Tongue River Fish Entrainment Study

On the T&Y Canal

May 29 to October 10, 1997

By

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ABSTRACT

Entrainment of fish and debris in the T&Y canal on the Tongue River were evaluated during the irrigation season in 1997. An estimated 37,288 fish weighing 839 kg (1847 lbs) were captured entering the T&Y canal. Captured fish were predominantly juvenile fish and represented 21 species. Flathead chubs dominated the catch and accounted for 32% of the total number of fish captured. Other abundant species captured included: crappie (white, black and undetermined), 15% of the total catch, carp, 13%, longnose dace, 13%, and channel catfish, 10%. We found no relationship between fish entry into the T&Y canal and stream discharge, percentage of canal discharge to stream discharge, or turbidity. Some fish were found to be exiting the canal at downstream locations.

Debris movement into the T&Y canal are very significant during high flow periods and appeared related to the formation of a bar immediately upstream of the headgate during the non-irrigation season. When the headgate is opened the bar is eroded in typical headcutting type of action. Solutions to both the fish entrainment problem and the debris movement into the canal will serve as a good example of how cooperative efforts can be used to benefit both agriculture operations and fish resources.

INTRODUCTION

This project was completed with the cooperation of the T&Y Irrigation District, Bureau of Reclamation, and Montana Fish, Wildlife and Parks. The T&Y diversion is located at river mile 20.4 on the Tongue River and is considered an upstream fish passage barrier to shovelnose sturgeon, goldeye, sauger, and other fish species.

The objectives of the project were to identify the: 1) numbers, size and species of fish entrained in the canal during the irrigation season, 2) quantity of debris entering the canal, 3) identification of factors that may encourage or discourage fish entrainment into the canal.

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 being considered for special status due to declining abundance. Tributary streams play a vital role for spawning, rearing, migration and a host of other functions for these fish assemblages.

The Yellowstone River and tributary streams also provide vital 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 significant problems associated with some water diversion designs. Many of the problems are associated with upstream fish migration barriers and entrainment into diversion systems by upstream or downstream migrating fish. Both problems are correctable through design changes.

This project focused on the later problem, entrainment into the diversion system by downstream migrating fish.

METHODS

Water diverted into the T&Y canal was sampled with specially designed nets that spanned the entire canal. One net was placed in each of the two openings leading from the diversion structure to the canal. The nets were constructed of ½ inch mesh size netting and fitted with a purse bag at the end to empty debris and fish into sample tubs for sorting. Fish species, lengths, and weights were recorded on all captured fish. Debris type, size, and weight was visually estimated from each sample.

Canal sampling activities occurred during the irrigation season from May 29 to October 10 for 1 day every 2 weeks. A total of ten days were sampled. Each day was subsampled by two hour period through a complete 24 hour cycle. Additional subsampling 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.

Total numbers of fish and quantity of debris was calculated by expanding the subsample results to the total period length using the appropriate expansion factor.

Four locations downstream of the diversion structure were sampled in August and September to see if fish were exiting the canal via bypass structures and the canal were it terminates at the Yellowstone River. A single net identicle to those used to sample the headgate structure were used.

RESULTS & DISCUSSION

Fish Species Composition

Twentyone fish species were captured in the T&Y canal. Non-minnow (Cyprinidae) species captured were generally juvenile fish evident by the short mean length noted in Table 1. Flathead chubs dominated the catch and accounted for 32% of the total number of fish captured (Table 2). Other abundant species captured included: carp, 13%, longnose dace, 13%, crappie (white, black and undetermined), 15%, and channel catfish, 10%.

In November, 1994 the T & Y ditch was sampled using a backpack shocker to see what fish remained after the ditch was shut down for the winter (Stewart, 1995). Four locations were sampled and 14 species were collected (Table 3). Three of these species, rock bass, mountain sucker and plains\silvery minnow (Hybognathus sp.) were not collected during the current study. Three species, flathead chub, longnose dace and channel catfish were well represented in both the fall,1994 electrofishing and the 1997 entrainment studies. Crappie represented 15 % of the fish sampled in the current study and was not observed at all in 1994. White suckers while representing not more than 4 % of the fish in the current study made up 26 % of the sample in the 1994 fall effort. Gear sampling efficiency or abundance in the river of these two species between years may explain these differences.

In the fall of 1993 K.M. Backes sampled three sections of the Tongue River near Ashland with electrofishing gear. His closest section to the T&Y canal was 70 miles upstream. Twelve trips down the 5.5 mile long section were completed and resulted in the catch of 1725 fish (Table

4). The fish species composition Backes found was very similar to the composition captured in the T&Y canal in 1997. Although the relative contribution of each species to the total fish sample differed between Backes' 1993 work and the T&Y sampling in 1997.

An estimated 37,288 fish weighing 839 kg entered the T&Y canal during the 1997 irrigation season (Table 5). The entrainment of these fish would suggest significant downstream migratory behavior of these species. This downstream movement could be a permanent displacement or a temporary life history movement which would normally be followed with an upstream migration at some later date. The later case would cause canal losses to have the most impact in upstream fish populations. The answer to this question probably is also species specific.

It should be noted that upstream fish passage problems at the T&Y diversion could possibly have the same impact as the problem with entrainment into the canal. In other words if fish need to get back upstream whether they are lost in the ditch or over the diversion structure getting back upstream will not be possible.

Seasonal Timing of Fish Movements

Estimated fish entry into the canal peaked between June 12 and August 11 (Figure 1). Fifty two percent of the total number of fish collected during this study from May 29 to October 10 came during this 2 month peak period (Table 2). Flathead chubs, carp, longnose dace, channel catfish, white sucker and black crappie were the dominant species caught during the period in descending order of occurrence in the canal (Table 6). These dominant fish species comprised 88% of the total fish captured of all species during the peak movement period. However fish losses during the non-peak loss period still add up to 48%. This is a significant number of the fish lost over a longer time period.

Diurnal Timing of Fish Movements

Migration of various fish species has been documented to be influenced by light conditions throughout fisheries literature. Some fish species have been shown to migrate primarily during daylight hours while others utilize the dark lighting conditions of night. In recognition of this diurnal timing of fish movement sampling was conducted through the full 24 hour day period.

We captured the least fish during the early morning hours 2 am to 10 am at the T&Y canal averaging 11.3 fish captured per 2 hrs (Table 7).. The greatest numbers of fish were captured 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.

Possible Fish Entrainment Factors

We looked at the effect of Tongue River stream discharge, percentage of irrigation withdrawl related to Tongue River discharge, and Tongue River turbidity 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.

No clear relationship appears to exist between stream discharge, percentage of diverted water discharge to stream discharge or turbidity and fish entry into the T&Y canal (Table 8). Low numbers of fish entered the canal at both high flows and low flows. Highest numbers of fish entered the canal at both high discharge, 1525 cfs on June 26-27, and moderate discharge, 549 cfs on July 21-22.

Fish Exiting the Canal

Three fish species were sampled exiting the canal at bypass structures where excess water is released from the canal and at the canal terminus (Table 9). The greatest number of fish captured were at the Pumkin Creek bypass which is approximately 100 yards below the headgate structure. Only flathead chubs were sampled at this location. One smallmouth bass was captured at the Bensley Creek bypass approximately 15 miles below the headgate and one white crappie was captured at the Jones Creek bypass approximately 17 miles below the headgate. Three flathead chubs were captured where the canal drains into the Yellowstone River approximately 20 miles below the head gate.

Debris Composition

Debris that collected in the sampling nets was sorted and quantities documented. 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 strongly correlated to stream discharge (Table 10). The relationship is obviously non-linear and probably approaches an exponential function.

Vegetation entry into the canal was not related to stream discharge with highest quantities following the rainfall event in October during the low discharge period.

The west collection net captured 8 to 80 times more gravel than the east net 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 in the bar formed immediately upstream of the diversion during the non-irrigation season. Modifications planned to the diversion structure need to address this non-irrigation season bar development. Channel hydraulics changed by the opening and closing of the headgate 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.

RECOMMENDATIONS

1. Upstream fish migration should be addressed at the T&Y diversion. The native fish populations of the Yellowstone River most certainly utilized a significant part of the Tongue River historically prior to fishery data collections. Opportunities to enter into partnerships for fiscal and design planning appear to be feasible. The prevention of fish losses down the canal system will result in fish displacement over the diversion dam also causing a net loss to upstream areas. Therefore fish populations will not likely benefit until both problems are addressed.

2. Entrainment of fish into the T&Y diversion that is currently being addressed needs to be completed in addition to recommendation 1. The numbers of fish currently being lost to upstream areas appears to be significant.

LITERATURE CITED

Backes, K.M. 1993. Fish population investigations for the Tongue River, 1993. Special Report State of Montana, Dept. Of Fish, Wildlife and Parks, Fisheries Division - Region 7, 11pp.

Clancy, C. 1975. Vital statistics and instream flow requirement of fish in the Montco Mine Area of the Tongue River, Montana. Montana Dept. Of Fish, Wildlife and Parks. 55 pp.

Stewart, P.A. 1995. Southeast Montana Warmwater Streams Investigations. Montana Job Progress Report, F-78-R-1, Job III-B. 13 pp.

Table 1. Fish species, length and weight summary statistics of fish captured in the T&Y canal in 1997.

	Length (mm)				Weight*(gm)				
FISH SPECIES	Minimum	Maximum	Total	Mean	Minimum	Maximum	Total	Mean	Number of Fish
Black Bullhead	105	105	105	105	10	10	10	10	1
Black Crappie	73	211	2351	138.3	1	140	747	43.9	17
Carp	24	314	6166	55.5	1	475	1386	12.5	111
Channel Catfish	40	548	14801	166.3	1	465	4095	46.0	89
Crappie *	22	84	2704	44.3	1	2	62	1.0	61
Creek Chub	180	180	180	180	70	70	70	70	1
Emerald Shiner	75	103	354	88.5	1	5	10	2.5	4
Fathead Minnow	46	65	278	55.6	1	2	6	1.2	5
Flathead Chub	45	264	34482	124.5	1	200	5118	18.5	277
Green Sunfish	36	92	399	66.5	1	25	48	8	6
Longnose Dace	47	102	8071	74.0	1	40	412	3.8	109
Longnose Sucker	43	325	1852	205.8	1	335	1218	135.3	9
Minnow **	22	75	264	44	1	5	10	1.7	6
Pumpkinseed	32	65	318	45.4	1	3	9	1.3	7
River Carpsucker	48	105	341	68.2	1	10	14	2.8	5
Sauger/Walleye ***	43	43	43	43	1	1	1	1	1
Shorthead Redhorse	207	365	4975	261.8	65	370	3095	162.9	19
Smallmouth Bass	31	192	883	110.4	1	110	379	47.4	8
Stonecat	78	158	1142	126.9	10	30	138	15.3	9
Sucker ****	25	45	396	39.6	1	1	10	1	10
Walleye	38	38	38	38	1	1	1	1	1
White Crappie	43	274	6344	117.5	1	260	1333	24.7	54
White Sucker	36	346	3408	131.1	1	370	2106	81	26
Yellow Bullhead	31	130	702	78	1	25	48	5.3	9
Yellow Perch	35	97	760	76	1	15	50	5	10
TOTAL							20376		855

*Fish to small to register on scale were given an arbitrary weight of 1 gram.

Table 2. Distribution of fish species captured among the ten sampled days and percentage of total fish caught by species.

FISH SPECIES	May 29 & 30	June 12 &13	June 26 & 27	July 10 & 11	July 21 & 22	August 11 & 12	August 20 & 21	September 2 & 3	September 22 & 23	October 9 & 10	TOTAL	PERCENT OF CATCH
Black Bullhead			1								1	0.12
Black Crappie				3	3		2	1	4	4	17	1.99
Carp			44	24	28	2		2		11	111	12.98
Channel Catfish		1	6	17	28	3	8	13	1	12	89	10.41
Crappie *						5	31	8		17	61	7.13
Creek Chub									1		1	0.12
Emerald Shiner		1		3							4	0.47
Fathead Minnow				2		1		2			5	0.58
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	12.75
Longnose Sucker			5		1	1		1	1		9	1.05
Minnow **			1	3			1	1			6	0.12
Pumpkinseed										7	7	0.82
River Carpsucker			3						1	1	5	0.58
Sauger/Walleye ***			1								1	0.12
Shorthead Redhorse			3	2		4	1	3	1	5	19	2.22
Smallmouth Bass				4					1	3	8	0.94
Stonecat			1	1		1	2	1		3	9	1.05
Sucker ****			5	4		1					10	1.17
Walleye				1							1	0.12
White Crappie	1			2	9	17	6	6	7	6	54	6.32
White Sucker			1	16		1	1	2	4	1	26	3.04
Yellow Bullhead	1	3	1			2		1		1	9	1.05
Yellow Perch					2				1	7	10	1.17
TOTAL	12	9	114	154	173	57	106	81	64	85	855	99.42
				52%								

Table 3. Fish sampled at four locations in the T&Y Canal using electrofishing gear on November 7, 1994 (Stewart 1995).

Location	Species	N*	N**	Range in Length (mm)	Mean Length (mm)
0.25 Miles	Channel Catfish	20	33	71-255	91
Below	Stonecat	6	12	85-170	125
Headgate	Rock Bass	4		50-64	56
	Shorthead redhorse	4	6	83-122	96
	White sucker	4	20	98-195	127
	Longnose sucker	6		66-132	107
	Mountain sucker	3		72-113	88
	Carp	3		145-162	153
	Flathead chub	11	25	51-68	59
	Longnose dace	8	29	42-81	58
Bill	Green sunfish	2	2	72-174	79
Jones	Shorthead redhorse	1			62
Farm	Longnose sucker	1			35
	White sucker	10	23	55-174	96
	Carp	2		160-188	174
	Black bullhead	1			122
	Fathead minnow	3	2	35-60	47
	Flathead chub	1	5		85
	Longnose dace	1	7		35
	Plains/silvery minnow	2	10	40-45	43
Oschner	Channel catfish	2	15	95-95	95
Farm	Shorthead redhorse	1			65
	White sucker	10	23	65-225	109
	Longnose sucker	1			176
	Mountain sucker	1			80
	Carp	1			140
	Flathead chub	6	11	50-95	76
	Fathead minnow	1			70
	Longnose dace	5	13	50-65	57
Baker	White sucker	3		50-210	121
I-94	Longnose dace	1			62
Interchange					

N* Number weighed and measured.
N** Number counted only.

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 5. Estimated numbers and weight of fish entering the T&Y Canal during the irrigation season in 1997 based upon sanpling expansion.

	DATA PER SAMPLE					DATA PER 24 HOURS			IRRIGATION SEASON	
DATE	SAMPLE TIME IN MINUTES	FACTOR	FISH SAMPLED	COMBINED FISH WEIGHT (grams)	MEAN WEIGHT (grams) PER FISH	TOTAL FISH IN 24 HOURS	COMBINED FISH WEIGHT (grams) IN 24 HOURS	DAYS IN A PERIOD	TOTAL FISH NUMBERS IN SEASON	TOTAL FISH WEIGHT (grams) IN SEASON
May 29 & 30	154	9.35	12	185	15.42	112.2	1730	21	2356.2	36333
June 12 & 13	108	13.33	9	79	8.78	119.97	1053	14	1679.6	14747
June 26 & 27	247	5.83	114	3018	26.47	664.62	17592	14	9304.7	246295
July 10 & 11	560	2.6	154	3003	19.5	400.4	7808	12.5	5005.0	97598
July 21 & 22	470	3.06	173	2864	16.55	529.38	8761	16	8470.1	140180
August 11 & 12	592	2.43	57	1806	31.68	138.51	4388	15	2077.7	65820
August 20 & 21	563	2.56	106	1410	13.3	271.36	3609	11	2985.0	39700
September 2 & 3	735	1.96	81	3186	39.33	158.76	6244	16.5	2619.5	103027
September 22 & 23	1000	1.44	64	2429	37.95	92.16	3497	18	1658.9	62954
October 9 & 10	975	1.48	85	2396	28.19	125.8	3546	9	1132.2	31917
TOTAL			855	20376		2613.16	58230	147	37288.8	838569

Figure 1. Estimated fish entry into the T&Y Canal during the ten sampled days of the irrigation season.

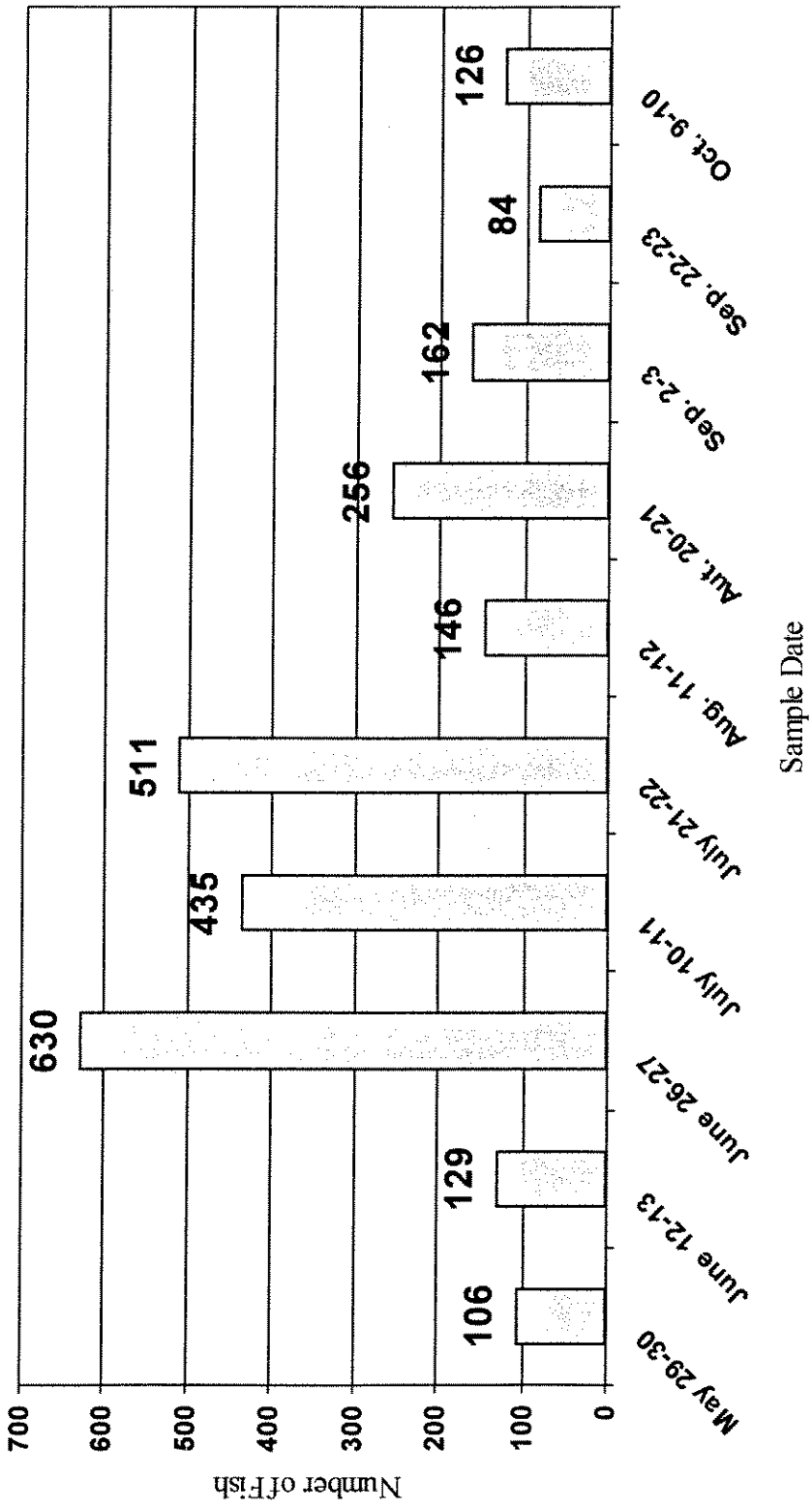

Table 6. Dominant fish species captured entering the T&Y Canal during the peak movement period between June 13 and August 11, 1997.

Species*	Number for Period	Percent for Period
Carp	96	22
Channel catfish	51	12
Flathead chub	135	31
Longnose dace	81	18
White sucker	17	4
Black crappie	6	1
Total	386	88

* 441 total fish representing 21 species were captured for the period.

Table 7. Diurnal timing of fish movements into the T&Y Canal by two hour sampling intervals.

	CALCULATED FISH ENTRY INTO THE T&Y CANAL BY TWO HOUR INERVALS												
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
May 29 & 30	11.4	0	16	12.6	9.2	0	24	0	0	12	24	0	109.2
June 12 & 13	0	24	0	45	15	30	0	0	0	15	0	0	129
June 26 & 27	68.8	36	54	84	77.4	96	66	50	20	48	30	0	630.2
July 10 & 11	34.2	60.9	51	84	36	30	33.6	60	8.7	12	12.8	12	435.2
July 21 & 22	48	45	57.6	69	72	21	81	24	24	15	42	12	510.6
August 11 & 12	15	21	9	20.3	12	15	9.6	4	8	4	24	4	145.9
August 20 & 21	16.8	12	26.4	59.4	33.6	26.4	14	21.6	12	6	15.6	12	255.8
September 2 & 3	14.4	4	30	22	24	16	16	12	6	5.4	5.1	6.8	161.7
September 22 & 23	3.4	8.4	20.4	13	14.4	6	10	1.6	3.3	0	1.4	2.4	84.3
October 9 & 10	8.8	4.5	13.5	16.5	7.5	10.5	9	8.4	5.2	7.8	19.5	15	126.2
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	2588.1
MEAN	22.08	21.58	27.79	42.58	30.11	25.09	26.32	18.16	8.72	12.52	17.44	6.42	
			AVERAGE = 33.5						AVERAGE = 11.3				

Table 8. Micellaneous phyiscal data related to the T&Y Canal fish entrainment study, 1997.

Date	River Flow at Miles City	Canal Flow	Canal Flow as % of River Flow	Turbidity Range (NTU)	Fish Entry into Canal for 24 Hrs
May 29-30	1855	181	9.97	391-514	112.2
June 12-13	1965	166	8.45	270-344	119.97
June 26-27	1525	171	11.21	179-201	629.64
July 10-11	625	169	27.04	102-123	2023.4
July 21-22	549	173.5	31.6	73-268	529.38
August 11-12	453	188.5	41.61	95-117	136.08
August 21-22	465.5	186.5	40.06	44-60	271.36
September 2-3	397	163	41.06	37-44	158.76
September 22-23	308	159.5	51.79	15-26	92.15
October 9-10	271	141.5	52.2	204-842	125.8

Table 9. Fish captured leaving the T&Y Canal at four locations, 1997.

Location	Date	Species	Number Captured	Range in Length (mm)	Mean Length (mm)	Sample Time (minutes)
Pumkin	8/28/97	Flathead Chub	5	84-125	104	40
Creek	9/19/97	No Fish				42
Bypass	9/29/97	Flathead Chub	6	88-175	124	40
Bensley	8/28/97	No Fish				20
Creek	9/19/97	No Fish				20
Bypass	9/29/97	Smallmouth Bass	1		158	20
Jones	8/18/97	No Fish				20
Creek	8/29/97	No Fish				15
Bypass	9/19/97	White Crappie	1		157	20
	9/26/97	No Fish				20
T&Y Canal Terminus	8/18/97	Flathead Chub	3	50-72	63	20

Table 10. 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
5-29/30	154	1815	4840.97	3251.93	480.89	31.68
6-12/13	108	1965	6144.37	3617.08	915.16	34.98
6-26/27	247	1525	1186.69	1046.60	215.56	2.88
7-10/11	560	625	82.81	125.66	10.94	58.97
7-21/22	470	549	7.25	162.62	4.62	33.57
8-11/12	592	453	9.45	119.54	66.81	7.7
8-20/21	563	465	13.62	268.62	65.83	18.56
9-2/3	735	397	22.96	83.10	40.51	6.99
9-22/23	1000	308	0.22	30.91	9.81	22.07
10-9/10	975	271	0.01	12.64	0.04	60.81