker size structure during the estimates (Figure 15) and throughout the study area indicate a slow shift to larger fish (Figure 14). At Coal Banks, the average Blue Sucker size was 780 mm in 2016, 746 mm in 2005 and 726 mm in 1995 (Appendices 18, 20 and 21). Only three tagged Blue Suckers have been recaptured after being at large for at least five years; those fish grew between 1 and 2.5 mm annually. Blue Sucker age has not been evaluated for the middle Missouri River due to concerns about the accuracy of aging of old fish as discussed in several studies (e. g. Lyons et al., 2016, Acre et al 2017). All Blue Suckers are now PIT tagged to help evaluate growth rate and age of adult Blue Suckers. It may be worth sacrificing some Blue Suckers for aging, perhaps using atomic bomb radio carbon (Braaten et al. 2015), to determine if Blue Suckers live more than 50 years. It is remotely possible the growing conditions are creating bigger

fish at age, but it is more likely Blue Suckers are getting older and the size increases are a warning that Blue Sucker recruitment is inadequate. Blue Suckers appear to spawn in several locations in the study area (Gardner and Jensen, 2011) but only three Blue Suckers less than 400 mm have been sampled in the study area since 2001 (MFWP files). They were all caught near Fort Peck Reservoir. The ecology of Blue Suckers from the larval stage until adulthood is not understood in the study area. Therefore, it is not known if Blue Sucker recruitment is non-existent or if young fish are not sampled due to habitat preferences or locations not sampled under the Middle Missouri sampling protocol (Table 2). Under that protocol, only trawling is used to sample small fish downstream of Robinson Bridge. Additional funding and a carefully designed study may provide insight into the early life history of Blue Suckers upstream of Fort Peck.

Table 9. Number of fish sampled with standard spring set lines from 2008 – 2016 in the Robinson Section.

Species	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Bigmouth buffalo						1			
Burbot	1			1	1	2	6	3	4
Channel catfish	25	38	139	28	182	99	154	160	52
Common carp	5	12	14	1	3	2	2	15	10
Flathead chub	39	31	35	8	38	25	4	6	11
Freshwater drum		6	10		1			5	
Goldeye	50	14	63	15	19	104	63	70	95
Longnose sucker					1				
Northern pike						2			
Pallid sturgeon	59	132	228	116	206	232	125	96	112
Rainbow trout	1		1			1		1	
Sauger	19	14	62	3	37	63	34	51	73
Shorthead redhorse	1	1	7	1	6	25	13	13	18
Shovelnose sturgeon	13	9	26	9	13	7	15	16	10
Sicklefin chub			1						
Stonecat	5	21	41	17	40	22	39	23	
Walleye	5	9	14		12	19	17	45	48
White Sucker									1
Yellow perch			1						1
Total fish	223	284	642	199	559	602	472	504	435
Total sets	45	90	90	43	90	90	91	90	90
Mean hours per set	14.1[a]	16.9	19.2	11.4	19.1	19.7[a]	18.9[a]	19.7	20.5[a]

[a] a subset (most of the sets) of total sets were used in the calculation of the mean

Table 10. Number of fish captured during seine hauls for 5 sections of the Middle Missouri River for 2007- 2016. Sampling protocol was changed in 2012/2013 (see Appendix 3).

Species	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Black Crappie				1	3	133		5	7	2
Brook Stickleback						1			1	2
Bigmouth Buffalo	7	2								
Common Carp yoy	282	126	27	116	508	14	49	8	100	38
Channel Catfish yoy	184	4	24		1	7	138	11	5	20
Emerald shiner	621	3744	314	10080	1118	2724	1187	353	5778	1525
Flathead chub	1238	611	543	1651	678	718	32	44	129	535
Fathead minnow	185	305	93	264	375	130	106	2	4	6
Freshwater drum							2	3		
Goldeye yoy	1	8			64	1	9	8	30	9
Hybognathus spp.	1133	1837	328	1818	2854	2132	497	204	1483	98
Iowa Darter										1
Lake chub	2			1	147	6		1		1
Longnose dace	4	6	12	185	233	48	28	44	57	21
Longnose sucker	3	30	98	215	32	101	80	22	960	227
Rocky Mtn sculpin	1					1	3		2	1
Mountain sucker				1						
Mountain whitefish						1	2			
Northern pike						2		11		
Northern redbelly dace							6			
Pumpkinseed	6	60		2		3	1	1		8
River carpsucker yoy	122	92		10	3178	36	4	2	5	11
Sand shiner	165	51	6	31	44	35	20	16		33
Sauger yoy	1						2		1	
Shorthead redhorse	948	309	416	1187	552	608	873	170	567	589
Sicklefin chub		1	2					2		
Smallmouth bass	1196	299	130	239	269	676	933	200	405	773
Smallmouth buffalo yoy	9	17	27	30			3	2	1	2
Spottail shiner	3	1	1	34	205	102	29	18	11	26
Stonecat							10	6	8	8
Walleye yoy		15	9			7		1		
White sucker	983	683	339	883	1408	793	1471	184	305	1029
Yellow perch	11	7		20	5	8	2	17		
Crayfish	13	5	6				85	14		67
sucker unidentified						88	56	41	553	395
minnow unidentified						81	29	2	7	39
General unidentified			42		3490	172	97			
# fish species	22	21	18	19	17	23	24	25	22	23
Total catch	7118	8213	2417	16768	15164	8459	5669	1386	10419	5467
Total # of seine hauls	50	50	50	50	50	50	100	100	100	100

Table 11. Number of Fish sampled by seining in the middle Missouri River, 2016, by section. For fish < 150mm.

Species	Morony	Fort Benton	Coal Banks	Judith Landing	Robinson	Total
Black Crappie					2	2
Brook Stickleback		2				2
Channel Catfish	6	1		4	9	20
Common Carp	7	20	9	2		38
Crayfish	64	3				67
Emerald Shiner	399	45	729	110	242	1525
Fathead Minnow	1	2		1	2	6
Flathead Chub			4	476	55	535
Goldeye					9	9
Iowa Darter		1				1
Lake Chub	1			1		2
Longnose Dace		5	1	15		21
Longnose Sucker	35	159	23	10		227
Minnow					39	39
Pumpkinseed		8				8
River Carpsucker	2			8	1	11
Rocky Mtn Sculpin	1					1
Sand Shiner				26	7	33
Stonecat			1	6	1	8
Shorthead Redhorse	83	132	203	157	14	589
Smallmouth Bass	281	391	67	34		773
Smallmouth Buffalo	1			1		2
Spottail Shiner	21	2	3			26
Sucker		340	43	12		395
White Sucker	253	608	168			1029
Western Silvery Minnow		53	5	11	29	98
Total	1155	1772	1256	874	410	5467
Number of hauls	20	20	20	20	20	100

Table 12. Average trawling catch rates (#/tow) for and size statistics fish species sampled in the middle Missouri River, 2016, Robinson Section RM 1880 – 1913, for 102 hauls.

			Length (mm)		
Species	N	CPUE	Mean	Min	Max
Channel Catfish	109	1.1	41	22	133
Emerald Shiner	28	0.3	60	35	87
Flathead Chub	5	<0.1	82	42	112
Goldeye	1	<0.1	71	71	71
Pallid Sturgeon	3	<0.1	463	442	482
Shorthead Redhorse	6	0.1	60	25	115
Shovelnose Sturgeon	4	0.0	86	38	145
Sicklefin Chub	31	0.3	46	36	84
Spottail Shiner	1	<0.1	89	89	89
Stonecat	41	0.4	72	27	145
Sturgeon Chub	107	1.0	35	18	81
Western Silvery Minnow	6	0.1	59	32	123
Total	342	3.4			

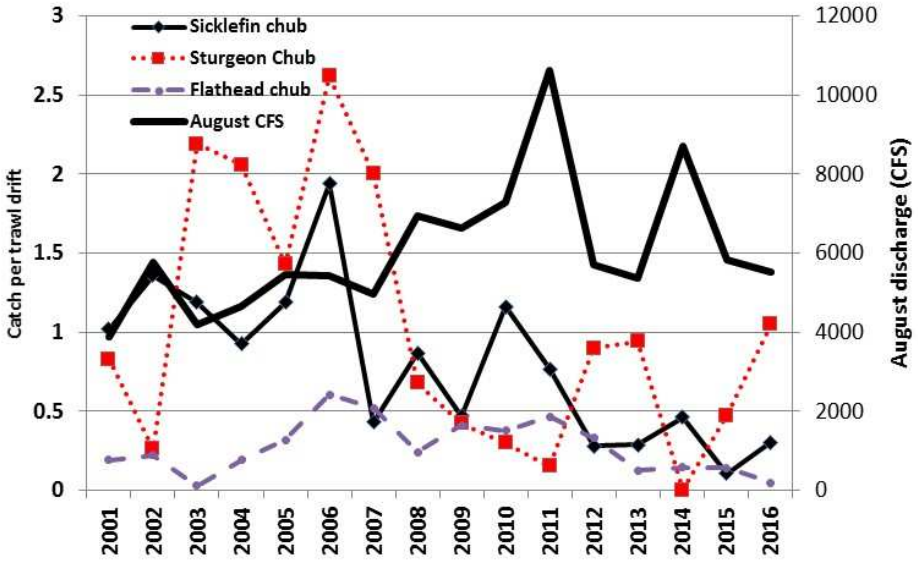

Figure 12. Beam trawl trends for common minnow species in the Robinson Section, compared with mean August flow at Landusky.

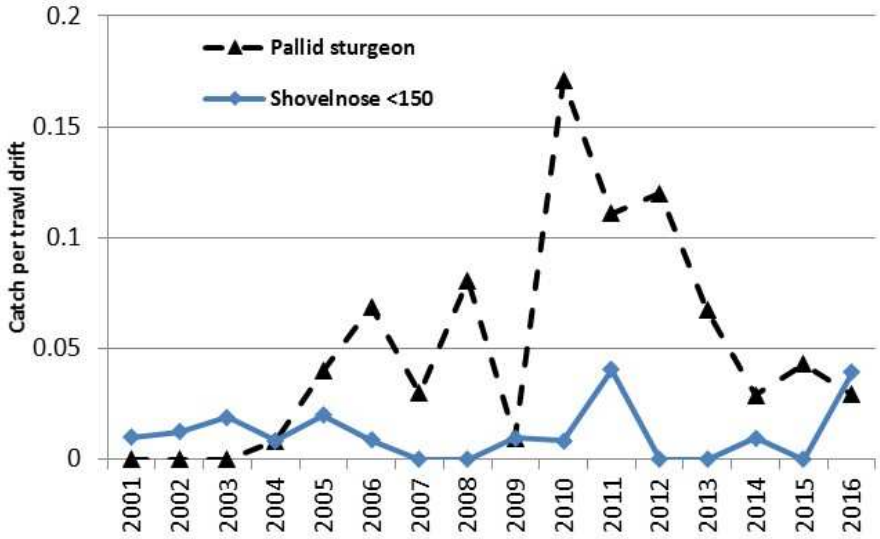

Figure 13. Sturgeon catch rates with a beam trawl, 2001 – 2016.

Table 13. Number of state species of concern sampled in the middle Missouri River during the 2007-2016 field seasons by MFWP.

	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Blue sucker	37	32	35	30	18	16	58	28	21	58
Paddlefish	9	0	18	6	0	3	2	0	0	17
Pallid sturgeon	180	146	271	347	302	334	451	217	257	224
Sauger	714	674	796	620	436	594	576	597	487	663
Sicklefin chub	51	88	49	138	76	28	32	51	10	31
Sturgeon chub	228	75	56	35	17	93	100	0	44	107

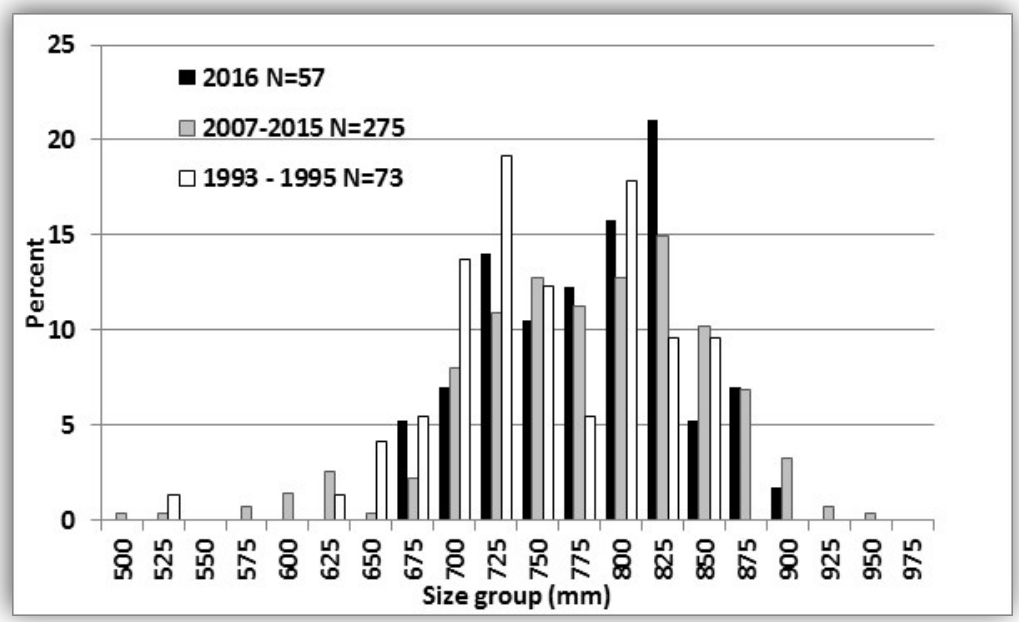

Figure 14. Blue sucker size structure for three different time periods; 2016, 2007 – 2015 and 1993 – 1995.

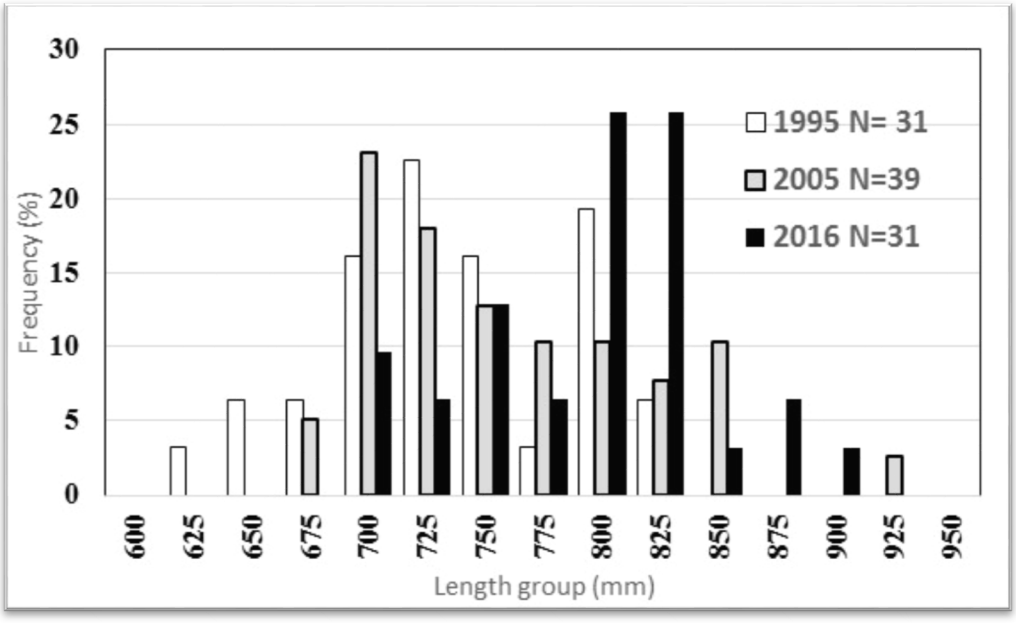

Figure 15. Blue sucker size structure during three Shovelnose Sturgeon estimates near Coal Banks Landing.

Recommendations

1) Continue standardized sampling for comparisons between years.
2) A review of data collected since 2001 is warranted to evaluate long term trends and determine if NWE operations are influencing fish populations, especially for Species of Concern and to make recommendations for flow management to reduce impacts to fish in the study area.
3) Consider additional sampling gear or techniques to evaluate Iowa Darter distribution and abundance.
4) Blue Sucker ecology, age and recruitment should be evaluated. This will require additional funding and a detailed study design.
5) Pallid Sturgeon distribution should continue to be monitored. Recent evidence indicates that Pallid Sturgeon inhabit the Missouri River at least up to the Marias River Confluence, which may require additional sampling effort above the Robinson Section.
6) Aging fish spines is very time consuming and should be discontinued until a study is designed to answer specific questions, such as influence of overharvest or if poor recruitment is suspected.

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APPENDICIES

Appendix 1. Locations and river mile boundaries of electrofishing trend areas in the middle Missouri River study area.

Section	River mile	Location
Morony	2097.0 to 2102	N47.688º / W110.985º to N47.632º / W111.032 º
Fort Benton	2073.5 to 2079.2	N47.816º / W110.668º to N47.787º / W110.724 º
Coal Banks	2029.5 to 2035.5	N48.032º / W110.207º to N48.018º / W110.281º
Judith Landing	1980.5 to 1987.0	N47.747º / W109.575º to N47.731º / W109.687 º
Robinson	1925.5 to 1931.5	N47.646º / W108.752º to N47.705º / W108.816 º

Appendix 2. Locations, river mile boundaries and habitat information (Gardner 1994) for general sections on the middle Missouri River.

Section	River mile	Location	Mean Velo-city	Mean Depth	Geography	Dominate substrate
Morony	2079.0 to 2104.0	47.60229 º; 111.0480 º to 47.79090; 110.72560 º	Fast	Shallow	Sandstone/ Shale canyon	Cobble/ boulder
Fort Benton	2078.9 to 2052.3	47.79090 º; 110.72560 º to 47.92840 º; 110.49078 º	3.0ft/s	6.1 ft	Moderately Wide valley	Gravel/ cobble
Coal Banks	2052.2 to 1994.4	47.92840; 110.49078 º to 47.71624 º; 109.82484 º	3.0ft/s	6.1 ft	Narrow sandstone canyon	Gravel/ cobble
Judith Landing	1994.3 to 1944.0	47.71624 º; 109.82484 º to 47.78848 º; 108.93754 º	3.8ft/s	5.4 ft	Narrow sandstone canyon	Small to large cobble
Robinson	1943.9 to 1867.0	47.78848 º; 108.93754 º to 47.45098 º; 107.89330 º	3.0ft/s	7.6 ft	Wide valley lake delta lower end	Sand

Appendix 3. Instructions for monitoring minnow abundance in 10-mile sections with 50 foot bag seine with ¼ inch mesh starting in 2013. This protocol was developed in, and generally followed in 2012.

Section	Location
Morony	RM 2086 – 2096
Fort Benton	RM 2068 – 2078
Coal banks	RM 2026 – 2036
Judith Landing	RM 1977 – 1987
Robinson	RM 1918 – 1928

- Conduct two seine hauls every mile in representative habitat that can be sampled effectively. 20 seine hauls total for each ten mile section.
-Measure 10 random fish of each species from each seine haul. Include all sized fish identified to species including those <40mm.
-Classify unknown YOY fish as Sucker, Minnow or RCSU/Buff. Count these fish, estimate a length range, and list on a separate line of the data sheet (i.e. YOY Sucker 35-45mm, N=20).

-For fish ≥ 6 inches (150mm) record in comment field.

-Objective is <u>not</u> to catch maximum number of minnows. Objective is to determine minnow species composition and abundance in representative habitats that can be sampled effectively with the seine in a repeatable fashion year after year. This new methodology may reduce overall catch rates since it reduces sampling in some minnow haves such as backwaters.

- Low catches (or even catches of zero) are OK if representative habitats are sampled with reasonable effectiveness.

- Aim for 100 ft long seine hauls, measured with a rangefinder or tape. If haul exceeds +/- 10% of 100 ft record exact distance on data sheet comment field.

- Most samples should be taken in channel crossovers and inside bends as these are usually the most common habitats on the middle Missouri. Outside bends usually cannot be sampled effectively due to deep and fast water.

- Seine hauls should always start at an upstream location and move in a downstream direction, even in backwaters and non-connected secondary channels.

- Avoid using bank or habitat features to “trap” minnows because this artificially inflates the catch and will adversely affect statistical analysis by causing huge increases in sample-to-sample variation.

- In rare instances it may be necessary to conduct seining by beginning at the downstream end and moving in an upstream direction. In such rare events, be sure to avoid seining towards a habitat feature (such as the upstream end of a backwater or side channel) that will trap and concentrate minnows and artificially inflate the catch. Record any upstream seine hauls as such in the comment field.
- No more than one sample can be taken in secondary channel or backwater habitat types in each 1-mile subsection of the 10-mile sampling reaches.

Appendix 4. Minimum, Average and Maximum daily water temperatures (F°) for the Missouri, Marias and Teton Rivers, 2016.

Morony Dam, Missouri River RM 2105.0

2016

	April			May			June			July			Aug			Sept			Oct	
Date	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1				48.4	49.9	51.5	57.3	58.2	59.0	70.6	72.0	73.9	70.9	72.0	73.6	67.3	68.1	69.4	60.4	60.8	62.4
2				50.1	52.1	54.3	58.1	59.1	59.9	71.5	72.6	73.9	70.0	71.4	72.7	66.5	67.5	68.8	59.6	60.2	61.3
3				52.9	54.7	56.2	58.1	59.1	60.1	71.5	72.6	73.9	69.1	70.3	71.2	65.3	66.3	67.6	57.6	58.5	59.6
4				55.4	57.2	59.0	59.6	61.4	63.3	69.7	71.1	72.4	67.6	68.6	69.7	62.7	63.9	65.0	55.1	56.3	57.6
5				58.4	59.7	61.3	61.8	63.7	65.3	67.6	69.5	70.9	66.5	68.2	69.7	59.9	61.6	62.7	52.6	53.7	55.1
6				59.9	60.3	61.0	63.6	65.4	67.3	66.2	67.2	68.2	68.2	68.9	70.3	58.7	59.7	61.3	50.9	51.8	52.6
7				59.0	60.0	61.0	65.6	67.1	68.5	65.3	66.4	67.9	67.9	68.7	70.0	57.9	58.9	60.4	50.1	50.4	50.9
8				58.7	60.1	61.6	66.8	68.0	69.4	65.0	66.4	67.9	67.0	68.3	69.7	58.4	59.0	59.9	49.5	49.9	50.4
9				56.5	58.0	59.9	67.6	68.3	69.4	66.2	67.4	69.1	67.3	68.2	69.4	58.4	59.0	60.4	50.1	50.5	52.3
10				53.1	54.3	56.5	67.0	67.8	68.8	66.8	67.3	67.9	65.9	66.9	68.2	58.1	59.2	60.7	50.1	50.4	51.2
11				50.9	52.1	53.1	66.5	67.1	67.6	64.4	65.7	66.8	64.4	65.5	66.8	58.7	59.2	59.9	48.1	49.5	50.1
12				49.8	50.9	52.3	64.7	65.7	66.5	63.3	63.9	65.0	65.0	66.3	68.2	56.8	58.0	58.7	47.3	48.2	49.5
13				49.2	50.5	52.0	63.6	64.5	65.6	62.7	63.6	65.0	66.5	67.9	69.7	55.4	56.5	58.1	46.7	47.1	47.6
14				50.6	52.2	53.7	63.0	63.9	65.0	63.6	65.0	66.8	67.6	69.0	70.9	55.1	56.0	57.3	46.7	47.0	47.6
15	48.1	49.7	51.5	52.6	53.6	54.5	62.1	62.7	63.8	65.0	66.3	68.2	68.8	70.0	71.8	55.4	56.5	58.1	46.5	47.4	48.7
16	46.5	47.3	48.4	52.9	53.7	54.8	61.3	62.1	63.0	66.2	67.0	68.5	70.0	71.1	72.7	56.2	57.4	59.3	47.6	48.3	49.8
17	46.2	47.4	49.0	53.4	55.1	56.8	60.1	60.9	61.6	65.9	67.4	68.8	70.6	71.6	73.3	57.6	58.4	59.3	48.1	49.1	49.8
18	46.5	48.0	49.2	55.1	56.4	57.6	59.9	61.2	62.7	67.3	68.7	70.3	69.1	70.5	72.1	57.9	58.9	60.4	48.7	49.2	50.1
19	48.7	50.5	52.3	57.3	58.1	59.0	61.0	62.4	63.8	68.8	70.2	71.8	66.8	68.5	69.7	57.0	57.8	59.3	48.4	48.9	49.8
20	52.0	53.7	55.4	57.0	57.8	58.4	61.0	62.7	64.1	69.7	71.0	72.7	65.9	67.0	68.5	57.0	57.5	58.4	48.1	48.5	49.0
21	54.5	55.7	57.0	53.7	55.4	57.0	63.3	64.8	66.5	70.3	71.6	73.3	65.9	67.1	68.8	56.5	57.0	57.3	48.1	48.6	49.2
22	55.9	56.8	57.9	51.2	52.2	53.7	64.1	65.6	67.3	70.6	71.8	73.6	65.6	66.3	67.6	55.9	56.4	57.0	48.4	52.0	60.7
23	56.2	56.7	57.0	49.8	50.5	50.9	65.0	66.8	68.8	70.3	71.1	72.4	64.1	65.0	66.2	55.6	56.1	57.0	51.5	56.6	62.4
24	52.9	54.6	56.2	49.8	50.6	51.7	66.2	67.2	68.2	68.8	70.2	71.8	62.7	63.5	64.1	55.4	56.0	56.8	51.7	55.8	59.6
25	50.9	52.1	52.9	51.7	53.4	54.8	63.0	64.8	66.2	69.1	70.5	72.4	61.8	62.9	64.4	54.8	55.8	57.0	54.5	57.2	60.4
26	48.7	49.8	50.9	54.8	55.8	56.5	61.6	63.2	65.3	70.3	71.6	73.3	62.4	63.2	64.7	55.4	56.4	57.6	53.7	55.8	58.4
27	47.6	48.1	48.7	56.2	56.7	57.0	62.7	64.7	66.5	70.9	72.0	73.6	62.7	63.7	65.3	56.5	57.6	59.3	55.1	56.4	58.1
28	46.7	47.2	47.9	57.0	57.4	57.9	65.3	66.7	68.5	71.2	72.5	73.9	63.6	64.7	66.2	57.6	58.6	60.1	55.1	56.2	57.9
29	46.2	46.9	48.1	57.0	57.5	58.1	67.3	69.1	70.9	71.8	73.0	74.5	63.8	65.2	66.8	58.4	59.5	60.7	52.3	54.3	55.9
30	47.0	48.1	49.2	57.3	57.9	58.4	69.4	70.9	72.4	72.4	73.6	75.4	65.3	66.4	67.9	59.6	60.4	61.8	52.6	54.6	56.5
31				57.0	57.3	57.9				72.1	73.0	74.5	66.2	67.5	69.1				54.8	63.5	70.9

Appendix 4 continued. Minimum, Average and Maximum daily water temperatures (F°) for the Missouri, Marias and Teton Rivers, 2016.

Loma Bridge, Missouri River 2053.0

2016

	April			May			June			July			Aug			Sept			Oct	
Date	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	44.3	46.7	49.3	48.7	51.3	53.7	57.4	59.2	61.3	70.7	73.5	76.8	71.8	74.1	76.8	68.6	70.1	72.7	59.9	61.7	63.6
2	46.2	48.9	51.8	52.4	54.5	56.5	59.9	61.0	61.6	73.0	75.3	78.0	70.7	73.7	77.1	66.8	68.4	70.9	58.5	59.7	61.6
3	49.0	50.9	54.0	54.9	57.3	59.6	59.6	61.5	63.3	73.4	75.1	77.4	68.0	71.2	73.0	64.5	66.7	69.2	55.4	57.6	58.5
4	48.5	50.7	53.7	57.7	59.8	61.9	61.3	63.6	65.7	70.7	73.3	75.8	67.1	70.2	73.9	61.3	64.2	66.0	52.6	53.5	55.4
5	46.0	47.6	49.6	59.6	61.6	63.6	64.5	66.3	68.3	68.9	70.8	73.0	69.2	71.4	74.6	59.3	60.4	61.6	50.4	52.0	52.6
6	45.7	48.2	50.7	60.5	61.5	62.5	66.2	67.8	69.5	66.5	68.8	70.9	68.0	68.8	70.1	58.5	60.9	63.9	50.1	50.6	51.5
7	48.2	50.8	53.7	59.3	61.6	63.6	67.4	69.0	71.2	65.1	68.4	71.5	67.7	70.0	73.7	59.9	61.8	64.2	47.9	48.9	50.4
8	49.6	51.8	54.3	61.1	63.0	64.8	67.7	70.1	72.7	68.3	70.7	73.9	67.7	70.5	73.4	59.1	60.4	61.3	47.1	48.4	49.6
9	51.2	52.9	55.4	55.2	59.0	63.6	69.8	71.2	72.1	68.9	71.1	73.7	69.2	71.0	73.9	57.9	59.8	62.2	48.7	50.2	52.4
10	51.2	53.2	55.7	52.1	53.2	55.2	68.9	70.0	70.9	66.5	68.6	70.1	65.1	67.7	69.5	58.5	60.7	63.6	46.0	47.9	50.4
11	50.4	53.2	55.7	50.7	53.3	55.4	66.8	68.1	69.5	64.5	65.5	66.5	64.8	66.6	68.6	56.8	59.2	60.5	43.7	45.7	46.0
12	53.2	55.6	58.2	51.8	53.2	54.9	65.7	67.3	68.9	63.3	65.3	67.1	66.5	68.5	71.2	55.4	56.7	58.5	33.0	44.7	48.2
13	54.3	55.7	57.1	51.2	52.1	53.5	65.7	67.5	68.9	64.8	66.0	67.7	67.1	69.8	72.7	53.5	56.4	59.6	43.7	46.2	47.9
14	50.7	52.8	54.3	50.4	52.9	55.2	64.8	66.4	67.7	64.8	66.9	69.2	68.6	70.7	73.4	55.4	58.1	61.3	46.0	46.6	48.2
15	46.8	48.5	50.7	52.6	54.1	55.2	62.8	64.0	65.4	66.2	68.3	71.5	68.6	71.5	74.9	56.0	58.5	61.9	23.5	46.8	48.5
16	46.0	48.8	51.8	54.0	56.4	59.1	63.6	64.7	66.2	66.2	67.9	70.3	70.3	73.3	77.1	57.1	59.7	63.1	47.1	48.5	50.4
17	48.5	50.2	51.8	55.4	57.4	59.3	61.6	63.2	64.2	67.4	70.0	72.7	70.7	73.1	76.8	57.1	58.6	59.9	46.0	47.0	48.2
18	49.0	50.8	52.6	58.2	59.5	61.1	62.2	64.1	66.5	68.9	71.2	73.9	65.1	69.7	71.5	56.0	58.3	60.8	23.5	47.7	50.1
19	49.6	52.0	54.0	58.8	59.4	59.9	62.2	63.7	64.8	70.3	73.1	76.4	65.1	67.1	69.8	56.8	58.9	61.3	48.2	49.0	50.4
20	52.9	55.3	57.4	57.1	58.0	59.1	63.1	65.6	68.3	71.8	73.7	76.4	66.5	69.3	72.7	57.7	59.1	61.1			
21	55.4	57.6	59.6	54.6	55.8	57.1	65.4	66.5	68.3	71.2	73.9	76.8	67.1	69.8	73.4	56.3	57.4	58.2			
22	57.7	59.0	60.2	53.2	54.3	55.4	64.2	67.3	70.1	72.4	74.3	77.7	65.1	67.8	69.8	55.4	55.7	56.0			
23	56.3	57.7	59.3	51.5	52.4	53.7	67.4	69.7	72.1	70.3	72.1	74.3	63.6	65.0	67.1	55.2	56.4	58.5			
24	54.0	55.1	56.3	50.7	52.2	54.0	64.8	68.1	70.1	69.8	72.9	76.1	63.1	63.8	64.5	55.2	56.3	57.4			
25	51.0	52.4	54.0	52.4	54.1	56.3	63.1	63.7	64.8	70.9	74.0	77.1	61.3	64.1	67.4	54.9	56.6	59.1			
26	50.1	50.7	51.5	54.0	56.8	59.6	62.8	65.9	69.2	72.7	75.2	79.6	63.6	65.6	68.0	55.7	57.8	60.5			
27	47.6	49.0	50.4	56.5	58.5	59.9	65.1	68.0	70.7	71.5	74.3	77.4	63.6	65.8	68.9	56.8	59.2	62.2			
28	46.8	47.8	48.7	57.1	58.8	60.2	66.8	69.4	72.1	71.8	75.0	78.3	64.5	67.0	70.3	57.9	59.7	62.2			
29	47.1	48.2	49.0	57.1	59.2	61.1	68.9	71.5	74.3	73.4	76.0	79.3	64.5	67.3	70.7	57.7	60.3	63.1			
30	47.9	48.9	50.1	57.7	58.9	60.8	70.7	72.5	75.5	73.7	76.4	79.6	66.0	68.6	72.1	59.3	61.5	64.2			
31				56.0	57.8	59.1				73.0	75.3	78.3	67.4	69.9	73.4						

Appendix 4 continued. Minimum, Average and Maximum daily water temperatures (F°) for the Missouri, Marias and Teton Rivers, 2016.

Judith Landing, Missouri River 1984.0

2016

	April			May			June			July			Aug			Sept			Oct		
Date	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	44.4	47.1	50.0	48.3	51.5	54.7	57.2	59.3	61.2	71.1	74.0	76.9	74.3	76.5	78.9	69.8	71.5	73.9	60.4	62.2	64.0
2	46.5	49.9	53.1	51.8	55.3	58.6	60.2	61.5	62.8	72.8	75.6	77.8	72.1	74.9	77.3	68.9	70.1	71.3	59.2	60.7	62.1
3	50.0	52.5	55.1	55.3	58.9	62.3	61.3	63.1	64.8	74.4	76.6	78.5	69.6	72.2	74.9	66.5	67.9	69.3	55.8	58.5	59.9
4	51.1	53.4	55.6	58.4	61.8	64.9	62.7	65.6	68.4	73.2	75.2	76.9	67.9	70.9	73.9	63.1	65.2	67.5	50.2	51.5	55.6
5	47.0	49.0	53.0	61.1	63.8	66.1	65.4	68.1	71.0	70.7	73.1	75.2	69.3	71.7	74.1	60.0	61.4	63.1	48.5	49.7	50.7
6	46.7	48.3	50.4	61.6	62.8	64.5	67.2	69.7	72.2	68.9	70.1	72.3	69.0	69.9	71.2	58.2	60.2	62.0	47.5	48.1	48.7
7	47.3	50.3	53.2	59.8	62.7	65.7	67.8	70.1	73.0	66.6	69.8	72.5	67.3	69.7	72.4	59.4	61.1	62.7	46.5	47.2	47.8
8	49.4	52.4	55.2	60.8	63.7	66.7	68.3	71.7	75.1	69.5	72.0	74.6	68.1	71.4	74.4	59.5	60.9	61.6	45.4	46.7	48.0
9	51.7	53.7	55.8	57.4	61.5	64.2	71.4	72.7	73.9	70.7	73.3	76.2	70.4	72.3	74.4	59.0	60.1	61.9	47.8	49.2	50.8
10	52.0	53.9	55.8	50.6	53.7	57.3	70.8	72.3	74.6	70.0	71.7	73.3	68.0	70.0	71.9	58.2	60.5	62.7	46.2	47.8	49.5
11	50.5	53.3	55.7	49.3	52.1	54.6	68.5	70.0	71.3	65.3	67.3	69.9	66.8	68.7	70.5	58.6	59.8	61.0	44.0	44.9	46.1
12	51.7	54.9	57.6	52.2	54.2	56.5	67.4	69.2	71.4	63.5	65.7	68.1	67.2	69.2	71.2	56.1	57.2	58.5	41.8	43.5	44.9
13	55.6	56.7	58.5	53.6	54.6	56.1	66.5	69.1	71.2	64.6	67.1	69.1	68.0	71.0	74.0	54.0	56.2	58.3	42.2	43.8	45.2
14	53.7	54.9	56.3	52.8	54.9	57.2	67.3	69.2	71.6	65.5	68.2	70.7	69.6	72.0	74.5	53.8	56.5	58.7	44.6	45.8	47.1
15	48.5	50.7	53.6	52.9	55.1	57.2	65.1	66.3	67.6	67.0	69.4	71.9	69.9	73.0	75.9	56.3	58.9	61.4	45.6	47.1	48.5
16	47.1	49.5	51.9	54.9	57.3	60.0	63.7	65.4	67.8	67.5	69.2	71.4	71.3	74.0	76.8	58.5	60.8	63.0	47.4	48.3	50.0
17	47.8	50.4	52.7	55.7	58.9	61.8	62.5	65.3	67.8	67.4	70.5	73.5	71.7	74.2	76.6	58.8	59.9	61.0	46.7	47.4	48.0
18	49.6	52.2	54.6	59.2	61.6	63.9	65.1	67.6	70.3	69.5	72.4	75.3	69.9	72.2	73.9	58.0	59.4	61.3			
19	51.2	54.5	57.5	60.6	62.2	63.8	64.4	66.3	68.0	70.7	74.2	77.8	67.2	68.6	69.8	56.6	58.6	60.4			
20	54.0	57.0	60.0	58.9	60.3	61.1	64.2	67.1	70.1	73.3	76.0	78.5	65.4	67.9	70.1	57.2	58.6	59.7			
21	55.8	58.6	61.3	55.9	57.4	58.8	66.0	68.6	71.4	74.1	76.7	78.9	66.3	69.7	72.9	57.5	58.3	58.8			
22	57.1	59.8	62.1	54.8	56.0	57.8	65.2	68.6	71.5	74.3	76.2	78.6	67.5	68.9	70.4	55.9	56.5	57.5			
23	58.9	60.1	61.3	54.5	55.1	55.9	67.4	70.5	73.6	72.3	73.7	75.2	65.5	67.0	68.8	55.4	55.9	56.9			
24	54.3	57.0	58.9	53.6	54.6	55.8	68.9	71.2	74.0	71.0	74.1	77.3	62.7	63.6	65.7	54.5	55.9	57.5			
25	51.9	52.9	54.2	53.5	54.8	55.7	64.1	65.6	68.8	72.1	75.3	78.2	61.0	63.5	65.8	54.4	56.4	58.3			
26	50.2	51.2	51.9	54.4	56.3	58.5	63.5	66.7	69.5	74.3	76.9	80.2	62.8	65.1	67.6	55.3	57.5	59.7			
27	49.2	49.9	50.3	57.9	59.4	60.7	65.5	69.2	72.7	74.5	76.8	79.5	63.4	66.3	68.7	56.5	59.1	61.4			
28	48.2	49.2	50.5	60.1	61.2	62.5	68.7	71.2	73.9	74.4	76.6	78.9	65.3	67.7	69.9	58.5	60.3	61.9			
29	47.9	49.3	50.9	59.5	61.2	62.6	69.7	73.2	76.8	74.1	76.9	79.7	65.8	68.2	70.5	58.3	60.4	62.2			
30	48.7	49.6	50.4	59.7	61.1	62.1	72.1	74.3	76.7	75.1	77.9	80.7	67.1	69.4	71.7	59.8	61.9	64.0			
31				57.1	58.2	59.6				74.9	77.3	79.6	67.8	70.4	73.0						

Appendix 4 continued. Minimum, Average and Maximum daily water temperatures (F°) for the Missouri, Marias and Teton Rivers, 2016.

Fred Robinson Bridge, Missouri River 1924.0

2016	April			May			June			July			Aug			Sept			Oct		
Date	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1				50.1	52.7	55.3	57.9	59.8	61.8	72.9	75.9	79.0	75.3	77.6	80.0	70.9	72.8	75.5	61.6	63.5	65.8
2				52.5	55.3	58.1	60.3	61.8	63.4	74.7	77.3	80.1	74.1	77.0	79.8	69.9	71.5	73.5	59.8	61.5	63.3
3				56.3	59.3	62.4	61.5	63.5	65.5	75.6	77.8	79.7	70.0	74.1	77.3	68.1	69.3	71.1	55.2	58.6	60.2
4				59.7	62.7	65.4	63.7	66.1	68.6	74.9	77.1	79.3	68.1	71.5	75.2	63.7	66.2	68.5	47.6	50.3	55.6
5				63.0	65.2	67.5	66.6	69.0	71.7	72.3	74.6	76.5	69.7	72.7	75.7	60.4	61.9	63.6	46.0	47.1	48.7
6				62.6	63.8	66.3	68.6	70.4	72.3	70.4	71.7	73.6	70.6	71.8	73.0	59.0	61.4	64.1	45.2	45.7	46.2
7				62.5	63.9	65.7	68.7	71.3	73.8	67.8	70.8	73.6	69.0	71.5	74.3	60.9	62.5	64.1	43.8	44.9	45.5
8				61.2	64.2	66.8	71.0	73.4	75.7	70.2	72.4	75.2	69.7	72.6	75.6	60.6	61.8	63.3	44.4	45.8	47.3
9				60.0	62.9	66.0	72.6	73.9	74.8	71.6	74.4	77.9	70.8	72.6	75.2	59.3	60.7	63.3	46.7	47.7	49.0
10				51.0	55.1	59.9	69.1	72.8	75.0	71.8	73.3	74.6	68.9	71.2	73.7	58.0	60.7	63.6	47.3	48.3	48.8
11				50.0	51.7	53.9	68.1	69.7	71.3	65.3	67.3	71.7	68.3	70.0	71.8	58.9	60.6	61.6	44.6	45.9	47.3
12				51.1	52.9	54.5	67.6	69.6	71.6	64.6	66.6	68.7	68.9	70.6	72.9	56.9	58.3	59.6	42.4	43.9	45.4
13				52.5	54.5	56.8	67.8	70.0	71.8	65.4	67.1	68.8	68.7	71.6	74.5	54.4	56.2	58.5	42.6	43.8	45.0
14				53.4	55.5	57.5	68.7	70.2	72.4	66.5	69.4	72.5	70.5	73.2	75.8	54.2	56.8	59.6	44.0	44.8	45.7
15	49.9	52.7	55.6	54.7	56.7	58.8	66.8	68.1	69.7	68.9	71.0	73.3	71.7	74.1	76.9	58.0	59.6	62.5	44.6	46.3	48.0
16	48.3	50.2	52.1	55.4	57.3	58.8	65.1	67.3	69.6	68.7	70.1	71.4	71.8	75.0	78.0	58.4	61.2	64.3	47.1	48.5	50.2
17	49.0	51.4	53.6	56.8	59.4	61.9	64.8	67.2	69.3	67.9	70.9	73.9	73.0	75.9	79.0	60.1	61.8	63.2	47.3	48.0	48.7
18	50.8	51.9	52.8	59.6	61.9	64.2	66.4	68.9	71.4	70.8	73.3	75.8	70.4	73.2	75.2	59.9	61.3	63.2	46.4	47.3	48.5
19	52.0	54.5	57.2	62.4	63.8	65.2	68.0	69.1	70.4	71.8	74.8	77.9	67.9	69.4	70.8	57.6	60.3	63.0	46.3	47.2	48.5
20	55.3	57.7	60.3	61.8	62.7	63.6	65.6	68.2	70.5	74.0	76.3	78.8	65.8	68.6	71.6	58.7	59.9	61.7	46.2	47.2	48.5
21	57.8	59.8	61.8	57.5	59.6	62.5	68.0	70.3	73.0	75.2	77.6	80.0	67.2	70.3	73.3	57.4	58.1	58.8	46.1	47.6	49.1
22	59.0	61.0	63.0	55.9	57.4	58.8	66.6	69.7	72.8	75.9	77.4	78.8	68.1	69.8	71.8	55.3	56.4	57.4	48.0	49.0	50.5
23	60.4	61.5	62.6	56.2	57.0	57.9	69.3	72.0	74.7	73.1	75.1	76.9	65.7	67.8	69.7	54.6	55.1	55.6	47.8	49.0	50.1
24	55.2	58.4	61.5	55.5	56.6	57.9	71.1	72.8	75.5	72.3	75.3	78.1	63.3	64.7	65.7	54.8	55.7	57.5	47.4	48.7	50.0
25	52.8	53.5	55.1	55.7	56.9	57.9	67.1	68.9	71.4	73.0	76.3	79.5	61.4	64.4	68.2	54.3	56.3	58.5	48.3	49.4	50.8
26	50.6	51.2	52.8	55.4	56.1	57.4	64.9	67.6	70.4	75.8	78.0	80.8	63.2	65.5	68.4	55.3	57.1	59.2			
27	49.0	50.0	50.6	55.9	58.3	61.1	66.7	70.2	73.8	73.6	75.7	77.2	63.1	66.3	69.6	56.4	58.9	61.7			
28	48.2	49.0	49.6	60.7	61.7	62.9	69.9	72.1	74.7	75.0	76.9	79.3	66.4	68.9	72.0	58.7	60.6	62.6			
29	48.7	49.5	50.4	60.9	62.7	64.8	71.2	74.4	78.0	75.0	77.7	80.5	66.8	69.6	72.6	59.5	61.6	63.9			
30	50.0	51.4	53.2	61.3	62.8	64.2	73.5	75.5	77.5	75.2	78.1	81.1	67.8	70.1	72.7	61.0	63.1	65.5			
31				58.9	59.8	61.2				76.6	79.0	81.4	68.6	71.5	74.7						

Appendix 4 continued. Minimum, Average and Maximum daily water temperatures (F°) for the Missouri, Marias and Teton Rivers, 2016.

Marias River upstream of Teton River Confluence, Marias River RM 3.0

2016	April			May			June			July			Aug			Sept			Oct		
Date	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	47.9	43.8	52.5	54.0	47.8	60.3	60.5	55.0	65.7	75.5	70.8	81.1	75.0	71.5	78.7	71.7	68.7	75.3	61.3	59.9	62.7
2	51.2	45.7	56.7	58.7	52.3	64.9	63.4	59.7	68.1	76.7	72.6	80.5	74.1	69.6	78.5	69.1	66.9	71.4	58.4	56.1	60.0
3	54.1	49.6	59.3	62.9	56.8	69.0	65.5	59.9	71.2	76.7	73.4	80.8	70.7	67.8	74.5	66.3	62.6	69.9	55.9	53.5	57.9
4	53.8	50.2	58.1	65.7	60.4	70.6	69.7	63.2	76.1	73.8	70.7	77.5	69.9	64.8	75.1	61.7	59.2	65.3	50.5	48.9	53.4
5	47.9	46.1	52.0	66.6	61.9	71.6	72.9	67.1	78.7	70.8	67.0	74.4	71.0	67.1	75.4	58.1	56.4	59.2	47.3	45.8	48.8
6	47.8	44.1	51.5	64.8	61.6	68.8	73.5	69.1	78.0	68.0	65.3	71.3	69.4	67.8	71.4	57.4	53.6	61.1	46.0	44.9	47.5
7	50.7	45.4	56.2	64.2	59.4	69.1	73.1	68.8	78.5	68.4	62.8	73.9	69.6	66.1	73.4	59.8	56.3	63.4	44.4	43.0	45.5
8	53.1	47.8	58.2	65.7	60.0	71.7	73.7	67.7	79.5	71.9	67.1	77.7	71.1	66.2	75.9	60.1	58.4	62.0	44.6	42.8	46.3
9	55.1	51.3	58.2	58.3	54.1	65.4	74.8	70.4	79.0	73.1	69.1	77.0	72.0	68.9	75.7	59.8	56.9	63.3	47.9	45.5	50.4
10	55.1	51.1	59.4	50.4	48.4	54.0	73.2	69.1	77.7	69.9	67.9	72.4	68.8	66.8	70.8	61.1	56.9	65.1	45.1	43.1	48.3
11	54.0	48.9	58.9	51.3	46.2	56.0	70.3	67.9	72.3	65.9	64.5	67.8	66.8	63.6	69.7	59.1	56.6	61.8	42.1	40.5	43.8
12	56.1	51.3	60.4	53.0	50.2	56.6	67.3	63.8	70.5	65.3	62.7	68.2	70.0	66.2	74.6	55.7	53.6	57.4	41.0	38.2	43.9
13	56.7	54.6	59.7	53.8	50.4	57.9	67.4	62.8	71.1	66.7	62.9	70.4	71.5	66.6	76.2	54.3	50.0	58.7	40.6	38.6	41.8
14	51.9	49.4	54.8	56.2	50.4	62.1	67.3	64.9	70.7	70.0	65.1	75.1	72.4	68.8	75.8	55.9	51.5	59.9	42.8	41.2	44.5
15	45.8	43.3	49.3	57.8	53.4	61.8	64.9	61.2	68.7	70.9	66.6	76.3	73.0	68.1	78.3	58.0	53.3	62.6	45.0	42.4	47.3
16	45.4	40.9	50.2	60.7	55.8	66.3	65.9	62.8	69.6	70.4	66.6	75.6	74.6	69.9	79.4	60.5	56.3	64.5	48.2	46.2	50.9
17	49.0	43.6	54.3	63.2	57.3	69.2	64.6	60.0	68.6	71.9	66.4	77.2	74.5	70.4	79.1	59.2	57.6	61.0	47.2	45.9	48.4
18	52.8	47.3	58.3	65.4	60.2	70.5	67.6	63.0	72.6	74.1	69.6	79.2	69.4	65.7	73.0	58.7	56.3	61.8	47.8	46.4	49.7
19	56.8	50.9	62.7	64.9	62.2	67.5	66.9	62.6	71.2	76.2	70.8	82.0	66.0	63.0	69.2	57.8	54.3	61.0	47.8	46.3	50.0
20	60.4	54.9	65.7	62.0	60.1	64.2	68.5	62.3	74.8	76.1	72.1	80.8	66.6	61.7	71.3	58.5	56.1	60.6			
21	61.8	57.3	66.1	57.2	53.9	60.1	69.6	66.7	73.6	75.4	70.5	80.4	68.5	63.8	73.2	56.9	55.7	58.6			
22	62.1	58.2	66.0	54.3	51.5	57.2	69.2	63.2	75.2	75.4	71.6	81.1	67.6	65.0	70.7	55.1	54.6	55.6			
23	59.1	57.3	62.1	54.1	51.7	56.3	72.0	66.3	77.7	72.0	67.9	75.5	64.2	61.7	66.4	55.2	54.0	57.0			
24	54.8	52.3	57.2	56.1	52.5	60.6	69.5	65.6	72.4	73.4	67.7	78.8	62.8	61.1	64.6	54.7	52.4	56.6			
25	50.9	49.6	52.2	59.3	54.8	63.7	64.1	62.1	66.3	75.6	70.0	81.0	62.5	58.3	66.6	55.5	51.9	59.1			
26	48.8	47.2	50.3	62.1	56.8	67.3	66.0	60.1	71.7	76.8	73.6	82.0	64.1	60.7	67.8	57.5	53.7	61.5			
27	47.1	46.2	48.2	65.4	61.2	69.2	70.4	64.5	76.5	75.4	71.5	79.7	65.1	61.4	68.4	59.9	55.8	64.2			
28	47.3	44.5	50.1	65.0	61.9	68.3	72.3	67.1	77.9	76.1	72.1	80.2	67.8	64.0	72.0	60.2	57.1	63.2			
29	48.7	46.2	51.0	64.3	59.4	69.9	74.8	69.2	80.4	77.9	73.8	82.4	68.4	63.9	73.0	60.6	56.7	64.5			
30	49.9	46.5	53.3	62.7	60.4	64.7	75.6	71.9	80.3	78.0	74.2	81.2	70.3	66.3	74.0	61.8	58.4	65.1			
31				58.5	56.1	61.8				76.8	73.6	80.3	71.5	67.5	75.4						

Appendix 4 continued. Minimum, Average and Maximum daily water temperatures (F°) for the Missouri, Marias and Teton Rivers, 2016.

Teton River, Teton River RM 2.3

2016

	April			May			June			July			Aug			Sept			Oct		
Date	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	42.1	49.4	57.7	46.1	56.4	67.2	55.2	63.7	71.8	66.3	75.4	86.4	65.9	73.5	80.9	59.5	68.9	86.7	58.9	61.8	65.1
2	44.2	53.0	62.6	50.7	61.0	71.6	60.8	65.5	71.9	71.0	76.6	82.4	65.2	73.9	82.7	55.2	62.9	77.7	52.1	57.5	61.9
3	48.6	55.8	64.5	54.5	64.8	75.4	58.0	66.8	76.6	70.8	76.9	82.8	63.9	69.2	73.9	45.1	58.5	74.2	50.8	54.2	56.9
4	48.1	54.8	63.0	58.2	67.4	76.4	60.6	71.5	82.8	68.1	72.6	76.3	60.7	70.3	79.7	51.1	53.1	55.3	46.8	48.5	50.6
5	44.4	46.7	51.8	60.0	67.6	77.4	64.1	74.4	85.4	64.2	69.7	74.9	64.8	72.1	80.5	52.0	55.0	60.1	44.0	46.1	48.0
6	41.7	48.4	55.8	58.2	63.9	70.2	65.8	74.5	84.2	64.2	67.5	70.4	66.0	68.3	71.1	47.2	57.3	69.8	43.3	45.2	48.4
7	43.9	52.9	63.2	55.6	65.0	75.2	65.6	74.2	86.1	61.6	68.6	76.1	63.3	70.5	79.2	51.7	58.9	71.5	40.0	43.2	45.5
8	45.8	55.1	64.8	57.8	67.7	77.9	65.1	75.4	86.3	67.9	73.6	80.6	63.4	71.7	80.6	51.9	56.7	64.5	40.9	44.2	48.1
9	50.6	56.4	63.4	51.3	56.0	66.0	68.1	75.8	83.0	69.5	74.7	79.2	65.5	71.4	79.2	49.2	56.5	72.1	45.1	48.5	53.9
10	48.2	55.8	64.8	48.0	49.1	51.2	64.6	73.1	82.5	67.6	70.6	74.3	62.7	67.2	74.4	45.0	57.1	72.4	39.2	42.4	47.0
11	45.4	55.3	66.3	44.4	53.6	62.8	66.4	69.0	72.4	62.5	65.5	68.1	60.0	66.8	73.6	48.2	51.4	56.4	37.7	40.4	43.0
12	50.0	58.5	67.0	50.4	54.8	62.4	60.9	69.1	77.9	61.0	66.0	71.2	63.0	70.2	80.4	38.1	48.0	58.7	33.4	39.9	47.4
13	53.5	57.8	63.5	48.7	54.4	62.4	58.7	70.2	81.2	63.5	67.4	70.6	62.3	72.1	82.9	33.1	49.7	71.1	36.3	40.5	43.9
14	47.6	49.9	53.2	48.0	57.3	67.9	62.9	68.6	76.1	64.0	69.9	76.9	64.1	71.4	80.4	37.8	53.9	76.6	41.4	44.0	47.2
15	42.0	44.1	47.5	50.7	58.8	67.4	56.8	65.0	74.1	66.3	72.0	79.0	63.2	72.0	82.0	39.1	56.2	80.8	40.7	45.7	50.4
16	38.6	48.6	59.9	53.0	62.1	72.4	61.3	67.2	75.1	65.1	70.4	77.8	62.3	73.4	85.3	41.2	57.5	80.4	46.3	49.0	54.3
17	43.2	52.8	63.0	54.6	64.7	75.0	55.5	65.2	74.0	60.6	73.3	85.0	62.4	71.7	85.7	42.1	54.2	65.1	42.9	45.3	48.0
18	45.7	55.2	65.2	58.7	67.2	76.9	61.5	70.1	81.0	67.7	76.6	86.3	60.4	64.3	68.0	45.4	57.4	71.2	44.3	46.8	50.8
19	48.7	58.6	69.0	60.3	65.1	70.5	58.6	67.6	76.7	68.8	77.5	87.6	57.6	65.0	72.7	39.0	54.2	73.9	44.3	47.0	51.4
20	53.0	62.2	71.7	57.1	59.9	62.7	58.7	70.9	83.9	70.3	75.7	81.9	58.0	67.9	79.1	46.7	55.2	69.2			
21	55.4	63.4	71.5	51.9	54.9	57.0	64.1	70.5	78.5	67.7	75.0	82.0	60.0	69.6	82.6	51.3	53.4	56.6			
22	56.6	63.3	70.2	48.7	54.8	62.4	58.5	70.6	83.1	70.9	75.9	84.0	57.4	63.5	72.4	51.9	53.4	55.0			
23	56.2	59.3	62.6	50.5	54.7	59.4	63.3	74.8	87.0	66.9	72.9	77.9	52.2	60.8	70.3	52.8	55.5	60.2			
24	50.7	53.8	56.1	51.5	57.7	65.3	60.9	68.3	74.8	67.5	74.6	82.1	55.4	59.5	65.0	48.9	55.0	62.5			
25	47.6	50.0	53.1	53.6	61.4	69.1	55.9	61.5	68.2	68.3	76.1	83.8	49.2	61.6	74.6	47.8	55.7	66.5			
26	46.1	49.1	53.3	56.1	64.1	73.0	58.8	67.3	75.1	72.9	77.9	86.3	54.3	62.8	76.6	49.5	58.3	70.3			
27	46.1	47.7	48.8	61.5	66.8	72.7	62.6	71.8	80.8	68.5	75.1	82.2	51.5	63.6	76.2	51.1	60.3	73.9			
28	44.1	48.7	54.2	61.1	65.3	69.8	67.1	73.4	80.2	68.0	76.1	84.3	56.6	65.4	78.7	53.3	60.0	67.9			
29	46.2	50.6	55.2	57.4	65.2	73.2	66.6	74.2	81.8	71.9	78.8	85.9	50.8	65.5	82.8	53.5	61.2	69.6			
30	46.3	51.9	58.4	60.0	63.5	67.3	69.6	76.1	83.4	71.0	78.4	84.6	58.3	68.7	84.3	56.2	62.9	70.5			
31				55.9	59.6	66.0				69.3	75.4	83.9	57.9	70.2	88.8						

Highlighted data shows days where extreme low flows (less than 10 cfs) likely impacted data logger accuracy.

Appendix 5. Average monthly temperatures Morony and Loma Bridge 2001 - 2016

Morony RM 2104.3	15-Apr	MAY	JUN	JUL	AUG	SEP	15-Oct
2001	48.8	57.2	63.1*				
2002							
2003	Lost						
2004	53.2*	53.7	58.9	69.3	66.8	58.8	54.3
2005	49.3*	54.4	60.2	69	67.7	59.3	52.3
2006							
2007	49.3*	54.4	60.2	69	67.7	59.3	52.3
2008	46.1	52.4	56.7	67.5	66.8	58.4*	--
2009	--	53.7*	60.9	67.8	67.5	63.6	47.1
2010	51.0*	49.4	56.9	66.3	67.6	58.4	58
2011	45.9	51	56.4	66.1	68.9	62.4	56.1
2012	--	56.0*	61.3	71.4	68.7	61.5	52.6
2013	47	56.5	62.9	72.6	69.8	63.6	50.5
2014	47.8*	54.1	61	69	68.7	60.7	55.3
2015							
2016	50.8	55.2	64.5	69.4	67.6	59.1	52.1
Mean (N)	47.4 (4)	53.4 (9)	60 (11)	38.8 (11)	68 (11)	60.7 (10)	53.1 (10)

Loma Bridge (RM 2053)	15-Apr	MAY	JUN	JUL	AUG	SEP	15-Oct
2001	49.8	58.4	65.4	72.3	71.3	63	52.2
2002	47.4	53.8	61.4	72.9	66.5	61.4	50.6
2003		55.7*	64	72.5			
2004	54.4	55.8	62.3	72.4	69	60	54.6
2005	50.6*	55.9	62.8	70.8	68.8	60	52.3
2006	51.2	58.3	66.1	74.9	70.2	60.9	54.2
2007	52.5	58.6	65.5	76	69.3	60.1	51.5
2008	47.1*	54.7	59.2	69.7	68.7	59.1	52.3
2009							
2010	51.5	52	59	67.6	68.7	58.7	59.7*
2011	46.6	51.7	57.1	67.3	70.1	62.7	57.8*
2012	52.6	56	62.9	73.6	70.4	62.1	52.2
2013	47.6	58	64.1	74.5	71.7	64.6	50.6*
2014							
2015	54	57.4				61	55.5
2016	52	56.7	66.6	71.7	69.1	59.9	50.7
Mean (N)	50.9 (11)	55.9 (14)	62.8 (13)	72 (13)	69.5 (12)	61 (13)	52.6 (11)

Appendix 6. Average monthly temperatures Judith Landing and Robinson Bridge 2001 – 2016.

Judith Landing (RM 1983)	15-Apr	MAY	JUN	JUL	AUG	SEP	15-Oct
2001							
2002	48.6	55.1	63.3	73.2	67.5	61.7	42.8
2003	56*	57.4	65.8	73.3	72.3	60.2	54.8*
2004	55.5	56.8	63.9	73.5	69.7	60.7	54.2
2005	51.3	57	64.4	72.4	69.2	60.2	51.8
2006	Lost						
2007	54.5	60.4	67.5	77.6	70.4	60.6	51.5
2008							
2009	48.6*	55.3	64.2	71.3	69.3	64.3	45
2010	--	53.6	60.7	69.3	70.2	58.9	59.5*
2011	47.7	52.8	58.5	68.9	71.2	62.6	56
2012	--	57.9*	64.9	75.6	71.7	62.3	51.7
2013	47.8	59.6	65.5	75.5	72.9	65	49.8
2014	49.7	57	63.6	72.1	70.9	61.3	54.9
2015	54.9	58.6	70.5	71.9	69.8	61.4	55.2
2016	53.2	58.1	68.3	73.2	70	60.2	49.8
Mean	51.5 (9)	56.8 (12)	64.7 (13)	72.9 (13)	70.4 (13)	61.5 (13)	51.5 (11)

Robinson Bridge (RM 1921)	15-Apr	MAY	JUN	JUL	AUG	SEP	15-Oct
2001	52.6	60.9	67.4	74.5	73.6	63.5	55*
2002	46.9*	55.7	64.7	74.4	68.2	62.4	50.2
2004	55.9	56.9	64.4	74.1	70	61	53.8
2005	50.7	57.9	65.6	73.6	70.2	61.1	52
USGS 2006	52.8*	61	69.4*	77.1*	71.7*	60.8	54.3
2007	54.7	61	68.4	78.8	71.8	62	51.8
2008	48.2	57.1	62.1	72.6	70.9	60.2	51.1
2009	50.3*	56	65	71.8	69.4	64.9	46.3
2010	52.4	53.8	61.2	69.6	70.7	58.3	56.9
2011	50.2*	53.7	59.7	70.2	72.3	63.1	56.6
2012	--	58.7*	65.4	76.2	72.7	63.3	53
2013	48.4	60.7	66.3	76.3	73.8	65.8	50.4*
USGS 2015	55.1	56.7*	68.2	70	67.8	58.7	52.3
2016	54.1	59	69.5	74.2	71.1	60.9	49.2
Mean (N)	52.4 (9)	57.8 (12)	64.5 (13)	73.6 (13)	71 (13)	61.9 (14)	52.3 (13)

Appendix 7. Average monthly temperatures Marias at Circle Bridge and RM1or 3 2001 – 2016.

Circle Bridge (RM 59)	15-Apr	MAY	JUN	JUL	AUG	SEP	15-Oct
2001	47.9	55.7	62	66.8	65.8	59	50.5
2002	45	51.5	56.2	61	56.2	55.3	53.2
2003		52.4*	57.7	61.8	62.2	60.4	55.4
2004	49.7	53.6	59.5	65.6	62	57.2	53.6
2005	46	52.5	60.7	65.8	62.4	57.4	52.3
2006		54.5*	58.6	61.1	59.9	55.4	52
2007		53.6	59.8	67.3	62.6	56.2	52
2008	--	54.2*	57.7	63.2	61.8	56	53.0*
2009	--	53.4*	57.2	60.1	58.4	56.2	48.4*
2010	--	51.1*	58.8	62.7	61.2	56.4	56.2
2011	--	--	56.5	62	66	61.4	57.4
2012	--	52	58.7	65.4	63.8	59.3	53.4
2013	--	--	58.3	61.6	60.2	57.6	--
2014		50.8	56.7	61.2	60.2	56.4	54.7
2015	48.6	51.1	57.3	57.5	58.1	55.2	53.6
2016	47.9	53.1	60.2	63	61.5	57.1	49.7
Mean (N)	47.5 (6)	52.6 (9)	58.5 (16)	62.9 (16)	61.4 (16)	57.3 (16)	53.4 (14)

Marias (RM 1 or 3)	15-Apr	MAY	JUN	JUL	AUG	SEP	15-Oct
2001	51.2	60	67.1	72.9*			
2002	47.5	54.9	60.2	67.3	63.6	58.2	49.2
2003		58*	66	72.9	71.7	58.8	52.1*
2004	54.1	56.7	64.6	72.6	68.9	59.8	52.6
2005	51.4*	58.7	66.3	71.6	69.3	59.7	51.4
2006	53.2	60.5	66.8	74.2	69.3	59.3	51.3
2007	53.9	60.7	69.4	77.8	70.1	59.8	51.1
2008	47.7*	56.8	63.7	70.3	67.3	58.3	50.5
2009	--	58.9	66.3	71.5	67.6	62.2	43.2
2010	53	55.7	65	71	68.9	58.2	58.7*
2011	45.6*	51.8	61.5	69.2	68.6	61.7	57.4*
2012	--	58.5*	65	74.9	70.8	61.3	50.8
2013	47.5	59.8	64.9	73.1	70.1	62.8	49.8*
2014	51.1*	57.2	61.3	68.7	67.8	59.4	54.1
2015	54.5	58.5	69.5	69.3	67.9	59.8	54.3
2016	52.5	60	69.1	73.1	69.3	59.3	47.5
Mean (N)	51.9 (9)	57.9 (14)	65.4 (16)	71.8 (15)	68.7 (15)	59.9 (15)	50.5 (11)

Appendix 8. Electrofishing statistics for Morony Section, Fall 2016, for all sizes of fish, 9.0 hours electrofishing.

			Length (mm)			Weight (mm)			mean
Species	N	CPUE	mean	min	max	mean	min	max	Wr
Bigmouth Buffalo	2	0.2	714	714	714	6305	6305	6305	93.5
Brown Trout	13	1.4	266	200	493	243	80	1135	91.9
Channel Catfish	173	19.2	564	433	765	2045	860	6305	107.8
Common Carp	123	13.6	663	553	740	4143	2525	6040	103.8
Freshwater Drum	104	11.5	395	272	594	945	245	2770	107.2
Goldeye	216	23.9	322	217	385	306	190	555	
Longnose Sucker	163	18.1	351	218	473	561	110	1170	
Mountain Sucker	3	0.3	196	188	208	100	90	105	
Mountain Whitefish	3	0.3	280	276	289	228	200	270	102.6
Northern Pike	4	0.4	708	595	849	2583	1320	4245	100.5
Rainbow Trout	20	2.2	288	202	422	296	100	650	93.5
River Carpsucker	28	3.1	446	382	576	1379	810	3220	107.7
Rocky Mtn Sculpin	2	0.2	91	82	100	15	15	15	
Sauger	25	2.8	376	248	548	530	200	1515	92.1
Shorthead Redhorse	1484	164.3	438	278	566	1059	225	1970	104.2
Smallmouth Bass	245	27.1	280	154	417	422	50	1310	117.8
Smallmouth Bass <150	8	0.9	135	105	150	59	15	195	116.0
Smallmouth Buffalo	22	2.4	647	496	825	5175	1900	10160	93.1
Stonecat	5	0.6	163	153	171	40	35	50	
Walleye	42	4.7	345	235	501	390	110	1350	89.2
White sucker	74	8.2	286	162	482	402	35	1430	99.6
White sucker <150	1	0.1	133	133	133	30	30	30	97.3
Total	2760								

Appendix 9. Electrofishing statistics for Fort Benton Section, Fall 2016, for all sized fish, 9.8 hours electrofishing.

				Length (mm)			Weight (mm)		mean
Species	N	CPUE	mean	min	max	mean	min	max	Wr
Blue Sucker	1	0.1	746	746	746	4520	4520	4520	106.6
Brown Trout	3	0.3	337	210	528	520	85	1300	77.2
Burbot	1	0.1	392	392	392	300	300	300	67.6
Channel Catfish	168	17.2	571	331	830	2253	735	7675	108.7
Common Carp	86	8.8	642	211	792	3695	155	7870	98.8
Freshwater Drum	92	9.4	364	270	595	696	250	3370	103.1
Goldeye	363	37.2	332	222	383	324	175	475	
Longnose Sucker	130	13.3	371	212	473	640	95	1510	
Longnose Sucker <150	1	0.1	118	118	118	20	20	20	
Mountain Whitefish	5	0.5	242	218	273	124	95	190	85.9
Mountain Whitefish <15-	2	0.2	135	133	137	20	20	20	
Northern Pike	8	0.8	648	466	795	2276	1285	3445	146.5
River Carpsucker	35	3.6	451	370	540	1324	690	2360	100.5
Rocky Mtn Sculpin	1	0.1	88	88	88	10	10	10	
Sauger	123	12.6	387	288	545	517	170	1430	83.0
Shorthead Redhorse	1375	140.9	426	158	532	938	30	1800	96.2
Shorthead Redhorse < 150	2	0.2	142	138	146	30	25	35	86.9
Smallmouth Bass	110	11.3	305	155	417	563	55	1255	118.7
Smallmouth Bass <150	4	0.4	118	91	147	30	10	50	
Smallmouth Buffalo	6	0.6	517	463	677	2551	1485	5630	90.5
Walleye	51	5.2	359	276	458	420	185	915	85.4
White sucker	196	20.1	298	165	484	439	35	1385	98.6
White sucker <150	2	0.2	148	147	148	68	45	90	160.9
Total	2765								

Appendix 10. Electrofishing statistics for Coal Banks Section Fall 2016, for all sized fish, 12.8 hours electrofishing.

			Length (mm)			Weight (mm)			mean
Species	N	CPUE	mean	min	max	mean	min	max	Wr
Bigmouth Buffalo	1	0.1	652	652	652	4260	4260	4260	83.9
Blue Sucker	1	0.1	722	722	722	3615	3615	3615	95.5
Channel Catfish	73	5.7	555	420	820	2094	765	6975	108.1
Common Carp	76	5.9	529	263	767	2470	230	5735	99.5
Common Carp <150	3	0.2	120	64	150	1150	45	3340	
Flathead Chub	2	0.2	135	125	144				
Freshwater Drum	44	3.4	353	262	432	589	220	1075	102.4
Goldeye	373	29.2	313	161	375	268	50	465	
Longnose Sucker	31	2.4	291	166	441	340	60	1000	
Longnose Sucker <150	1	0.1	69	69	69				
Mountain Whitefish	8	0.6	212	183	244	89	55	130	90.9
Mountain Whitefish <15-	1	0.1	136	136	136				
Northern Pike	8	0.6	638	479	975	1834	690	6055	89.0
Pumpkinseed	1	0.1	84	84	84				
River Carpsucker	179	14.0	427	268	550	1146	525	2940	104.2
Sauger	108	8.5	373	229	504	439	170	1085	80.4
Shorthead Redhorse	585	45.8	314	151	512	473	30	1395	91.7
Shorthead Redhorse < 150	34	2.7	119	20	150	26	5	45	91.7
Shovelnose Sturgeon	4	0.3	818	718	872	2618	2060	3275	101.8
Smallmouth Bass	36	2.8	253	155	466	365	60	1515	115.8
Smallmouth Bass <150	27	2.1	99	78	139	24	10	50	
Smallmouth Buffalo	5	0.4	568	460	822	3365	1520	8090	87.0
Walleye	33	2.6	330	261	455	322	145	945	85.8
White Crappie	1	0.1	132	132	132	30	30	30	100.4
White sucker	22	1.7	258	153	443	274	40	1040	91.4
White sucker <150	3	0.2	83	76	88	5	5	5	54.6
Yellow Perch	4	0.3	124	67	144	45	35	55	95.1
Total	1664								

Appendix 11. Electrofishing statistics for the Judith Landing Section, Fall 2016, for all sized fish, 11.0 hours electrofishing.

			Length (mm)			Weight (mm)			mean
Species	N	CPUE	mean	min	max	mean	min	max	Wr
Bigmouth Buffalo	4	0.4	792	725	905	8575	6485	13450	89.0
Black Crappie	4	0.4	213	189	234	140	95	190	90.7
Blue Sucker	5	0.5	768	662	863	4442	2545	6160	92.7
Bluegill	2	0.2	139	122	156	105	105	105	132.7
Burbot	2	0.2	365	344	385	275	220	330	75.3
Channel Catfish	38	3.5	584	368	822	2354	435	6430	98.5
Cisco	2	0.2	249	201	296	128	85	170	
Common Carp	43	3.9	383	218	655	1136	190	3970	97.3
Common Carp < 150	2	0.2	119	91	147				
Emerald Shiner	36	3.3							
Flathead Chub	74	6.7	134	94	291	73	35	200	
Freshwater Drum	36	3.3	334	291	412	477	305	745	102.8
Goldeye	715	65.0	310	249	356	237	120	335	
Longnose Sucker	25	2.3	272	172	433	268	55	760	
Longnose Sucker <150	2	0.2	98	98	98				
Northern Pike	8	0.7	593	467	670	1172	625	1655	82.3
Pallid Sturgeon	1	0.1	513	513	513	435	435	435	93.2
River Carpsucker	131	11.9	435	151	638	1239	40	3665	104.0
River Carpsucker <150	4	0.4	140	131	150	50	50	50	106.4
Rocky Mtn Sculpin	1	0.1	92	92	92				
Sauger	140	12.7	348	226	520	345	130	1030	78.7
Shorthead Redhorse	515	46.8	286	151	496	354	35	1230	90.1
Shorthead Redhorse < 150	174	15.8	124	56	150	33	20	40	88.4
Shovelnose Sturgeon	1	0.1	917	917	917	3750	3750	3750	99.2
Smallmouth Bass	8	0.7	256	155	412	433	55	1290	112.4
Smallmouth Bass <150	19	1.7	96	71	141	25	25	25	
Smallmouth Buffalo	4	0.4	534	415	646	2573	1000	3855	82.3
Walleye	36	3.3	347	250	589	425	125	1865	85.2
Western Silvery Minnow	35	3.2	108	99	130				
White sucker	10	0.9	245	172	377	198	45	625	84.7
Yellow Perch	1	0.1	204	204	204	90	90	90	75.9
Total	2077	188.8							

Appendix 12. Electrofishing statistics for Robinson Section Fall 2016, for all sized fish, 12.4 hours electrofishing.

			Length (mm)			Weight (mm)			mean
Species	N	CPUE	mean	min	max	mean	min	max	Wr
Bigmouth Buffalo	2	0.2	729	694	763	6810	5705	7915	93.9
Black Crappie	47	3.8	198	136	287	125	35	265	93.2
Blue Sucker	3	0.2	746	655	817	3502	2275	4405	89.7
Burbot	6	0.5	360	291	492	248	110	530	65.1
Channel Catfish	98	7.9	483	223	781	1034	95	5845	85.2
Cisco	37	3.0	275	214	315	162	75	230	
Common Carp	42	3.4	413	243	712	1227	200	4640	95.4
Emerald Shiner	6	0.5							
Flathead Chub	70	5.6	139	40	235	52	25	125	
Freshwater Drum	85	6.8	309	253	479	382	190	1350	101.3
Goldeye	519	41.8	304	185	363	222	55	395	
Goldeye <150	51	4.1							
Longnose Sucker	3	0.2	340	302	409	467	310	765	
Northern Pike	5	0.4	791	725	865	3300	2350	4355	94.0
Rainbow Trout	1	0.1	532	532	532	1430	1430	1430	80.0
River Carpsucker	146	11.8	450	151	566	1375	45	2665	103.6
River Carpsucker <150	1	0.1	135	135	135				
Sauger	109	8.8	344	164	570	345	25	1855	78.2
Sauger <150	1	0.1	143	143	143				
Shorthead Redhorse	200	16.1	338	151	459	487	40	1060	97.7
Shorthead Redhorse < 150	12	1.0	134	119	150	30	30	30	83.0
Shovelnose Sturgeon	1	0.1	690	690	690	1755	1755	1755	119.6
Smallmouth Buffalo	3	0.2	540	453	699	2923	1350	5700	86.4
Stonecat	7	0.6	136	83	177	37	30	50	
Walleye	44	3.5	349	164	693	543	30	3655	81.8
Western Silvery Minnow	4	0.3	118	112	127				
Total	1503	121.0							

Appendix 13. Sauger length (mm) at age from spines sampled from August – October 2014-2016, by year and sampling section.

		2014 Length					**2015** Length					**2016** Length		
AGE	N	Mean	Min	Max	AGE	N	Mean	Min	Max	AGE	N	Mean	Min	Max
							Morony							
2	1	250	250	250						2	1	248	248	248
3	4	321	270	352	3	1	356	356	356	3	4	335	308	352
4	5	387	338	427	4	4	347	308	401	4	8	358	303	437
5	6	446	427	482	5	5	406	343	432	5	5	428	341	548
6	9	460	410	518	6	2	486	471	500	6	2	501	485	517
7	2	415	414	415	7	1	552	552	552	8	1	495	495	495
8	2	484	483	485						10	1	522	522	522
Total	29					13					22			
							Fort Benton							
2	3	295	278	314										
3	3	327	303	362	3	7	335	313	352	3	5	310	277	340
4	4	352	319	400	4	3	374	360	395	4	9	350	318	392
5	12	411	345	443	5	15	415	324	498	5	12	420	326	505
6	10	433	376	463	6	6	450	385	506	6	13	441	348	523
7	5	462	375	524	7	7	455	421	496	7	6	477	383	545
8	6	488	468	512	8	2	545	539	551					
9	5	492	397	535										
Total	48					40					45			
							Coal Banks							
2	7	280	256	314	2	4	238	224	247	2	1	297	297	297
3	4	330	323	336	3	3	253	247	257	3	12	318	296	334
4	5	365	339	406	4	6	341	260	402	4	5	364	347	375
5	7	377	329	436	5	6	378	347	415	5	5	396	331	471
6	8	396	347	436	6	10	405	294	480	6	14	437	372	585
7	4	403	359	451	7	5	454	386	497	7	3	429	386	488
8	6	456	398	488	8	1	497	497	497	8	1	481	481	481
9	1	476	476	476										
Total	42					35					41			

Appendix 13 continued. Sauger length (mm) at age from spines sampled from August – October 2014-2016, by year and sampling section.

2014		Length			2015		Length			2016		Length		
Age	N	Mean	Min	Max	Age	N	Mean	Min	Max	Age	N	Mean	Min	Max
							Judith	Landing						
0	8	140	131	155										
1	2	264	261	267	1	1	178	178	178					
2	11	275	226	322	2	6	264	226	301	2	5	286	257	315
3	9	315	297	346	3	7	309	265	339	3	11	320	277	370
4	6	361	332	398	4	5	355	317	400	4	5	372	330	404
5	6	382	347	416	5	5	384	372	402	5	7	415	350	477
6	11	414	350	493	6	7	448	412	485	6	9	408	334	477
7	4	420	379	475	7	3	422	405	436	7	3	488	440	520
8	8	462	385	539	8	1	475	475	475	8	1	503	503	503
9	1	426	426	426										
Total	66					35					41			
							Robinson							
0	6	143	124	170	0	7	168	143	182	0	4	164	143	183
1	4	228	162	263	1	4	192	166	215	1	3	224	186	246
2	7	265	236	280	2	16	253	213	289	2	10	272	253	283
3	4	284	261	337	3	6	317	302	342	3	5	318	292	341
4	11	317	291	346	4	1	373	373	373	4	7	352	323	413
5	10	395	319	486	5	14	382	332	493	5	5	413	378	456
6	11	392	326	495	6	8	422	349	487	6	11	415	328	492
7	8	429	363	480	7	1	435	435	435	7	3	445	376	519
8	5	441	376	552	8	1	471	471	471	8	1	390	390	390
9	1	456	456	456						9	2	501	432	570
Total	67					58					51			
							Overall							
0	14	141	124	170	0	7	168	143	182	0	4	164	143	183
1	6	240	162	267	1	5	189	166	215	1	3	224	186	246
2	31	276	226	322	2	26	253	213	301	2	17	276	248	315
3	28	318	261	387	3	24	314	247	356	3	37	319	277	370
4	34	349	291	427	4	19	353	260	402	4	34	358	303	437
5	45	398	319	486	5	45	395	324	498	5	34	415	326	548
6	52	417	326	518	6	33	431	294	506	6	49	430	328	585
7	23	429	359	524	7	17	453	386	552	7	15	463	376	545
8	27	464	376	552	8	5	507	471	551	8	4	467	390	503
9	8	477	397	535						9	2	501	432	570
										10	1	522	522	522
Total	268					181					200			

Appendix 14. Walleye length (mm) at age from spines sampled from August – October 2014-2016, by year and sampling section.

2014		Length			2015		Length			2016		Length		
Age	N	Mean	Min	Max	Age	N	Mean	Min	Max	Age	N	Mean	Min	Max
							Morony							
					1	6	264	234	286	1	2	250	242	257
2	10	261	239	292	2	7	280	271	302	2	9	330	285	378
3	3	321	272	348	3	8	327	300	352	3	14	353	294	403
4	6	348	292	383	4	6	360	324	419	4	3	374	320	408
5	6	403	361	482	5	12	396	332	502	5	4	441	404	501
6	8	471	418	529	6	3	478	404	590					
7	3	518	473	546										
8	2	520	435	604	8	1	652	652	652					
12	1	689	689	689										
Total	39					43					32			
							Fort Benton							
					1	3	292	282	304	1	2	281	276	285
2	4	269	248	289						2	4	320	299	351
3	3	281	256	305	3	6	340	317	368	3	11	352	321	395
4	10	342	294	422	4	4	380	351	436	4	8	398	360	427
5	9	405	341	462	5	6	404	370	473	5	3	411	370	435
6	5	407	286	474	6	2	469	433	504	6	1	458	458	458
7	5	464	438	482	7	1	385	385	385					
8	2	458	457	459	8	1	575	575	575					
9	1	591	591	591										
10	1	606	606	606	10	1	605	605	605					
11	1	561	561	561										
14	1	731	731	731										
Total	42					24					29			
							Coal Banks							
0	8	139	120	156	0	2	180	180	180					
1	1	163	163	163	1	1	246	246	246					
					2	4	320	311	327	2	2	268	261	274
3	1	325	325	325	3	1	344	344	344	3	7	313	299	329
4	5	339	310	388	4	3	395	385	409	4	7	368	343	455
5	1	419	419	419						5	2	344	336	351
6	1	421	421	421										
					7	1	387	387	387					
Total	17					12					18			

Appendix 14 continued. Walleye length (mm) at age from spines sampled from August – October 2014-2016, by year and sampling section.

2014		Length			2015		Length			2016		Length		
Age	N	Mean	Min	Max	Age	N	Mean	Min	Max	Age	N	Mean	Min	Max
							Judith	Landing						
0	4	141	135	149										
2	1	280	280	280	2	6	278	253	296	2	7	280	250	308
3	2	351	311	390	3	2	339	338	339	3	5	313	286	349
4	11	379	295	425	4	5	364	299	410	4	4	355	320	385
5	3	354	297	395	5	6	371	296	421	5	5	405	371	461
7	2	500	455	545	6	5	395	362	444	6	3	505	401	589
8	1	536	536	536	7	1	670	670	670					
9	2	454	430	478	9	2	618	605	630					
11	2	462	444	479	10	2	572	498	646					
					14	1	461	461	461					
					15	1	474	474	474					
Total	28					31					24			
							Robinson							
0	6	131	123	147	0	7	156	125	180	0	2	197	164	229
1	2	173	170	176	1	3	237	233	241	1	2	247	245	248
2	3	279	223	342	2	6	260	240	282	2	5	273	225	297
3	1	315	315	315						3	8	310	275	361
4	2	408	367	448	4	4	382	375	389	4	4	345	324	386
8	3	465	414	564	5	1	465	465	465	5	1	385	385	385
9	2	504	500	508	6	1	506	506	506	6	1	369	369	369
10	3	636	530	705	9	1	654	654	654	7	1	693	693	693
11	1	626	626	626	11	1	706	706	706	8	3	514	475	539
13	1	739	739	739	12	1	691	691	691	9	1	642	642	642
15	1	672	672	672	13	1	670	670	670	10	2	619	615	622
					19	1	723	723	723					
	25					27					30			
							All Sections Combined							
0	18	137	120	156	0	9	161	125	180	0	2	197	164	229
1	3	170	163	176	1	13	263	233	304	1	6	259	242	285
2	18	267	223	342	2	23	281	240	327	2	27	300	225	378
3	10	315	256	390	3	17	334	300	368	3	45	334	275	403
4	36	359	292	448	4	22	373	299	436	4	26	372	320	455
5	20	398	297	482	5	25	394	296	502	5	15	406	336	501
6	14	444	286	529	6	11	441	362	590	6	5	469	369	589
7	11	480	412	546	7	3	481	385	670	7	1	693	693	693
8	8	486	414	604	8	2	614	575	652	8	3	514	475	539
9	5	501	430	591	9	3	630	605	654	9	1	642	642	642
10	4	628	530	705	10	3	583	498	646	10	2	619	615	622
11	4	528	444	626	11	1	706	706	706					
12	1	689	689	689	12	1	691	691	691					
13	2	660	581	739	13	1	670	670	670					
14	1	731	731	731	14	1	461	461	461					
15	1	672	672	672	15	1	474	474	474					
					19	1	723	723	723					
Total	156					137					133			

Appendix 15. Size at age for Smallmouth Bass sampled in 2016 by sampling section.

			Length (mm)		
Section	AGE	N	Mean	Min	Max
Morony	0	4	165	162	170
	1	5	201	182	219
	2	8	237	188	268
	3	8	276	246	322
	4	15	308	272	353
	5	7	345	314	378
	6	2	368	358	378
	7	2	390	364	415
	Total	51			
Fort	0	5	168	155	183
Benton	1	7	188	165	219
	2	8	234	197	270
	3	5	295	263	354
	4	10	341	308	371
	5	8	351	305	403
	6	2	358	311	405
	7	1	417	417	417
	Total	46			
Coal	0	4	103	87	110
Banks	1	7	176	157	218
	2	3	192	182	204
	3	1	341	341	341
	4	4	356	351	361
	5	2	360	349	371
	6	3	408	404	415
	8	1	440	440	440
	Total	25			
Judith	0	2	104	97	110
Landing	1	4	166	141	195
	2	1	198	198	198
	3	1	337	337	337
	4	1	394	394	394
	5	1	412	412	412
	Total	10			
Overall	0	15	141	87	183
	1	23	184	141	219
	2	20	227	182	270
	3	15	291	246	354
	4	30	328	272	394
	5	18	353	305	412
	6	7	382	311	415
	7	3	399	364	417
	8	1	440	440	440
	Total	132			

Appendix 16. Trammel net fish size statistics from Fort Benton Section in 2016 (20 drifts).

			Length (mm)			Weight (g)			Mean
Species	N	CPUE	Mean	Min	Max	Mean	Min	Max	Wr
Common Carp	3	0.2	654	617	680	3928	3000	4520	101.4
Goldeye	18	0.9	317	283	357	269	195	360	
Longnose Sucker	38	19	427	264	528	836	195	1435	
River Carpsucker	1	<0.1	457	457	457	1470	1470	1470	111.6
Sauger	3	0.2	435	328	556	773	280	1460	80.9
Shorthead Redhorse	82	4.1	428	349	514	889	460	1450	97.3
Shovelnose Sturgeon	29	1.5	846	662	980	3102	1280	5295	104.2
Smallmouth Bass	2	1.0	336	313	359	650	535	765	113.3
Smallmouth Buffalo	3	0.2	801	733	868	6558	5686	7430	72.1
White Sucker	11	0.6	392	272	442	797	245	1030	104.6
Total	190								

Appendix 17. Trammel net fish statistics from the Robinson Section in 2016 (50 drifts).

			Length (mm)			Weight (g)			Mean
Species	N	CPUE	Mean	Min	Max	Mean	Min	Max	Wr
Blue Sucker	2	<0.1	815	799	831	4538	4005	5070	74.5
Channel Catfish	22	0.4	332	252	546	326	125	1320	88.9
Common Carp	11	0.2	449	292	620	1392	350	3140	94.2
Freshwater Drum	2	<0.1	300	294	305	353	330	375	107.4
Flathead Chub	2	<0.1	250	243	257	138	120	155	
Goldeye	16	0.3	292	233	352	200	95	315	
Pallid Sturgeon	61	1.2	480	267	1148	580	70	7650	96.4
River Carpsucker	10	0.2	491	422	562	1725	1300	2910	104.5
Stonecat	1	<0.1	183	183	183	70	70	70	
Shovelnose Sturgeon	155	3.1	713	389	863	1797	189	3265	107.9
Sauger	1	<0.1	439	439	439	805	805	805	94.7
Shorthead Redhorse	30	0.6	363	192	421	574	85	915	97.6
Walleye	4	0.1	424	312	540	746	245	1535	81.1
Total	317	6.3	560	183	1148	1224	70	7650	101.9

Appendix 18. Trammel net fish size statistics at Coal Banks Section 2016. Includes all nets for Shovelnose Sturgeon estimates.

			Length (mm)			Weight (g)		
2016 = 118 drifts	N	CPUE	Mean	Min	Max	Mean	Min	Max
Blue Sucker	32	0.3	780	691	878	4451	2700	7080
Carp	5	<0.1	526	526	526	2110	2110	2110
Channel Catfish	21	0.2	522	345	709	1770	330	4480
Cisco	1	<0.1						
Freshwater Drum	4	<0.1	379	281	452	729	285	1125
Goldeye	121	1.0	311	297	329	251	210	325
Longnose Sucker	224	1.9	419	340	695	755	400	1255
Pallid Sturgeon	29	0.2	563	282	1205	950	68	7820
River Carpsucker	5	<0.1	415	415	415	840	840	840
Sauger	39	0.3	362	287	462	370	180	775
Shorthead Redhorse	573	4.9	384	239	516	630	120	1360
Shovelnose Sturgeon	1174	9.9	798	520	1040	2487	530	6140
Smallmouth Bass	20	0.2	292	185	445	490	90	1445
Smallmouth Buffalo	10	0.1	670	485	762	4811	1790	6855
Walleye	2	<0.1	343	302	384	398	230	565
White Sucker	8	0.1	375	375	375	670	670	670
Total	2268							

Appendix 19. Population estimate for Shovelnose Sturgeon in the Coal Banks Section, Missouri River, 2016. Multiple recaptures per trip not included.

Date	R Marked fish captured	# unmarked fish captured	C Total fish captured	M Total marked fish at large	CxM	# drifts	River miles
16 – 18 Aug		506	506	0		45	2032.6 – 2038.9
22 – 25Aug	43	268	311	506	157366	41	2032.6 – 2038.9
29 – 31 Aug	62	267	329	774	254646	32	2032.6 – 2038.7
Total	105	485	1041		412012	118	

Calculation of 95% CI (from Van Den Avyle 1993)
N= 412,012/105 = 3925
Variance of 1/N = $105/(3925)^2$; Then 1/N= (+/-) 1.96sqrt of V(1/N)
1/3924 =2.5484×10^{-4};
$105/(412012)^2 = 6.1854 \times 10^{-6}$; 1.96 X Sqrt$6.1854 \times 10^{-6}$= +/- 4.87462×10^{-5}
Inverses result in estimate of: 3924 (3294-4852)

Estimate was also calculated in Mark (White and Burnham 1999) using a closed full likelihood Model.
The time influenced model had the best fit.

Appendix 20.Trammel net fish statistics from Shovelnose Sturgeon estimates at Coal Banks 2005.

			Length (mm)			Weight (g)		
105 Drifts	N	CPUE	Mean	Min	Max	Mean	Min	Max
Blue Sucker	40	0.4	746	665	902	3772	2622	6350
Brown Trout	1	<0.1	229	229	229	159	159	159
Common Carp	17	0.2						
Channel Catfish	2	<0.1	645	632	658	3391	3175	3606
Freshwater Drum	2	<0.1						
Goldeye	31	0.3	303	274	338	264	104	363
Longnose Sucker	129	1.2	389	279	658	668	245	1452
Rainbow Trout	1	<0.1	305	305	305	286	286	286
River Carpsucker	8	0.1	437	437	437	885	885	885
Sauger	3	<0.1	380	366	391	470	363	544
Shorthead Redhorse	220	2.1	372	241	480	578	145	1225
Shovelnose Sturgeon	1302	12.3	784	429	990	2365	272	5489
Smallmouth Bass	2	<0.1	331	330	333	708	699	717
Smallmouth Buffalo	18	0.2	667	516	759	5880	2204	9526
White Sucker	2	<0.1	279	279	279	277	277	277

Appendix 21.Trammel net fish statistics from Shovelnose Sturgeon estimates at Coal Banks 1995.

			Length (mm)			Weight (g)		
126 Drifts	N	CPUE	Mean	Min	Max	Mean	Min	Max
Blue Sucker	31	0.2	726	622	808	3615	2268	5171
Common Carp	19	0.2	558	485	630	2293	1588	3357
Channel Catfish	9	0.1	360	287	462	474	204	998
Goldeye	35	0.3	306	279	335	283	204	363
Longnose Sucker	213	1.7	417	236	511	835	136	1452
River Carpsucker	13	0.1	447	401	572	1122	862	2948
Sauger	7	0.1	390	343	503	531	363	1089
Shorthead Redhorse	312	2.5	422	201	523	855	91	1452
Shovelnose Sturgeon	975	7.7	792	508	1016	2504	499	5176
Smallmouth Bass	1	<0.1	356	356	356	862	862	862
Smallmouth Buffalo	7	0.1	610	574	640	3509	2767	3901
White Sucker	6	<0.1	420	394	437	894	771	998

Appendix 22. Size statistics for fish caught with standard spring setlines (90 sets) in the Robinson Section, 2016.

			Length (mm)			Weight (g)			Mean
Species	N	CPUE	Mean	Min	Max	Mean	Min	Max	Wr
Burbot	4	<0.1	586	470	767	1140	463	2590	67.6
Channel Catfish	52	0.6	518	277	872	1687	175	7803	88.9
Common Carp	10	0.1	523	418	594	1918	1075	2950	94.3
Flathead Chub	11	0.1	198	166	247	81	35	125	
Goldeye	95	1.1	324	271	384	275	110	465	
Pallid Sturgeon	112	1.2	504	378	1106	540	132	6495	91.1
Sauger	73	0.8	381	236	557	478	90	1550	77.4
Shorthead Redhorse	18	0.2	353	280	416	466	170	770	87.6
Shovelnose Sturgeon	10	0.1	693	600	831	1707	1005	2500	112.7
Walleye	48	0.5	404	246	781	819	100	5050	84.0
White Sucker	1	<0.1	386	386	386	580	580	580	82.0
Yellow Perch	1	<0.1	222	222	222	155	155	155	99.5
Total	435								

Appendix 23. Size statistics for fish caught at RM 1931.5-1942.2, in 2016 with 14 set lines.

			Length (mm)			Weight (g)			Mean
Species	N	CPUE	Mean	Min	Max	Mean	Min	Max	Wr
Channel Catfish	12	0.9	537	358	808	1875	345	6250	88.0
Goldeye	9	0.6	317	292	353	274	205	435	
Pallid Sturgeon	2	0.1	538	509	566	517	466	568	95.3
Sauger	2	0.1	336	279	392	292	158	425	75.3
Shorthead Redhorse	1	0.1	406	406	406	810	810	810	105.4
Shovelnose Sturgeon	8	0.6	714	638	777	1623	1075	1805	98.9
Stonecat	1	0.1	173	173	173	45	45	45	
Walleye	4	0.3	392	346	432	518	350	585	82.8
Total	39	2.8							

Appendix 24. Size statistics for seine hauls conducted in 2016 for fish<150mm.

			Length (mm)		
Section	Species	N	Mean	Min	Max
Morony	Channel Catfish	6			
	Common Carp	7	48	35	59
	Emerald Shiner	399	68	58	74
	Fathead Minnow	1	54	54	54
	Lake Chub	1	67	67	67
	Longnose Sucker	35	51	36	78
	River Carpsucker	2			
	Rocky Mtn Sculpin	1	63	63	63
	Shorthead Redhorse	83	39	22	129
	Smallmouth Bass	281	46	30	67
	Smallmouth Buffalo	1			
	Spottail Shiner	21	73	39	92
	White Sucker	253	62	28	150
	Total	1091			
Fort	Brook Stickleback	2	41	32	50
Benton	Channel Catfish	1			
	Common Carp	20	62	27	80
	Emerald Shiner	45	73	67	84
	Fathead Minnow	2	53	49	57
	Iowa Darter	1	39	39	39
	Longnose Dace	5	46	27	76
	Longnose Sucker	159	56	36	83
	Pumpkinseed	8	67	51	109
	Shorthead Redhorse	132	45	22	127
	Smallmouth Bass	391	51	30	140
	Spottail Shiner	2	72	63	81
	Sucker	340	53	41	60
	Western Silvery Minnow	53	90	85	100
	White Sucker	608	54	33	147
	Total	1769			

Appendix 24 continued. Size statistics from seine hauls conducted in 2016 for fish < 150 mm.

			Length (mm)		
Section	Species	N	Mean	Min	Max
Coal Banks	Common Carp	9	78	68	100
	Emerald Shiner	729	73	53	85
	Flathead Chub	4	81	43	124
	Longnose Dace	1	37	37	37
	Longnose Sucker	23	62	46	79
	Shorthead Redhorse	203	49	26	149
	Smallmouth Bass	67	61	35	88
	Spottail Shiner	3	41	29	50
	Stonecat	1	43	43	43
	Sucker	43	35	20	50
	Western Silvery Minnow	5	92	84	97
	White Sucker	168	67	40	141
	Total	1256			
Judith Landing	Channel Catfish	4	35	33	39
	Common Carp	2	81	73	88
	Emerald Shiner	110	70	50	93
	Fathead Minnow	1	44	44	44
	Flathead Chub	476	69	28	176
	Lake Chub	1	78	78	78
	Longnose Dace	15	52	17	67
	Longnose Sucker	10	70	46	135
	River Carpsucker	8	39	30	43
	Sand Shiner	26	51	37	65
	Shorthead Redhorse	157	48	24	117
	Smallmouth Bass	34	72	46	87
	Smallmouth Buffalo	1			
	Stonecat	6	33	28	40
	Sucker	12	48	27	55
	Western Silvery Minnow	11	87	48	111
	Total	874			

Appendix 24 continued. Size statistics from seine hauls conducted in 2016 for fish < 150 mm.

			Length (mm)		
Section	Species	N	Mean	Min	Max
Robinson	Black Crappie	2	130	128	132
	Channel Catfish	9	46	25	134
	Emerald Shiner	242	73	45	87
	Fathead Minnow	2	33	33	33
	Flathead Chub	55	61	22	135
	Goldeye	9	74	66	79
	Minnow	39	27	16	35
	River Carpsucker	1	135	135	135
	Sand Shiner	7	44	43	46
	Shorthead Redhorse	14	41	30	74
	Stonecat	1	146	146	146
	Western Silvery Minnow	29	90	43	146
	Total	410			