Montana Fish, Wildlife & Parks

FISHERIES DIVISION

FINAL REPORT

STATE: Montana **Project No.: F-78-R-5 & R-6**

PROJECT TITLE: YELLOWSTONE RIVER FISH PASSAGE - BOR

Final Report for 1997-2000

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ABSTRACT

A study to characterize the fish communities and evaluate effects of low-head diversion dams and irrigation water intake structures on fish species distribution and abundance in the Yellowstone River was initiated in 1997 and completed in 2000. A total of 70,685 fish was sampled in the middle Yellowstone River and irrigation canals and tributary streams including the Bighorn, Tongue and Powder rivers. Electro fish sampling in the middle Yellowstone River collected a total of 8,550 fish represented by 30 species. Goldeye, shorthead redhorse, *Hybognathus spp.*, white sucker and common carp were the five most abundant species and composed 78% of the fish sampled. Goldeye was especially abundant and wide-ranging species sampled at an average catch rate of 44.4 fish/hr. Trammel net sampling found goldeye and shorthead redhorse as the two most common species in the deep-water areas of the river. These two species along with longnose sucker composed 70% of the fish sampled. Shovelnose sturgeon dominated the trammel net sample at Forsyth averaging 4.0 sturgeon/drift but was sampled at very low levels (0.1/drift) immediately upstream of the dam. A total of 48,113 fish were sampled in the seining surveys in the middle Yellowstone River represented by 21 species. The seining surveys indicated that minnow populations were exceptionally abundant, especially at Hysham and Forsyth, where the minnow catch rate was greater than 300 fish/seine haul. Emerald shiner, fathead minnow, flathead chub, Hybognathus spp. and shorthead redhorse dominated the catches and composed 85% of the total number of minnows sampled. Results from the Bighorn River electrofish sampling found that white sucker and common carp dominated the catches, and the average relative abundance for each of these two species exceeded 15 fish/hr. The Tongue River spring surveys sampled high numbers of fish representing 18 species, which was considerably more than the other two tributary rivers. Game fish representation was fairly high with channel catfish and walleye being the most common species, sampled at catch rates of 9.4 and 8.4 fish/hr, respectively. The Powder River surveys sampled relatively high numbers of sauger. Sample composition was largely goldeye, sauger and shorthead redhorse, where catch rates for these commonly sampled spring species averaged 13.7, 9.2 and 6.2 fish/hr. Sauger average relative abundance (CPUE) for the middle Yellowstone River fall surveys were found to be low at all the sections ranging from a very low catch rate of 0.1/hr at Waco to 4.6 sauger/hr at Miles City. A sauger density estimate was completed for the Miles City Section in 1999. The density of sauger ($\geq$ 9 inches) in the section was 123 sauger/mile. This estimate represents a 53% decrease from the most recent estimate (1990). Data from this study indicates that mostly migratory fish species were negatively impacted by the partial barrier effect of the low-head dams. Sauger and shovelnose sturgeon were the two species in particular that showed definite declines because of passage problems related to the dams. Sauger average relative abundance was found to be very low in the upper reach (average CPUE = 0.4/hr), but eight times more abundant (average CPUE = 3.4/hr) in the lower reach. Shovelnose sturgeon was another species that was sampled at a greater average relative abundance below Cartersville Diversion Dam (4.0 sturgeon/net) compared to above the dam (0.1/net). The Cartersville Irrigation Canal was routinely sampled to evaluate fish entrainment during summer. Emerald shiner, flathead chub and fathead minnow were the most common species sampled, composing 81% of the total. Total number of fish entrained was estimated to be ~ 68,500 fish for the three month irrigation season. During October the Ranchers, Yellowstone and Cartersville canals were evaluated for fish losses associated with fall canal closure. A total of 6,063 fish were sampled including 16 species. Flathead chub and *Hybognathus spp.* were the most common species sampled averaging 53% of the total catch. A considerable number of sauger was observed trapped in nearly all of the siphon pools examined.

INTRODUCTION

The 678-mile long Yellowstone River is the longest free-flowing river in the contiguous United States (White and Bramblett 1993). The fish community is diverse comprised of 56 species, 6 of which are on the Montana Species of Special Concern List. The reach of Yellowstone River for this study lies within the middle segment, a 212-mile reach located between Billings and Terry, MT. This reach, the middle Yellowstone River (MYSR) has experienced considerable irrigation development over the past 75 years, having numerous diversion dams and water intake structures, along with similar developments on two major tributary streams, the Bighorn and Tongue rivers. Agriculture (mostly for irrigation of crops) is by far the largest user of water in the basin with an estimated water use of 7.7 million acre-ft per year (Zelt et al. 1999) or about 84% of the mean annual flow (measured at the USGS station near Sidney). With this level of water use, it is likely that water shortages are a chronic problem in the Yellowstone River Basin, especially during drought years.

In addition to the dewatering effects on aquatic habitats, the irrigation structures associated with the numerous irrigation projects in this reach have caused major fisheries problems. There are five irrigation diversion dams located on MYSR; most of these low-head dams extending completely across the channel. These barriers impede, if not block, up river passage for most species of fish. About a half-dozen, gravity flow irrigation intake canals, with capacities greater than 100 cfs occur within the study area (Albers and Mefford 1997) and the effects of these diversions on fish entrainment is largely unknown.

This study will provide information pertaining to the need for improving passage over diversion dams, baseline fisheries information in the general area of the dams and an evaluation of the effects some of the larger diversion intake canals may be having on the fisheries. Most of the work was centered in the Forsyth area, evaluating the Cartersville Irrigation Project. The study began in 1997 and was completed in 2000. The emphasis for the last two years was to evaluate tributary use by sauger during the spawning season and collect fisheries information specific to the effects of the irrigation structures.

OBJECTIVES

1. Describe the fish distribution and abundance of the MYSR fish communities relative to diversion dams in the 212-mile study area, with particular emphasis on sauger shovelnose sturgeon and blue sucker.

2. Evaluate fish losses and effects related to operations of irrigation intake canals in the study area. The Cartersville intake canal was sampled with nets and several other canals were sampled during 2000 to determine fish losses from the MYSR

3. Evaluate sauger spawning use in the lower reaches of the Bighorn, Tongue and Powder rivers

PROCEDURES

Electrofish sampling was used to sample the mid-depth to shallow water habitats. The system used was a dual boom-type and mounted to a 19-foot aluminum boat powered by a 105 hp outboard jet motor. Power was supplied by a 5,000-watt generator. The alternating current was delivered to a Coffelt Model VVP-10 rectifying unit, which changes the alternating current to pulsed or smooth DC. The positive electrode setup consisted of two fiberglass booms with 4, 18-

inch stainless steel cables attached to the tip of each boom, with the cables partially submerged in the water. The boat hull served as the negative. The unit was typically operated at 2-7 amps, 100-215 volts. Average relative abundance for a given fish species was expressed as number of fish caught per hour.

Trammel nets were used to sample deep-water fish habitats. The nets were 150 ft. long and 6 ft. deep. Two mesh sizes were used: 1 inch inner wall with 10 inch outer walls, and 2 inch inner wall with 12 inch outer walls. Mesh material for both walls were lightweight for better fish tangle characteristics and to insure that the net could be retrieved off submerged objects in the event that net material had to be torn free. The trammel nets were set perpendicular in the channel in snag-free areas of the river and allowed to drift with the current along the bottom. Nets were drifted no longer than 7 minutes, usually a distance of about 300 yds. Average relative abundance for a given fish species was expressed as number of fish caught per drift. Experimental gill nets were also used for capturing fish. The sinking net was 125 x 6 ft with graduated mesh size from ¾ to 2-inch square measure. Overnight stationary sets with these nets in areas of the river with little or no current, generally produced good catches of a wide variety of fish species. Catch per unit effort was expressed as number of fish caught per overnight set

A 50 x 4 foot beach seine with ¼ -inch mesh was used to sample shallow peripheral habitats. The seine was dragged in a variety of shoreline habitats, typically for a distance of about 30 yards in areas with water depths generally less than 2½ feet. All captured fish were counted and identified, and associated habitat type was recorded. Catch per unit effort was expressed as number of fish caught per haul.

An assortment of fish sampling gear was used to sample the fish species in the canal and species entrained. The list includes seines, gill nets, hoop nets and a surface trawl. Most of these sampling gear types were used to detect presence/absence of fish in the canal. The trawl had a 6 x 6 ft. wide opening and was 18 ft long with a ¼ inch-mesh cod. The bottom of the surface trawl was weighted at the opening so that the net rested near the bottom and sampled the complete water column.

DESCRIPTION OF STUDY AREA

The middle portion of the Yellowstone River (MYSR) where this fisheries study was conducted is a 212-mile reach of mostly free-flowing river from just downstream of Billings to the Powder River Confluence near Terry, MT. The MYSR is fairly large this far down in the basin and the mean annual flow is 11,440 cfs (Zelt et al.1999). Major tributaries are Bighorn, Tongue and Powder rivers, all of which enter the Yellowstone from the south. The Bighorn and Tongue rivers have storage reservoir impoundments that regulate stream flows in the Yellowstone Basin. These drainages comprise nearly 1/4 of the basin and, therefore, have probably reduced peak flows in the system (Koch et al. 1977). There are five low-head dams located on the MYSR (Figure1.) These 1-4 feet high dams span the entire river channel and vary from rock dikes (Ranchers) to concrete structures (Huntley). All the dams undoubtedly restrict fish passage at low flows. The MYSR throughout most of this reach meanders through a wide valley, 1 to 4 miles wide, but becomes fairly entrenched in a narrow valley near the lower end. The gradient is fairly steep (3-8 ft/mi) and bottom substrates are mostly large cobble with several large gravel bars and islands throughout the reach. The physiographic, geomorphology and hydrology have been more thoroughly described by Koch et al. (1977) and Zelt et al. (1999). Important reference sites for this study are shown in Figure 1. Geo-referenced sampling site locations are given in Appendix A.

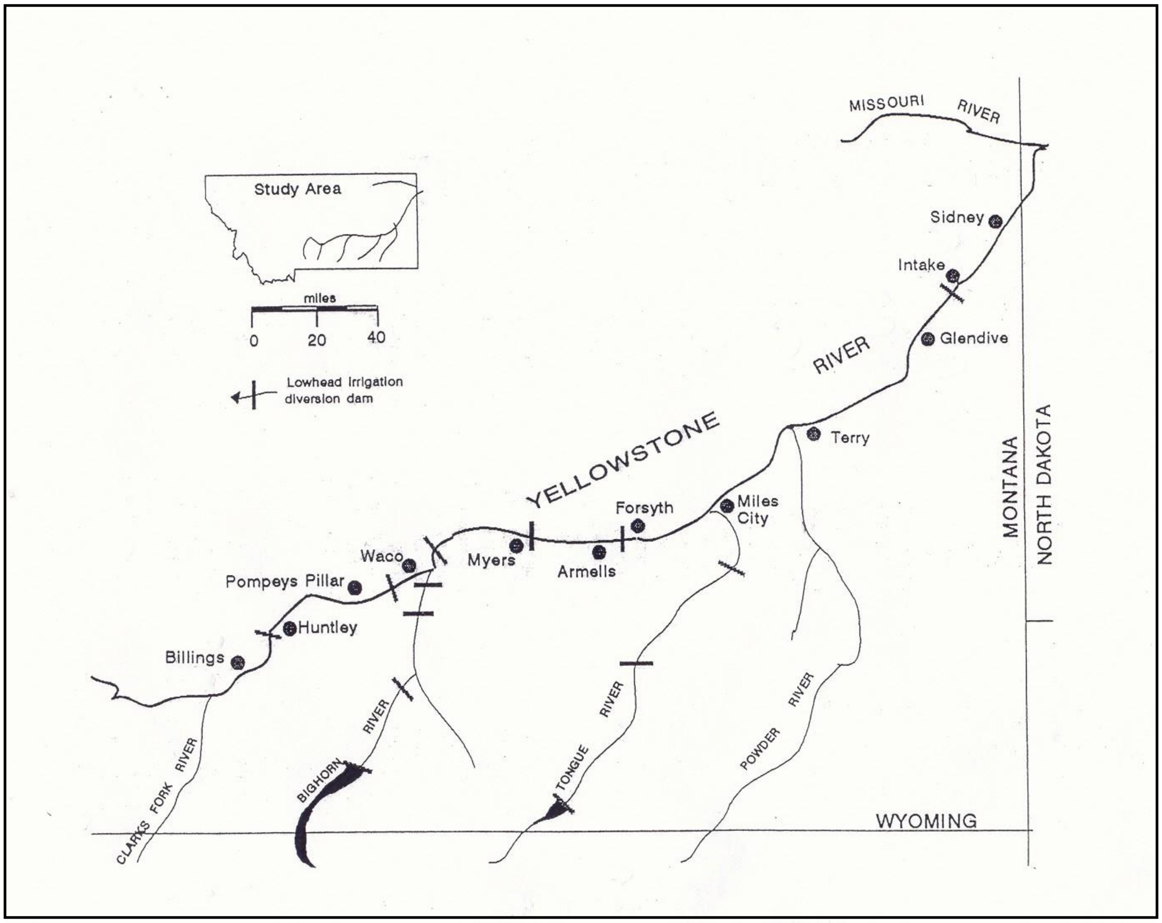

Figure 1. Map of the Yellowstone River.

RESULTS

Summary flow statistics of the Yellowstone, Bighorn,Tongue and Powder rivers for the sampling years 1997 through 2000 are given in Table 1 (USGS, 2001). Stream flows in the MYSR were very high in 1997 and the mean monthly flows averaged 84% greater than the long-standing median flow. In contrast 2000 was a low water year and the mean monthly flows averaged 26 % lower than the median flows. Stream flows in the MYSR for 1998-99 were generally greater than the long-standing median flow. The major tributaries in the MYSR section pretty much mirrored the main stem except that the Powder River showed much greater extremes (the 1997 monthly mean flows averaged 211% higher than the median flows and the low water year of 2000 had monthly mean that was 50% less than the median flow). The MFWP's assessed instream flows for the MYSR (at Miles City) were met or exceeded about 70% of the time (April-September) during 1997-2000 (Appendix B). The MFWP assessed instream flows were met or exceeded for the Bighorn and Powder rivers all the time during 1997,1998 and 1999, but, not any of the months (April-September) during 2000. The Tongue River flows during these four years were mostly abnormally lower ranging from exceeding the assessed minimum flows 16% of the time during 2000 to 100% of the time during 1997 (Appendix B). In summary, flow conditions for the MYSR and the major tributaries during the 4 years of study pretty much covered a wide array of flow conditions, therefore habitat conditions and fish populations sampled should have been representative of more normal existing conditions.

Water temperatures were monitored only in the tributary rivers and mean monthly values are summarized in Table 2 with daily records reported in Appendix C-E. Water temperatures were considerably colder in the Bighorn compared to the Tongue River. Mean monthly temperatures for the Bighorn River during April, May and June were 4, 6, and 7 ^{o} F colder than the Tongue River. This is probably related to the cold-water hypolimnion releases the Bighorn River receives from Yellowtail Dam 86 miles upriver. A dam also impounds the Tongue River, however, the Tongue River Dam is located farther upriver (RM 189) compared to the Bighorn. Also, water releases from the dam are from a mid-level or surface outlet and, therefore the temperature of the water discharge is closer to the ambient air temperature. The colder water temperatures (along with the clear water conditions) in the Bighorn probably inhibit several Yellowstone River warm-water fish species from migrating up the Bighorn to spawn during the spring.

Table 1. River discharge statistics (cfs) for the Yellowstone and Tongue rivers at Miles City Bighorn River at Tullock Creek and Powder River at Locate, MT, 1997-2000. (USGS 1998-01).

	Apr	May	Jun	Jul	Aug	Sep	Peak flow
Yellowstone							
1997	14,030	27,880	61,860	27,780	16,540	11,020	82,300
1998	9,276	13,460	22,880	23,560	11,470	8,325	39,100
1999	7,850	17,940	38,840	21,580	10,680	8,971	51,200
2000	6,490	14,163	22,467	9,921	4,914	4,992	32,900
Median	7,301	15,806	32,343	18,183	7,164	6,730	36,500
Bighorn							
1997	7,881	5,297	11,280	6,799	6,972	4,551	15,000
1998	5,296	4,278	4,156	6,062	5,039	4,489	7,640
1999	4,950	8,702	10,640	7,162	4,208	3,820	12,200
2000	2,771	3,262	3,038	2,537	2,536	2,171	4,690
Median[1/]	3,397	3,841	5,658	4,586	2,847	2,808	6,440
Tongue							
1997	663	826	1,746	686	482	367	2,790
1998	377	235	312	333	247	531	985
1999	281	565	2,010	484	273	150	3,070
2000	214	224	819	142	76	119	1,460
Median [2/]	371	584	1,078	344	163	191	1,270
Powder							
1997	1,040	1,174	2,099	806	857	290	3,900
1998	966	1,317	992	719	614	339	1,820
1999	1,093	2,734	2,281	440	181	231	8,045
2000	400	747	502	160	10	36	2,080
Median	570	881	1,248	373	113	71	1,580

1/ Based on period of record after Yellowtail Dam, 1966 – 2000.

2/ Based on period of record after Tongue River Dam, 1940 – 2000.

Table 2. Mean monthly water temperatures for the Bighorn River (RM 3.0), Tongue River (RM 2.3), and Powder River (RM 1.0), 2000.

	April	May	June	July	Aug.	Sept.	Oct.
Bighorn River 2000 [1/]	48	56	61	66	65	60	--
Tongue River 2000 [1/]	52	62	68	77	73	61	--
Powder River 2000 [2/]	50	59 [3]	--	--	--	--	--

[1/] Data from USGS station .
[2/] FWP Onset temperature logger.
[3/] Represents a mean for a period of 20 days.

General Fisheries

Recent fisheries data for the middle Yellowstone River is limited especially for evaluating the effects of diversion dams and irrigation water intake structures on fish species distribution and abundance. Also, sauger, a native species found throughout the study area, is thought to be declining statewide (McMahon and Gardner 2001) and very little is known about the factors causing this decline. More information on sauger would be beneficial for a better understanding about its status in the Yellowstone. Species abundance and distribution, along with migratory use by downstream species were the specific parameters that were investigated for evaluating the present fishery and assessing effects from irrigation developments.

Electrofish sampling.

A total of 8,550 fish were sampled in the MYSR electrofish surveys during the 1998, 1999 and 2000 field seasons. Average relative abundance for each species at the study sections are given in Table 3. Average sizes for the sampled fish are calculated for each study section and reported in Appendix F - I. Thirty species were sampled in the five study sections, combined, with the greatest number (28) recorded at the Forsyth Section. Seven percent of the total number of fish sampled were represented by 11 species of game fish.

Goldeye, shorthead redhorse, *Hybognathus spp.*, white sucker and common carp were the five most abundant species and composed 78% of the fish sampled. Goldeye was especially abundant and wide-ranging species sampled at an average catch rate of 44.4 fish/hr. Game fish species were sampled at relatively low rates, rarely exceeding 4 fish/hr (Table 3). Channel catfish sauger and smallmouth bass were the three most common game fish sampled in the MYSR. The highest catch rate for channel catfish (8.7/h) was recorded at Myers Section and sauger were sampled in greatest relative abundance at the Miles City Section (4.6/h). Low sauger catch rates in all of the five sampled sections indicates that this important species is not doing well here. Smallmouth bass were sampled only from Myers on downstream and had the greatest relative abundance in the lower two sections, Forsyth (3.8/h) and Miles City (3.7/h).

Trammel net sampling.

The purpose of the trammel net sampling was to sample deep-water habitats that electrofishing is ineffective at sampling and diversifying our sampling methods. The trammel net sampling results were similar to electrofishing indicating that goldeye and shorthead redhorse were the two most common species in the deep-water areas of the river (Table 4). These two species along with longnose sucker composed 70% of the fish sampled. Longnose sucker and redhorse were the most abundant species sampled in the Dover island Section (6.8/drift and 5.4/drift), whereas goldeye average relative abundance was greatest at Huntley, Myers and Armells sections. Channel catfish and shovelnose sturgeon were the most common game fish netted, averaging 0.8 fish /drift. Channel catfish were widespread and sampled throughout the MYSR, whereas, shovelnose were only sampled at Armells and Forsyth sections. Shovelnose sturgeon dominated the trammel net sample at Forsyth averaging 4.0 sturgeon/drift. Summary size statistics are given in Appendix J - N. Shovelnose sturgeon were only sampled in the lower two sections and may be deterred from occurring farther upriver because of the Cartersville Diversion Dam and the four other upstream low-head dams.

Table 3. Average catch rates (no./hour) and number of fish sampled by electrofishing in the Yellowstone River, MT, fall, 1998-2000.

	Waco	**Myers**	**Armells**	**Forsyth**	**Miles C.** [1/]
Bigmouth buffalo	0.2		0.1	0.2	0.1
Black crappie	0.1	0.1	0.1	0.3	0.1
Blue sucker				0.1	0.8
Brown trout	0.2	1.1	0.1	0.1	
Burbot		0.6	0.4	0.4	0.4
Carp	11.3	14.3	11.0	8.7	4.1
Channel catfish	0.8	8.7	1.7	1.8	0.7
Emerald shiner	0.8	2.3	0.4	2.0	5.6
Flathead chub	12.4	2.6	1.3	3.4	0.4
Freshwater drum		0.5	0.4	0.2	0.7
Goldeye	60.8	69.3	53.4	29.2	9.2
Green sunfish		0.1	0.4	0.2	
Hybognathus spp.	66.5	8.1	4.0	8.4	2.3
Largemouth bass			0.2	0.2	
Longnose sucker	4.5	20.0	4.5	5.2	6.8
Mountain sucker	0.1	0.5		0.1	
Mountain whitefish		0.1	0.2		
Northern pike			0.1	0.3	0.1
Rainbow trout		0.1		0.1	
River carpsucker	5.1	11.8	6.2	6.6	7.6
Sauger	0.1	0.7	1.5	2.1	4.6
Shorthead redhorse	16.4	37.5	34.9	21.2	31.5
Shovelnose sturgeon				0.1	0.1
Smallmouth bass		0.7	0.7	3.8 [2/]	3.7 [2/]
Smallmouth buffalo	0.2		0.3	0.4	0.1
Stonecat				0.3	0.4
Walleye	1.0	1.2	0.7	0.4	0.6
White crappie				0.2	0.1 [2/]
White sucker	17.0	18.7	8.5	5.8	2.6
Yellow perch	0.5		0.1		0.8
Total no. of fish	1457	1666	1443	2311	1673
Total no. of hours	6.3	8.4	11.0	29.0	53.7

[1/] Non-game fish counted only during 2000 surveys.

[2/] Age-0 fish present but not included in CPUE

Table 4. Average catch rates (no./drift) and number of fish sampled with trammel nets in the Yellowstone River, MT, 1997 and 2000.

	Dover Island	Huntley	Myers	Armells	Forsyth
Blue sucker				0.2	
Burbot	0.6	0.4	0.1		
Carp	0.3	0.1	0.3	0.6	0.2
Channel catfish	0.2	0.2	2.0	0.7	0.7
Goldeye	4.2	4.4	2.6	1.2	1.0
Longnose sucker	6.8	2.1	0.5	0.5	0.4
Mountain whitefish	0.1				
River carpsucker	0.1		0.4	0.4	0.1
Sauger				0.1	
Shorthead redhorse	5.4	1.3	1.6	1.5	0.9
Shovelnose sturgeon				0.1	4.0
Smallmouth bass					T
Smallmouth buffalo			0.1	0.1	
White sucker	2.1	2.2	0.2	0.5	0.1
Total no. of fish	174	166	235	166	215
Total no. of drifts	9	16	32	29	29

Seining.

A total of 48,113 fish were sampled in the seining surveys in the MYSR during the 1997 - 2000 field seasons. The seining surveys indicated that minnow populations were exceptionally abundant, especially at Hysham and Forsyth, where the minnow catch rate was greater than 300 fish/seine haul. A total of 21 species were identified in the seine samples (Table 5 and Appendix O - R). The highest number of species, 19, was sampled at the Armells Section. Emerald shiner, fathead minnow, flathead chub, Hybognathus spp. and shorthead redhorse dominated the catches and composed 85% of the total number of minnows sampled (Table 5). Hybognathus and shorthead redhorse had the highest catch rates at the upper two sections, Huntley (404.8/haul) and Pompey's Pillar (83.8/haul), respectively. Emerald shiners were found in greatest abundance at the Myers Section (125.5/haul), fathead chub were most abundant at Hysham (231.7/haul) and the greatest catch rate for flathead chub was recorded at the lowest section sampled, Forsyth (89.0/haul). Smallmouth bass was the only age-0 game species seined, and were found at greatest relative abundance (5.4/haul) at Forsyth.

Table 5. Average catch per seine haul for fish sampled in the Yellowstone River, 1997-2000. (Only fish less than 7 inches were included. Yoy = young-of-year).

	Dover Island	Huntley	Pompey's Pillar	Waco	Myers	Hysham	Armells	Forsyth
Black crappie								0.2
Carp		12.2		0.1		24.9	0.2	0.1
Emerald shiner	1.5	12.6	0.2	17.8	125.5	33.6	26.7	29.5
Fathead minnow	2.0	131.2	150.5	8.6	0.2	231.7	19.9	6.2
Flathead chub	2.4	6.6	44.0	40.6	26.6	21.6	29.9	89.0
Green sunfish							3.4	
Hybognathus spp.	0.7	404.8	0.5	38.3	22.6	129.7	43.7	101.2
Largemouth bass (yoy)		2.8					0.3	
Longnose dace	24.8	1.8	6.8	0.9	4.4	2.5	2.1	3.9
Longnose sucker (yoy)	12.5	3.9	2.0	2.9	9.7	4.2	5.0	2.4
Mountain sucker	0.3	0.4		T	0.1	0.3	0.6	0.3
Plains killifish							0.3	
River carpsucker (yoy)		0.1		0.2	0.4	1.7	5.1	19.5
Sand shiner				T	1.1	0.1	1.7	2.4
Shorthead redhorse (yoy)	32.7	7.6	83.8	22.4	12.8	33.1	44.2	18.5
Smallmouth bass (yoy)		0.4				2.9	0.4	5.4
Smallmouth buffalo (yoy)				T		0.3		
Spottail shiner				T			0.1	
White crappie		0.4						0.4
White sucker (yoy)	1.7	1.9	0.5	8.1	0.9	34.2	1.7	2.8
Yellow perch		0.2					0.1	
Unidentified fish	21.5	26.2	0.5	9.3	17.2	16.3	17.6	23.1
Total Number of fish	1201	5518	1155	6419	4430	11,816	6293	11,281
Number of Hauls	12	9	4	43	20	22	31	37

Tributary rivers

Tributary rivers of the MYSR were sampled during the spring to evaluate seasonal composition and assess their value as sauger spawning tributaries for Yellowstone River migratory fish. The species compositions for the three tributary streams were noticeably different from each other (Table 6 and Appendix tables T-V). Results from the Bighorn River electrofish sampling found that white sucker and common carp dominated the catches, and the average relative abundance for each of these two species exceeded 15 fish/hr. Game fish species representation was low, with channel catfish being the most common, sampled at the catch rate of 1.2/hr. The Tongue River spring surveys sampled large numbers of fish representing 18 species, which was considerably more than the other two tributary rivers. Game fish representation was fairly high with channel catfish and walleye being the most common species, sampled at catch rates of 9.4 and 8.4 fish/hr, respectively. The Powder River surveys sampled relatively large numbers of sauger. Sample composition was largely goldeye, sauger and shorthead redhorse, where relative catch rates for these commonly sampled spring species averaged 13.7, 9.2 and 6.2 fish/hr.

Table 6. Average catch rates (no./hour) and number of fish sampled by electrofishing in the Bighorn, Tongue and Powder rivers, MT, April-May, 2000.

	Bighorn River	**Tongue River**	**Powder River**
Black bullhead	0.3		
Black crappie	0.3		
Burbot			0.1
Carp	15.3	13.0	0.2
Channel catfish	1.2	9.4	2.2
Emerald shiner		5.0	
Flathead chub	0.3	58.6	3.0
Goldeye	10.9	8.0	13.7
Hybognathus		11.8	0.2
Longnose sucker	7.4	39.4	0.5
Mottled sculpin		0.5	
Mountain whitefish	1.5		
Rainbow trout	0.9		
River carpsucker	0.3	7.8	0.5
Sauger		2.8	9.7
Shorthead redhorse	2.4	94.4	6.2
Shovelnose sturgeon			1.6
Smallmouth bass	0.3	1.0	
Smallmouth buffalo		0.1	
Stonecat		2.6	
Sturgeon chub		0.4	0.1
Walleye		8.4	0.2
White crappie		0.1	
White sucker	21.5	8.0	
Yellow perch	1.5		
Total no. of fish	218	5605	723
Total no. of hours	3.4	16.8	15.1

Species of special concern sampled.

There are five state species of special concern that have been recorded residing in the MYSR and associated tributaries. Three of these species were sampled during the 1999 and 2000 field seasons. Totals of 43 blue sucker, 397 sauger and 9 sturgeon chub were sampled while conducting electrofishing, trammel netting and summer seining surveys in the MYSR, Bighorn Tongue and Powder rivers. There is very little information regarding the ecological status of burbot in Montana. This species was consistently sampled in the MYSR electrofishing surveys from Myers on downstream to the lowest section, Miles City. Burbot were usually found in low numbers, however, electrofishing may not be the most effective sampling method for assessing burbot distribution and abundance in the MYSR.

Sauger Ecology and Management

Development of a sauger management plan for the MYSR sauger populations would be valuable for insuring that sauger stocks will be sustained at healthy productive levels. Important sauger ecological information that needs to be collected for the MYSR include distribution and abundance, age structure, growth, and mortality rates and a better knowledge of important habitats for all life stages. This study continues with the collection of as much of the pertinent information as possible and provides a baseline for future comparisons.

Sizes and abundance.

Sauger size and abundance statistics in the MYSR are given in Table 7. Sauger average lengths ranged between 13.6 inches in the Miles City Section to 18.3 inches in the Myers Section. The sauger size range for the upper four sections was above average for sauger populations in other Montana Rivers (MFWP 1997). Sauger average relative abundance (CPUE) for the fall surveys were found to be low at all the sections ranging from a very low catch rate of 0.1/hr at Waco to 4.6 sauger/hr at Miles City (Table 7). From past experience, average catch rates for sauger in the range of 7 – 10 fish/hr appear to be indicative of a healthy population abundance.

Condition of the sauger population can also be evaluated with size structure and length/weight indices. Size structure measurements can provide insight or predictive ability about population dynamics (Anderson and Neuman, 1996). Relative weight measurements can provide an index of population condition. Relative weights also can be a predictor of reproductive success, fecundity, growth and survival (Anderson and Neuman, 1996). The size structure and average relative weights (Wr) for the MYSR sauger are listed for the five sections in Table 7. Very few sauger were sampled above Forsyth so comparisons can only be made between the lower two sections. Both the Average Wr and PSD were considerably higher at the Forsyth Section and is probably, in part, a reflection of the shortage of young sauger migrating into upriver areas.

A sauger density estimate was completed for the Miles City Section in 1999 so that the present population abundance could be compared to past years. A 5-mile reach of the MYSR at Miles City was electrofished during the period September 13 - 24. The Schnabel statistics matrix for the estimate is presented in Table 8 and Appendix W. The density of sauger ($\geq$ 9 inches) at Miles City Section was determined to be 613 (C.I. 95%, 371-1094) in the 5-mile reach or 123 sauger/mile. This estimate represents a 53% decrease from the most recent estimate.

Stewart (1992) has previously reported sauger estimates of 208 and 261 fish/mi for this section during 1985 and 1990, respectively. Not only has densities decreased over the years, but the population structure had changed. The Mile City sauger population PSD decreased 26 points from 1985 (PSD= 88) compared to 1999 (PSD= 62) estimates (Table 9). The low 1999 PSD value (compared to the 1985 value) may indicate a relatively high harvest rate of adults in this section. Apparently, sauger are in a downward trend in the MYSR. The body condition of MYSR sauger sampled at Miles City during 1999 were near normal compared to sauger throughout the geographic range and were nearly equal to the Wr value of the 1985 sample. The Wr in 1999 averaged 91 and was near the suggested (95 – 105) Wr range suggested by Guy et al. (1990) as a reasonable target for sauger populations.

The sauger population size structure in the Miles City Section is shown in Figure 4. The size structure was computed based on the density estimate and therefore should be more representative of the real condition (see Appendix W). The size structure distribution shows that the 10-13 inch groups dominated the population, composing 68% of the size groups.

Table 7. Average relative abundance, sizes and proportional stock density for sauger sampled during fall surveys in the middle Yellowstone River, 1998- 2000.

	Number	**Effort** (hr.)	**CPUE** (No./hr)	**Avg. TL** (in)	**Avg. Wr**	**PSD**
Waco	1	4.3	0.1	16.7		
Myers	6	8.2	0.7	18.3	100	93
Armells	16	11.0	1.5	16.7	100	97
Forsyth	63	29.0	2.1	16.2	97	95
Miles City	197	53.7	4.6	13.5	90	69

Table 8. Sauger population estimate statistics in the 5-mile Miles City Section, Middle Yellowstone River, 1999.

Schnabel population matrix

	R Marked fish captrd	# unmrked fish captrd	C Total # fish captrd	M Ttl #mrk fish@large	C x M
13-Sep	0	28	28	0	
14-Sep	0	15	15	28	420
15-Sep	2	18	20	43	860
16-Sep	3	12	15	61	915
21-Sep	5	16	21	73	1533
22-Sep	0	13	13	89	1157
23-Sep	2	15	17	102	1734
24-Sep	3	19	22	117	2574
					9,193
Totals	15	136	151		
				N=	613

CI 95% = 371 - 1094

Table 9. Density estimates, average size statistics, proportional stock density (PSD), relative stock density of preferred length fish (RSD-P), relative weights (Wr) for sauger sampled by electrofishing in the Miles City Section, middle Yellowstone River, fall, 1985 and 1999. (The 1985 statistics are from Stewart (1985).

	Number	**Density** (No./mi)	**Avg. TL** (in)	**Avg. WT** (g)	**Avg. Wr**	**PSD**	**RSD-P** ($\geq$15 in)
Miles City 1985	118	208	14.5	0.99	92.0	88	41
Miles City 1999	151	123	13.2	0.76	91.0	62	24

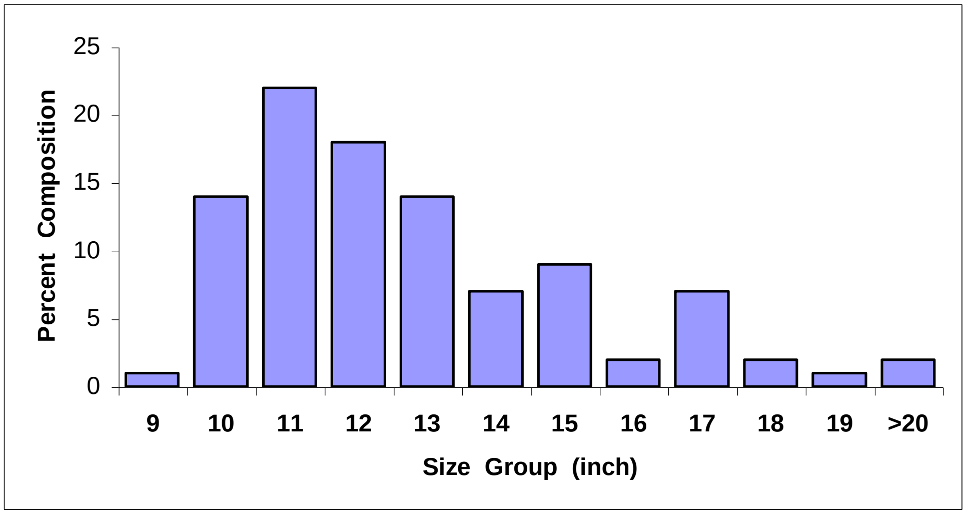

Figure 2. Sauger size composition in the Miles City Section, middle Yellowstone River, 1999

Tributary streams

Tributary streams of the MYSR were evaluated for present use by sauger during the spring spawning season. The importance of tributary streams for Yellowstone River sauger spawning has been documented extensively over the years by several researchers working in this area. All have concluded that both the Tongue and Powder rivers provided key sauger spawning habitat (Elser et al. 1977 and Penkal 1992). More recently, Stewart (1993) has expressed concern for the extremely low numbers of sauger sampled in the Tongue River during the spawning season. He attributed this to the chronic low river flows during the spring over the past several years. Monitoring the sauger spawning use in the Tongue and Powder rivers is important for documenting and evaluating any changes that may have occurred over the years.

Both the Tongue and Powder rivers were surveyed by electrofishing during April in 1999 and the Bighorn, Tongue and Powder rivers during the spring, 2000. The survey results for sauger are presented in Table 10. Consistent catches of sauger in the Powder River indicated that this tributary continues to attract significant numbers of sauger during the spawning season. A total of 115, mostly mature sauger, were captured with 11 hours of sampling during spring, 2000. Peak numbers of sauger were sampled April 18, but sauger numbers appeared to continue at high levels even through the last sampling period, May 20. Sauger use of this tributary during the spawning season has been previously noted. Penkal (1992) reported that 620 sauger (mostly mature fish) were sampled in the lower 4 miles of the Powder River during spring, 1976-80.

The 1999-2000 spring sauger surveys in the Tongue River indicated that there is presently very little sauger use of this tributary during the spawning season. A total of only 26 sauger was sampled in about 11 hours of electrofishing during the 2000 spawning period (Table 10). This same sampling effort did capture a total of 131 walleye in the Tongue River. It has been well documented that the Tongue River historically attracted high numbers of sauger during the spawning period. Elser et al. (1977) estimated the sauger spawning population to be approximately 3,700 sauger in the lower 14 miles of the Tongue River during spring, 1976. Penkal (1992) conducted electrofishing surveys during the sauger spawning season (1976-80) and reported average peak catch rates of about 43 sauger/mile sampled; most of these fish were mature spawners. Clearly there has been a severe decline of sauger use in the Tongue River during the spawning season. Low spring flow conditions, due to the Tongue River Dam operations, has been attributed to the decline of sauger use in the Tongue River (Stewart 1993). In fact 2000 was a low spring flow year where the Tongue River discharge averaged 219 cfs (46% of median) for the months of April and May 2000, compared to the Powder River where flows averaged 573 cfs (79% of median) for the same period (Table 1). Elser et al. (1977) recommended a flow of 525 cfs for sauger spawning in the Tongue River.

The Bighorn River was sampled only twice during the spring, 2000, and no sauger were captured. This was not surprising because river conditions have been radically changed since Yellowtail Dam closed in 1965. Soltero et al. (1973) reported that a comparison of mean turbidity for the Bighorn and Shoshone rivers with that of the reservoir discharge reveals a 60-fold decrease in turbidity for the Bighorn downstream of the dam. Additionally, water temperatures in the Bighorn appear to be cooler than normal. The average water temperature for April 2000 was 4 ^{o} cooler than that for the Tongue River (Table 2). Sauger prefers turbid water conditions and 50 ^{o} F spawning temperatures (Brown 1971) both of which are limited in the Bighorn. Passage for migratory sauger is also a problem because there are four diversion dams on the lower Bighorn beginning at River mile 5. Sauger have rarely been sampled in the lower Bighorn River since 1990 (McMahon and Gardner 2001).

Table 10. Electrofishing survey results for sauger sampled in tributary streams of the Yellowstone River, spring, 1999-2000.

	Date	**Count**	**CPUE** (no./hr)	**% Mature**	**Effort** (hrs)
Tongue River 1999					
	Apr 7	4	6.0	100	0.7
	Apr 8	2	1.6	50	1.3
Tongue River 2000					
	Mar 23	3	1.9	0	1.6
	Mar 24	3	1.4	50	2.1
	Apr 4	9	2.4	56	3.7
	Apr 19	5	1.8	40	2.8
	Apr 20	3	2.7	33	1.1
	Apr 25	3	0.9	67	3.5
Powder River 1999					
	Apr 28	20	8.3	100	2.4
Powder River 2000					
	Mar 25	10	3.9	70	2.5
	Apr 5	23	8.9	91	2.6
	Apr 18	57	26.9	90	2.1
	Apr 27	27	13.2	89	2.0
	May 20	28	16.2	79	1.7
Bighorn River 2000					
	Apr 6	0	0		2.9
	Apr 26	0	0		0.5

Irrigation development and effects on fish

The MYSR has considerable irrigation infrastructure developments including five diversion dams and associated intake canals within the 212-mile MYSR reach. Additionally, another four water diversions (gravity feed or pumps) greater than 50 cfs are located within the reach. Clearly, with this level of irrigation development there is potential for adverse effects on the river fisheries. Some of the effects of irrigation diversion dams and canal operations on the MYSR fisheries were investigated as part of the objectives for this study. The objectives were to focus specifically on the effects of migratory passage and entrainment and not evaluate the effects of dewatering on the fisheries. Although most of the sampling was focused on the Cartersville system, the Yellowstone Ditch and Ranchers Ditch systems were also sampled.

<u>Low-head irrigation diversion dams effects on the fish community</u>

There are six low-head irrigation diversion dams on the main stem Yellowstone River and five of these are located in the MYSR study area (Huntley, Waco-Custer, Ranchers Ditch, Yellowstone and Cartersville diversion dams). Therefore, there is potential to seriously limit migratory species if adequate passage is not provided. Helfrich et al. (1999) evaluated the influences the Yellowstone River diversion dams had on fish communities and found no noticeable effects on general fish abundance, species richness or size structure. However, they did find that the more migratory species (i.e. paddlefish, shovelnose sturgeon, sauger and blue sucker) were vulnerable to maintaining an upriver presence because of the dams. They concluded that the cumulative effect of the six dams might ultimately restrict fish distributions and limit abundance, especially during low flows in drought years.

Data from this study supports these conclusions, that mostly migratory fish species were negatively impacted by the partial barrier effect of the dams to passage and upriver dispersal. Sauger average relative abundance was found to be very low in the upper reach (average CPUE = 0.4/hr) and 8 fold greater (average CPUE = 3.4/hr) in the lower reach (Table 3). Density estimates of sauger in 1989 were reported to be 28.8 sauger/mile above Cartersville Diversion Dam compared to 208 sauger/mile downstream of the dam (Stewart, 1990) demonstrating how vastly different population densities were above and below the dam. Sauger have a unique life cycle where the majority of the young rear in downstream areas 150-250 miles downriver and must eventually disperse back upstream to repopulate upriver areas. The partial barrier effects caused by these six low-head diversion dams are probably limiting the sauger population from reaching its potential carry capacity in the MYSR.

Shovelnose sturgeon was another species that was sampled at a greater average relative abundance below Cartersville Diversion Dam (4.0 sturgeon/net) than above the dam (0.1/net) (Table 4). Similar to sauger, the shovelnose young rear far downriver and eventually migrate upriver to repopulate upstream areas. The series of diversion dams on the Yellowstone River are probably limiting shovelnose sturgeon upriver distribution to Cartersville Diversion Dam. Blue sucker and smallmouth bass were two additional species that showed the same trend in average relative abundance differences as the previously mentioned species and their upstream distributions are most likely limited by the presence of the series of low-head diversion dams.

Irrigation canal entrainment effects on the fish community

Cartersville Irrigation Canal was completed in 1904 with the diversion dam constructed in 1934 (Cartersville Irrigation District, 1984). Approximately 100- 260 cfs of Yellowstone River water is diverted into a 2.2 mile- long slough to a point where the water is diverted by another head gate into the main canal that extends for about 21 miles where any excess water is returned to the river (Figure 3). The remaining mile of the slough channel connects back to the river about 2 miles downstream from the dam. The 3½-mile slough channel is fairly natural with dense riparian bank cover, however, flow volumes and velocities are artificially high during the summer irrigation season and the lower end is only intermittently watered and connected to the river.

The canal was routinely sampled to evaluate fish entrainment during summer, 1999. Coarse drift nets, hoop nets, experimental gill nets, and electrofishing methods were used to sample fish in the canal. Most of the fish sampling in the canal occurred within 100 feet of the head gate. A total of 132 fish (11 species) were captured in the 34.1 hours of drift net sampling (Table 11). This type of sampling measured the fish entrainment rate for fish sizes approximately 2-6 inches (fish sizes that could effectively be retained in the ¼-inch mesh x 18 ft long net). Emerald shiner, flathead chub and fathead minnow were the most common species sampled, composing 81% of the total. The sampling intensity was low, however, a rough calculation of the total number of fish entrained was ~ 68,500 fish into Cartersville Diversion Canal during the 3 month irrigation season (~ June20 to September 20) (Appendix Table X).
Electrofish sampling, hoop netting and seining were also used to evaluate entrainment of fish into the Cartersville Irrigation Ditch. A diverse assemblage of fish was sampled including 20 species (9 additional species more then the drift net samples) (Tables 12-14). Most of the species sampled were non game fish or cypinids, and channel catfish was the only game species sampled in the Cartersville Canal.

During October the Ranchers, Yellowstone and Cartersville canals were visited at various access points to look for places where water remained in the canals and evaluate species abundance and composition of the fish remaining in the un-drained pools. The deeper water areas were associated with bridge crossings and siphon crossings. This and the more common shallow canal areas (<2 ft) is where seine sampling was attempted. A total of 6,063 fish were sampled including 16 species. Flathead chub and *Hybognathus spp.* were the most common species sampled averaging 53% of the total catch (Table 14). Gill net sampling was limited because of the lack of deep-water areas. Five siphon areas were visited, including Box Elder, Sarpy, Reservation and Little Porcupine creeks and at all sites sauger and several other fish were observed. Most of theses siphons were difficult to sample but one was gill netted and results are given in Table 15. Shorthead redhorse and white sucker were the most abundant species sampled together composing 64% of the catch. Sauger was the only game fish sampled at what appeared to be relatively greater numbers in the canal compared to the adjacent river. It appears large numbers of several fish species, including sauger, gather (and most likely eventually die) in the siphon pools when the irrigation system is shut down for the season and the ditches are drained.

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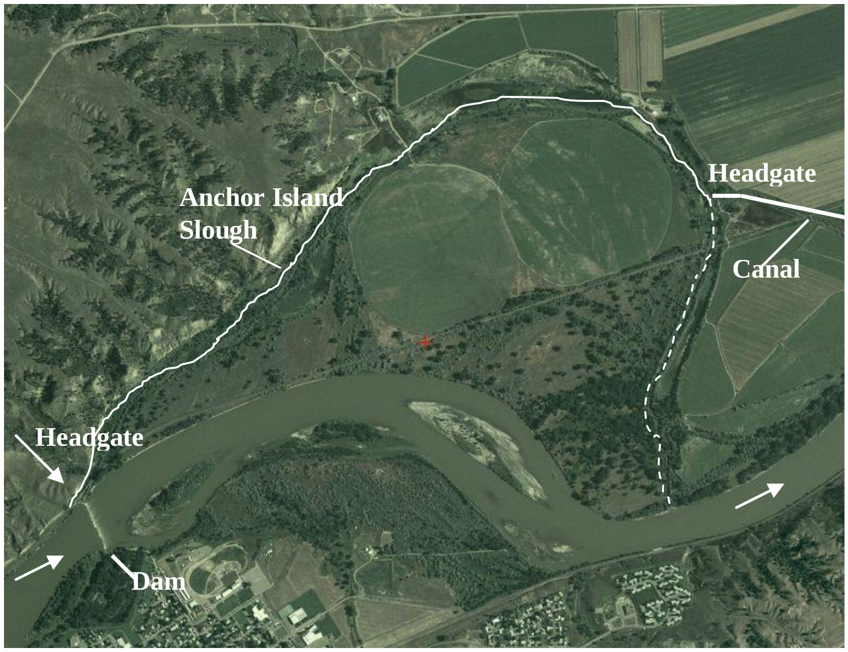

Figure 3. Photo of Cartersville Diversion Dam and irrigation canal works.

Table 11. Number and species of fish drift net sampled in the Cartersville Diversion Canal river head gate, 1999.

	Count	Time	CPUE (no/h)	BMB	ES	FHC	FHM	HYB	LND	Other
July 20-21										
(171cfs)										
Morning	6	2.0	3.0		3	1		2		
Morning	3	2.2	1.4			1		2		
Afternoon	27	2.0	13.5		11	4	11		1	
Afternoon	25	2.0	12.5	1	17	2	5			
Late-day	6	2.0	3.0		2	1	3			
Evening	13	4.8	3.8			2	2	7	2	
Evening	7	3.6	1.9		1	3	1	1	1	
Aug 10										
(not meas.)										
Morning	7	2.5	3.0		2		3	1		1
Afternoon	10	3.0	3.3		1		9			
Late-day	0	2.0	0							
Evening	20	3.0	6.7			1	16	2		1
Aug 31										
(260cfs)										
Afternoon	2	2.0	1.0		1	1				
Late-day	6	3.0	2.0		1	2				3

Table 12. Percent composition and sizes of fish electrofish sampled in the Cartersville Irrigation Ditch (upper end near head gate), middle Yellowstone River during the fall, 1999.

	Count	Percent Composition	Average Length (inches)	Average Weight (pounds)
Carp	36	17	17.3	2.80
Emerald shiner	1	T		
Flathead chub	58	28		
Freshwater drum	1	T		
Goldeye	12	6	13.7	0.90
Longnose sucker	3	1	7.2	0.16
Shorthead rehorse	47	22	5.4	0.10
Smallmouth bass	2	1	3.6	
Stonecat	2	1	6.6	0.15
White sucker	47	22	7.8	0.32
Total catch	209			
Total duration	1.8 hr			

Table 13. Percent composition of fish sampled by hoop nets in Cartersville Irrigation Ditch (upper end near head gate) , middle Yellowstone River during the fall, 1999.

	Count	Percent Composition
Channel catfish	12	21
Flathead chub	9	16
Shorthead rehorse	13	23
Smallmouth bass	1	2
Stonecat	18	32
White crappie	1	2
White sucker	3	5
Yellow perch		
Total catch	57	
Total # sets	44	

Table 14. Percent composition of fish seined in irrigation ditches of the middle Yellowstone River during the fall, 1999.

	Ranchers Ditch	**Yellowstone Ditch**	**Cartersville Ditch**
Black crappie	T		
Carp	T	T	
Emerald shiner	30	1	2
Flathead chub	17	61	40
Fathead minnow	15	T	21
Goldeye			T
Hybognathus spp. [2/]	21	7	15
Longnose dace	10	3	7
Longnose sucker		T	T
Mountain sucker		T	T
River carpsucker	T	T	
Sand shiner	7		13
Shorthead rehorse		22	T
Smallmouth bass		T	
White sucker	1	6	1
Yellow perch		T	
Total catch	3100	1747	1216
Total # seine hauls	1	8	6

1/ y denotes age-0 fish

2/ Difficult to differentiate between species; could include western silvery, plains and/or brassy minnows

3/ Denotes presence

Table 15. Percent composition and sizes of fish gillnetted in the Yellowstone River Irrigation Ditch, middle Yellowstone River during the fall, 1999.

	Count	Percent Composition	Average Length (inches)	Average Weight (pounds)
Goldeye	6	10	13.2	0.84
Longnose sucker	7	12	11.4	0.70
River carpsucker	2	3	15.6	1.90
Sauger	5	8	18.2	2.06
Shorthead rehorse	20	34	8.8	0.29
Stonecat	1	1		
White sucker	18	31	12.9	1.03
Total catch	59			
Total # sets	4			

1/ y denotes age-0 fish

2/ Difficult to differentiate between species; could include western silvery, plains and/or brassy minnows

3/ Denotes presence

RECOMMENDATIONS

The MYSR fish communities were found to be represented by a wide diversity of fish with many species occurring in healthy abundance. However, the native migratory species here appear to be sparsely populated and limited in their natural distribution. Sauger, shovelnose sturgeon and blue sucker are at least three native species that were found to occur in abnormally low numbers. These species may require more complex habitat conditions and would therefore be sensitive to alterations of the MYSR natural environment. Irrigated agriculture is a major use in the MYSR and the associated water withdrawals, low-head diversion dams and canal diversions all probably have negative impacts, especially on the migratory fish species.

The potential for water shortages in the MYSR is high, although for the four years of this study minimum instream flows were met or exceeded 70% of the time. Low river flows would increase the detrimental effects of irrigation structures and operations. The canals would increase the proportion of river flow being diverted, consequently fish entrainment would be greater. Low flows would make the diversion dams even more of a passage barrier for fish. There is a huge difference in flow rates between the assessed instream flows compared to the granted (reservation) flows (Appendix Table B), therefore, MFWP's water reservations are inadequate to protect the existing fisheries. More fisheries information needs to be gathered to support a reapplication for acquiring a water reservation more inline with the biological assessed flows.

The preliminary entrainment netting that was done on the Cartersville Diversion Canal indicated that fish entrainment was moderate, however, MYSR flows were abnormally high that year (9,000 – 11,000 cfs) and the proportion of river being diverted was low. Seining the canals after they were closed indicated there were considerable numbers of minnows trapped in the dewatered canals. Additionally, several adult sauger were also observed in the canal siphon pools. It appears there is a considerable loss of MYSR fish due to operations of the canals. All the irrigation canals diverting more than 100 cfs should be screened to prevent four-inch or greater size fish from being entrained into the canal system. An excellent way to screen a canal such as the Cartersville Canal would be to locate the screen 2 miles down the canal, near the canal head gate, and provide a continuous by-pass flow that would route the screened fish back into the MYSR. This arrangement would help protect the screen from floating debris keeping it functioning and damage-free and reconnect the Anchor Island side channel with the MYSR. A radio telemetry study, focusing on how the fish enter the canals and what happens once the fish are in the canal would provide insight on how fish screens should be implemented in the MYSR system and provide canal operators with information on how to reduce fish losses.

The six low-head diversion dams are undoubtedly affecting the distribution and abundance of migratory fish in the MYSR. This could be related to the specific life history characteristics of this group of fish. Both sauger and shovelnose young rear far downriver and maintenance of healthy upriver populations requires open passage for these sub-adults to travel upstream 150-250 miles to repopulate open habitat. While some passage is presently occurring, it appears to be inadequate for maintaining healthy populations of sauger, shovelnose sturgeon and blue sucker in the MYSR. Complete dam removal appears to be unfeasible due to the volume of water diverted and social concerns. Therefore, providing fish ways around or over the low-head dams seems to be the most practical option.

It appears there is almost no sauger spawning occurring in the lower Tongue River. This tributary historically provided exceptional spawning habitat. The loss of this critical upriver spawning stream may be linked to the currently low sauger abundance in the MYSR upstream of Miles City. It is suspected that the chronically low Tongue River flows during the spring are the cause for the lack of sauger spawning use. The Montana Department of Natural Resources and Conservation operations for the Tongue River Dam need to include sauger-spawning flows of 525-600 cfs during the period April through May.

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APPENDIX SECTION

Appendix A. Locations and rivermile boundaries of trend areas in the middle Missouri River study area.

Section	Rivermile Boundary	Location	Lat./Long.
Dover Is.	RM 356.0 – 351.8	Downstream of Billings to Huntley Dam	N45.87389*/W108.34806* to N45.22028*/W108.47306
Huntley	RM 351.9 – 345.8	Huntley Dam to 0.3 mile downstream of Huntley Bridge	N45.22028*/ W108.47306* to N45.93833* / W108.29472*
Pompey's P.	RM 338.0 – 329.0	Worden to 2 mi. downstream of Pomeys P. Monument	N45.99389*/ W108.17972* to N45.99611* / W108.01278*
Waco	RM 316.7 – 311.0	Waco Dam to 5 miles downstream of Waco	N46.04222*/ W107.80167* to N46.07833* / W107.70917*
Myers	RM 293.0 – 284.3	Ranchers Ditch Dam downstream to Myers D. Dam	N46.17944*/ W107.43361* to N46.25444* / W107.34556*
Hysham	RM 278.3 – 270.0	Myers D. Dam to Froze to Death Cr.	N46.28097*/ W107.30192* to N46.31000* / W107.05530*
Armells	RM 246.1 – 237.4	Big Porcupine Cr. to Cartersville Dam	N46.28000*/ W106.80639* to N46.27500* / W106.68000*
Forsyth	RM 237.4 – 230.6	Cartersville Dam to Little Porcupine Cr.	N46.27500*/ W105.89773* to N46.43352* / W105.82090*
Miles City	RM 187.0 – 182.0	0.4 mi above Ft Keogh Brg. to Piorgue Is.	N46.39173*/ W106.68000* to N46.29639* / W106.55639*
Bighorn R.	RM 0 – 4.9	Confluence w/ YSR to Manning D. Dam	N46.15447*/ W107.47491* to 46.10872* / W107.474.6*
Tongue R.	RM 0 – 20.0	Confluence w/YSR to Tongue River Diversion Dam	N46.40890*/ W105.86617* to 46.24491* / W105.75037*
Powder R.	RM 4.9 –10.0	3 miles downstrm of Ten Mile Cr. to 2 mi above Tenmile Cr.	N46.15447*/ W107.47491* to 46.10872* / W107.474.6*

Appendix B. Montana Fish Wildlife and Parks minimum instream flow (cfs) requests and granted minimum instream flows for the middle Missouri and Marias rivers. (MFWP 1976 and MDNRC 1978).

	L. Yellowstone R. (below Bighorn R.)		**Bighorn R.** (below Bighorn R.)		**Tongue R.** (below Bighorn R.)		**Powder R.** (below Bighorn R.)	
Month	Assessed	Granted	Assessed	Granted	Assessed	Granted	Assessed	Granted
January	4,800	3,738	3,300	3,300	190	75	80	21.9
February	5,500	4,327	3,200	3,200	190	75	80	71.8
March	11,000	6,778	4,000	4,000	525	75	500	291
April	11,000	6,808	3,600	3,600	525	75	500	347
May	12,935 *	11,964	3,800	3,800	600	75	800	424
June	38,033 *	25,140	5,200	5,200	600	75	800	184
July	13,639 *	12,526	3,600*	3,600*	412*	75	200	70
August	7,000	2,670	2,800	2,800	225	75	40	14.5
September	7,000	3,276	2,600	2,600	190	75	40	8.9
October	7,000	6,008	2,700	2,700	190	75	80	9.4
November	7,000	5,848	3,100	3,100	190	75	80	61.6
December	5,600	3,998	3,200	3,200	190	75	80	61

* Average of the two separate flows given for the month.

Appendix C. Mean daily temperatures recorded for Bighorn River @ (RM 3) Tullock, 2000. (USGS)

Day	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	40.9	43.2	53.4	53.1	66.2	66.3	60.5
2	40.4	42.0	56.5	56.6	65.1	67.3	62.7
3	41.0	41.8	57.0	60.5	65.9	67.1	63.7
4	42.2	44.8	57.9	61.5	65.9	66.5	64.2
5	43.2	45.7	57.3	62.1	65.1	65.3	65.5
6	43.8	46.5	55.7	64.4	66.9	64.8	63.3
7	42.7	43.7	52.6	66.2	67.7	64.4	60.6
8	40.0	44.3	51.0	66.0	68.7	65.0	60.8
9	38.0	47.3	51.7	64.6	69.2	64.9	60.7
10	40.0	45.9	53.4	62.2	67.3	64.4	58.1
11	40.6	45.7	52.7	62.0	66.8	65.0	60.0
12	41.5	48.4	48.9	61.1	67.7	65.5	62.1
13	41.2	48.0	47.3	57.3	66.4	66.2	63.5
14	40.7	43.0	50.5	56.5	65.3	65.6	63.9
15	40.0	41.9	55.3	57.4	64.8	65.0	64.7
16	40.7	44.0	57.2	56.5	64.3	65.0	66.0
17	43.0	48.0	55.7	56.7	63.5	64.1	65.5
18	43.3	49.0	53.6	59.0	62.0	63.9	62.6
19	41.8	49.1	55.4	60.0	60.6	63.9	60.0
20	40.1	50.3	57.0	57.2	62.3	63.1	57.2
21	40.3	52.9	58.3	58.7	65.9	62.4	53.6
22	42.6	54.8	59.4	61.3	66.6	63.0	48.0
23	44.8	54.5	60.4	63.0	67.6	62.7	47.5
24	44.0	53.0	59.8	64.2	67.0	64.4	49.4
25	43.6	49.4	60.0	63.2	66.0	65.9	52.1
26	45.9	51.7	59.2	60.6	67.0	66.5	55.0
27	46.6	53.4	59.9	62.0	67.1	66.0	57.0
28	46.2	54.4	60.5	63.7	66.7	64.1	57.9
29	45.8	52.8	58.3	65.2	67.3	64.0	58.7
30	44.8	51.7	55.4	66.3	67.3	61.6	59.0
31	44.0		54.0		66.5	58.7	
Mnthly avg	42.4	48.0	55.7	61.0	66.0	64.6	59.5

Appendix D. Mean daily temperatures recorded for Tongue River @ (RM 1) Miles City, 2000. (USGS)

Day	MAR	APR	MAY	JUN	JUL	AUG	SEP
1		46.0	62.6	57.0	74.3	79.0	67.0
2		43.7	64.6	60.5	75.8	76.4	71.3
3		43.4	66.4	64.4	75.4	75.8	70.1
4		48.6	67.8	66.2	75.2	77.7	72.1
5		51.3	62.7	67.2	74.7	74.3	69.8
6		47.6	61.1	70.7	76.3	74.5	65.3
7		44.9	58.4	73.8	79.2	74.0	63.1
8		47.6	58.1	76.1	79.0	75.4	65.0
9		52.1	61.1	74.7	77.3	75.7	61.1
10		49.1	63.0	71.5	76.9	75.9	58.0
11		45.4	57.5	72.4	76.7	77.3	61.9
12		49.9	45.4	70.6	79.8	76.6	63.7
13		53.0	51.1	67.4	81.8	76.6	65.1
14		44.6	57.2	64.6	82.4	75.0	65.0
15		45.6	62.0	64.6	80.8	73.1	66.4
16		47.6	64.1	61.9	75.2	70.0	68.3
17		54.8	61.0	62.8	70.7	69.8	68.5
18		56.6	61.0	66.0	72.5	70.2	64.8
19		55.7	62.9	67.9	75.0	70.9	60.0
20		57.0	64.4	63.5	76.3	72.3	56.1
21		62.0	65.6	64.6	75.4	67.8	54.7
22	44.9	64.1	66.2	68.9	76.3	70.0	45.9
23	46.2	60.8	65.5	71.8	78.7	71.3	45.0
24	44.9	54.5	65.3	72.5	76.9	72.3	47.9
25	45.1	55.4	66.0	69.1	75.5	73.5	51.6
26	48.4	58.3	63.6	68.0	75.6	73.0	55.0
27	48.7	58.1	63.5	69.0	76.9	72.8	57.0
28	49.7	60.2	67.1	71.0	79.8	68.3	57.4
29	50.4	54.8	65.5	74.3	80.2	68.5	58.1
30	46.4	54.2	64.4	75.2	80.2	64.8	58.4
31	45.1		62.8		78.5	61.9	
Mnthly avg		52.2	62.2	68.3	77.1	72.7	61.1

Appendix E. Mean daily temperatures recorded for the Powder River @ RM 1, 2000.
(Onset logger - MTFWP)

Day	MAR	APR	MAY	JUN	JUL	AUG	SEP
1		44.3	60.9				
2		41.9	63.0				
3		42.1	64.3				
4		47.1	65.7				
5		48.3	60.4				
6		45.0	59.0				
7		43.6	57.3				
8		44.5	57.2				
9		47.6	59.4				
10		47.3	61.7				
11		45.1	56.7				
12		45.9	45.0				
13		48.2	47.8				
14		41.4	55.2				
15		41.4	60.6				
16		47.6	62.2				
17		54.2	59.5				
18		55.4	59.1				
19		55.1	60.3				
20		55.9	62.6				
21		60.2					
22		62.9					
23		57.1					
24	45.3	54.0					
25	43.5	55.5					
26	46.5	55.8					
27	45.4	56.3					
28	46.2	57.8					
29	46.9	53.1					
30	45.4	55.1					
31	43.7						
Mthly avg		50.3	58.9				

Appendix F. Summary size statistics for fish sampled in the Waco Section by electrofishing, Middle Yellowstone River, 1999-2000.

	Count	**Average TL** (in)	**Range**	**Average WT** (lb.)	**Range**
Bigmouth buffalo	1	20.7		5.07	
Black crappie	1	7.5		0.30	
Brown trout	7	13.2	7.4 – 19.3	1.18	0.13 – 2.64
Carp	44	22.5	14.3 – 30.6	6.43	0.51 – 13.22
Channel catfish	21	18.9	12.5 – 25.5	2.83	0.70 – 7.51
Flathead chub	2	6.3	6.2 – 6.4	0.12	0.11 – 0.12
Freshwater drum	1	18.6		3.52	
Goldeye	171	12.6	11.3 – 14.3	0.65	0.44 – 0.99
Longnose sucker	21	9.5	5.5 – 15.0	0.58	0.11 – 1.50
Mountain sucker	1	7.8		0.20	
River carpsucker	21	15.6	12.6 – 17.3	2.00	0.70 – 3.02
Sauger	1	16.7		1.40	
Shorthead redhorse	88	14.5	5.6 – 19.2	1.46	0.10 – 2.95
Smallmouth buffalo	1	10.3		0.68	
Walleye	4	22.1	21.7 – 22.7	3.47	3.08 – 3.88
White sucker	84	13.05	7.3 – 17.9	1.21	0.22 – 2.73
Yellow perch	2	9.2	9.1 – 9.2	0.45	0.42 – 0.48

Appendix G**.** Summary size statistics for fish sampled in the Myers Section by electrofishing, MiddleYellowstone River, 1998 and 2000.

	Count	**Average TL** (in)	**Range**	**Average WT** (lb.)	**Range**
Black crappie	1	5.6		0.35	
Brown trout	8	11.7	7.4 – 15.8	0.77	0.13 – 1.76
Burbot	5	23.7	15.5 – 33.0	3.18	0.62 – 6.80
Carp	119	21.3	13.0 – 26.2	5.65	1.10 – 10.0
Channel catfish	73	20.3	13.3 – 29.0	3.69	0.62 – 10.2
Freshwater drum	4	14.6	12.5 – 18.6	1.19	1.00 – 3.52
Goldeye	469	12.9	10.3 – 15.5	0.73	0.22 – 1.60
Green sunfish	1	4.4			
Longnose sucker	167	10.8	4.2 – 16.6	0.70	0.05 – 2.00
Mountain sucker	4	5.8	4.0 – 8.3		
Mountain whitefish	1	12.2		0.60	
Rainbow trout	1	5.0			
River carpsucker	100	15.4	9.7 – 18.6	1.86	0.45 – 3.00
Sauger	6	18.3	16.7 – 19.6	1.93	1.43 – 2.40
Shorthead redhorse	314	13.0	4.0 – 20.1	1.46	0.05 – 3.20
Smallmouth bass	6	3.9	2.8 – 5.0		
Walleye	10	21.0	16.5 – 26.0	3.57	1.82 – 8.50
White sucker	156	12.7	5.8 – 19.9	1.04	0.05 – 2.73

Appendix H. Summary size statistics for fish sampled in the Armells Section by electrofishing, MiddleYellowstone River, 1998.

	Count	Average TL (in)	Range	Average WT (lb.)	Range
Bigmouth buffalo	1	21.0	--	5.75	--
Black crappie	1	6.3	--	0.18	--
Burbot	4	16.0	(10.2 – 23.4)	0.95	0.36 – 2.15
Goldeye	248	12.9	(8.7 – 15.1)	0.74	0.25 – 1.25
Green sunfish	2	3.5			
Largemouth bass	2	5.4	(5.2 – 5.7)		
Longnose sucker	49	11.3	(5.5 – 17.0)	0.90	0.05 – 1.25
Mountain whitefish	2	12.5	(10.8 – 14.2)	0.69	0.38 – 1.00
Northern pike	1	36.5	--	12.4	--
River carpsucker	68	15.8	(13.0 – 18.2)	1.96	1.25 – 3.10
Sauger	15	16.6	(13.0 – 20.8)	1.56	0.60 – 2.95
Shorthead redhorse	221	14.6	(4.8 –20.0)	1.56	0.07 – 3.62
Smallmouth bass	8	7.5	(3.5 –13.5)	0.62	0.05 – 1.80
Smallmouth buffalo	3	24.4	(21.0 – 28.0)	8.04	5.0 – 11.5
Walleye	8	11.9	(8.4 – 19.9)	0.96	0.25 – 3.15
White sucker	94	13.4	(5.4 – 18.2)	1.23	0.12 – 2.62
Yellow perch	1	7.0	--	0.15	--

Appendix I. Summary size statistics for fish sampled in the Forsyth Section by electrofishing, MiddleYellowstone River, 1999-2000.

	Count	Average TL (in)	Range	Average WT (lb.)	Range
Bigmouth buffalo	4	23.4	19.1 – 26.9	8.22	4.63 – 11.50
Black crappie	1	8.0		0.35	
Burbot	2	16.2	13.3 – 19.0	0.84	0.31 – 1.38
Carp	55	21.1	16.0 – 21.3	4.86	1.60 – 9.31
Channel catfish	37	21.1	15.4 – 28.3	3.70	0.99 – 11.50
Freshwater drum	1	14.5		1.49	
Goldeye	60	12.8	11.4 – 14.6	0.68	0.47 – 0.93
Largemouth bass	2	10.6	8.0 – 13.1	0.86	0.33 – 1.40
Longnose sucker	29	15.0	4.7 – 18.8	1.61	0.17 – 2.60
Northern pike	6	28.2	23.8 – 34.7	6.13	3.85 – 11.50
River carpsucker	30	15.7	14.0 – 17.5	1.99	1.40 – 2.77
Sauger	24	16.5	10.8 – 20.0	1.46	0.40 – 2.53
Shorthead redhorse	68	15.1	5.1 – 19.6	1.70	0.10 – 3.22
Smallmouth bass	31	10.8	3.0 – 17.7	1.26	0.04 – 3.48
Smallmouth buffalo	3	19.3	16.2 – 26.2	4.96	2.10 – 10.18
Walleye	6	17.5	15.5 – 18.7	1.92	1.44 – 2.52
White sucker	40	13.1	4.2 – 17.2	1.19	0.15 – 2.40

Appendix J. Summary size statistics for fish sampled in the Miles City Section by electrofishing, Middle Yellowstone River, 1999-2000.

	Count	**Average TL** (in)	**Range**	**Average WT** (lb.)	**Range**
Bigmouth buffalo	1	25.7		11.00	
Black crappie	17	8.5	3.8 – 9.5	0.51	0.04 – 0.54
Blue sucker	29	27.9	23.2 – 31.2	7.44	3.70 – 11.50
Burbot	11	14.4	9.3 – 15.5	0.46	0.26 – 0.69
Carp	61	20.7	12.6 – 27.5	4.49	1.04 – 9.28
Channel catfish	102	18.6	7.5 – 28.0	2.83	0.10 – 11.50
Flathead chub	6	4.7	3.5 – 5.7	0.09	0.6 – 0.11
Freshwater drum	47	11.9	9.0 – 16.6	0.79	0.15 – 2.45
Goldeye	91	12.8	8.2 – 14.5	0.67	0.15 – 1.00
Green sunfish	1	5.0		0.15	
Hybognathus	4	4.3	3.5 – 4.8		
Largemouth bass	1	8.0		0.33	
Longnose sucker	75	12.4	4.1 – 18.3	1.06	0.08 – 2.25
Northern pike	5	26.8	21.8 – 34.7	5.71	2.63 – 11.50
River carpsucker	60	15.9	13.4 – 19.7	20.7	1.26 – 3.98
Sauger	197	13.6	9.1 –24.0	0.76	0.24 – 4.30
Shorthead redhorse	94	10.7	4.8 – 18.6	0.76	0.06 – 2.63
Shovelnose sturgeon	2	37.0*	35.0 – 39.0	9.93	8.76 – 11.10
Smallmouth bass	175	6.5	2.9 – 17.2	0.65	0.03 – 3.44
Smallmouth buffalo	1	32.1		19.00	
Stonecat	6	6.7	5.5 – 8.1	0.13	0.12 – 0.14
Walleye	34	16.8	12.2 – 20.4	1.76	0.56 – 2.91
White crappie	13	5.5	2.5 – 8.6	0.35	0.04 – 0.36
White sucker	41	13.1	3.5 – 17.0	1.20	0.50 – 2.10
Yellow perch	26	7.6	6.7 – 8.9	0.25	0.18 – 0.37

* denotes fork length

Appendix K. Summary size statistics for fish sampled in the Dover Island Section by trammel netting, middle Yellowstone River, 1997.

	Count	Average TL (in)	Range	Average WT (lb.)	Range
Carp	3	16.7	14.4 –19.1	2.35	1.60 –3.50
Channel catfish	2	21.0	19.5 – 22.8	3.05	2.45 – 3.65
Goldeye	38	12.7	9.3 – 14.7	0.64	0.40 – 0.70
Longnose sucker	61	12.7	9.2 – 18.0	0.90	0.32 – 2.40
Mountain whitefish	1	12.2	--	0.57	--
River carpsucker	1	16.2	--	2.15	--
Shorthead redhorse	49	16.0	12.3 – 19.6	1.59	0.74 – 2.75
White sucker	19	11.8	0.84 – 1.69	0.81	0.26 – 1.90

Appendix L. Summary size statistics for fish sampled in the Huntley Section by trammel netting, Middle Yellowstone River, 1997.

	Count	Average TL (in)	Range	Average WT (lb.)	Range
Burbot	1	22.8	--	2.50	--
Carp	2	22.2	19.7 – 24.8	4.84	2.40 – 7.28
Channel catfish	3	18.1	16.9 – 18.8	2.10	1.80 – 2.25
Goldeye	70	12.7	11.2 – 15.6	0.62	0.46 – 0.90
Longnose sucker	34	12.3	0.94 – 1.85	0.80	0.35 – 2.45
Shorthead redhorse	21	14.5	9.0 – 19.4	1.33	0.25 – 2.47
White sucker	35	12.2	8.4 – 16.9	0.81	0.26 – 1.90

Appendix M. Summary size statistics for fish sampled in the Myers Section by trammel netting, middle Yellowstone River, 2000.

	Count	Average TL (in)	Range	Average WT (lb.)	Range
Carp	4	20.8	18.6 – 22.5	4.63	3.15 – 5.34
Channel catfish	26	16.4	9.7 – 23.9	1.62	0.25 – 4.60
Goldeye	51	12.5	10.7 – 14.3	0.59	0.40 – 0.90
Longnose sucker	11	14.1	10.9 – 17.7	1.06	0.45 – 1.95
River carpsucker	7	15.4	14.3 – 16.3	1.67	1.50 – 1.80
Shorthead redhorse	21	17.5	14.0 – 20.3	2.13	1.05 – 3.50
Stonecat	1	6.2		0.10	
White sucker	5	15.5	14.8 – 17.0	1.49	1.27 – 2.05

Appendix N. Summary size statistics for fish sampled in the Armells Section by trammel netting, Middle Yellowstone River, 2000.

	Count	**Average TL** (in)	**Range**	**Average WT** (lb.)	**Range**
Carp	1	22.3		6.61	
Channel catfish	9	15.0	12.6 – 16.9	1.14	0.64 – 1.78
Goldeye	15	13.0	12.1 – 14.1	0.81	0.69 – 1.00
Longnose sucker	2	16.9	15.9 – 17.8	1.99	1.58 – 2.40
Sauger	1	15.0		1.05	
Shorthead redhorse	5	14.1	8.9 – 17.1	1.25	0.38 – 2.00
White sucker	4	13.7	10.5 – 18.2	1.38	0.61 – 2.58

Appendix O. Summary size statistics for fish sampled in the Forsyth Section by trammel netting, Middle Yellowstone River, 2000.

	Count	**Average TL** (in)	**Range**	**Average WT** (lb.)	**Range**
Channel catfish	7	20.6	17.2 – 24.2	3.41	1.78 – 5.74
Goldeye	7	12.7	12.2 – 13.1	0.71	0.60 – 0.86
Longnose sucker	2	15.7	15.0 – 16.3	1.44	1.20 – 1.68
Shorthead redhorse	8	14.0	10.4 – 17.0	1.13	0.52 – 1.83
Shovelnose sturgeon	29	33.1*	28.8 – 37.0	7.51	3.80 – 11.60
Smallmouth bass	1	7.8		0.32	

* denotes fork length

Appendix P. Average catch per seine haul by macro habitat for fish sampled in the Waco Section, Middle Yellowstone River, 1999- 2000.

	Main chnl. border	**Main chnl. pool**	**Side chnl border**	**Side chnl pool**	**Backwaters**
Carp					0.4
Emerald shiner	15.8	23.0	3.7	23.0	31.4
Fathead minnow	11.4	7.5	5.7	6.2	8.1
Flathead chub	6.3	7.0	9.7	4.8	1.4
Hybognathus spp.	49.6	29.5	94.7		39.1
Longnose dace	1.2		1.0		0.5
Longnose sucker	1.6	5.0	1.0		0.1
Mountain whitefish	0.01				
Shorthead redhorse	5.5		6.0		0.6
White sucker			0.3		1.01
Unidentified	6.5	15.0	5.0	112	19.1
Total no. of fish	1080	174	381	181	1121
Total hauls	11	2	3	4	11

Appendix Q. Average catch per seine haul by macro habitat for fish sampled in the Hysham Section, Middle Yellowstone River, 1999- 2000.

	Main chnl. border	Main chnl. pool	Side chnl border	Side chnl pool	Backwaters
Carp	1.8		167.3	4.0	2.2
Emerald shiner	8.1		19.0	110.4	13.2
Fathead minnow	7.9		1333.3	182.4	24.4
Flathead chub	8.8	16.0	12.0	43.6	27.2
Hybognathus spp.	4.2		50.7	430.0	103.6
Longnose dace	1.2	1.0	1.3	8.2	
Longnose sucker	6.8	18.0	2.0	1.8	1.0
Mountain sucker			0.3	1.0	
River carpsucker	2.2		1.0	1.4	1.8
Sand shiner					0.4
Shorthead redhorse	28.9	65.0	57.7	15.4	36.4
Smallmouth bass	2.1	2.0	0.3	3.4	5.2
Smallmouth buffalo	0.5				0.4
White sucker	14.8	9.0	106.7	34.4	26.8
Unidentified	15.0			47.4	0.4
Total no. of fish	818	111	5255	4417	1215
Total hauls	8	1	3	5	5

Appendix R. Average catch per seine haul by macro habitat for fish sampled in the Armells Section, Middle Yellowstone River, 1999- 2000.

	Main chnl. border	Main chnl. pool	Side chnl border	Side chnl pool	Backwaters
Carp					4.0
Emerald shiner		3.0	3.0		228.0
Fathead minnow					
Flathead chub	9.0	190.0	22.0		47.0
Hybognathus spp.		417.0	9.0		383.0
Longnose dace	8.0	1.0			
Longnose sucker		22.0			5.0
Mountain sucker		2.0			
River carpsucker			11.0		9.0
Sand shiner		5.0	7.0		2.0
Shorthead redhorse	10.0	108.0	77.0		92.0
Smallmouth bass		13.0			2.0
Smallmouth buffalo					
Spottail shiner	0.5		3.0		
White sucker		34.0			
Unidentified					
Total no. of fish	55	805	132		772
Total hauls	2	1	1		1

Appendix S. Average catch per seine haul by macro habitat for fish sampled in the Forsyth Section, Middle Yellowstone River, 1999- 2000.

	Main chnl. border	Main chnl. pool	Side chnl border	Side chnl pool	Backwaters
Carp		0.6			
Emerald shiner	2.0	64.4			
Fathead minnow		1.6			
Flathead chub	0.7	21.0			
Hybognathus spp.	2.7	84.2			
Longnose dace		0.2			
Longnose sucker					
Mountain sucker					
River carpsucker		0.8			
Sand shiner	0.3	2.4			
Shorthead redhorse	47.7	86.8			
Smallmouth bass	51.0	3.8			
Smallmouth buffalo					
White sucker	3.3	6.8			
Unidentified		9.4			
Total no. of fish	323	1410			
Total hauls	3	5			

Appendix T. Summary size statistics for fish sampled electrofishing, Bighorn River, 2000.

Species	Count	Average TL (in)	Range	Average WT (lb.)	Range
Black bullhead	1	6.8		0.10	
Black crappie	1	7.1		0.29	
Carp	52	22.2	15.6-28.5	6.37	1.75-15.42
Channel catfish	4	20.6	15.8-26.0	3.85	1.13-8.40
Flathead chub	1	5.9			
Goldeye	37	12.6	11.3-14.5	0.65	0.43-0.90
Longnose sucker	27	13.3	5.1-19.0	1.47	0.10-3.10
Mountain whitefish	4	11.7	8.0-18.0	0.77	0.22-1.95
Rainbow trout	3	10.0	5.8-12.7	0.54	0.10-0.86
River carpsucker	1	15.5		1.77	
Shorthead redhorse	8	10.6	5.4-18.8	0.91	0.10-3.00
Smallmouth bass	1	13.5		1.7	
White sucker	55	11.2	4.5-17.8	1.04	0.10-3.00
Yellow perch	5	7.5	3.0-9.7	0.29	0.17-0.48

Appendix U. Summary size statistics for fish sampled electrofishing, Tongue River, 1999 & 2000.

	Count	**Average TL** (in)	**Range**	**Average WT** (lb.)	**Range**
Burbot	2	16.6	15.5 - 17.8	0.91	0.77 - 1.05
Carp	80	17.4	10.4 - 22.5	2.51	0.50 - 5.50
Channel catfish	253	17.5	3.0 - 30.5	2.89	0.02 - 15.42
Goldeye	77	12.5	11.0 - 14.0	0.50	0.30 - 0.82
Longnose sucker	90	14.9	7.2 - 19.0	1.73	0.13 - 2.95
Mountain sucker	3	5.8	5.3 - 6.5	0.11	0.07 - 0.15
River carpsucker	97	11.9	6.1 - 15.2	0.77	0.10 - 1.42
Sauger	32	15.2	12.0 - 20.7	1.07	0.42 - 2.80
Saugeye	2	22.1	16.0 - 28.3	4.93	1.42 - 8.44
Shorthead redhorse	89	12.6	5.5 - 19.5	0.88	0.05 - 3.55
Smallmouth bass	31	13.8	7.0 - 17.5	1.66	0.11 - 3.52
Smallmouth buffalo	1	12.0		0.74	
Stonecat	3	5.0	4.7 - 5.2	0.03	0.02 - 0.04
Walleye	145	19.2	11.9 - 29.3	2.84	0.53 - 11.50
White sucker	87	12.9	4.5 - 16.4	1.02	0.05 - 2.30

Appendix **V.** Summary size statistics for fish sampled electrofishing, Powder River, 1999 & 2000.

	Count	**Average TL** (in)	**Range**	**Average WT** (lb.)	**Range**
Burbot	2	16.6	15.5 – 17.8	0.91	0.77 – 1.05
Carp	1	20.0		3.75	
Channel catfish	34	24.8	15.5 – 29.2	6.18	1.21 – 12.24
Flathead chub	4	5.7	5.0 – 6.3	0.11	0.09 – 0.13
Goldeye	122	12.9	11.3 – 15.3	0.74	0.40 – 1.17
Longnose sucker	6	13.9	11.8 – 15.0	1.40	0.20 – 1.60
River carpsucker	6	17.1	14.1 – 19.3	2.80	1.70 – 3.80
Sauger	162	15.4	9.4 – 22.3	1.12	0.30 – 4.14
Saugeye	4	16.2	15.5 – 17.1	1.34	0.55 – 1.41
Shorthead redhorse	76	11.1	8.0 – 17.5	0.61	0.20 – 2.50
Shovelnose sturgeon	27	31.4*	27.3 – 36.4	6.13	3.48 – 11.67
Walleye	3	18.3	15.8 – 19.8	2.03	1.21 – 2.75

* denotes fork length

Appendix W. Sauger population estimate statistics, Miles City trend area, Yellowstone River, 1999.

Calculation of 95% confidence limits

Van Den Avyle (1993) recommends that in cases where recaptures are < 25 , confidence intervals should be calculated by using Poisson distribution given in Ricker (1975).

Lower 95% C.I. limit = CxM/lower coefficient value = 9193/24.8 = 371
Upper 95% C.I. limit = CxM/upper coefficient value = 9193/8.4 = 1094

Breakdown into efficiency groups

Size group (inch)	**M**	**R**	Catch eff (R/M)
9	2	0	
10	19	3	0.158
11	31	3	0.097
12	24	3	0.125
13	18	2	0.111
14	10	0	
15	11	3	0.273
16	4	0	
17	9	1	0.111
18	4	0	
19	1	0	
20+	3	0	

Schnabel estimate by efficiency group

Effic. group (inch)	Est. (N)*	% Comp.
9 - 11	229	37
12+	382	63
	611	

* Total estimated number (N) for each sauger efficiency group was calculated using the Schnabel estimator. The estimate of N based on summation of each efficiency group (611) did not equal the estimate for N when all sizes were combined (613). This discrepancy of N was believed to be the result of model limitations when low number of recaptures are used as was the case for the calculation by efficiency groups. However, I believe calculating the estimate by efficiency groups can be useful for providing a reliable method for determining the population size composition.

Population size composition (based on efficiency groups)

Size group (inch)	Efficiency groups	% Composition of efficiency group	Estimate Number (N)	% Composition of N
9	9 – 11	3	7	1
10	9 - 11	37	85	14
11	9 – 11	59	135	22
12	12+	28	107	18
13	12+	22	84	14
14	12+	11	42	7
15	12+	15	57	9
16	12+	4	15	2
17	12+	11	42	7
18	12+	4	15	2
19	12+	1	4	1
20+	12+	3	11	2

Appendix X. Estimated fish entrainment rates sampled with a drift net in the Cartersville Ditch, 1999.

Period	**# days in period**	**Estimated # fish /day**	**Estimated # fish /period**
June 20 – July 31	42	887	37,254
August 1 - 20	20	662	13,240
Aug 21 – Sept 20	30	600	18,000
Total fish			68,494

Formula used to calculate average # fish/day: # fish/hr caught in net while sampling x the proportion of the inflow x 24 hr. On 7/20-21 the avg. # fish/hr = 5.6; The net was sampling 15% of the inflow so the proportion factor = 6.6. (5.6fish/hr x 6.6) 24 hr = 887 fish/day.

Appendix Y. Historical account of the construction and operation of Cartersville irrigation canal and low-head diversion dam. (Provided by Pam Ash, 1999).

CARTERSVILLE IRRIGATION CANAL

The first irrigation system on the lands now occupied by the Cartersville Irrigation District was started by John E. Edwards. On April 17, 1903, he filed a notice of appropriation for 30,000 cubic inches of water to be diverted from the Yellowstone River in Lot 2 of Section 14, Township 6 North, Range 40 East. Water from this point was to be diverted into a slough. The point of diversion from the slough was given as in the Northwest quarter of Section 7, Township 6 North, Range 41 East. The system was described as a dam, ditch, and slough; said ditch to be 16 feet wide on the bottom, 22 feet wide on top and from 5 to 15 feet deep. The land description of intended place of use was described as lands in the Little Porcupine Bottom. The notice of appropriation is on file in Book I, page 352 of Water Rights Records in the Rosebud County Courthouse.

The construction of the canal was begun in July, 1903 and was completed in May, 1904. Water was turned into the canal on May 22, 1904.

In April of 1904, John E. Edwards associated with George D. Beattie and Peter Larson to form the Rosebud Land and Improvement Company. The company operated the canal until the creation of the Cartersville Irrigation District. The company dissolved in about 1936. On July 16, 1909, the Cartersville Irrigation District was created in the District Court of the 13th Judicial District.

In 1926, the District irrigable lands were re-classified and as a result, the assessed acreage was changed from 12,387.63 acres to 8,043.58 acres.

In 1931, 1932, and 1933 the flow of the Yellowstone River was so low that no water was available at the intake to the slough after high water by gravity. To supply water to the District it was necessary to install pumps. In order to assure ample water, a dam was constructed across the Yellowstone River in 1934.

In 1936 the south end of the dam washed out as a result of high water, and to repair this damage the Reconstruction Finance Corporation granted the District a loan of $22,000.00.

The District diverts water by gravity from the Yellowstone River in the Northeast quarter of Section 14, Township 6 North, Range 40 East, into a slough. Water is carried in the slough for 2¼ miles to

Appendix Y. (Continued).

to a point where the water is diverted into the main canal. From this point the main canal follows in an easterly direction on the north side of the Yellowstone River for about 21 miles.

The principal structures of the irrigation system consist of: a submerged dam across the Yellowstone River of pile, rock, brush, and concrete construction located on the north end of the dam at the point of diversion into the slough; concrete spillgate and headgate at the canal intake from the slough; concrete rectangular syphons under Little Porcupine Creek and Horse Creek and Lentz syphon under a coulee; McCurdy box type wood flume across a coulee; metal syphon and concrete spillgate under Sand Creek; and concrete drop at the end of the canal.

The District is located on the north side of the Yellowstone River, and extends from a point just north of Forsyth to a point about 4 miles east of Thurlow. It comprises a narrow strip of land averaging about 2 miles in width lying in the Yellowstone River Valley.

In 1947, there were 9,021.06 acres being irrigated under the Cartersville Irrigation District system, with a potential acreage under existing facilities of 1,463.86 acres, or a maximum irrigable acreage of 10,482.92 acres.

All water transported to the canal from the Yellowstone River is now gravity flow. The cost for water in 1984 was $6.50 per acre, or $4.35 per acre for water pumped to land not within the Cartersville Irrigation District. A summary of the expenses incurred by the District for one year is given on an attached sheet.

In 1984, there were 9055.3 acres of land irrigated by the Cartersville Canal, and 34 operators. The crops grown are listed below.

alfalfa hay	45.0%
corn	21.2%
winter wheat	11.9%
pasture	9.9%
barley	6.0%
spring wheat	2.0%
grass	1.8%
beans	1.7%
oats	0.5%

The 1984 Ditch Board consisted of Robert Adams, Ed Kraus, and Robert Sleaford; the secretary was Garry Burke; and the Ditch rider was Steve Seleg.

Update given at February 17, 2000 Cartersville meeting

Pamala Ash, Kirk Montgomery and Jim McDonagh described the present operation of the Cartersville Diversion and usage of diverted water. They indicated that the dam and canal serve about 40 flood irrigators who farm approximately 10,000 acres. Irrigation season generally occurs between mid-May and early October: they measure the water level in the ditch with a staff gauge. The gauge is not yet calibrated for purposes of measuring flow. Irrigators grow lower value crops such as corn, alfalfa and grain. Irrigators presently pay $8.50/acre to cover costs of maintaining and managing the dam and canal. The dam, which is in relatively poor condition, was last recapped in 1960: in recent years the ditch company has spent about $10,000/yr to repair the dam. They divert 100-150 cfs with about 20-40 cfs returned to the river.

(Notes taken by Glenn Phillips; MTFWP)