Montana Fish, Wildlife & Parks

Fisheries Division

Federal Aid Job Progress Report

Montana Statewide Fisheries Management

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Project Title: Montana Statewide Fisheries Management

Job Title: Southeastern Montana Warm-water Streams Investigation

Abstract: The Tongue River is a major tributary to the Yellowstone River. Anthropogenic activities, particularly the construction of dams, in the Tongue River watershed has affected the fish assemblage. A monitoring program was initiated in 2003 to monitor relative abundance, size distribution, and body condition of fish populations through time. Annual trend sampling consists of electrofishing at six locations. Seining was part of annual trend sampling from 2003 to 2009. In 2007 a bypass channel (Muggli Bypass) was constructed to provide fish passage around T&Y Diversion Dam. Modified fyke nets and electrofishing gears were used to assess the success of the fish passage structure. Passage was evaluated from 2008 to 2012. Twenty fish species have been documented using the Muggli Bypass since its construction. Fish passage for most species was deemed successful based on similar trends in abundances between the bypass channel and the river reach downstream of the diversion dam. However, Shovelnose Sturgeon, a species found in the reach of river below T&Y Diversion Dam, have not been documented passing through the bypass channel. Alterations to the Muggli Bypass may be necessary to facilitate Shovelnose Sturgeon passage.

INTRODUCTION

The Tongue River is a major tributary to the Yellowstone River in Eastern Montana. It supports a rich assemblage of native warm-water fish and provides spawning habitat and fish production that contributes to Yellowstone River fish populations. Few long-term studies have focused on the status of the Tongue River fish assemblage despite a long history of human activity in the drainage. Although game fishes are present in the river, sport fishing is limited by access and flow conditions. The primary human activities in the Tongue River watershed are agriculture and the development of coal resources.

Agriculture is the primary land use practice in the Tongue River watershed. Water from the Tongue River is used to irrigate tens-of-thousands of acres of farmland in the Tongue River drainage. Irrigation projects have had and still have a substantial impact on the Tongue River fish assemblage. Water withdrawal is so extensive that reaches of the Tongue River are completely dewatered during low water years. Irrigation diversion dams function as barriers to fish movement and have fragmented fish populations. Fish are also lost from the Tongue River fishery through entrainment into irrigation canals. Development of coal resources is another major industry in the watershed. Construction of a Tongue River Railroad has been proposed to facilitate increased coal extraction and transport. The proposed railroad would be constructed along the banks of the Tongue River for much of its course. Numerous sites in the Tongue River watershed have been permitted for the development of coal bed methane extraction. The extraction of coal bed methane involves pumping methane and groundwater from coal seams. Water with high salinity and conductivity is a byproduct in the process that is discharged into the Tongue River above Tongue River Reservoir.

Although many of the changes occurring in the Tongue River drainage have the potential to negatively affect the fish assemblage, there are ongoing projects intended to improve and protect the fishery. These projects have focused primarily on reducing entrainment and improving or creating fish passage at three major irrigation diversion dams on the Tongue River. Since its construction in the 1886, the Tongue & Yellowstone (T&Y) Diversion Dam has prevented the upstream movement of fishes beyond the dam, and fragmented a once connected system. In 1999, the T&Y canal head gate and louver structure was replaced to reduce fish entrainment into the irrigation canal. In August 2007, a fish passage structure, the Muggli Bypass, was constructed around T&Y Diversion Dam (Figure 1). In October 2008 SH Diversion Dam upstream of T&Y was removed (Figure 1). In 2005 water withdrawals from the Mobley Diversion Dam were transferred to pumps. The dam is no longer maintained and damage from ice scour and high flow has created some fish passage opportunity. However, Mobley Diversion Dam still impedes fish movement during low water periods. A more complete removal of Mobley Diversion Dam would further improve fish passage. The completion of the Muggli Bypass and removal of SH Dam has provided a means for fish to move upstream to the Tongue River Dam with little restriction.

Collection of baseline data before possible expansion of energy development and assessment of fish passage opportunities prompted the implementation of a monitoring program in the Tongue River. The monitoring program began in 2003 to assess the status of the Tongue River fish assemblage and evaluate fish population trends.

Goals and Objectives

The purpose of this project is to monitor fish population trends in the Tongue River. Specifically, the objectives are to:

(1) assess the current relative abundance, size structure, and body condition of fish populations in the Tongue River,

(2) evaluate changes in relative abundance, size structure, and body condition through time, and

(3) evaluate the success of fish passage around T&Y Diversion Dam.

Through carrying out these objectives, Montana Fish, Wildlife & Parks will be able to identify concerns or benefits that activity in the Tongue River watershed may have and make more informed management decisions.

STUDY AREA

The Tongue River originates on the eastern side of the Big Horn Mountains in north-central Wyoming. The Tongue River has a drainage area of 5379 square miles (13,932 km^2), approximately 70% occurring in Montana. The total length of river in Montana is 209 miles (337 km), stretching from the Wyoming state line to its confluence with the Yellowstone River, near Miles City (Figure 1). The Fort Union Coal Formation underlies the Tongue River watershed (Elser et al. 1977).

The Tongue River in Montana has been divided into five segments separated by four dams (Figure 1). There are three irrigation diversion dams: (1) Tongue and Yellowstone (T&Y) Diversion Dam at river mile 20 (km 32), (2) SH Diversion Dam at river mile 51(km 82) which no longer exists, and (3) Mobley Diversion Dam at river mile 105 (km 169), and one flood control dam, Tongue River Dam at river mile 189 (km 304). There is a thermally unique sixth river segment created by cold-water releases from the hypolimnion zone of Tongue River Reservoir. This segment is approximately ten river miles long and ends downstream of the dam near the Rosebud/Big Horn County line.

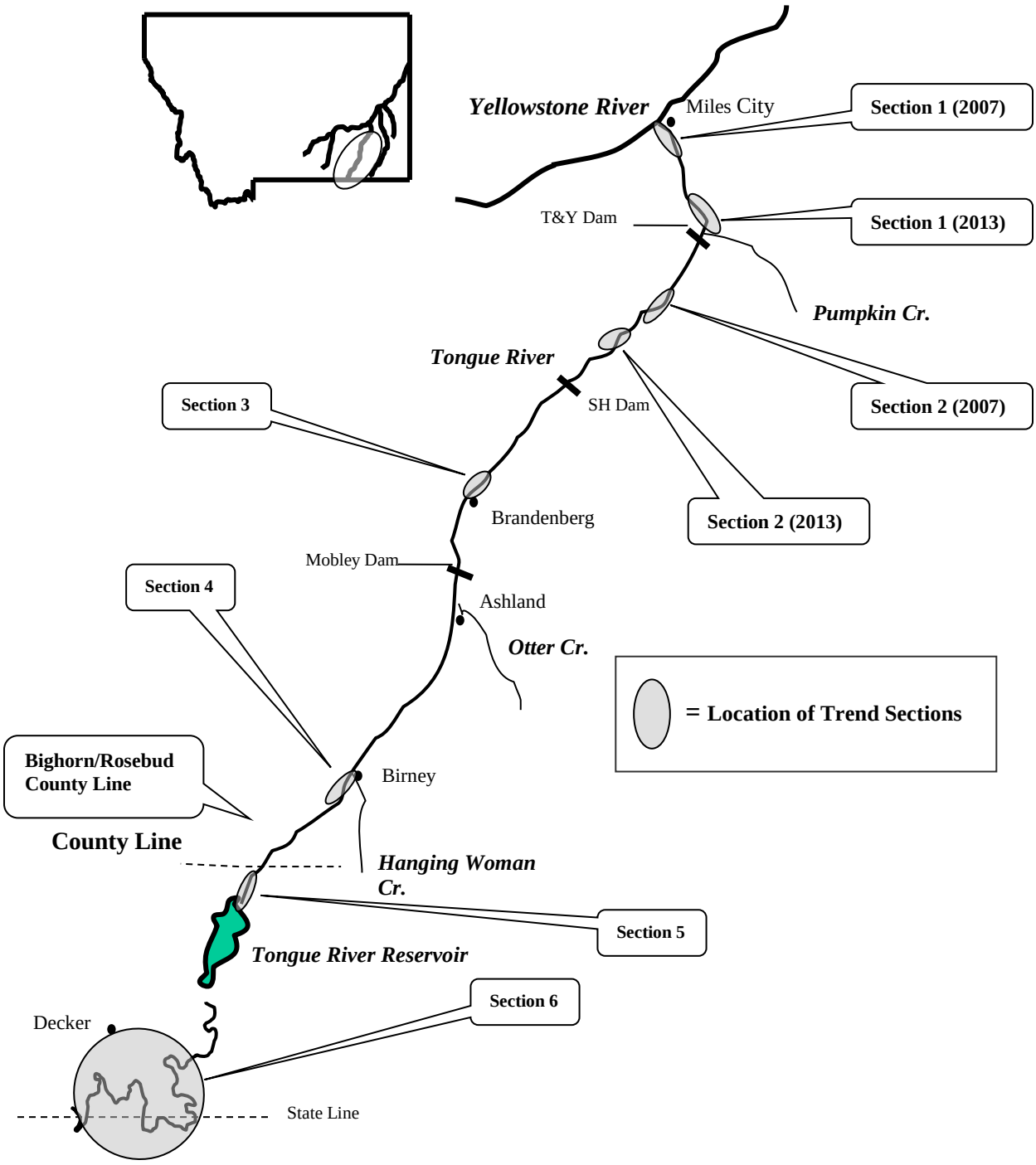

Figure 1. Tongue River, tributaries, diversion dams and trend sections.

Average annual discharge of the Tongue River at Miles City from 1940 to 2017 was 406 cfs (Figure 2). Drought conditions from 2000 to 2006 resulted in below average flows in the Tongue River. During this period, drought and irrigation demand nearly dewatered the river during summer months. Flows were above average in 2007, 2008, 2010, 2011, 2014, and 2017 near average in 2009 and 2015 and below average in 2012, 2013, and 2016 (USGS 2017). In recent years, the Montana Department of Natural Resources Conservation (DNRC) has increased spring discharge from Tongue River Reservoir to reduce the amount of high salt, coal bed methane water stored in the reservoir prior to the start of irrigation season.

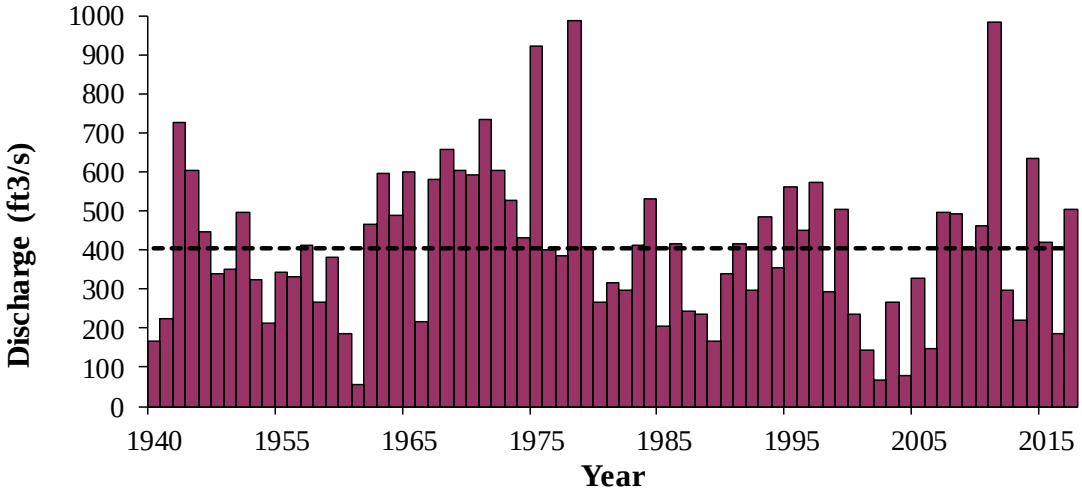

Figure 2. - Mean annual discharge of the Tongue River at Miles City, period of record 1939-2017. Dashed line represents overall mean annual discharge for the period of record.

METHODS

Annual trend sampling

Six trend sections were established to represent the six segments of river (Figure 1). Annual electrofishing of the Tongue River began in 2003. Electrofishing gear included a 14-foot flat bottom boat, 3500-watt generator, Coffelt VVP-15, single boom anode, ½ inch-mesh dip net and a single netter. In 2012 the Coffelt VVP-15 was replaced with the Smith-Root VVP-15B model. In 2014 the Smith-Root VVP-15B model was replaced with the Smith-Root GPP 5.0 model. One riverbank was continuously sampled in each section to reduce sampling bias and to include all habitat types. Seines were incorporated into annual trend sampling from 2003 to 2009. Trend sections were sampled in one-mile increments and for a total distance of five miles for Hirsch trend area, nine miles for the State Line trend area, and six miles for each of the other four trend areas.

Catch per unit effort (C/f) (Fabrizio and Richards 1996; Hubert 1996; Ney 1996) was calculated as the number of fish caught per hour of electrofishing, and used to describe the relative abundance of each fish species. Calculations of C/f were made for each species in each trend section, and C/f was compared between trend sections and across years.

Proportional size distribution (PSD) (Anderson and Neumann 1996; Guy et al. 2006 and 2007) was used to describe the length structure of fish species sampled. Calculations of PSD values were made for: Brown Trout (Milewski and Brown 1994), Channel Catfish, Sauger, Smallmouth Bass, Walleye, Northern Pike (Gablehouse 1984), Rainbow Trout (Anderson and Neumann 1996), River Carpsucker, Shorthead Redhorse Sucker, and White Sucker (Bister et al. 2000). Calculations of PSD values for Brown Trout and Rainbow Trout were made using data from trend section five. Calculations of PSD values for the other species were made using pooled data from all trend sections. Comparisons of PSD values were made between years.

Body condition of fish species sampled was calculated using relative weight (W_r) (Wege and Anderson 1978; Anderson and Neumann 1996; Blackwood et al. 2002). Relative weight was calculated for Brown Trout (Milewski and Brown 1994), Channel Catfish (Brown et al. 1995), Northern Pike (Anderson and Neumann 1996), Rainbow Trout, Sauger (Anderson and Neumann 1996), River Carpsucker, White Sucker, Shorthead Redhorse Sucker (Bister et al. 2000), Smallmouth Bass (Kolander et al. 1993), and Walleye (Murphy et al 1990). Calculations of mean W_r values for Brown Trout and Rainbow Trout were made using data from trend section five. Calculations of mean W_r for the other species were made using pooled data from all trend sections. Comparisons of mean W_r values were made between years.

Water Chemistry

Water chemistry and river flows were recorded on days that electrofishing and bypass sampling occurred. A handheld water meter (YSI model 85) was used to collect water temperature, dissolved oxygen, specific conductivity, and salinity data. A Hanna pHep pH meter was used to measure pH. A Secchi tube was used to quantify water clarity. River discharge was obtained from the United States Geological Survey web page (USGS 2017).

RESULTS

Annual trend sampling

All six trend sections were sampled using electrofishing gear in 2017. The locations of the trend sections have been the same since 2009 (Figure 1). Section locations, lengths

and sampling dates are provided in Appendix 1, Table 1. Electrofishing catch rates by trend section for 2017 are summarized in Appendix 1, Table 2.

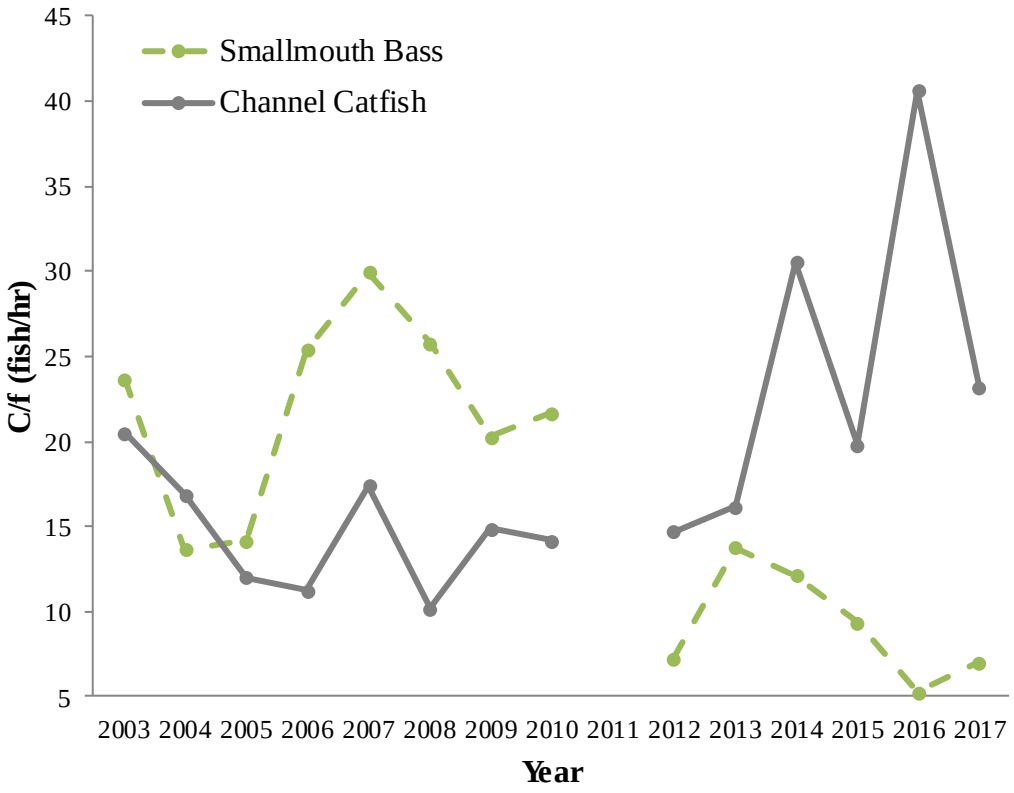

Figure 3. Relative abundance of Smallmouth Bass and Channel Catfish (y-axis) measured in C/f (fish/hour) as a function of year (x-axis) for the Tongue River 2003-2017.

Twenty-two species were collected in the 2017 trend survey of the Tongue River. Shorthead Redhorse Suckers were the most abundant species sampled overall. Smallmouth Bass and Channel Catfish were the most abundant game fish collected in the Tongue River. Catch rates suggest a decline in the number of Smallmouth Bass collected in recent years, possibly a function of a return to higher average discharges which are less favorable for bass than the drought conditions of the 2000's (Figure 3).

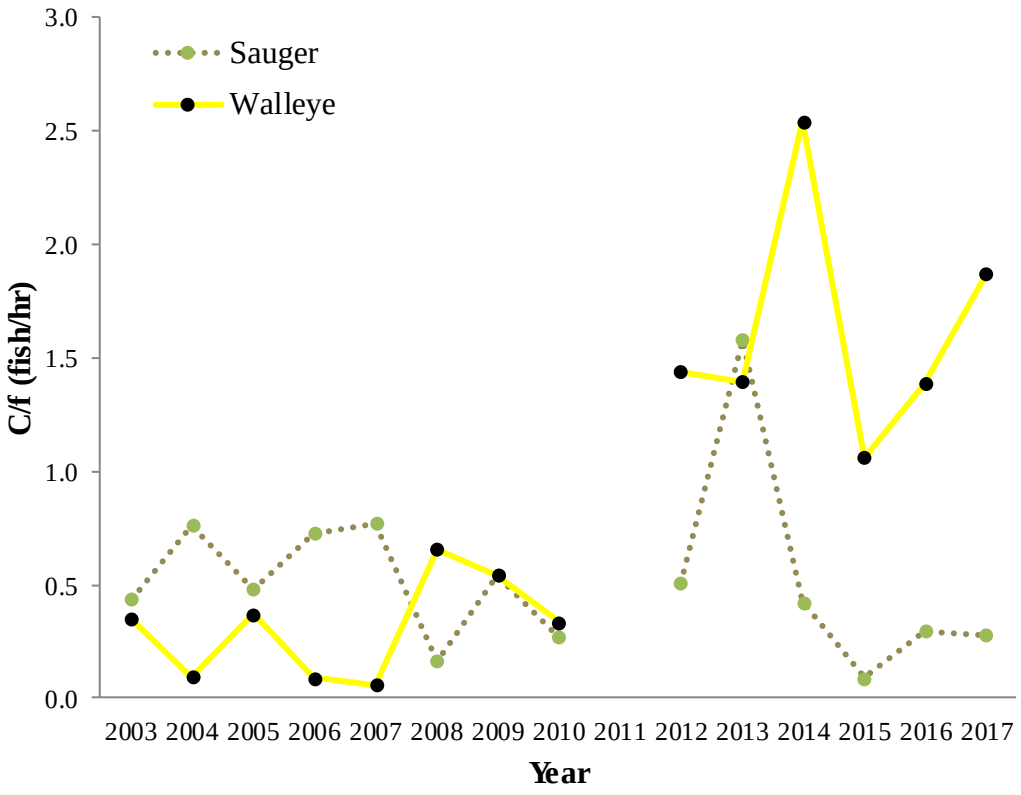

Figure 4. Relative abundance of Sauger and Walleye (y-axis) measured in C/f (fish/hour) as a function of year (x-axis) for the Tongue River 2003-2017.

Catch rates for Sauger and Walleye are both consistently low and somewhat variable. Sauger are generally only collected in the State Line and Miles City sections with collections from the middle sections rare and infrequent. Walleye are also not regularly sampled in all sections. Prior to completion of the Muggli Bypass in 2007 Walleye were only consistently found in the State Line section. Since completion of the passage projects that have restored connectivity between the Yellowstone River and the middle sections of the Tongue River as well as some relief from dewatering in the Miles City reach, Walleye have been consistently found in the State Line, Tongue River Dam, Brandenburg, and Miles City sections. In 2017, a few Walleye were found in five of six sections and their overall abundance throughout the river has been higher in recent years (Figure 4).

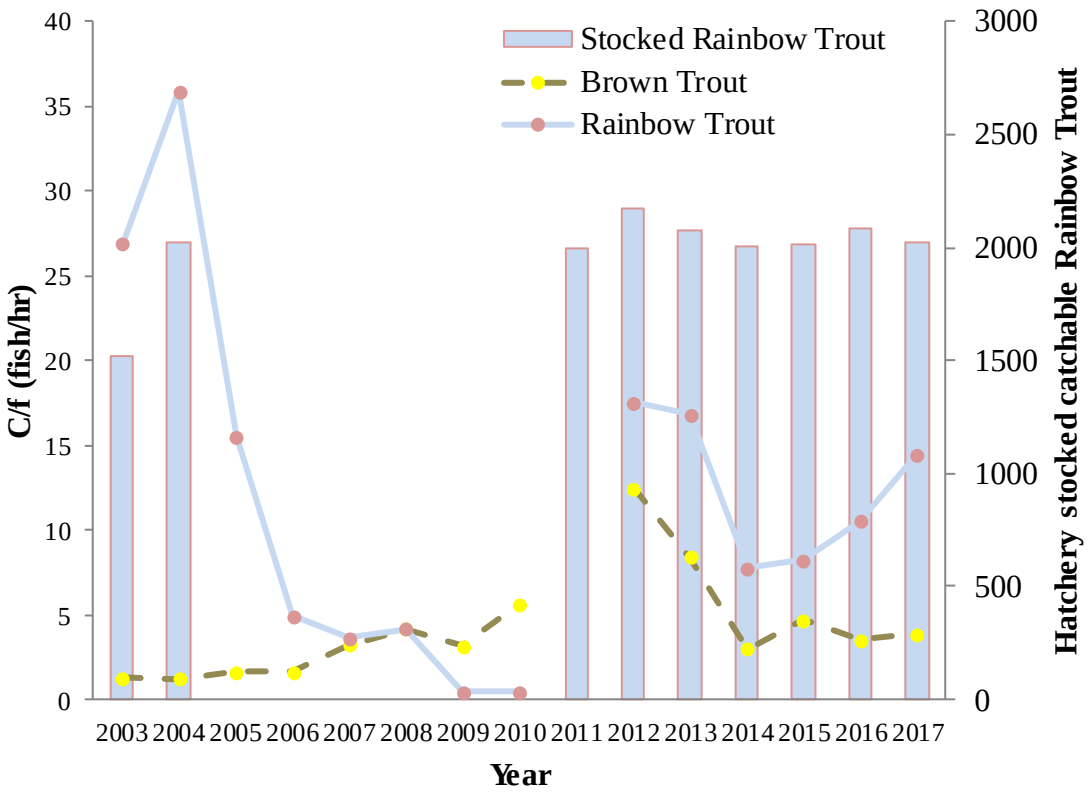

Figure 5. Relative abundance of Rainbow Trout and Brown Trout (primary y-axis) measured in C/f and number of catchable Rainbow Trout stocked as a function of year (x-axis) for the Tongue River Dam Tailrace 2003-2017.

Catch rates in the Tongue River Dam tailrace are providing a quality trout fishery and have improved for Rainbow Trout since hatchery stocking resumed in 2011 (Figure 5). Size structure measured by PSD suggests Rainbow Trout up to memorable size and Brown Trout up to trophy size are available to anglers (Appendix 2 table 2). Body condition measured by W_r suggest trout in the Tongue River Dam tailrace fishery are of above average condition for their size (Appendix 2 table 2).

Size structure (PSD) and body condition (W_r) have been consistent throughout the study period (2003-2017) for most species. Trout, Sauger, and Walleye have demonstrated the most variability among game fishes (Appendix 2 tables 2 and 3). Smallmouth Bass and Channel Catfish have had consistent results with the size structure of bass skewed towards small fish while Channel Catfish size structure has been more evenly distributed across size classes (Appendix 2 table 1). Results of size structure and body condition indexes have been less variable for non-game fishes (River Carpsucker, Shorthead Redhorse Sucker, and White Sucker). Size structure is generally more evenly distributed across size classes and relative weights are consistently high (Appendix 2 table 4). Sample size is likely a strong factor influencing variability of index results.

Fish passage

The Muggli Bypass was not sampled in 2017. Passage was evaluated from 2008 to 2012. Twenty fish species have been documented using the Muggli Bypass since its construction. Fish passage for most species was deemed successful based on similar trends in abundances between the bypass channel and the river downstream of the bypass (McKoy 2012). However, Shovelnose Sturgeon, which are found in the Tongue River below T&Y Diversion Dam, have not been documented passing through the bypass. A study to further evaluate passage at the Muggli Bypass specific to Shovelnose Sturgeon led by Dennis Scarnecchia at the University of Idaho has been proposed if funding can be secured. Alterations to the Muggli Bypass may be necessary to facilitate Shovelnose Sturgeon passage.

DISCUSSION

Changes to Tongue River fish populations attributable to coal bed natural gas production have not been documented but may exist as they are difficult to quantify. Coal bed methane extraction is currently at a low level of development because of market prices. Continued monitoring will be important to detect impacts to fisheries if activity expands in the future. Low sample sizes of small bodied fishes preclude use for trend analysis. Mini-fyke nets could be added to the sampling regime in the future to provide a more robust sample design for small bodied fishes. Mini-fyke nets were efficient and effective for detecting composition of the small bodied fish assemblage of the Yellowstone River (Duncan et al. 2012), but have not been as efficient a tool in the Upper Missouri (Anne Tews, pers. communication). Addition of this gear is not planned for 2018, and electrofishing will only be completed on a subset of the trend sections in 2018 due to a budget shortfall in the fisheries division.

Results of this study must be viewed with some caution. The use of data combined from all trend sections and the variation inherent to prairie stream sampling will make detection of changes in fish populations difficult. Large sample sizes are needed to overcome the inherent variation in field data. Continued and increased monitoring is recommended because of the potential for further expansion of irrigation and mining activity.

Despite the success of the Muggli Bypass, improvements are needed to increase its effectiveness. Shovelnose Sturgeon is the only species observed in abundance below the dam that has not been documented successfully navigating the bypass. The bypass was designed specifically to pass Shovelnose Sturgeon. Water velocity and turbulence between boulders in the lower third of the channel are hypothesized to prevent sturgeon from using the constructed bypass channel. Water velocities in the lower third of the bypass were rarely below 7 ft/s during periods of high flow. Recommended water velocity for Shovelnose Sturgeon passage is between 3 and 4 ft/s (White and Medford 2002). The high-water velocities in the bypass can be attributed to a steeper than designed gradient in the lower third of the constructed channel that compensates for a

flatter than designed slope in the upper third of the constructed channel. Spacing of the boulders in the channel may also be a problem. Many of the boulders were placed with a gap of 8 to 10 inches; attempting to offset the steeper slope of the channel. The narrow gap may be a barrier to the passage of large fish. The recommended boulder spacing was intended to be 24 inches (White and Medford 2002).
In 2008 & 2009, when river discharge exceeded 800 cfs attraction velocities of 2 ft/s maintained from the bypass channel to the thalweg of the river were masked by turbulent water flowing over T&Y Diversion Dam. During periods of high discharge fish may have difficulty finding the bypass channel entrance due to this back-eddy effect. To address velocity issues in the lower third of the bypass and the masking of attraction flows the channel was re-sloped and moved downstream 1.5 channel widths in the fall of 2009. This modification reduced the magnitude of decreased attraction flows, but sampling results indicates problems still exist, particularly water velocities in the lower third of the channel. Increasing the spacing between boulders, using different boulder placement patterns, and modifying the slope of the entire bypass channel to design specifications should be explored.

Keywords: Fish Passage, T&Y Diversion Dam, Coal Bed Methane, Tongue River Railroad, Tongue River Reservoir, Paddlefish, Shovelnose Sturgeon, Blue Suckers, Sauger

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Appendix 1

Table 1. Summary of Tongue River sections and water quality, 2017.

	Section Number and Name					
	1 Miles City	2 Hirsch	3 Brandenberg	4 Birney	5 TR Dam	6 State Line
Date Sampled	7/5/2017	7/14/2017	7/7/2017	7/11/2017	7/6/2017	7/3/2017
Latitude Start	46.25006	46.04764	45.79121	45.30115	45.13889	44.99309
Longitude Start	-105.75284	-105.93974	-106.26279	-106.56489	-106.76843	-106.88669
Latitude Stop	46.32507	46.07216	45.82399	45.3203	45.3209	45.01045
Longitude Stop	-105.77387	-105.9314	-106.231	-106.5201	-106.52151	-106.8224
River Mile Start/Stop	20 - 15	51 - 46	90 - 85	165 - 160	189 - 184	209 - 199
Water Temperature (Fahrenheit)	NA	NA	80.1	NA	74.0	72.5
Specific Conductivity (mS/cm)	NA	568	455	NA	298	387
Salinity (ppt)	NA	0.3	0.2	NA	NA	0.2
Turbidity (cm)	NA	NA	NA	NA	NA	NA
pH	NA	NA	NA	NA	NA	NA
River Flow (cfs)	411	319	433	401	404	581

Table 2. Results of Tongue River electrofishing by section, 2017.

Species	N	Catch/ Hour	Percent of Catch	Length Mean (mm)	Length Range (mm)	Weight Mean (gm)	Weight Range (gm)
Section 1 Miles City (T&Y Dam - Yellowstone R.) - 92 minutes; 6 river miles							
Channel Catfish	24	15.7	15.3	450	175 - 625	970	60 - 2240
Common Carp	4	2.6	2.5	443	290 - 560	887	300 - 1320
Flathead Chub	19	12.4	12.1	108	82 - 192	15	10 - 20
Freshwater Drum	2	1.3	1.3	334	310 - 358	410	300 - 520
Goldeye	12	7.8	7.6	322	304 - 342	223	200 - 220
Longnose Sucker	2	1.3	1.3	245	230 - 260	150	120 - 180
River Carpsucker	24	15.7	15.3	348	75 - 435	617	20 - 1220
Stonecat	1	0.7	0.6	82	-	-	-
Shorthead Redhorse Sucker	56	36.5	35.7	263	103 - 372	194	10 - 380
Smallmouth Bass	5	3.3	3.2	301	258 - 350	365	220 - 520
Walleye	5	3.3	3.2	397	385 - 415	548	400 - 680
Western Silvery Minnow	1	0.7	0.6	125	-	10	-
White Sucker	2	1.3	1.3	348	325 - 370	360	-
	157	102	100				
Section 2 (Hirsch) - 95 minutes; 5 river miles							
Channel Catfish	17	10.7	8.3	462	190 - 619	995	40 - 2080
Common Carp	9	5.7	4.4	404	300 - 455	868	380 - 1180
Flathead Chub	1	0.6	0.5	158	-	10	-
Freshwater Drum	4	2.5	2.0	293	267 - 340	260	220 - 320
Goldeye	13	8.2	6.4	331	246 - 365	265	100 - 340
Northern Pike	1	0.6	0.5	596	-	1360	-
River Carpsucker	29	18.3	14.2	345	270 - 403	496	220 - 880
Rock Bass	1	0.6	0.5	108	-	10	-
Sauger	2	1.3	1.0	384	383 - 385	385	370 - 400
Shorthead Redhorse Sucker	100	63.2	49.0	278	123 - 348	234	20 - 400
Smallmouth Bass	20	12.6	9.8	241	112 - 442	282	10 - 1180
Walleye	3	1.9	1.5	416	367 - 470	693	460 - 1000
White Sucker	4	2.5	2.0	254	226 - 282	185	140 - 240
	204	129	100				

Table 2. Results of Tongue River Electrofishing by Section, 2017 (continued).

Species	N	Catch/ Hour	Percent of Catch	Length Mean (mm)	Length Range (mm)	Weight Mean (gm)	Weight Range (gm)
Section 3 (Brandenberg) - 100 minutes; 6 river miles							
Channel Catfish	25	15.0	12.0	461	302 - 710	920	190 - 3700
Common Carp	12	7.2	5.7	432	334 - 610	1160	480 - 2440
Freshwater Drum	1	0.6	0.5	325	-	360	-
Goldeye	19	11.4	9.1	330	292 - 372	258	180 - 340
Longnose Sucker	2	1.2	1.0	359	340 - 377	430	360 - 500
Northern Pike	1	0.6	0.5	817	-	3120	-
Rock Bass	1	0.6	0.5	188	-	140	-
River Carpsucker	30	18.0	14.4	365	301 - 467	604	320 - 1080
Shorthead Redhorse Sucker	101	60.6	48.3	285	85 - 395	271	10 - 480
Smallmouth Bass	12	7.2	5.7	238	111 - 346	222	10 - 600
Walleye	2	1.2	1.0	505	405 -604	500	-
White Sucker	2	1.2	1.0	326	318 - 334	360	320 - 400
Yellow Perch	1	0.6	0.5	143	-	30	-
	209	125	100				
Section 4 (Birney) - 88 minutes; 6 river miles							
Black Crappie	2	1.4	0.7	145	138 - 152	45	40 - 50
Channel Catfish	38	25.9	13.5	523	360 - 667	1690	380 - 3700
Common Carp	5	3.4	1.8	570	525 - 610	2470	1710 - 2900
Goldeye	24	16.4	8.5	352	293 - 391	371	200 - 620
Longnose Sucker	14	9.5	5.0	322	184 - 398	438	20 - 760
River Carpsucker	36	24.5	12.8	395	296 - 454	822	320 - 1100
Shorthead Redhorse Sucker	136	92.7	48.2	388	304 - 479	630	320 - 1020
Stonecat	2	1.4	0.7	169	165 - 172	45	40 - 50
Smallmouth Bass	9	6.1	3.2	236	178 - 309	177	80 - 320
White Crappie	4	2.7	1.4	160	135 - 172	45	30 - 60
White Sucker	10	6.8	3.5	397	369 - 442	741	540 - 1000
Yellow Bullhead	1	0.7	0.4	212	-	120	-
Yellow Perch	1	0.7	0.4	150	-	10	-

Table 2. Results of Tongue River Electrofishing by Section, 2017 (continued).

Species	N	Catch/ Hour	Percent of Catch	Length Mean (mm)	Length Range (mm)	Weight Mean (gm)	Weight Range (gm)
Section 5 (Tongue River Dam) - 111 minutes; 6 river miles							
Brown Trout	5	2.7	1.4	448	295 - 532	1095	340 - 1720
Channel Catfish	135	73.0	37.7	523	422 - 647	1669	800 - 3420
Common Carp	30	16.2	8.4	567	195 - 679	2741	130 - 3800
Goldeye	7	3.8	2.0	353	305 - 467	344	260 - 440
Longnose Sucker	6	3.2	1.7	318	148 - 451	623	10 - 1200
Rainbow Trout	26	14.1	7.3	421	244 - 586	1040	200 - 1800
Rock Bass	2	1.1	0.6	200	182 - 218	160	100 - 220
River Carpsucker	24	13.0	6.7	408	312 - 506	948	360 - 1440
Shorthead Redhorse Sucker	84	45.4	23.5	427	318 - 520	939	360 - 1680
Smallmouth Bass	5	2.7	1.4	223	163 - 298	176	70 - 380
Stonecat	3	1.6	0.8	166	137 - 190	40	10 - 60
Walleye	7	3.8	2.0	528	430 - 605	1586	850 - 1750
White Sucker	24	13.0	6.7	421	248 - 489	939	200 - 1280
	358	194	100				
Section 6 (Stateline) - 155 minutes; 10 river miles							
Brown Trout	2	0.8	0.8	166	153 - 178	55	40 - 70
Channel Catfish	9	3.5	3.7	735	469 - 830	6505	1040 - 8700
Common Carp	23	8.9	9.5	622	570 - 720	3231	2160 - 4760
Longnose Sucker	6	2.3	2.5	183	105 - 270	93	10 - 240
Rock Bass	1	0.4	0.4	150	-	80	-
Sauger	1	0.4	0.4	525	-	1360	-
Shorhead Redhorse Sucker	146	56.5	60.3	374	98 - 481	657	60 - 1140
Smallmouth Bass	24	9.3	9.9	194	90 - 433	153	30 - 1120
Spottail Shiner	1	0.4	0.4	99	-	-	-
Walleye	3	1.2	1.2	489	462 - 538	1313	1020 - 1820
White Crappie	1	0.4	0.4	168	-	40	-
White Sucker	25	9.7	10.3	288	105 - 490	414	10 - 1420
	242	94	100				

Appendix 2

Table 1. Size distribution and body condition of abundant game fishes of the Tongue River

Smallmouth Bass

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	149	81	15	4	-	-	104	89	79	-	-
2004	143	83	14	3	-	-	91	96	74	-	-
2005	264	87	11	2	1	<1	87	80	105	67	93
2006	277	88	8	3	1	-	92	85	93	11	-
2007	112	42	49	9	-	-	89	97	102	-	-
2008	304	87	11	2	1	-	94	87	53	86	-
2009	262	85	10	2	3	-	93	92	82	92	-
2010	321	82	13	4	1	-	92	90	79	87	-
2012	81	73	20	8	-	-	105	91	85	-	-
2013	148	84	5	9	2	-	91	89	76	85	-
2014	83	82	8	8	1	-	89	94	80	87	-
2015	69	80	10	10	-	-	88	93	90	-	-
2016	46	72	22	7	-	-	88	95	89	-	-
2017	53	72	21	4	4	-	96	93	87	87	-

Channel Catfish

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	215	29	50	19	3	<1	96	95	88	126	96
2004	177	24	61	1	13	-	89	108	93	103	-
2005	341	42	54	4	-	-	94	101	89	-	-
2006	118	16	79	5	-	-	95	106	96	-	-
2007	472	29	35	29	7	-	92	96	100	102	-
2008	124	39	48	11	3	-	96	114	99	96	-
2009	191	41	48	10	1	-	95	110	110	99	-
2010	210	37	55	6	2	-	102	120	110	95	-
2012	197	16	63	20	1	-	104	104	106	105	-
2013	174	25	66	8	1	-	96	104	101	83	-
2014	348	14	74	7	5	-	93	104	97	101	-
2015	220	11	76	9	4	-	93	110	102	103	-
2016	405	16	77	6	1	-	92	107	103	113	-
2017	244	9	81	7	3	-	88	109	101	124	-

Appendix 2 continued

Table 2. Size distribution and body condition of Tongue River Dam tailrace trout

Brown Trout

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	2	-	50	-	50	-	-	112	-	97	-
2004	0	-	-	-	-	-	-	-	-	-	-
2005	3	67	33	-	-	-	105	119	-	-	-
2006	10	50	20	30	-	-	97	91	128	-	-
2007	3	67	-	-	33	-	81	-	-	52	-
2008	10	-	22	11	56	11	-	82	176	129	123
2009	7	-	67	14	17	-	-	129	127	189	-
2010	14	-	77	8	15	-	-	107	117	116	-
2012	31	23	10	39	16	13	113	112	120	127	129
2013	17	17	-	17	28	38	77	-	115	87	97
2014	7	14	14	-	14	57	132	94	-	106	100
2015	8	-	-	-	13	88	-	-	-	114	95
2016	7	-	43	-	14	43	-	101	-	119	88
2017	7	29	14	-	14	43	107	122	-	117	108

Rainbow Trout

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	43	71	24	5	-	-	133	113	106	-	-
2004	58	83	17	-	-	-	123	106	-	-	-
2005	29	41	59	-	-	-	109	108	-	-	-
2006	9	89	11	-	-	-	113	96	-	-	-
2007	0	-	-	-	-	-	-	-	-	-	-
2008	8	-	50	50	-	-	-	81	94	-	-
2009	2	-	100	-	-	-	-	104	-	-	-
2010	1	-	-	100	-	-	-	-	98	-	-
2012	42	92	8	-	-	-	136	139	-	-	-
2013	27	36	55	9	-	-	146	119	108	-	-
2014	13	8	85	8	-	-	125	111	100	-	-
2015	14	-	64	36	-	-	-	126	110	-	-
2016	21	57	24	19	-	-	138	127	116	-	-
2017	24	17	54	29	-	-	149	123	94	-	-

Appendix 2 continued

Table 3. Size distribution and body condition of Sauger and Walleye of the Tongue River

Sauger

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	5	20	40	40	-	-	97	88	91	-	-
2004	8	13	-	38	50	-	46	-	86	101	-
2005	9	13	50	25	13	-	63	82	79	67	-
2006	8	-	25	75	-	-	-	83	88	-	-
2007	58	29	43	26	2	-	84	86	83	98	-
2008	2	-	-	100	-	-	-	-	99	-	-
2009	8	-	29	57	14	-	-	71	86	94	-
2010	4	-	50	50	-	-	-	87	90	-	-
2012	8	80	-	-	-	20	96	-	-	-	128
2013	18	12	88	-	-	-	87	88	-	-	-
2014	5	-	20	60	20	-	-	56	86	92	-
2015	1	-	-	100	-	-	-	-	96	-	-
2016	3	-	-	100	-	-	-	-	85	-	-
2017	3	-	-	67	33	-	-	-	69	90	-

Walleye

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	4	-	50	25	25	-	-	99	112	100	-
2004	1	-	-	-	-	-	-	-	-	-	-
2005	7	17	50	33	-	-	82	85	91	-	-
2006	1	-	-	-	-	-	-	-	-	-	-
2007	55	15	67	17	-	-	92	91	96	-	-
2008	8	43	29	14	14	-	87	148	94	80	-
2009	7	83	17	-	-	-	91	88	-	-	-
2010	5	33	67	-	-	-	84	98	-	-	-
2012	23	33	40	20	7	-	93	97	94	100	-
2013	15	87	13	-	-	-	92	101	-	-	-
2014	30	23	40	30	7	-	86	90	95	90	-
2015	12	8	67	17	8	-	93	109	104	95	-
2016	12	-	75	17	8	-	-	92	91	83	-
2017	20	5	60	35	-	-	91	90	94	-	-

Appendix 2 continued

Table 4. Size distribution and body condition of abundant non-game fishes of the Tongue River

Shorthead Redhorse Sucker

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	249	16	61	23	-	-	85	81	78	-	-
2004	877	8	24	31	37	1	75	88	89	93	76
2005	1080	16	9	40	34	<1	84	85	87	89	80
2006	431	27	8	30	34	<1	94	86	95	94	94
2007	644	19	17	33	6	<1	103	90	94	99	56
2008	932	38	24	13	26	<1	81	88	93	97	100
2009	798	32	23	15	30	1	89	85	97	97	94
2010	1063	22	29	16	32	<1	79	70	76	79	82
2012	895	9	33	17	40	2	84	75	75	83	79
2013	1065	11	30	25	33	1	80	73	73	78	81
2014	227	16	26	29	26	2	90	86	85	95	100
2015	226	15	25	36	22	1	89	86	87	87	91
2016	197	6	27	41	25	1	82	83	87	93	94
2017	228	12	28	32	27	<1	90	85	86	95	98

River Carpsucker

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	154	5	24	57	6	-	88	81	93	93	-
2004	120	3	43	51	4	-	182	87	97	88	-
2005	174	8	19	61	12	-	86	83	93	87	-
2006	39	19	30	51	-	-	96	92	98	-	-
2007	1602	6	20	61	13	1	92	93	98	98	83
2008	144	30	33	35	1	-	84	89	95	85	-
2009	144	16	30	52	3	-	85	85	93	94	-
2010	133	15	33	46	5	-	89	91	93	87	-
2012	168	1	49	45	5	-	99	96	97	99	-
2013	105	1	35	61	3	-	99	96	95	94	-
2014	134	4	34	59	3	-	86	95	93	115	-
2015	114	2	27	68	4	-	94	96	92	100	-
2016	143	3	26	66	4	-	96	95	94	93	-
2017	139	1	30	68	1	-	81	87	94	79	-

Appendix 2 continued

Table 4 continued. Size distribution and body condition of abundant non-game fishes of the Tongue River

White Sucker

		PSD					Wr				
Year	N	S-Q	Q-P	P-M	M-T	T	S-Q	Q-P	P-M	M-T	T
2003	258	39	35	23	3	-	94	89	98	84	-
2004	354	37	12	36	14	-	99	97	99	103	-
2005	127	26	12	38	25	-	84	84	96	97	-
2006	127	46	34	20	-	-	87	102	99	-	-
2007	231	38	47	13	6	-	98	88	85	91	-
2008	243	25	31	26	17	1	94	93	99	101	27
2009	253	21	29	30	22	-	109	87	97	102	-
2010	414	19	31	35	15	-	89	90	95	97	-
2012	361	18	31	27	25	-	100	97	97	100	-
2013	401	15	25	40	20	-	91	92	92	93	-
2014	137	12	22	42	25	-	84	91	97	98	-
2015	63	8	24	56	13	-	83	93	94	95	-
2016	71	13	15	49	23	-	85	92	96	97	-
2017	62	16	8	39	37	-	95	85	96	99	-

Appendix 3

(See 2013 Report)

Tongue River Fish Entrainment Study

On the T&Y Canal

1997, 2004, 2005, 2013

By

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ABSTRACT

The point of diversion for the T&Y Canal is located at river mile 20.4 on the Tongue River. Nets were placed in the irrigation ditch spanning the entire channel in 1997, 2004, 2005 and 2013 to determine fish entrainment. In 1998/1999, the headworks structure of the T&Y Canal was rehabilitated and louver style fish screens and a bypass channel which returned fish to the Tongue River were added. The louvered fish screens and bypass channel return fish back to the Tongue River that would otherwise be lost to the system down the irrigation ditch. In 2004, 2005 and 2013, after installation of the fish louvre, an additional net was placed in the bypass channel to evaluate entrained fish that were screened out and returned to the river. All fish sampled were identified to species, weighed in grams, and measured in millimeters total length. In 1997 flathead chubs were the most abundant species at 32% of total catch, common carp were the most abundant species in 2004 and 2005 in both the T&Y Canal and Bypass Channel at 47% and 32% in 2004 and 36% and 33% in 2005. In 2013 channel catfish were the most abundant species in the canal at 59%, but in the bypass both channel catfish and shorthead redhorse suckers each accounted for 20% of the total catch.

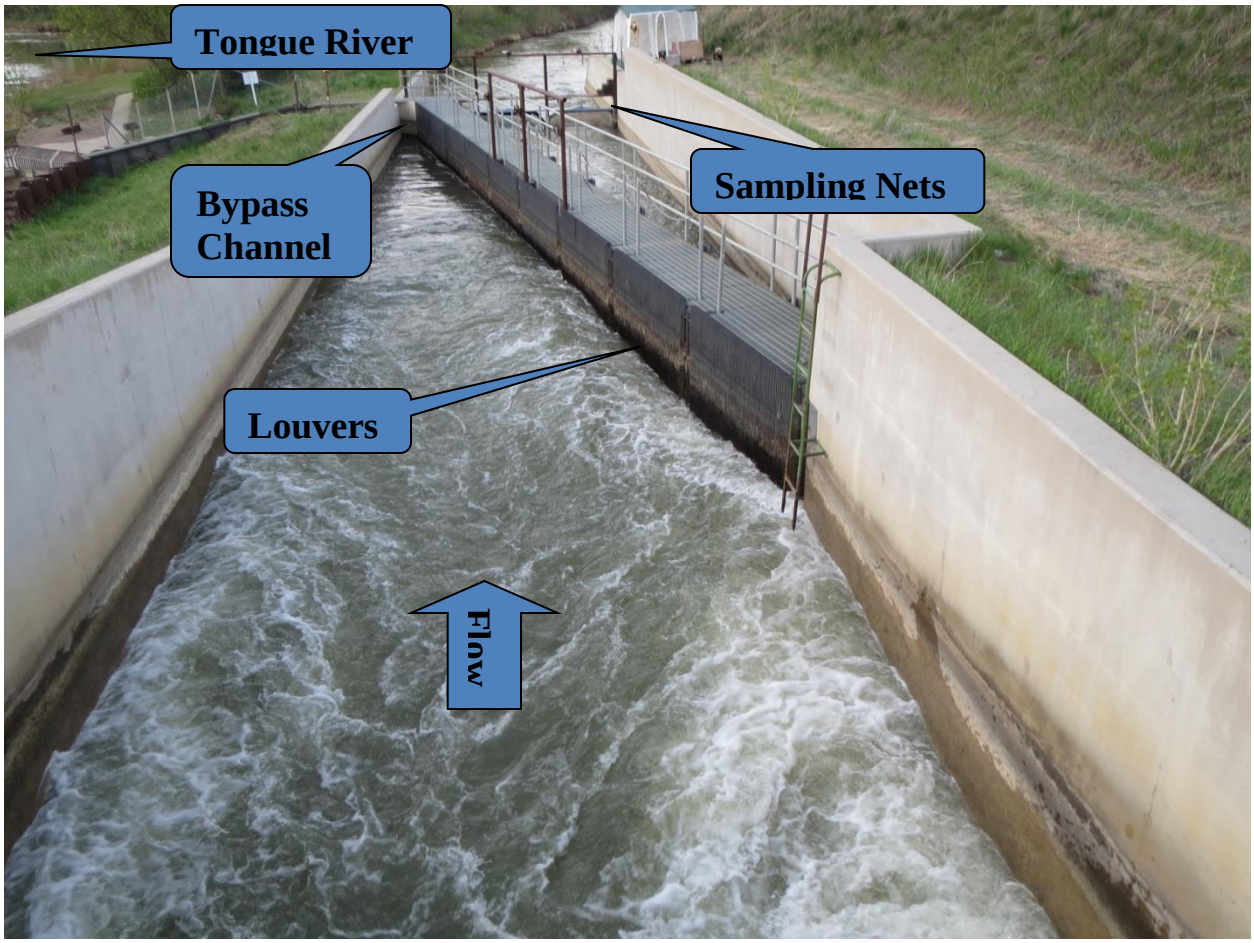
INTRODUCTION

In 1998/1999, the headworks structure of the T&Y Canal was rehabilitated and louver style fish screens and a bypass channel which returned fish to the Tongue River were added (Bureau of Reclamation 2002). The T&Y rehabilitation project was completed with the cooperation of the T&Y Irrigation District, Bureau of Reclamation, and Montana Fish, Wildlife & Parks. T&Y Diversion Dam is located at river mile 20.4 on the Tongue River and has been an upstream fish passage barrier to shovelnose sturgeon, goldeye, sauger, and other fish species since it was constructed in 1886. Construction of the Muggli Fish Passage in 2007 has provided passage around the diversion dam for most of the species in the fish assemblage. The Muggli Fish Passage, along with the removal of other irrigation diversion dams has opened passage all the way to Tongue River Reservoir Dam.

The Tongue and Powder Rivers are two of the largest tributaries entering the lower 240 miles of the Yellowstone River system. The Yellowstone River supports a diverse assemblage of native and non-native warm and cool-water fish species. Some of the species are threatened or endangered and others are state species of special concern. Tributary streams play a vital role for spawning, rearing, and migration of the species within the Lower Yellowstone fish assemblage.

The Yellowstone River and tributary streams also provide irrigation water to agricultural enterprises throughout the basin. The highly migratory nature of many of the native fish species and their ability to navigate through or around irrigation inlet structures was not well understood in the past. However a growing body of information is beginning to identify substantial problems related to fish migration and entrainment associated with some water diversion designs. Changes to the T&Y headworks structure and diversion dam were made in an effort to reduce entrainment and improve fish passage while maintaining water supply for irrigation of agricultural lands.

In 1997 objectives for the entrainment study were to identify: 1) composition of fish and debris entrained into the T&Y Canal, 2) seasonal trends in entrainment, and 3) diurnal trends in entrainment. The objectives of the sampling effort in 2004, 2005 and 2013 were to identify: 1) composition of fish entrained into the T&Y Canal and fish returned to the Tongue River by the bypass channel, 2) seasonal trends in entrainment, and 3) diurnal trends in entrainment.



Picture 1. T & Y Canal looking from the head gates looking down the ditch.

METHODS

Custom built nets that sample the entire diversion of water flowing down T&Y Canal were used to quantify entrainment during the 1997, 2004, 2005, and 2013 irrigation seasons. In 1997 a single net was placed in each of the two openings leading from the diversion structure to the canal. The nets were constructed of 0.5" mesh netting and fitted with a purse bag at the end to empty fish and debris into sample tubs for sorting. All fish captured were identified to species, enumerated, and measured for length and weight. Debris type, size, and weight were estimated for each sample in 1997. In 2004, 2005 and 2013 three nets were placed in a frame secured to the walls of the irrigation ditch seamlessly spanning the canal immediately behind the louver screens. The nets were constructed of 0.5" mesh size netting and fitted with a purse bag at the end to empty fish into sample tubs for sorting. All fish captured were identified to species, enumerated, and measured for length and weight.

Canal sampling was conducted bi-weekly throughout the irrigation season. The irrigation season varied between years, starting as early as May 16 and ending as late as October 10. In general irrigation went from mid May through late September/early October. In 1997 each day was sub-sampled by two hour periods through a complete 24 hour cycle. Additional sub-sampling was required of each two hour period due to large quantities of debris that collected in the nets. Sample periods within each two hour subsample ranged from 4 to 75 minutes depending upon relative debris quantities moving into the net during the different sample periods. In 2004, 2005 and 2013 each day was sub-sampled by one hour periods through a complete 24 hour cycle. Total number of fish and quantity of debris was calculated by extrapolating the subsample results to the total period length using the appropriate expansion factor.

RESULTS & DISCUSSION

Fish Species Composition

1997

An estimated 37,288 fish weighing 1,847 lbs. were entrained in the T&Y Canal during the 1997 irrigation season (Table 3a). Fish from 22 species were observed being entrained in 1997. Non-cyprinid species captured were generally juvenile fish evident by the short mean length noted in Table 1a. Flathead chubs were the most abundant species entrained accounting for 32% of the total number of fish observed (Figure 2a). Other abundant species observed being entrained included: common carp (13%), longnose dace (13%), crappie (15%), and channel catfish (10%).

Prior to 1997, the nearest sampling to the T&Y Canal was 70 miles upstream of the canal (T & Y Canal 1998, Peters et al.). In the fall of 1993, three sections of the Tongue River near Ashland were sampled using electrofishing gear. Twelve trips down the 5.5 mile long section were completed and resulted in the catch of 1,725 fish (Table 4). The species of fish observed in electrofishing samples in 1993 were similar to those entrained in the T&Y Canal in 1997 but the species that comprised the largest proportion of electrofishing samples in 1993 (Backes et al. 1993) differed from those entrained in the T&Y Canal in 1997. Flathead chubs, longnose dace, channel catfish, and crappie seem to be entrained in the canal in numbers disproportionate to their abundance in electrofishing samples upstream.

The sampling efficiency for most of the species with electrofishing is unknown, so inferences about population size for all species could not be made. Recapture information on smallmouth bass and channel catfish yielded an approximate sampling efficiency of 10%, similar to the 14% +-5% Yeager found electrofishing for sauger in the Yellowstone River (Rhoten et al. 2010). Assuming a 10% average capture efficiency for all species in the sample results in an estimated 17,250 fish for this 5.5 mile section of river. The 37,288 fish estimated to be entrained during the 1997 irrigation season is roughly twice that of the estimated population of fish found in the 5.5 mile segment of the Tongue River sampled by Backes in 1993. This limited amount of Tongue River reference work suggests the number of fish annually entrained in the T&Y Canal could represent a substantial component of the population of Tongue River fish upstream of the diversion.

During sampling in 1997 debris that collected in the nets was sorted and quantified. Four classes of debris were identified including: gravel, sticks, coal, and vegetation. The calculated weight of gravel, coal and sticks collected in the sample nets appears to be positively correlated to stream discharge (Table 7 and Figure 3). The weight of vegetation debris in the canal did not appear to be related to stream discharge.

The collection net on the west side of the canal captured 8 to 80 times more gravel than the net on the east side of the canal which may be valuable in understanding the existing hydraulics acting at this site.

Estimated gravel entry into the canal was highest during our June 12-13 sample period when an estimated 13,534 lbs per day (24 hrs) entered the canal. We felt the origin of gravel entering the canal was from upstream headcutting of the gravel bar located immediately upstream of the diversion during the non-irrigation season. Modifications planned to the diversion structure need to address this non-irrigation season gravel bar development. Channel hydraulics changed by the opening and closing of the head gate may be a significant source of canal gravel and other debris accumulations. If solutions to both debris accumulation and fish entrainment could be addressed simultaneously the acceptance of fish friendly designs by the agricultural community may be greatly enhanced.

2004

An estimated 26,376 fish were entrained in the T&Y Canal during the 2004 irrigation season (Table 3b). Fish from 14 species were observed being entrained in 2004. Common carp were the most abundant species entrained comprising 47% of the total catch (Figure 2b). Other abundant species entrained in 2004 included: flathead chub, channel catfish, and various suckers.

An estimated 13,424 fish were returned to the Tongue River by the bypass channel during the 2004 irrigation season (Table 3b). Fish from 17 species were observed being returned to the Tongue River by the bypass channel in 2004. Common carp were the most abundant species returned comprising 32% of the total catch (Figure 2c). Other abundant species returned by the bypass channel in 2004 included: channel catfish, flathead chub and various suckers (Table 1b). Fish being returned to the river by the bypass channel were generally longer than fish entrained in the canal. This was expected because louvers will approach 100 percent exclusion efficiency with larger, stronger swimming fish (T&Y canal report 1998). However, efficiencies will decline for smaller, weaker swimming fish (T&Y canal report 1998). An exception to this occurs when small sample sizes do not accurately represent the actual size distribution of fish observed (Table 1b).

2005

An estimated 22,481 fish were entrained into the T&Y Canal during the 2005 irrigation season (Table 3c). Fish from 17 species were observed being entrained in 2005. Common carp were the most abundant species entrained comprising 36% of total catch (Figure 2d). Other abundant species entrained in 2005 included: channel catfish, stonecat and flathead chubs.

An estimated 8,460 fish were returned to the Tongue River by the bypass channel during the 2005 irrigation season (Table 3c). Fish from 19 species were observed being returned to the Tongue River by the bypass channel in 2004. Common carp were the most abundant species returned comprising 33% of the total catch (Figure 2e). Other abundant species returned in 2005

included: shorthead redhorse suckers, channel catfish and fathead minnows (Table 1c). Similar to 2004, fish being returned to the river by the bypass channel in 2005 were generally longer than fish entrained in the canal. White suckers were one species that were on average smaller in the bypass channel than in the canal.

2013

An estimated 22,798 fish were entrained into the T&Y Canal during the 2013 irrigation season (Table 3d). Fish from 22 species were observed being entrained in 2013. Channel catfish were the most abundant species entrained comprising 59% of total catch (Figure 2f). Other abundant species entrained in 2013 included stonecat and various minnows.

An estimated 29,791 fish were returned to the Tongue River by the bypass channel during the 2013 irrigation season (Table 3d). Fish from 24 species were observed being returned to the Tongue River by the bypass channel in 2013. Channel catfish and shorthead redhorse suckers were the most abundant species returned comprising 20% each of the total catch (Figure 2g). Other abundant species returned in 2013 included common carp and smallmouth bass. The catch from 2013 included seven different species which had not been previously sampled: bigmouth buffalo, bluegill, freshwater drum, goldeye, largemouth bass, northern pike, and smallmouth buffalo. All of the species listed above, except largemouth bass, have been documented using the Muggli Fish Passage.

Seasonal Trends in Entrainment

In 1997 of the total number of fish entrained in T&Y Canal 52 percent were entrained between June 26 and July 22 (Figure 1a). Flathead chub, common carp, longnose dace, channel catfish, white sucker and black crappie were the most abundant species entrained in the canal during this two month peak entrainment period (Table 2a). These species account for 88% of the total number of fish entrained during the peak movement period.

In 2004, 75% of the total number of fish entrained into T&Y Canal during the irrigation season were entrained between July 12 and 13 (Figure 1b). Daily fish entrainment during this peak period was 6.6 times that of any other date. Common carp, unknown suckers, flathead chubs and channel catfish were the most abundant species entrained in the canal during this period (Table 2b). These species comprised 87% of the total fish captured of all species during the peak movement period. Peak return of fish through the bypass channel was observed August 9 and 10 comprising 32% of total number of fish returned during the irrigation season.

In 2005, 44% of the total number of fish entrained into T&Y Canal during the irrigation season were entrained between June 29 and 30 (Figure 1c). Common carp, channel catfish and flathead chub were the most commonly entrained species in the canal during this period (Table 2c). These comprised 84% of the total fish entrained during the peak movement period. After peak movement the species composition changed to more stonecat, shorthead redhorse suckers, channel catfish and flathead chub. Peak return of fish through the bypass channel was also observed June 29 and 30 comprising 26% number of fish returned during the irrigation season.

In 2013, 43% of the total number of fish entrained into T&Y Canal during the irrigation season were entrained between July 10 and 26 (Figure 1d). Channel catfish, common carp, smallmouth bass, flathead chub and western silvery/plains minnows were the most abundant species entrained in the canal (Table 2d), and accounted for 80% of all the total catch during the peak movement period. Peak return of fish through the bypass channel was observed July 25 and 26 comprising 36% of total number of fish returned during the irrigation season.

Diurnal Trends in Entrainment

Light has been identified as a factor influencing the movement of various fish species in fisheries literature. Some species have demonstrated peak movement primarily during daylight hours while others most often move at night. We captured all species more frequently at night or twilight (n = 296) than during the day (n = 83) (Schmetterling and Adams 2004).

In 1997 the lowest rate of entrainment occurred during the early morning hours 2 am to 10 am at the T&Y Canal averaging 11.3 fish captured per 2 hrs (Table 5a). The highest entrainment rate occurred during the afternoon and early evening between 2 pm and 8 pm with an average of 33.5 fish captured per 2 hrs or 3 times more fish than the early morning hours.

In 2004 the lowest rate of entrainment occurred during the morning hours 6 am to 12 noon at T&Y Canal averaging 2.8 fish captured per 2 hours (Table 5b). The highest entrainment rate occurred during the late evening and early morning between 10 pm and 2 am with an average of 35.5 fish captured per 2 hours or 13 times more fish than the morning hours. In the bypass channel in the lowest rate of return occurred during the morning hours 8 am to 12 noon averaging 1.35 fish captured per 2 hours (Table 5b). The highest rate of return occurred during the late evening and early morning between 10 pm and 2 am with an average of 21.65 fish captured per 2 hours 16 times more fish than the early morning hours.

In 2005 the lowest rate of entrainment occurred during the morning hours 6 am to 10 am in the canal averaging 5.3 fish captured per 2 hours (Table 5c). The highest entrainment rate occurred during the late evening and early morning between 8 pm and 2 am with an average of 22.8 fish captured per 2 hours or 4 times more fish than the early morning hours. In the bypass channel the lowest rate of return occurred during the morning hours between 6 am and 12 noon averaging 3.0 fish captured per 2 hours (Table 5c). The highest rate of return occurred during the late evening hours from 8 pm to 12 midnight with an average of 22.8 fish captured per 2 hours 7.6 times more fish than the morning hours.

In 2013 the lowest rate of entrainment occurred during the morning hours 6 am to 12 noon in the canal averaging 3.5 fish captured per 2 hours (Table 5d). The highest entrainment rate occurred during the late evening and early morning hours between 10 pm and 4 am with an average of 17.7 fish captured per 2 hours or 5 times more fish than the morning hours. In the bypass channel the lowest rate of return occurred during the morning hours between 6 am and 10 am averaging 5.6 fish captured per 2 hours (Table 5d). The highest rate of return occurred during the late evening and early morning hours between 10 pm and 4 am with an average of 24.8 fish captured per 2 hours or 4 times more fish than the morning hours.

Factors Influencing Entrainment

In 1997 Tongue River stream discharge, percentage of irrigation withdrawal related to Tongue River discharge and Tongue River turbidity were evaluated as possible factors influencing numbers of fish entering the T&Y Canal. Turbidity is directly correlated to stream discharge with high turbidity occurring when stream discharge is also high. One exception to this pattern occurred in October when a rain event and suspected local run-off resulted in turbidity measurements that exceed high flow turbidity.

In 1997 no clear relationship appeared to exist between stream discharge, percent diverted water discharge, or turbidity and fish entry into the T&Y canal (Table 6a). Low numbers of fish entered the canal at both high flows and low flows. High entrainment rates occurred at both high discharge, 1525 cfs on June 26-27 sample, and moderate discharge 549 cfs, July 21-22.

In 2004 it appeared that fish were both entrained down the canal and returned to the river by the bypass channel during periods of low flow (Table 6b). Tongue River discharge in 2004 was lower than any other sampled year. More fish entered the canal at 19 cfs a low flow and few fish entered the canal and bypass at 100 cfs, a higher flow.

In 2005 it appeared that most fish entered the canal and bypass at higher discharge (Table 6c). The highest rate of fish entrainment down the canal and return to the river through the bypass occurred at a high discharge of 2250 cfs.

In 2013 it appeared that fish entry into the T&Y Canal and bypass was highest at lower discharge (Table 6d). The highest rate of fish entrainment down the canal and return to the river through the bypass occurred at 84 cfs.

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Table 1a. Fish species and length summary statistics of fish captured in the T&Y Canal in 1997.

	T&Y Canal				
	Fish	% of	Total Length (mm)		
Species	Collected	Catch	Min	Max	Avg
Black Bullhead	1	0.1	105	105	105
Black Crappie	17	2.0	73	211	138
Channel Catfish	89	10.4	40	548	166
Common Carp	111	13.0	24	314	56
Crappie	61	7.1	22	84	44
Creek Chub	1	0.1	180	180	180
Emerald Shiner	4	0.5	75	103	89
Fathead Minnow	5	0.6	46	65	56
Flathead Chub	277	32.4	45	264	125
Green Sunfish	6	0.7	36	92	67
Longnose Dace	109	12.7	47	102	74
Longnose Sucker	9	1.1	43	325	206
Pumpkinseed	7	0.8	32	65	45
River Carpsucker	5	0.6	48	105	68
Sauger/Walleye	1	0.1	43	43	43
Shorthead Redhorse Sucker	19	2.2	207	365	262
Smallmouth Bass	8	0.9	31	192	110
Stonecat	9	1.1	78	158	127
Unknown Minnow	6	0.7	22	75	44
Unknown Sucker	10	1.2	25	45	40
Walleye	1	0.1	38	38	38
White Crappie	54	6.3	43	274	118
White Sucker	26	3.0	36	346	131
Yellow Bullhead	9	1.1	31	130	78
Yellow Perch	10	1.2	35	97	76
Total Fish	855				

Table 1b. Fish species and length summary statistics of fish captured in the T&Y Canal and By Pass Channel in 2004.

	T&Y Canal					By Pass Channel				
	Fish	% of	Total Length (mm)			Fish	% of	Total Length (mm)		
Species	Collected	Catch	Min	Max	Avg	Collected	Catch	Min	Max	Avg
Black Bullhead						6	0.7	221	335	245
Black Crappie	1	0.1	112	112	112	2	0.2	133	230	182
Channel Catfish	126	7.1	16	227	68	194	23.7	15	290	145
Common Carp	946	53.3	29	137	41	262	32.0	37	595	72
Fathead Minnow	56	3.2	18	67	50	14	1.7	41	68	53
Flathead Chub	202	11.4	32	143	78	154	18.8	33	165	81
Green Sunfish	8	0.5	49	86	62	2	0.2	61	85	73
Longnose Dace	16	0.9	28	90	52	5	0.6	30	65	41
Longnose Sucker						2	0.2	255	290	273
Unknown Minnow	10	0.6	18	36	26	20	2.4	21	43	35
Plains Minnow	8	0.5	78	111	90	7	0.9	74	110	93
River Carpsucker	7	0.4	26	130	60	1	0.1	25	25	25
Rock Bass	2	0.1	62	108	85	1	0.1	63	63	63
Shorthead Redhorse Sucker	7	0.4	45	198	119	10	1.2	76	319	175
Smallmouth Bass						18	2.2	110	338	228
Stonecat	10	0.6	44	153	99	4	0.5	29	132	96
Unknown Sucker	220	12.4	12	125	27	96	11.7	20	48	35
Western Silvery Minnow	5	0.3	40	72	54	8	1.0	52	85	72
White Sucker	152	8.6	23	97	51	14	1.7	58	248	81
Total Fish	1776					820				

Table 1c. Fish species and length summary statistics of fish captured in the T&Y Canal and By Pass Channel in 2005.

	T&Y Canal					By Pass Channel				
	Fish	% of	Total Length (mm)			Fish	% of	Total Length (mm)		
Species	Collected	Catch	Min	Max	Avg	Collected	Catch	Min	Max	Avg
Black Bullhead	6	0.5	48	243	115	18	3.8	56	255	196
Black Crappie	1	0.1	26	26	26	25	5.2	118	232	176
Channel Catfish	176	15.2	14	568	103	76	15.9	19	247	120
Common Carp	419	36.1	19	564	37	114	23.9	23	556	73
Crappie	1	0.1	28	28	28	3	0.6	28	43	35
Fathead Minnow	113	9.7	37	80	58	66	13.8	40	67	55
Flathead Chub	111	9.6	34	146	84	9	1.9	47	152	98
Golden Shiner						1	0.2	122	122	122
Green Sunfish	6	0.5	28	46	36	6	1.3	31	77	45
Longnose Dace	47	4.0	38	93	59	13	2.7	47	90	60
Longnose Sucker						1	0.2	135	135	135
Plains Minnow	1	0.1	52	52	52	1	0.2	97	97	97
Pumkinseed	1	0.1	75	75	75					
River Carpsucker	11	0.9	36	106	64	3	0.6	42	109	86
Shorthead Redhorse Sucker	21	1.8	71	329	162	82	17.2	101	347	168
Smallmouth Bass						10	2.1	146	267	196
Stonecat	141	12.1	45	151	113	4	0.8	116	125	121
Unknown	7	0.6	11	37	27	4	0.8	25	98	46
Unknown Minnow	6	0.5	18	41	29	3	0.6	31	42	35
Unknown Sucker	3	0.3	29	33	31	1	0.2	41	41	41
Unknown Sunfish	1	0.1	51	51	51					
Walleye	1	0.1	30	30	30					
Western Silvery Minnow	60	5.2	42	104	64	5	1.0	62	126	91
White Crappie						8	1.7	156	232	174
White Sucker	20	1.7	67	349	171	19	4.0	32	238	147
Yellow Bullhead	8	0.7	50	190	79	5	1.0	54	75	61
Total Fish	1161					477				

Table 1d. Fish species and length summary statistics of fish captured in the T&Y Canal and By Pass Channel in 2013.

	T&Y Canal					By Pass Channel				
	Fish	% of	Total Length (mm)			Fish	% of	Total Length (mm)		
Species	Collected	Catch	Min	Max	Avg	Collected	Catch	Min	Max	Avg
Bigmouth Buffalo	7	0.5	27	46	34		0.0			
Black Bullhead	1	0.1	25	25	25	4	0.2	169	199	183
Bluegill	2	0.2	39	56	48		0.0			
Channel Catfish	767	58.6	24	458	78	406	20.4	37	685	370
Common Carp	53	4.0	37	267	61	261	13.1	30	630	110
Crappie		0.0				1	0.1	37	37	37
Creek Chub	5	0.4	21	99	67		0.0			
Emerald Shiner	74	5.7	26	71	42	9	0.5	40	90	50
Fathead Minnow	38	2.9	27	70	48	12	0.6	48	68	58
Flathead Chub	47	3.6	23	175	67	153	7.7	30	225	131
Freshwater Drum	3	0.2	33	52	42	6	0.3	275	386	343
Goldeye		0.0				99	5.0	132	413	347
Green Sunfish	8	0.6	35	58	51	9	0.5	40	105	71
Largemouth Bass		0.0				3	0.2	145	238	202
Longnose Dace	13	1.0	44	80	57	5	0.3	53	89	65
Longnose Sucker	19	1.5	77	226	108	16	0.8	110	243	208
Northern Pike		0.0				2	0.1	584	640	612
River Carpsucker	11	0.8	35	125	58	101	5.1	30	537	287
Rock Bass	4	0.3	42	124	84	4	0.2	137	158	145
Sauger		0.0				7	0.4	46	410	187
Shorthead Redhorse Sucker	6	0.5	45	215	103	397	20.0	62	475	345
Smallmouth Bass	20	1.5	32	210	116	219	11.0	28	410	163
Smallmouth Buffalo	1	0.1	60	60	60		0.0			
Stonecat	117	8.9	27	190	121	42	2.1	110	182	140
Unknown	6	0.5	18	32	24	2	0.1	22	33	28
Unknown Minnow	57	4.4	17	34	22		0.0			
Unknown Sucker	1	0.1	25	25	25		0.0			
Walleye	2	0.2	35	36	36	21	1.1	44	513	204
Western Silvery Minnow	20	1.5	35	145	78	141	7.1	38	147	113
White Sucker	27	2.1	26	240	114	64	3.2	25	380	170
Yellow Perch		0.0				2	0.1	37	238	138
Total Fish	1309					1986				

Table 2a. Distribution of fish species captured in the T&Y Canal and Bypass Channel among the ten sampled days and percentage of total fish caught by species, 1997.

Species	May 29 & 30	June 12 &13	June 26 & 27	July 10 & 11	July 21 & 22	August 11 & 12	August 20 & 21	Sept. 2 & 3	Sept. 22 & 23	Oct. 9 & 10	Total Fish	Percentage of catch
Black Bullhead			1								1	0.1
Black Crappie				3	3		2	1	4	4	17	2.0
Carp			44	24	28	2		2		11	111	13.0
Channel Catfish		1	6	17	28	3	8	13	1	12	89	10.4
Crappie *						5	31	8		17	61	7.1
Creek Chub									1		1	0.1
Emerald Shiner		1		3							4	0.5
Fathead Minnow				2		1		2			5	0.6
Flathead Chub	5	2	22	53	60	19	40	30	41	5	277	32.4
Green Sunfish	4									2	6	0.7
Longnose Dace	1	2	20	19	42		14	10	1		109	12.8
Longnose Sucker			5		1	1		1	1		9	1.1
Minnow **			1	3			1	1			6	0.1
Pumpkinseed										7	7	0.8
River Carpsucker			3						1	1	5	0.6
Sauger/Walleye ***			1								1	0.1
Shorthead Redhorse Sucker			3	2		4	1	3	1	5	19	2.2
Smallmouth Bass				4					1	3	8	0.9
Stonecat			1	1		1	2	1		3	9	1.1
Sucker ****			5	4		1					10	1.2
Walleye				1							1	0.1
White Crappie	1			2	9	17	6	6	7	6	54	6.3
White Sucker			1	16		1	1	2	4	1	26	3.0
Yellow Bullhead	1	3	1			2		1		1	9	1.1
Yellow Perch					2				1	7	10	1.2
Total Fish	12	9	114	154	173	57	106	81	64	85	855	
			52% of catch									

Table 2b. Distribution of fish species captured in the T&Y Canal and Bypass Channel among the seven sampled days and percentage of total fish caught by species, 2004.

Species	June 1 & 2	June 16 & 17	June 28 & 29	July 12 & 13	July 27 & 28	August 9 & 10	August 23 & 24	Total Fish	Percentage of Catch
Black Bullhead						6		6	0.2
Black Crappie		1		1	1			3	0.1
Channel Catfish	4	60	146	18	40	24	28	320	12.3
Common Carp		1	1	905	36	262	3	1208	46.5
Fathead Minnow	8	15	5	10	14	1	17	70	2.7
Flathead Chub	1	8	130	125	44	26	22	356	13.7
Green Sunfish	3	5	2					10	0.4
Longnose Dace	1	1		4	12	2	1	21	0.8
Longnose Sucker			1		1			2	0.1
Unknown Minnow	1		1	1	22	3	2	30	1.2
Plains Minnow			2	5	3	5		15	0.6
River Carpsucker				1	4		3	8	0.3
Rock Bass		1	1				1	3	0.1
Shorthead Redhorse Sucker		1		2	1	6	7	17	0.7
Smallmouth Bass		2	1		1	13	1	18	0.7
Stonecat		3		1	4	2	4	14	0.5
Unknown Sucker			28	91	188		9	316	12.2
Western Silvery Minnow	1	9	1		1		1	13	0.5
White Sucker		9	1	111	42	1	2	166	6.4
Total Fish	19	116	320	1275	414	351	101	2596	
				49 % of Catch					

Table 2c. Distribution of fish species captured in the T&Y Canal and Bypass Channel among the ten sampled days and percentage of total fish caught by species, 2005.

Species	May 16 & 17	May 31 June 1	June 13 & 14	June 29 & 30	July 11 & 12	July 25 & 26	August 8 & 9	August 22 & 23	Sept. 7 & 8	Sept. 19 & 20	Total Fish	Percentage of Catch
Black Bullhead	12	2		5	3	2					24	1.5
Black Crappie				1	2	10	2	6		5	26	1.6
Channel Catfish	10	6	2	14	34	60	24	44	49	9	252	15.4
Common Carp	9	1		456	11	29	22	1	3	1	533	32.5
Crappie								4			4	0.2
Fathead Minnow	59	27	16	5	9	2		1	2	1	122	7.4
Flathead Chub	5	5	12	9	25	30	25	49	12	5	177	10.8
Golden Shiner	1										1	0.1
Green Sunfish	11							1			12	0.7
Longnose Dace	7	4	1	6	10	1	3	19	9		60	3.7
Longnose Sucker						1					1	0.1
Plains Minnow		1						1			2	0.1
Pumkinseed							1				1	0.1
River Carpsucker		5	1	2	1	1		2	2		14	0.9
Shorthead Redhorse Sucker	4	1			11	1	37	23	21	5	103	6.3
Smallmouth Bass								1	3	6	10	0.6
Stonecat	6	1	8	12	1	3	3	2	80	29	145	8.9
Unknown					1	6	4				11	0.7
Unknown Minnow					2		3	3	1		9	0.5
Unknown Sucker				3	1						4	0.2
Unknown Sunfish			1								1	0.1
Walleye					1						1	0.1
Western Silvery Minnow	2			2	4			1	56		65	4.0
White Crappie						7	1				8	0.5
White Sucker	36		1				1		1		39	2.4
Yellow Bullhead	2	1	1	7					2		13	0.8
Total Fish	164	54	43	522	116	153	126	158	241	61	1638	
				32% of catch								

Table 2d. Distribution of fish species captured in the T&Y Canal and Bypass Channel among the ten sampled days and percentage of total fish caught by species, 2013.

Species	May 16 & 17	May 28 & 29	June 13 & 14	June 26 & 27	July 10 & 11	July 25 & 26	August 7 & 8	August 22 & 23	Sept. 5 & 6	Sept. 19 & 20	Oct. 3 & 4	Total Fish	% of Catch
Bigmouth Buffalo					7							7	0.2
Black Bullhead		4					1					5	0.2
Bluegill		1									1	2	0.1
Channel Catfish	7	25		53	495	429	109	20	15	1	19	1173	35.7
Common Carp		5	27	8	2	247	23	1				313	9.5
Crappie								1				1	0.0
Creek Chub	4					1						5	0.2
Emerald Shiner	1	6	6	49	12	4	2		3			83	2.5
Fathead Minnow	4	21	3		14	2	5		1			50	1.5
Flathead Chub	2	31	1	22	18	38	19	53	13		3	200	6.1
Freshwater Drum						7	1				1	9	0.3
Goldeye	2	75		2	11	3			4		2	99	3.0
Green Sunfish		5	3	3	1		2				3	17	0.5
Largemouth Bass	3											3	0.1
Longnose Dace	2	5	1	1	3		4	2				18	0.5
Longnose Sucker	32		2				1					35	1.1
Northern Pike	1					1						2	0.1
River Carpsucker		7	2	16	60	6	10	1		1	9	112	3.4
Rock Bass	4	2		1				1				8	0.2
Sauger	1	1			1	4						7	0.2
Shorthead Redhorse Sucker	236	115	1	15	3	14	8	2	3		6	403	12.3
Smallmouth Bass	21	83		3	13	96	5		4		14	239	7.3
Smallmouth Buffalo						1						1	0.0
Stonecat	51	37	31	12	6	13	8	1				159	4.8
Unknown		3			2		3					8	0.2
Unknown Minnow		6			51							57	1.7
Unknown Sucker						1						1	0.0
Walleye	6				4	12					1	23	0.7
Western Silvery Minnow	2	83	3	19	6	32		5	4	1	6	161	4.9
White Crappie												0	0.0
White Sucker	10	12	10	4	4	32	10	4	2		3	91	2.8
Yellow Perch		1			1							2	0.1
Total Fish	389	527	90	208	706	943	211	91	49	3	68	3285	
		66% of catch			**66 % of catch**								

Table 3a. Estimated numbers of fish entering the T&Y Canal during the irrigation season in 1997.

T&Y Canal

Date	Sample Time In Minutes	Factor	Fish Sampled	Estimated Fish In 24 Hours	Days In Period	Estimated Numbers In Season
May 29 &30	154	9.35	12	112	21	2356
June 12 & 13	108	13.33	9	120	14	1680
June 26 & 27	247	5.83	114	665	14	9305
July 10 & 11	560	2.57	154	396	12.5	4950
July 21 & 22	470	3.06	173	530	16	8481
August 11 & 12	592	2.43	57	139	15	2080
Aug. 20 & 21	563	2.56	106	271	11	2982
Sept. 2 & 3	735	1.96	81	159	16.5	2618
Sept. 22 & 23	1000	1.44	64	92	18	1659
Oct. 9 & 10	975	1.48	85	126	9	1130
Total			855	2609		37241

Table 3b. Estimated numbers of fish entering the T&Y Canal and By Pass Channel during the irrigation season in 2004.

T&Y Canal

Date	Sample Time In Minutes	Factor	Fish Sampled	Estimated Fish In 24 Hours	Days In Period	Estimated Numbers In Season
June 1 & 2	1345	1.07	15	16	7.5	120
June 16 & 17	1327	1.09	57	62	12	742
June 28 & 29	1321	1.09	66	72	14	1007
July 12 & 13	1380	1.04	1274	1329	15	19941
July 27 & 28	1327	1.09	212	230	13	2991
Aug. 9 & 10	1363	1.06	59	62	14	873
Aug. 23 & 24	1322	1.09	92	100	7	701
Total			1775	1872		26376

By Pass Channel

Date	Sample Time In Minutes	Factor	Fish Sampled	Estimated Fish In 24 Hours	Days In Period	Estimated Numbers In Season
June 1 & 2	1345	1.07	4	4	7.5	32
June 16 & 17 *	1267	1.14	59	67	12	805
June 28 & 29	1321	1.09	254	277	14	3876
July 12 & 13 **	720	2.00	1	2	15	30
July 27 & 28	1327	1.09	202	219	13	2850
Aug. 9 & 10	1363	1.06	292	308	14	4319
Aug. 23 & 24 ***	60	24.00	9	216	7	1512
Total			821	1094		13424

* One 60 minute sample period was not sampled.

** By Pass blocked with boards, sampled water that trickled around boards for 12 sample periods.

*** By Pass blocked with boards, removed boards for one 60 minute sample period.

Table 3c. Estimated numbers of fish entering the T&Y Canal and By Pass Channel during the irrigation season in 2005.

T&Y Canal

Date	Sample Time In Minutes	Factor	Fish Sampled	Estimated Fish In 24 Hours	Days In Period *	Total Fish Numbers In Season
May 16 & 17	859	1.68	97	163	8.5	1,382
May 31 & June 1	505	2.85	48	137	13	1,779
June 13 & 14	1123	1.28	42	54	14	754
June 29 & 30	815	1.77	427	754	13	9,808
July 11 & 12	675	2.13	76	162	12	1,946
July 25 & 26	1161	1.24	82	102	13	1,322
Aug. 8 & 9	1249	1.15	65	75	13	974
Aug. 22 & 23	1241	1.16	79	92	14	1,283
Sep. 7 & 8	1270	1.13	199	226	13	2,933
Sep. 19 & 20	1329	1.08	46	50	6	299
Total	10227		1161	1814		22,481

By Pass Channel

Date	Sample Time In Minutes	Factor	Fish Sampled	Estimated Fish In 24 Hours	Days In Period *	Total Fish Numbers In Season
May 16 & 17	859	1.68	67	112	8.5	955
May 31 & June 1	505	2.85	6	17	13	222
June 13 & 14	1123	1.28	1	1	14	18
June 29 & 30	815	1.77	95	168	13	2,182
July 11 & 12	675	2.13	40	85	12	1,024
July 25 & 26	1161	1.24	71	88	13	1,145
Aug. 8 & 9	1249	1.15	61	70	13	914
Aug. 22 & 23	1241	1.16	79	92	14	1,283
Sep. 7 & 8	1270	1.13	42	48	13	619
Sep. 19 & 20	1329	1.08	15	16	6	98
Total	10227		477	698		8,460

* Used May 27 as first day canal was turned on and October 1 as day it was turned off.

Table 3d. Estimated numbers of fish entering the T&Y Canal and By Pass Channel during the irrigation season in 2013.

T&Y Canal

Date	Sample Time In Minutes	Factor	Fish Sampled	Estimated Fish In 24 Hours	Days In Period	Estimated Numbers In Season
May 16 & 17	1360	1.06	89	94	3	283
May 28 & 29	1190	1.21	98	119	12	1423
June 13 & 14	1259	1.14	57	65	16	1043
June 26 & 27	1172	1.23	59	72	13	942
July 10 & 11	1071	1.34	485	652	15	9782
July 25 & 26	1159	1.24	371	461	15	6914
Aug. 7 & 8 *	1168	1.23	105	129	13	1683
Aug. 22 & 23	1305	1.10	18	20	15	298
Sept. 5 & 6	1273	1.13	14	16	14	222
Sept. 19 & 20	1313	1.10	0	0	14	0
Oct. 3 & 4	1260	1.14	14	16	13	208
Total			1310	1645		22798

By Pass Channel

Date	Sample Time In Minutes	Factor	Fish Sampled	Estimated Fish In 24 Hours	Days In Period	Estimated Numbers In Season
May 16 & 17	1360	1.06	301	319	3	956
May 28 & 29	1190	1.21	430	520	12	6244
June 13 & 14	1259	1.14	33	38	16	604
June 26 & 27	1172	1.23	149	183	13	2380
July 10 & 11	1071	1.34	229	308	15	4618
July 25 & 26	1159	1.24	573	712	15	10679
Aug. 7 & 8 *	1168	1.23	106	131	13	1699
Aug. 22 & 23	1305	1.10	73	81	15	1208
Sept. 5 & 6	1273	1.13	35	40	14	554
Sept. 19 & 20	1313	1.10	3	3	14	46
Oct. 3 & 4	1260	1.14	54	62	13	802
Total			1986	2396		29791

* One 60 minute sample period was not sampled.

Table 4. Maximum, minimum, and mean length and weight for all fish collected in twelve passes by K.M. Backes in 1993 near river mile 91.1 downstream of Ashland, MT.

Species	Number	Range in Length (mm)	Mean Length (mm)	Range in Weight (gm)	Mean Weight (gm)
Black bullhead	1		250		240
Black crappie	23	162-187	176	50-110	77
Carp	108	183-603	466	100-3340	1536
Channel catfish	86	105-787	295	5-5300	647
Flathead chub	84	100-194	144	5-70	25
green sunfish	3	96-118	107	80-100	90
Longnose dace	77	43-115	82	5-30	18
Longnose sucker	130	90-381	223	5-550	151
Mountain sucker	5	65-181	128	5-60	27
River carpsucker	93	94-346	285	15-510	292
Rock bass	66	99-218	183	70-240	141
Shorthead redhorse	200	122-358	285	20-410	234
Smallmouth bass	11	147-442	257	50-1410	379
Stonecat	50	77-221	164	5-100	50
Walleye	3	194-201	197	50-70	60
White Crappie	10	153-212	194	50-120	93
White sucker	114	61-376	229	5-650	204
Yellow bullhead	113	98-234	184	20-180	87

Table 5a. Diurnal timing of fish movements into the T&Y Canal by two hour sampling intervals, 1997.

	Fish Entry Into the T&Y Canal by Two Hour Intervals													
Date	10:00 AM to Noon	Noon to 2:00 PM	2:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 8:00 PM	8:00 PM to 10:00 PM	10:00 PM to 12:00 AM	12:00 AM to 2:00 AM	2:00 AM to 4:00 AM	4:00 AM to 6:00 AM	6:00 AM to 8:00 AM	8:00 AM to 10:00 AM	Total	Percentage
May 29 &30	11	0	16	13	9	0	24	0	0	12	24	0	109	4.2
June 12 & 13	0	24	0	45	15	30	0	0	0	15	0	0	129	5.0
June 26 & 27	69	36	54	84	77	96	66	50	20	48	30	0	630	24.3
July 10 & 11	34	61	51	84	36	30	34	60	9	12	13	12	435	16.8
July 21 & 22	48	45	58	69	72	21	81	24	24	15	42	12	511	19.7
August 11 & 12	15	21	9	20	12	15	10	4	8	4	24	4	146	5.6
Aug. 20 & 21	17	12	26	59	34	26	14	22	12	6	16	12	256	9.9
Sept. 2 & 3	14	4	30	22	24	16	16	12	6	5	5	7	162	6.2
Sept. 22 & 23	3	8	20	13	14	6	10	2	3	0	1	2	84	3.3
Oct. 9 & 10	9	5	14	17	8	11	9	8	5	8	20	15	126	4.9
Total	220.8	215.8	277.9	425.8	301.1	250.9	263.2	181.6	87.2	125.2	174.4	64.2	2588	
Mean	22.1	21.6	27.8	42.6	30.1	25.1	26.3	18.2	8.7	12.5	17.4	6.4		
Percentage	8.5	8.3	10.7	16.5	11.6	9.7	10.2	7.0	3.4	4.8	6.7	2.5		
			Average = 33.5						**Average = 11.3**					

Table 5b. Diurnal timing of fish movements into the T&Y Canal by two hour sampling intervals, 2004.

Fish Entry Into the T&Y Canal by Two Hour Intervals

Date	10:00 AM to Noon	Noon to 2:00 PM	2:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 8:00 PM	8:00 PM to 10:00 PM	10:00 PM to 12:00 AM	12:00 AM to 2:00 AM	2:00 AM to 4:00 AM	4:00 AM to 6:00 AM	6:00 AM to 8:00 AM	8:00 AM to 10:00 AM	Total	Percentage
June 1 & 2	1	1	3	1	3	2	2	1				1	15	1.3
June 16 & 17	4		3	7	4	9	16	8	4	1	1		57	4.9
June 28 & 29	3	3		5	8	12	18	6	1	4	1	5	66	5.7
July 12 & 13	16	42	42	50	47	105	152	143	54	10	1	5	667	57.1
July 27 & 28	5	5	5	11	8	8	74	35	46	11	2	2	212	18.2
Aug. 9 & 10	3	3	2	5	2	3	15	11	2	6	3	4	59	5.1
Aug. 23 & 24	1	7	8	6	13	30	15	1	9	1	1		92	7.9
Total	33	61	63	85	85	169	292	205	116	33	9	17	1168	
Mean	4.7	8.7	9.0	12.1	12.1	24.1	41.7	29.3	16.6	4.7	1.3	2.4		
Percentage	2.8	5.2	5.4	7.3	7.3	14.5	25.0	17.6	9.9	2.8	0.8	1.5		
	Avg. = 2.8						**Avg. = 35.5**				**Avg. = 2.8**			

Table 5b. Diurnal timing of fish movements into the Bypass Channel by two hour sampling intervals, 2004.

Fish Entry Into the Bypass Channel by Two Hour Intervals

Date	10:00 AM to Noon	Noon to 2:00 PM	2:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 8:00 PM	8:00 PM to 10:00 PM	10:00 PM to 12:00 AM	12:00 AM to 2:00 AM	2:00 AM to 4:00 AM	4:00 AM to 6:00 AM	6:00 AM to 8:00 AM	8:00 AM to 10:00 AM	Total	Percentage
June 1 & 2		1				1	2						4	0.5
June 16 & 17		1	9	5	5	10	11	5	6	3	3	1	59	8.1
June 28 & 29	7	6	5	5	10	34	96	36	23	20	8	4	254	34.9
July 12 & 13		1											1	0.1
July 27 & 28	2	6	1	15	10	64	2	58		4	1	1	164	22.5
Aug. 9 & 10		1	1	32	40	5	48	42	22	20	6	3	220	30.2
Aug. 23 & 24	1	2	2	2	10	2	2	1	2	1	1		26	3.6
Total	10	18	18	59	75	116	161	142	53	48	19	9	728	
Mean	1.4	2.6	2.6	8.4	10.7	16.6	23.0	20.3	7.6	6.9	2.7	1.3		
Percentage	1.4	2.5	2.5	8.1	10.3	15.9	22.1	19.5	7.3	6.6	2.6	1.2		
	Avg. = 1.35						**Avg. = 21.65**					**Avg. = 1.35**		

Table 5c. Diurnal timing of fish movements into the T&Y Canal by two hour sampling intervals, 2005.

Fish Entry Into the T&Y Canal by Two Hour Intervals

Date	10:00 AM to Noon	Noon to 2:00 PM	2:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 8:00 PM	8:00 PM to 10:00 PM	10:00 PM to 12:00 AM	12:00 AM to 2:00 AM	2:00 AM to 4:00 AM	4:00 AM to 6:00 AM	6:00 AM to 8:00 AM	8:00 AM to 10:00 AM	Total	Percentage
May 16 & 17	11	25	12	7					1	2	3	9	70	6.2
May 31 & June 1	3	9	6	5	6	3	1	2	5	3	1	4	48	2.2
June 13 & 14	2	4	6	10	6	3	4	2	1			4	42	2.0
June 29 & 30	23	26	33	12	36	71	93	61	29	20	13	10	427	20.3
July 11 & 12	4	4	11	11	3	6	8	10	7	4	3	5	76	4.5
July 25 & 26	1	2	5	5	1	10	37	12	4	3	1	1	82	5.1
Aug. 8 & 9	3	1		8	7	10	16	4	5	8	2	1	65	4.3
Aug. 22 & 23	12	11	10	14	10	9	2	1	4	2	1	3	79	5.4
Sep. 7 & 8	4	13	21	15	22	35	31	23	16	9	6	4	199	14.4
Sep. 19 & 20	2	3	1		4		13	12	6	2	3		46	3.9
Total	65	98	105	87	95	147	205	127	78	53	33	41	1134	
Mean	9.3	14.0	15.0	12.4	13.6	21.0	29.3	18.1	11.1	7.6	4.7	5.9		
Percentage	5.7	8.6	9.3	7.7	8.4	13.0	18.1	11.2	6.9	4.7	2.9	3.6		
						Average = 22.8					**Avg.= 5.3**			

Table 5c. Diurnal timing of fish movements into the Bypass Channel by two hour sampling intervals, 2005.

Fish Entry Into the Bypass Channel by Two Hour Intervals

Date	10:00 AM to Noon	Noon to 2:00 PM	2:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 8:00 PM	8:00 PM to 10:00 PM	10:00 PM to 12:00 AM	12:00 AM to 2:00 AM	2:00 AM to 4:00 AM	4:00 AM to 6:00 AM	6:00 AM to 8:00 AM	8:00 AM to 10:00 AM	Total	Percentage
May 16 & 17	4	8	14	7					9	7	8	10	67	14.1
May 31 & June 1			1				2		1		2		6	0.7
June 13 & 14	1												1	0.1
June 29 & 30		2	2	3	4	21	17	14	21	5	6		95	10.8
July 11 & 12		1	2	5	3	2	20	1	2	3	1		40	5.1
July 25 & 26	5	3	3	1	5	10	21	14	5	4			71	9.6
Aug. 8 & 9	3	8	2	4	4	7	12	9	5	1	2	3	60	8.9
Aug. 22 & 23	4	7	2	9	10	15	11	3	7	4	5	2	79	12.9
Sep. 7 & 8	1	1	2		5	7	7	4	8	2	4	1	42	7.9
Sep. 19 & 20			1		5	5		3		1			15	3.1
Total	18	30	29	29	36	67	90	48	58	27	28	16	476	
Mean	2.6	4.3	4.1	4.1	5.1	9.6	12.9	6.9	8.3	3.9	4.0	2.3		
Percentage	3.8	6.3	6.1	6.1	7.6	14.1	18.9	10.1	12.2	5.7	5.9	3.4		
	Avg. = 3.0					**Avg. = 11.3**					**Avg. = 3.0**			

Table 5d. Diurnal timing of fish movements into the T&Y Canal by two hour sampling intervals.

Fish Entry Into the T&Y Canal by Two Hour Intervals

Date	10:00 AM to Noon	Noon to 2:00 PM	2:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 8:00 PM	8:00 PM to 10:00 PM	10:00 PM to 12:00 AM	12:00 AM to 2:00 AM	2:00 AM to 4:00 AM	4:00 AM to 6:00 AM	6:00 AM to 8:00 AM	8:00 AM to 10:00 AM	Total	Percentage
May 16 & 17	2	6	6	4	2	8	17	26	11	5		2	89	6.8
May 28 & 29	5	8	8	8	8	10	12	8	13	13	3	2	98	7.5
June 13 & 14	3	5	6	9	10	4	6	5	2	2	2	3	57	4.4
June 26 & 27	3	29	10	10	1		1	1	1		2	1	59	4.5
July 10 & 11	25	21	19	4	2	7	102	99	130	60	6	10	485	37.1
July 25 & 26	6	47	85	60	33	37	52	21	17	5	5	3	371	28.3
Aug. 7 & 8	3	2	13	10	6	10	16	16	17	3	6	3	105	8.0
Aug. 22 & 23		1	1	2		2	3	3		5			17	1.3
Sept. 5 & 6		2	3		1	2			1		2	3	14	1.1
Sept. 19 & 20													0	0.0
Oct. 3 & 4							2	1	2	5	4		14	1.1
Total	47	121	151	107	63	80	211	180	194	98	30	27	1309	
Mean	4.3	11.0	13.7	9.7	5.7	7.3	19.2	16.4	17.6	8.9	2.7	2.5		
Percentage	3.6	9.2	11.5	8.2	4.8	6.1	16.1	13.8	14.8	7.5	2.3	2.1		
	Avg. = 3.5						**Avg. = 17.7**				**Avg. = 3.5**			

Table 5d. Diurnal timing of fish movements into the Bypass Channel by two hour sampling intervals.

Fish Entry Into the Bypass Channel by Two Hour Intervals

Date	10:00 AM to Noon	Noon to 2:00 PM	2:00 PM to 4:00 PM	4:00 PM to 6:00 PM	6:00 PM to 8:00 PM	8:00 PM to 10:00 PM	10:00 PM to 12:00 AM	12:00 AM to 2:00 AM	2:00 AM to 4:00 AM	4:00 AM to 6:00 AM	6:00 AM to 8:00 AM	8:00 AM to 10:00 AM	Total	Percentage
May 16 & 17	6	5	3	3		17	55	94	98	14	4	2	301	15.2
May 28 & 29	30	24	32	43	31	32	39	38	53	57	40	11	430	21.7
June 13 & 14	5	3	2	2	1	1	3	3	8	2		3	33	1.7
June 26 & 27	3	13	13	7	9	12	41	24	19	4		4	149	7.5
July 10 & 11	12	10	14	15	19	46	32	30	34	11	3	3	229	11.5
July 25 & 26	33	149	88	30	37	57	66	48	28	22	6	9	573	28.9
Aug. 7 & 8 *	2	4	9	4	6	18	13	20	18	5	4	**3**	106	5.3
Aug. 22 & 23		6	3	4	1	16	11	8	1	2	15	6	73	3.7
Sept. 5 & 6	1	1		6	6	12	2	2	1		2	2	35	1.8
Sept. 19 & 20		1				1					1		3	0.2
Oct. 3 & 4	2	1	3	2	1		5	4	19	12	5		54	2.7
Total	94	217	167	116	111	212	267	271	279	129	80	43	1986	
Mean	8.5	19.7	15.2	10.5	10.1	19.3	24.3	24.6	25.4	11.7	7.3	3.9		
Percentage	4.7	10.9	8.4	5.8	5.6	10.7	13.4	13.6	14.0	6.5	4.0	2.2		
							Avg.= 24.8				**Avg. = 5.6**			

*** = NET NOT OPERATING FOR 1 HOUR DURING THIS TIME**

Table 6a. Tongue River Discharge (CFS) measured at USGS gauge at Miles City and T&Y canal discharge (CFS) measured at headgate with estimated number of fish entrained and returned to Tongue River through bypass channel by sample date during the 1997 irrigation season.

Date	Tongue River Discharge (CFS)	Canal Dishcarge (CFS)	Canal Flow as % of River Flow	Turbidity Range (NTU)	Fish Entry into Canal for 24 Hrs **
May 29 &30	1855	181	10	391-514	112
June 12 & 13	1965	166	8	270-344	120
June 26 & 27	1525	171	11	179-201	665
July 10 & 11	625	169	27	102-123	396
July 21 & 22	549	174	32	73-268	530
August 11 & 12	453	189	42	95-117	139
Aug. 20 & 21	466	187	40	44-60	271
Sept. 2 & 3	397	163	41	37-44	159
Sept. 22 & 23	308	160	52	15-26	92
Oct. 9 & 10	271	142	52	204-842	126
Total					2610

Table 6b. Tongue River Discharge (CFS) measured at USGS gauge at Miles City and T&Y canal discharge (CFS) measured at headgate with estimated number of fish entrained and returned to Tongue River through bypass channel by sample date during the 2013 irrigation season.

Date	Tongue River Discharge (CFS)	Canal Dishcarge (CFS)	Canal Flow as % of River Flow	Fish Entry into Canal for 24 Hrs *	Fish Entry into By Pass for 24 Hrs*
June 1 & 2	100	105	105	16	4
June 16 & 17	80	125	156	62	67
June 28 & 29	16	147	918	72	276
July 12 & 13	19	N/A	N/A	1330	2 **
July 27 & 28	48	127	264	230	219
Aug 9 &10	54	N/A	N/A	62	309
Aug 23 & 24	21	N/A	N/A	100	216 ***
Total				1873	875

* Estimated numbers calculated from actual fish numbers collected.

** By Pass blocked with boards, sampled water that trickled around boards for 12 sample periods.

*** By Pass blocked with boards, removed boards for one 60 minute sample period.

Table 6c. Tongue River Discharge (CFS) measured at USGS gauge at Miles City and T&Y canal discharge (CFS) measured at headgate with estimated number of fish entrained and returned to Tongue River through bypass channel by sample date during the 2005 irrigation season.

Date	Tongue River Discharge (CFS)	Canal Dishcarge (CFS)	Canal Flow as % of River Flow	Fish Entry into Canal for 24 Hrs *	Fish Entry into By Pass for 24 Hrs*
May 16 & 17	1330	79	6	97	67
May 31 & June 1	1600	107	7	48	6
June 13 & 14	1350	86	6	42	1
June 29 & 30	2250	104	5	427	95
July 11 & 12	403	158	39	76	40
July 25 & 26	117	161	137	82	71
Aug. 8 & 9	80	167	209	65	61
Aug. 22 & 23	198	162	82	79	79
Sep. 7 & 8	182	140	77	199	42
Sep. 19 & 20	210	62	30	46	15
Total				1161	477

* Actual numbers of fish collected in 24 hour period.

** River flows came from provisional data, they need to be changed when corrected values are available.

Table 6d. Tongue River Discharge (CFS) measured at USGS gauge at Miles City and T&Y canal discharge (CFS) measured at headgate with estimated number of fish entrained and returned to Tongue River through bypass channel by sample date during the 2013 irrigation season.

Date	Tongue River Discharge (CFS)	Canal Dishcarge (CFS)	Canal Flow as % of River Flow	Fish Entry into Canal for 24 Hrs **	Fish Entry into By Pass for 24 Hrs**
May 16 & 17	13	N/A	N/A	94	319
May 28 & 29	261	N/A	N/A	119	520
June 13 & 14	1190	N/A	N/A	65	38
June 26 & 27	432	N/A	N/A	72	183
July 10 & 11	208	N/A	N/A	652	308
July 25 & 26	84	N/A	N/A	461	712
Aug. 7 & 8 *	203	N/A	N/A	129	131
Aug. 22 & 23	54	N/A	N/A	20	81
Sept. 5 & 6	111	N/A	N/A	16	40
Sept. 19 & 20	137	N/A	N/A	0	3
Oct. 3 & 4	135	N/A	N/A	16	62
Total				1644	2397

* One 60 minute sample period was not sampled.

** Estimated numbers calculated from actual fish numbers collected.

Table 7. Calculated wet weight (kilograms) of four categories of debris entering the T&Y Canal through headgates in 24 hour periods in 1997.

Date	Total Sampling Time (minutes)	Stream Discharge (cfs)	Gravel	Sticks	Coal	Vegetation
May 29 & 30	154	1815	4841	3252	481	32
June 12 & 13	108	1965	6144	3617	915	35
June 26 & 27	247	1525	1187	1047	216	3
July 10 & 11	560	625	83	126	11	59
July 21 & 22	470	549	7	163	5	34
Aug. 11 & 12	592	453	9	120	67	8
Aug. 20 & 21	563	465	14	269	66	19
Sept. 2 & 3	735	397	23	83	41	7
Sept. 22 & 23	1000	308	0	31	10	22
Oct. 9 & 10	975	271	0	13	0	61

Figure 1a. Estimated fish entry into T&Y Canal during the 10 sampled days of the irrigation season, 1997.

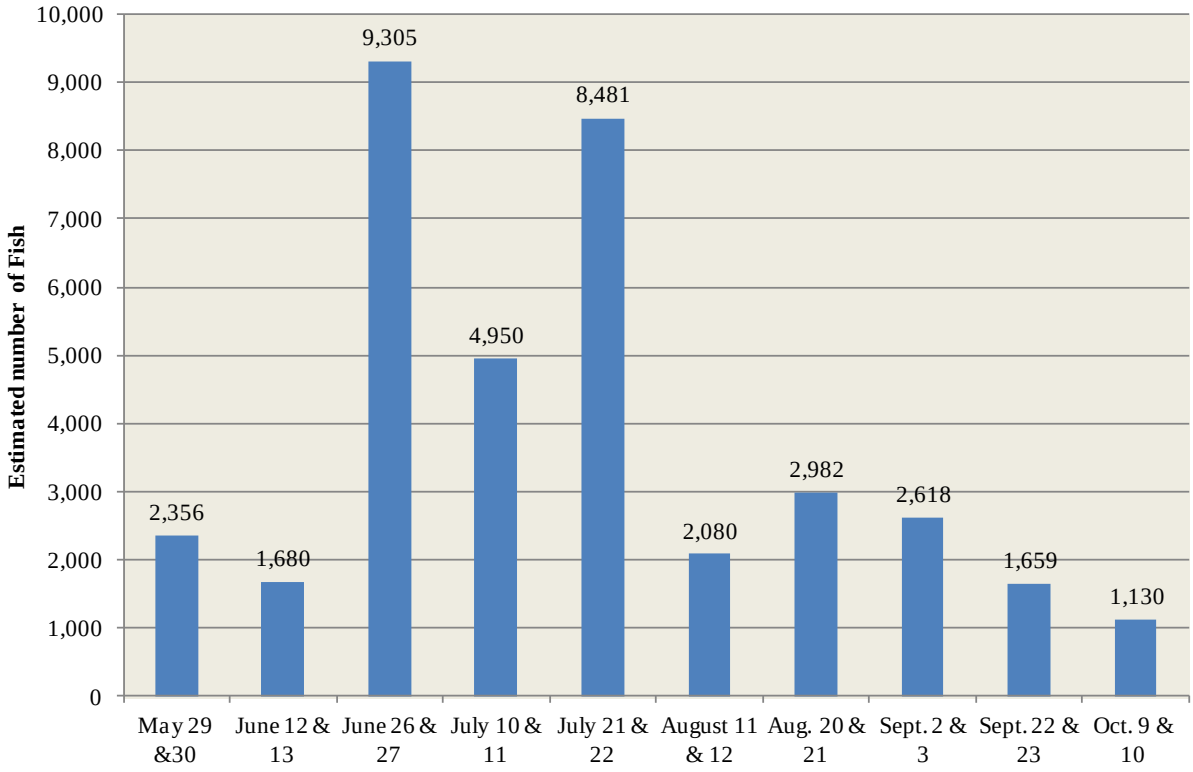


Figure 1b. Estimated fish entry into T&Y Canal and Bypass Channel during the 7 sampled days of the irrigation season, 2004.

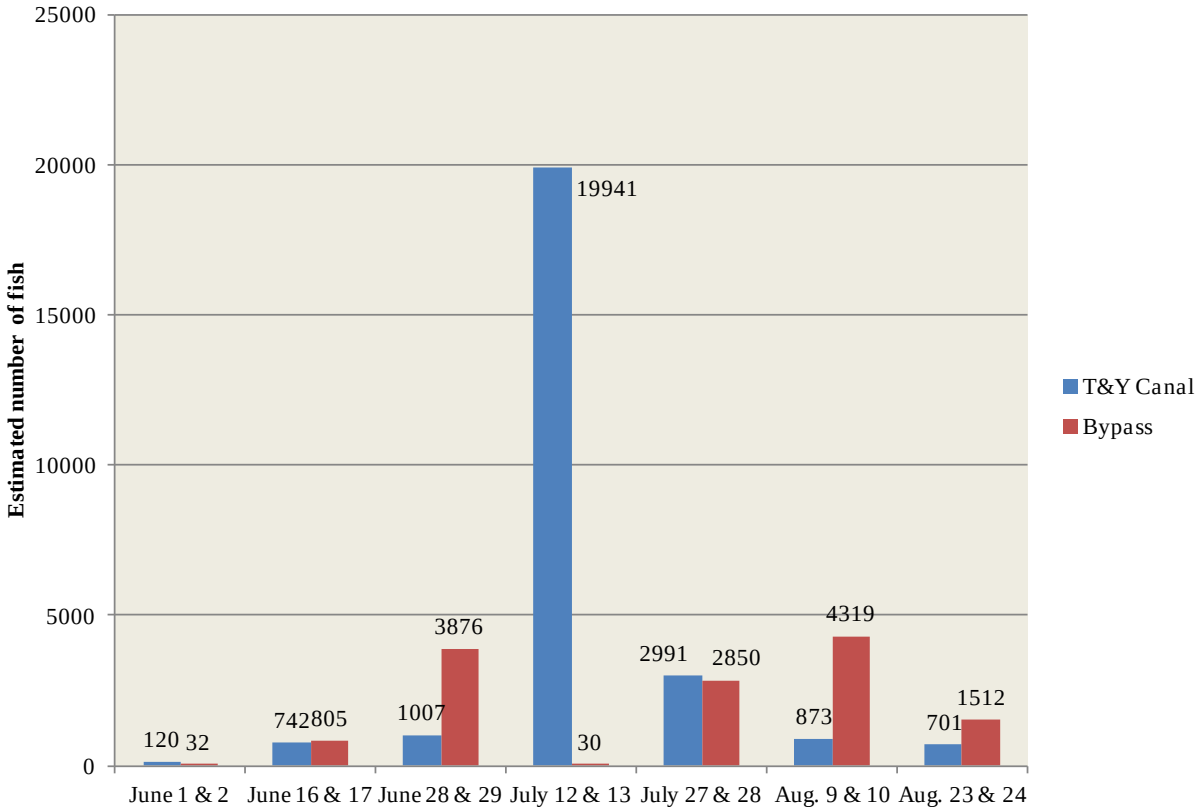


Figure 1c. Estimated fish entry into T&Y Canal and Bypass Channel during the 10 sampled days of the irrigation season, 2005.

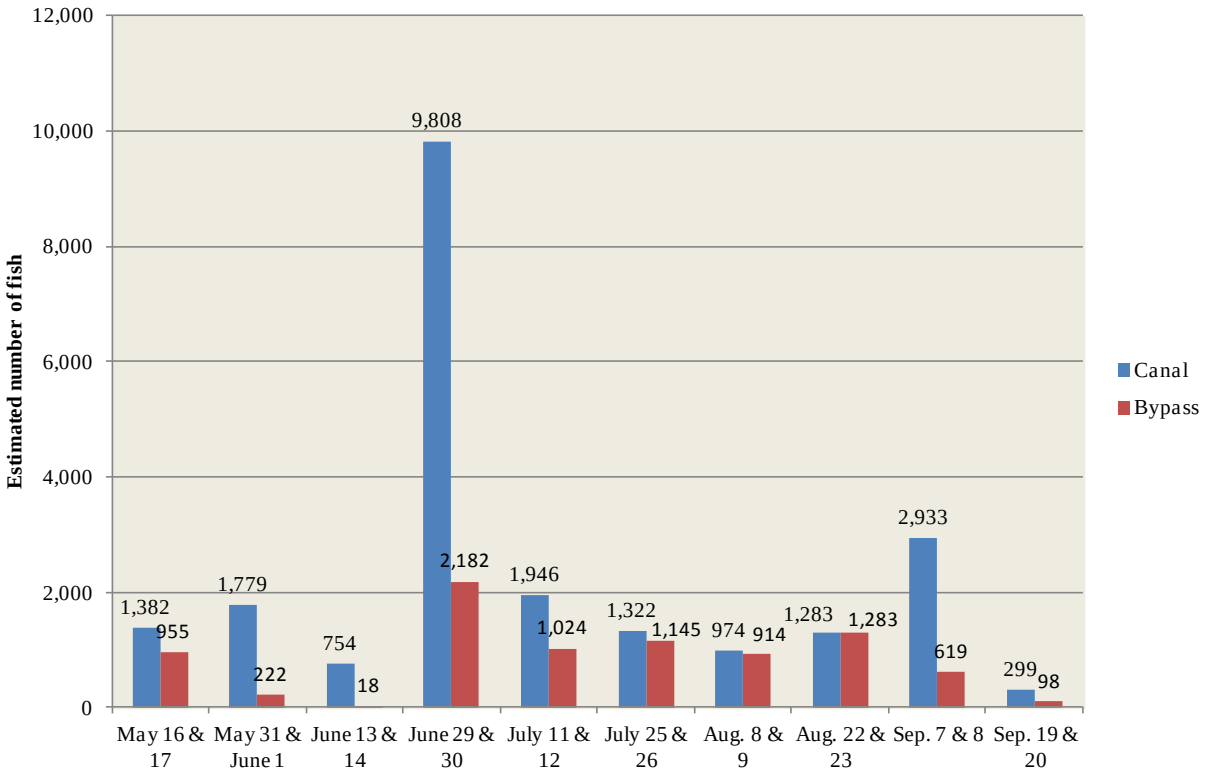


Figure 1d. Estimated fish entry into T&Y Canal and Bypass Channel during the 11 sampled days of the irrigation season,2013.

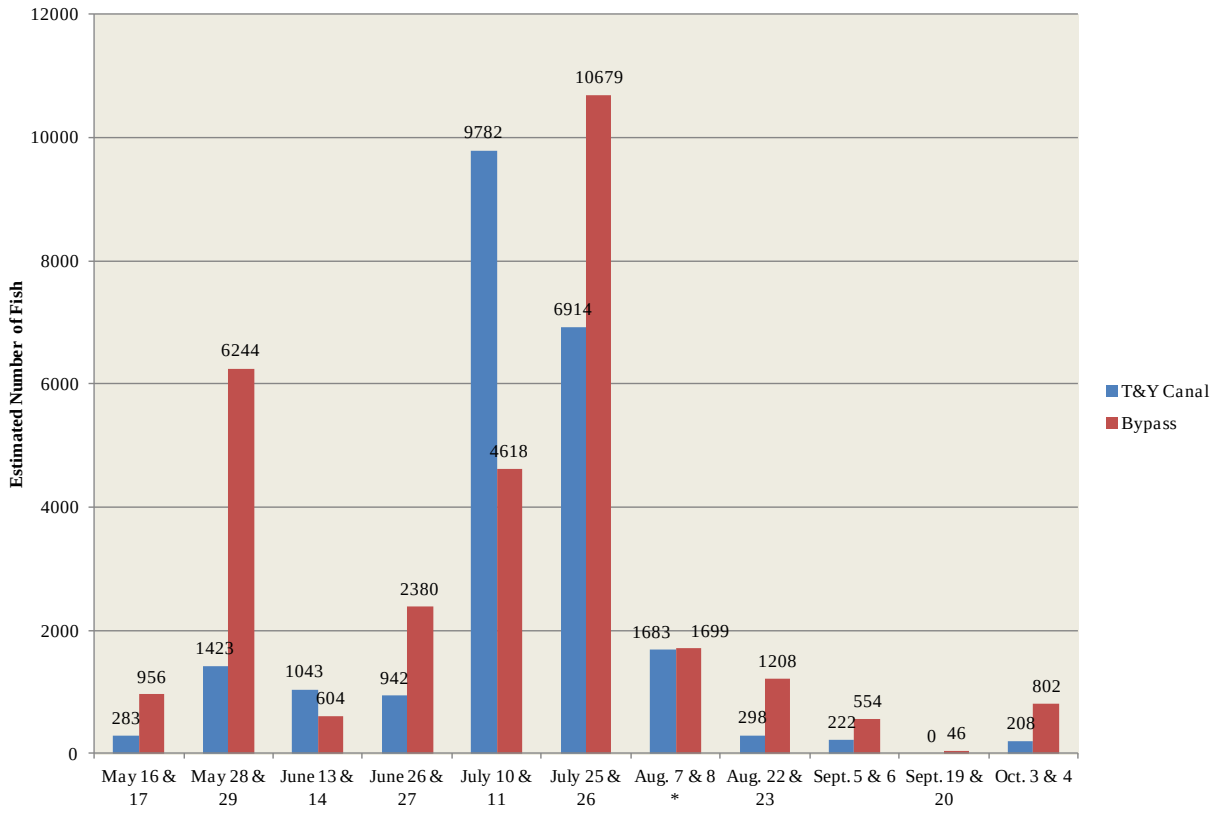


Figure 2a. Fish species composition T & Y Canal, 1997.

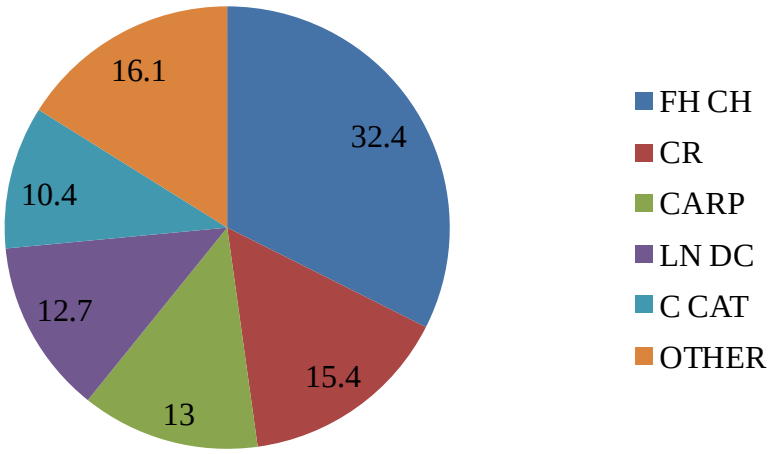


Figure 2b. Fish species composition T &Y Canal, 2004.

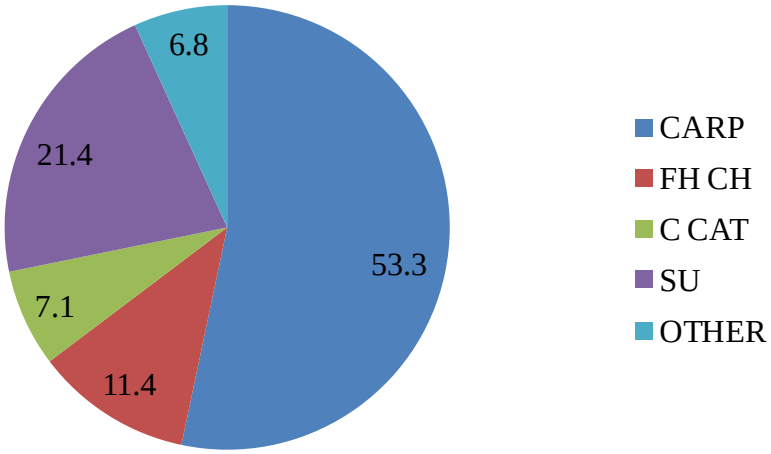


Figure 2c. Fish species composition Bypass Channel, 2004.

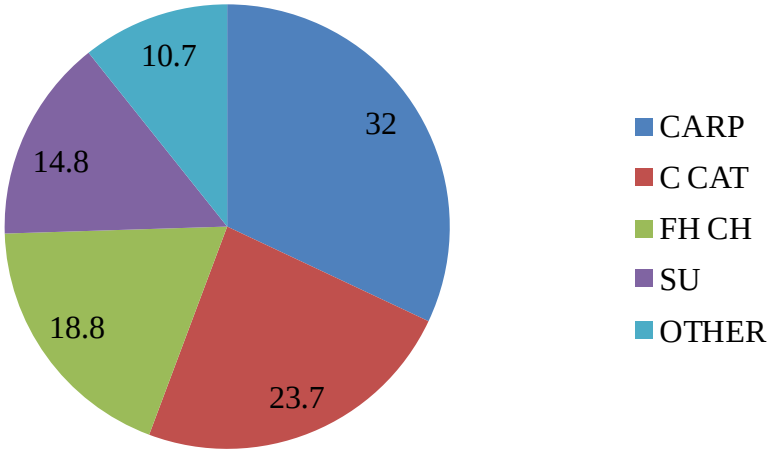


Figure 2d. Fish species composition T &Y Canal, 2005.

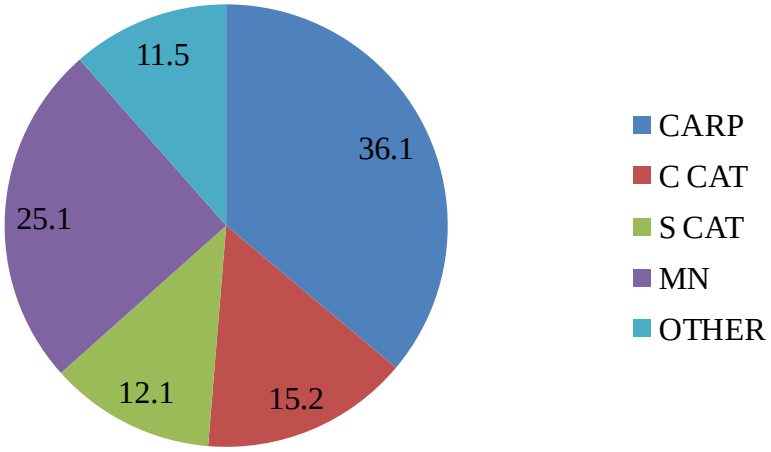


Figure 2e. Fish species composition Bypass Channel, 2005.

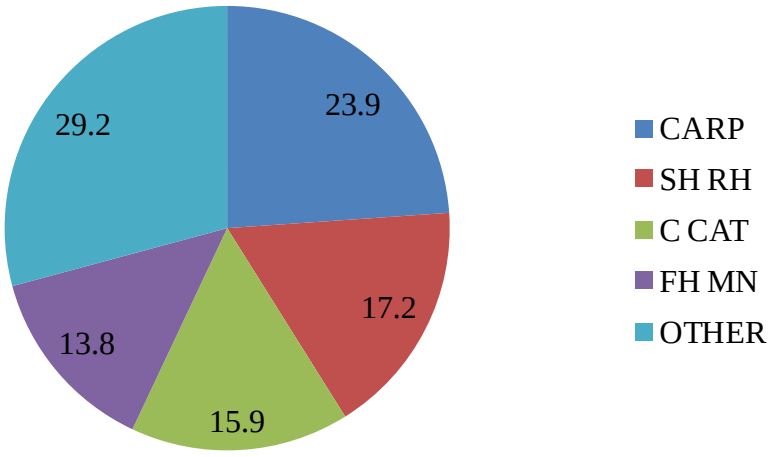


Figure 2f. Fish species composition T &Y Canal, 2013.

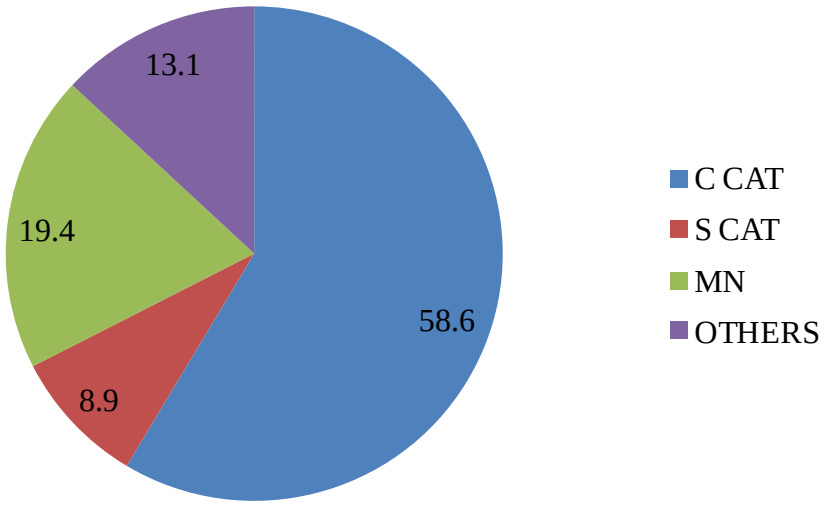
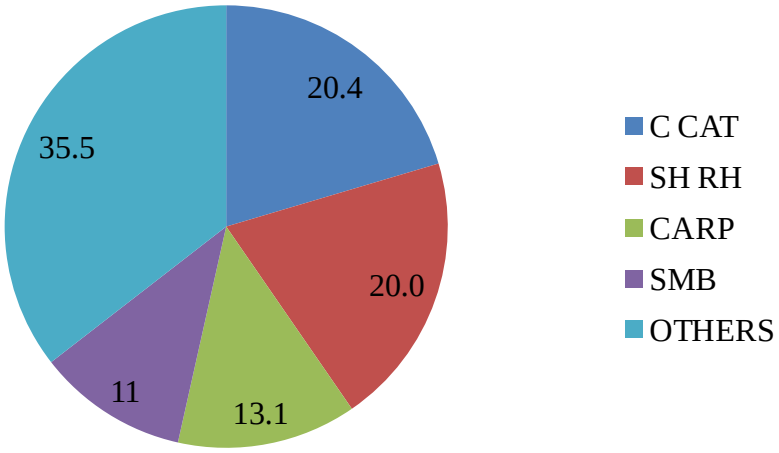


Figure 2g. Fish species composition Bypass Channel, 2013.



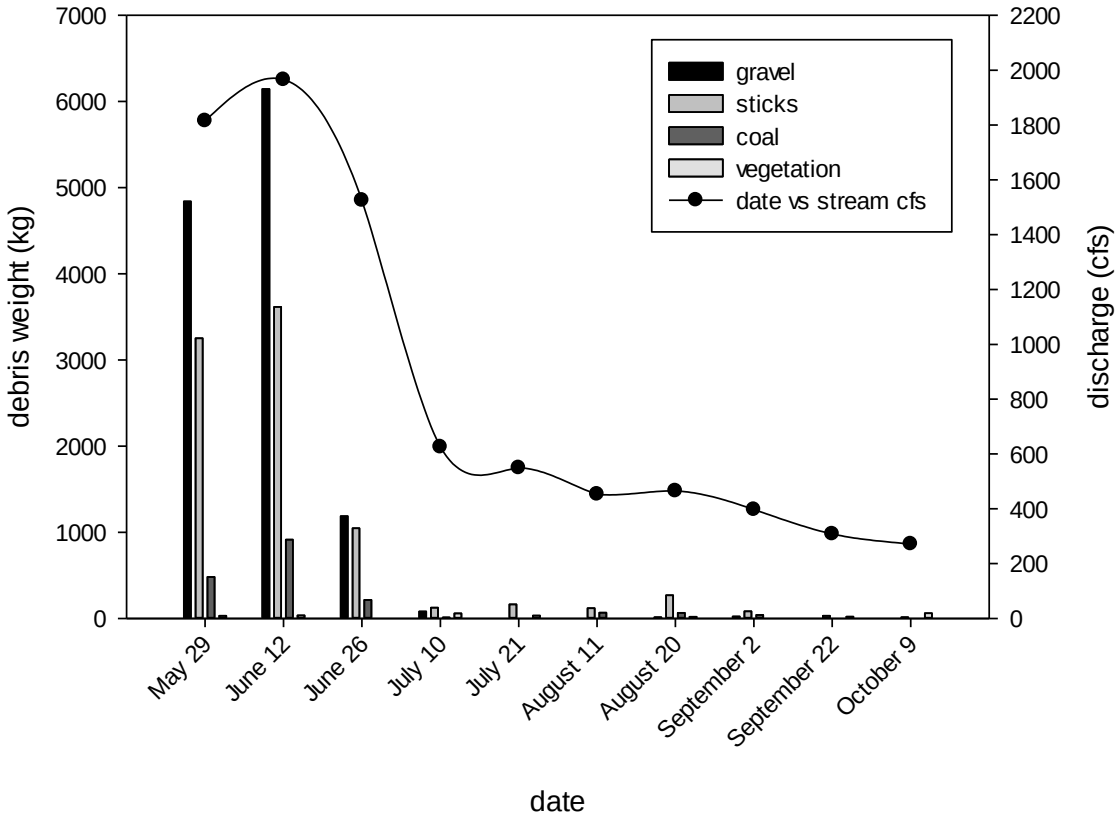


Figure 3. Calculated weight (kg) of debris entering the T & Y Canal and Tongue River discharge (CFS)
during the 1997 irrigation season.