Fish loss and movement in irrigation diversions from the West Gallatin River, Montana
by William D Clothier

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree
of Master of Science in Fish and Wildlife Management

Montana State University

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Fish loss and movement in irrigation diversions from the West Gallatin River, Montana, was investigated during 1950 and 1951. Two-way fish weirs were employed to study fish movement in the Keughen (70.3 cfs) and Low Line (147.5 cfs) Canals. Operation of the weirs was prevented during the spring and fall segments of irrigation seasons by debris-laden water. The Keughen weir operated 61 days in 1950 and 84 days in 1951. A total of 29 trout, 37 whitefish, and 758 non-game fish made up the initial fish movement the first season. There were 55 trout, 77 whitefish, and 767 non-game fish in the initial movement the second season. The Low Line weir operated 41 days in 1951 and had a total of 77 trout, 26 whitefish, and 94 non-game fish showing initial movement during this period. Random movement was shown by all species of fish except cutthroat trout. The up-canal movement of 59 trout was correlated with severe water reductions in the Low Line Canal. This was 88% of all up-canal migrant trout during the 41 days of weir operation. Fish loss (or gain) through the weirs was established by actual counts. Thirteen canals were sampled for fish loss. Game fish concentrations were found near headgates, near creeks where they entered a canal, and in 1 spring-fed ditch. Brook trout was the dominant trout species in the vicinity of creeks and springs. Fish loss did not seem to be correlated with canal length or volume of flow. There was an estimated loss of 2,835 legal game fish (7 or more inches in length) weighing 1,186 pounds in 11 of the canals studied.

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FROM THE WEST GALLATIN RIVER, MONTANA

by

William D. Clothier

A THESIS

Submitted to the Graduate Faculty

in

partial fulfillment of the requirements

for the degree of

Master of Science in Fish and Wildlife Management

at

Montana State College

Approved:

Head, Major Department

Chairman, Examining Committee

Dean, Graduate Division

Bozeman, Montana
June, 1952

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Abstract

Fish loss and movement in irrigation diversions from the West Gallatin River, Montana, was investigated during 1950 and 1951. Two-way fish weirs were employed to study fish movement in the Keughen (70.3 cfs) and Low Line (147.5 cfs) Canals. Operation of the weirs was prevented during the spring and fall segments of irrigation seasons by debris-laden water. The Keughen weir operated 61 days in 1950 and 84 days in 1951. A total of 29 trout, 37 whitefish, and 758 non-game fish made up the initial fish movement the first season. There were 55 trout, 77 whitefish, and 767 non-game fish in the initial movement the second season. The Low Line weir operated 41 days in 1951 and had a total of 77 trout, 26 whitefish, and 94 non-game fish showing initial movement during this period. Random movement was shown by all species of fish except cutthroat trout. The up-canal movement of 59 trout was correlated with severe water reductions in the Low Line Canal. This was 88% of all up-canal migrant trout during the 41 days of weir operation. Fish loss (or gain) through the weirs was established by actual counts. Thirteen canals were sampled for fish loss. Game fish concentrations were found near headgates, near creeks where they entered a canal, and in 1 spring-fed ditch. Brook trout was the dominant trout species in the vicinity of creeks and springs. Fish loss did not seem to be correlated with canal length or volume of flow. There was an estimated loss of 2,835 legal game fish (7 or more inches in length) weighing 1,186 pounds in 11 of the canals studied.

Introduction

Fish loss in irrigation diversions in Montana was a management issue even before the turn of the century. An attempt was made to prevent fish loss as early as 1893 when legislation was passed requiring screens to be placed in ditches from September 1 to March 1, during the period of little or no water use. The law obviously had no practical value and was repealed in 1897. No further legislation concerning screens has been enacted since that time.

An early typical account placed the loss of fish in the thousands for a single canal (Montana Fish and Game Department, 1904). Periodic pleas for control measures stimulated investigations of screening devices by the State Fish and Game Department. A few of the experimental installations were considered successful, but in 1942 the Department reported that annual maintenance for a statewide screening program would cost three times as much money as was available for the operations of the entire Fisheries Division (Montana Fish and Game Department, 1942). While past work in Montana was directed toward control, little quantitative information has been secured on the actual loss or the factors affecting it. Answers to inquiries indicate the same unsolved problem exists in other western states and provinces of Canada having a serious loss of non-migratory fish in irrigation diversions.

Data for the present study of fish loss and movement in irrigation diversions were collected during the 1950 and 1951 irrigation seasons (June to October). Observations were confined to the diversions of the West Gallatin River, Gallatin County, Montana.

Acknowledgments

The writer extends thanks to Dr. C. J. D. Brown who directed the problem and assisted in preparing the manuscript. The Montana Fish and Game Department furnished considerable time of field personnel, gave financial assistance and contributed weir materials. Mr. John Spindler and Mr. George Holton gave valuable field assistance. The help of Mr. Bill Papke, River Commissioner, in securing information on the various canals is gratefully appreciated. Thanks are also due the United States Fish and Wildlife Service, Missouri River Basin Studies, and the farmers and ranchers of Gallatin Valley for their cooperation.

Description of the West Gallatin River in the study area

The section of the West Gallatin River under observation (approximately 20 miles) extends from near the mouth of Gallatin Canyon to 1300 feet downstream from Irwin Bridge. The stream emerges from the canyon at about 5000 feet elevation and flows north through the west side of Gallatin Valley. Its gradient is approximately 34 feet per mile. Maximum channel width is 150 feet, and the average is near 70 feet. In several places the stream flow is divided into two or more channels as it passes through the relatively narrow flood plain (approximately 200 to 500 yards wide). Pools are slightly less abundant than riffles. Bottom materials are predominantly rubble and gravel and stream banks are generously covered by shrubs and cottonwood trees. Trout production is good. Intensive creel census in the study area disclosed an average rate of catch per fisherman hour of 0.57 (0.36 of a pound) in 1949 and 0.51 (0.35 of a

pound) in 1950 (Missouri River Basin Studies, 1951).

A total of 52 diversion canals originate within the study section. They range in size from 1 to 268 second-feet (decreed right) and irrigate approximately 90,000 acres. None of the diversions is screened. Each year some of the West Gallatin River below Irwin Bridge is subject to varying degrees of drying-up from dewatering practices. Pools become warm and stagnant and it is not unusual for many fish to die. In 1950 about 2 miles of the West Gallatin River in this area was lost due to dewatering. The average diverted flow of 822 second-feet (discounting return flows) varied from 1620 on June 5, to 387 on September 15. From 1930 to 1945 the average annual river flow was 682 second-feet. A minimum annual flow of 533 second-feet was recorded for the water year (October 1 to September 30) 1940-41, and a maximum annual flow of 956 second-feet occurred during the water year 1947-48 (Missouri River Basin Studies, 1951).

Species of fish found in the study area were rainbow trout (Salmo gairdnerii), brown trout (Salmo trutta), cutthroat trout (Salmo clarkii), eastern brook trout (Salvelinus fontinalis), mountain whitefish (Prosopium williamsoni), longnose sucker (Catostomus catostomus), white sucker (Catostomus commersonnii), sculpin (Cottus punctulatus bairdii), and longnose dace (Rhinichthys cataractae). Numerous rainbow-cutthroat hybrids were present, but for purposes of this study they were classified as rainbow or cutthroat, depending on which trait was dominant.

Fish movement in irrigation canals

A two-way fish weir, modified from a design described by Shetter (1938), was installed in the Keughen Canal in the spring of 1950 and another of similar design was placed in the Low Line Canal in the spring of 1951 for the purpose of securing information on the effect of water temperature and fluctuation on daily and seasonal movement of fish. The intakes of these two canals are approximately one-quarter mile apart on the same side of the river (Fig. 1). The Keughen Canal is of medium size (70.3 cfs) and the Low Line (147.5 cfs) is large in comparison with other canals of the area. Each of these ditches had a reputation for taking many fish. An effort was made to prevent fish loss in the Keughen Canal by local sportsmen in 1935. They installed a stationary-bar type screen with a paddle wheel scraper, but this device required so much maintenance that it was removed in 1936.

The Keughen Canal fish weir (Fig. 2) was placed 200 feet behind the headgate in order not to retard the flow at the intake. The main arm of the weir consisted of a grid with $\frac{1}{2}$ -inch openings. This was effective in taking fish over 5 inches in total length. The Low Line Canal fish weir (Fig. 2) was placed 160 feet behind the headgate, and its grid had openings of $\frac{1}{2}$ to $\frac{3}{4}$ inches. This spacing stopped most of the fish over 7 inches in total length.

The fish captured each day were weighed to the nearest 0.01 of a pound, and their total lengths were taken to the nearest 0.1 of an inch. Each fish was fin clipped and allowed to continue in the direction it was going when caught.

Fig. 1. A 20-mile section of the West Gallatin River showing the 13 canals studied.

Determination of fish loss for whole irrigation seasons was not possible because debris carried by spring run-off delayed weir operations 4 to 7 weeks, and operations had to be discontinued about 4 weeks early each fall because of leaves. The Keughen weir was operated 61 days in 1950--July 27 to September 26, and 84 days in 1951--June 28 to September 19. The Low Line installation was maintained 41 days from July 18 until the canal was turned off August 27, 1951.

Daily maximum and minimum water temperatures were taken at the Keughen fish weir. The water temperatures at this station were identical with those taken at the Low Line weir and in the river at the canal intakes. Canal water levels were recorded daily. A gage was maintained during the 1951 season in the West Gallatin River near the weir sites.

Initial movement

Two groups of fish are considered in relation to movement--those which were already in the canal when the trap was installed (up-canal migrants) and those which came down the canal subsequent to its installation (down-canal migrants). The total number of initial down-canal migrants in the Keughen Canal during the 61-day trap operation in 1950 was 502, and the initial number of up-canal migrants was 322. During the 84-day period of 1951, 546 fish showed initial down-canal movement and 353 initial up-canal movement (table 1). There were 24 down-canal trout migrants taken the first season, and 14 or 58.3% of these were cutthroat. This was not to be expected since cutthroat comprised less than 2% of all trout recorded in the 1950 creel census for the adjacent section of the

Fig. 2. A. Keughen Canal fish weir. B. Low Line Canal fish weir.

West Gallatin River (Missouri River Basin Studies, 1951). In the second season 38 trout moved down the canal with brook trout (13) and rainbow trout (12) predominating. There were only 5 up-canal trout migrants in 1950 as compared to 17 in 1951. Every trout species was represented in this up-canal movement except cutthroat. Trout comprised 3.5% of the 824 initial migrants the first year and 6.1% of 899 the second year.

Whitefish were also taken more frequently the second year. They numbered 77 or 8.6% of the total initial movement in 1951 as compared to 37 (4.5%) in 1950.

Suckers showed a greater movement than any other species, but their total number decreased from 374 the first season to 338 the second season. About 1% of these were white suckers and the rest were longnose.

Sculpins made up a substantial number of the initial fish movement. Their greatest abundance was reached in 1951 when 171 entered the up-canal trap.

Dace were relatively abundant both years. They comprised 14.6% of the total initial movement in 1950 compared to 12.9% in 1951.

Only a few large fish were taken in the Keughen Canal (table 1). One brown trout in 1950 and 2 in 1951 were over 17 inches in total length. Six of the whitefish captured exceeded 10 inches in total length. There were few suckers of intermediate size (9 to 16 inches). Most of the specimens taken were less than 9 inches in length.

Initial movement in the Low Line Canal during the 41 days of observation in 1951 consisted of 65 down- and 132 up-canal migrants (table 2). Of these 197 fish, 39.1% were trout, 13.2% were whitefish, and 31.5% were

Table 1. Initial fish movement in the Keughen Canal

July 27 to September 26, 1950

Species	Movement		Percentage movement			Length in inches (total movement)	
	down	up	down	up	total	average	range
Rainbow	5	0	1.0	0.0	0.6	6.2	4.6- 8.4
Cutthroat	14	0	2.8	0.0	1.7	7.8	5.9-10.0
Brook	3	3	0.6	0.9	0.7	7.0	2.5- 8.4
Brown	2	2	0.4	0.6	0.5	---	2.6-18.7
Whitefish	33	4	6.6	1.3	4.5	4.2	2.6-13.7
Suckers	209	165	41.6	51.3	45.4	5.3	2.6-17.7
Sculpins	156	108	31.1	33.5	32.0	3.1	2.0- 5.0
Dace	80	40	15.9	12.4	14.6	3.8	2.4- 5.8
Total	502	322	100.0	100.0	100.0		

June 28 to September 19, 1951

Rainbow	12	7	2.2	2.0	2.1	5.7	2.4-14.5
Cutthroat	5	0	0.9	0.0	0.6	8.5	5.9-11.0
Brook	13	5	2.4	1.4	2.0	5.1	2.4- 9.6
Brown	8	5	1.5	1.4	1.4	6.5	2.7-18.3
Whitefish	63	14	11.5	4.0	8.6	3.8	2.5-12.3
Suckers	211	127	38.6	36.0	37.6	5.9	2.3-17.4
Sculpins	142	171	26.0	48.4	34.8	3.3	2.0- 5.1
Dace	92	24	16.9	6.8	12.9	3.9	2.5- 6.2
Total	546	353	100.0	100.0	100.0		

Table 2. Initial fish movement in the Low Line Canal, July 18 to August 27, 1951

Species	Movement		Percentage movement			Length in inches (total movement)	
	down	up	down	up	total	average	range
Rainbow	1	33	1.5	25.0	17.3	11.3	7.0-18.5
Cutthroat	4	1	6.2	0.8	2.5	7.3	5.1- 8.6
Brook	0	9	0.0	6.8	4.6	9.5	5.5-12.9
Brown	5	24	7.7	18.2	14.7	10.2	6.9-20.0
Whitefish	9	17	13.8	12.9	13.2	10.8	4.0-15.9
Suckers	37	25	56.9	18.9	31.5	7.9	5.9-18.2
Sculpins	7	13	10.8	9.8	10.1	3.6	3.0- 4.3
Dace	2	10	3.1	7.6	6.1	5.3	4.7- 5.7
Total	65	132	100.0	100.0	100.0		

suckers. Only 10 trout moved down the canal compared to an initial up-canal movement of 67. Suckers again showed more initial movement than any other species.

The two largest trout taken in the Low Line Canal included a brown trout (20 inches, 3.53 pounds) and a rainbow trout (18.5 inches, 2.02 pounds). An additional 6 trout and 5 whitefish exceeded 1 pound each. The largest whitefish was 1.70 pounds. Only 1 sucker larger than 9.7 inches was taken.

Random movement

In 1950 all down-canal migrant trout in the Keughen Canal remained down, and all but 1 (brook trout) of the up-canal migrants remained up. Of the trout captured in this ditch the second year, 1 down-canal rainbow migrant came back up and returned down a second time, and 1 up-canal migrant of this same species returned down. The random movement for brook trout was exactly the same as that for rainbow. None of the 1951 down-canal brown trout migrants returned to the river, but of the up-canal migrants, 1 went back down and stayed.

There was no random whitefish movement observed the first year, but in 1951, 3 down-canal whitefish migrants circled back and down the canal a second time. Three of the up-canal whitefish migrants went back down and stayed.

There were 4 down-canal migrant suckers in 1950 that came back up and then moved down a second time, while 103 of the up-canal sucker migrants went back down. Six of these moved up the canal a second time but only 1

of them stayed. A total of 19 down-canal sucker migrants in 1951 moved back up only to return down a second time, and 2 of these came back up again and returned down a third time. The number of up-canal sucker migrants that went back down the second year was 105, and of these 3 came up and returned down again.

Only 1 down-canal sculpin migrant moved back up and then down the canal during the first season. A total of 21 up-canal migrants of this species went back down, and 3 of these came back out and stayed. Five of the down-canal migrants the second year returned back out of the canal. There were 28 up-canal migrants which returned down. Two of these made a second round trip through the traps.

Of the dace that were observed to move down the Keughen Canal in 1950, 6 made a complete circle back through the traps. Eight of the up-canal migrants moved back down, and 1 of these moved up and returned down the canal a second time. There were 17 down-canal dace migrants in 1951 that moved up and then returned down the canal. Four of these made still another round trip through the traps. Only 5 of the up-canal migrants showed random movement back down the canal. One of these moved up a second time and stayed.

Of all initial down-canal migrants in the Low Line Canal, 1 brown trout and 7 suckers came back up and stayed. The up-canal migrants which returned back down the canal included one each of rainbow trout, brown trout, and whitefish. The brown trout came back up a second time and stayed.

Movement in relation to temperature and water levels

The most concentrated down-canal movement of trout and whitefish in the Keughen Canal occurred both years during the third week in September. Mean weekly water temperatures for these periods (48.4° and 49.1°F) were the lowest reached while the trap was in operation. The temperature decline in each case was associated with rainy weather. Huntsman (1945) described freshets as a stimulant to the movement of certain salmonids and other fish. During the period August 2-8, 1951, twice as many trout and whitefish (14) moved down the Keughen Canal than were captured in the previous 5 weeks. This increased movement followed a day of heavy precipitation (0.99 of an inch). However, there was no marked increase in trout or whitefish movement following 2 days of rain of intermediate intensity (0.54 and 0.58 of an inch) which occurred 3 weeks later.

The 59 suckers that moved up the Keughen Canal during the first 5 weeks of trap operation (July 27 to August 30) in 1950 was about twice the down-canal number. Down-canal sucker migrants for the week August 31 to September 6 totaled 95, which was 5 times greater than for any previous week. Up-canal numbers increased, but to a lesser degree. The mean water temperature this week (58.7°F) was the highest recorded for the entire study period. Sucker movement in the second year could not be correlated with warm or cool periods.

More suckers moved down the canal during the day than at night in the week of highest mean water temperature. There were 50 day-time migrants as compared to 23 night migrants in a 3-day period. No day-time up-canal movement occurred on these days. With the exception of this period, only

an occasional fish of any species was taken in the traps during the day-time.

Sculpin movement increased both seasons after the end of August. Minimum dace movement coincided with low water temperatures. Those taken between June 28 and July 21 carried spawning colors and several were ripe.

Fish movements in the Keughen Canal were not observed to be affected by water reductions, but in the Low Line Canal a direct correlation existed between severe water fluctuations and trout movement upstream (Fig. 3). A total of 43 trout moved into the up-canal trap in the 3 days following a water reduction of 41 cfs (August 2). The volume of flow was decreased to about one-quarter of the canal capacity at this time. On August 16 the flow was reduced by 39 cfs, and 13 more trout moved up the canal. Only 3 trout moved up following the last reduction (49 cfs) on August 24. The 59 trout which came out following these reductions constituted 88% of all up-canal migrant trout for the season. Trout size as well as numbers decreased with each succeeding cut in water volume. Their average weight for the 3 reductions beginning with the first was 0.66, 0.53 and 0.19 pounds.

The river water level near the weir sites underwent a natural drop of 3.5 inches during the 1951 observation period. This shrinkage did not cause a measurable fish movement out of the river into the canals.

Fish loss in irrigation canals

Fish loss was investigated in 13 of the 52 irrigation canals in the study area (Fig. 1). Loss through the Keughen and Low Line weirs was

Fig. 3. Movement of trout, whitefish and suckers up the Low Line Canal following water reductions.

established by actual counts. Shocking supplemented by poisoning and general observations was employed in all 13 canals, including the 2 with weirs. Intensive sampling began in mid-July, 1951, after the volume of flow in the canals was reduced to decreed right. These reductions amounted to about one-half of the canal capacity in some instances. It was impractical to attempt sampling earlier in the season when the canal banks were full. The fish, therefore, had an opportunity to enter the canals approximately one month before sampling began. Samples were taken later in the season in 6 canals after they were turned off.

A 125-volt, 250-watt direct-current generator was generally used for shocking, but on 5 occasions a 240-volt, 500-watt alternating-current machine was employed. Holton (1952) found the direct-current generator 97% efficient in taking fish 3.5 inches and longer in total length from a spring-fed creek in the area (maximum flow 14.7 cfs). In irrigation ditches this equipment was not always effective in taking fish less than 7 inches in length. It was not used in the larger ditches when they were carrying a head of water. The difference in efficiency between ditches was undoubtedly due to their highly variable widths, depths, and velocities. Sections sampled were usually 300 feet in length for active canals. Each section was blocked at the ends with nets and shocked until no more game fish could be taken. In canals which were turned off (inactive), section lengths varied from 110 to 7,260 feet. Derris root (rotenone) was used to determine fish losses in parts of the High Line and Gilmore-Todd Canals following headgate closure.

One section was established near the headgate on each canal studied.

Other sample areas were chosen to represent all regions of a canal insofar as accessibility would permit. Unbiased selection at each point of access was strived for by sampling the first portion of the canal approached. Some spot sampling was done in areas likely to have concentrations of game fish. All sections except those of inactive canals containing clear, shallow water were sampled by shocking. Derris root was employed in the shallow areas where a slight current existed. Other shallow (or dry) sections were carefully canvassed. Of the total footage covered in the canals which were turned off, shocking comprised 53.4%, poisoning 28.5% and canvassing 18.1%. Six 300-foot stratified random sections were established by random numbers (Snedecor, 1946) in the Farmers Canal at a time when it carried 37.5 cfs of water. These were in addition to two sections (not random) selected in the upper one mile of the canal.

All trout and whitefish captured were counted, weighed and measured. Sculpins, dace and suckers were counted, but only a representative sample was weighed.

Loss determined by weirs

The fish loss determined by means of the weirs does not include spring and fall segments of the irrigations seasons when debris-laden water prevented trap operation. Net loss (numbers and pounds) for each trap operation period is the total permanent up-canal numbers of the various fish species less their total initial down-canal numbers. Net gain is given in numbers and pounds when more fish came out than went down through the weirs.

There was a net loss of 20 trout (5.56 pounds) through the Keughen Canal weir in 1950 and 24 trout (3.50 pounds) in 1951 (table 3). Whitefish comprised 9.4% of the total net number lost the first year (11.4% of the poundage compared to 15.5% the second year (4.1% of the poundage). Non-game species made up 84.1% of the number and 68.6% of the weight loss in 1950, and 77.4% of the number and 77.9% of the weight in 1951. A net gain of 57 trout (38.10 pounds) and 7 whitefish (8.51 pounds) returned to the river from the Low Line Canal during the season (table 4). There was a net loss of 5 suckers (0.09 of a pound) through the Low Line weir.

Table 3. Fish loss in the Keughen Canal as determined by weir

July 27 to September 16, 1950

Species	Down (loss)		Up (gain)		Net loss	
	number	weight (pounds)	number	weight (pounds)	number	weight (pounds)
Rainbow	5	0.45	0	0.00	5	0.45
Cutthroat	14	2.16	0	0.00	14	2.16
Brook	3	0.53	2	0.20	1	0.33
Brown	2	2.64	2	0.02	0	2.62
Whitefish	33	3.23	4	0.04	29	3.19
Suckers	209	19.83	63	2.78	146	17.05
Sculpins	156	2.16	90	1.08	66	1.08
Dace	<u>80</u>	<u>1.57</u>	<u>32</u>	<u>0.57</u>	<u>48</u>	<u>1.00</u>
Total	502	32.57	193	4.69	309	27.88

June 28 to September 19, 1951

Rainbow	12	1.86	6	0.05	6	1.81
Cutthroat	5	1.17	0	0.00	5	1.17
Brook	13	1.36	4	0.04	9	1.32
Brown	8	1.83	4	2.63	4	(0.80)
Whitefish	63	1.45	11	0.48	52	0.97
Suckers	211	18.86	22	2.04	189	16.82
Sculpins	142	2.46	148	2.15	(6)	0.31
Dace	<u>92</u>	<u>2.61</u>	<u>20</u>	<u>0.52</u>	<u>72</u>	<u>2.09</u>
Total	546	31.60	215	7.91	331	23.69

Table 4. Fish loss in the Low Line Canal, July 18 to August 27, 1951, as determined by weir

Species	Down (loss)		Up (gain)		Net	
	number	weight (pounds)	number	weight (pounds)	number	weight (pounds)
Rainbow	1	0.12	32	19.60	31 /	19.48 /
Cutthroat	4	0.49	1	0.20	3 -	0.29 -
Brook	0	0.00	9	3.36	9 /	3.36 /
Brown	5	0.75	25	16.30	20 /	15.55 /
Whitefish	9	3.31	16	11.82	7 /	8.51 /
Suckers	37	6.97	32	6.88	5 -	0.09 -
Sculpins	7	0.16	13	0.22	6 /	0.06 /
Dace	2	0.09	10	0.43	8 /	0.34 /
Total	65	11.89	138	58.81	73 /	46.92 /

Loss determined by sampling the canals

There is a great deal of diversity in the physical characteristics of the canals studied and in the numbers of fish each attracted. This was recognized by Wales (1948) who reported that some canals take few non-migratory trout. The immediate area behind canal headgates is characterized by maximum flow, clear water, and often pools. Progressing down the canals flow is reduced by withdrawal for irrigation and turbidities generally increase as a result of return flow and other factors. The greatest number of fish was found in the upper one-quarter to one-half mile of canal except in three ditches where fish concentrations were associated with spring-fed areas or creeks entering the channel. A few canals have two headgates--one at the point of diversion from the river and the other some distance down the canal. The downstream headgate is used to regulate the flow into the canal proper. Here surplus water is by-passed back to the river. Water was permitted to flow all year in the area between the two headgates of the Low Line Canal, but in the Keughen, High Line and

Farmers Canals this area is mostly dry after the canals are turned off in the fall.

The area between the headgates was shocked after headgate closure in the Keughen Canal in 1950 and Farmers Canal in 1951. There were 71 trout (12.31 pounds) and 22 whitefish (0.94 of a pound) taken from the 400-foot section of the Keughen Canal. These fish comprised 73.2% of the number and 72.2% of the weight of all trout and whitefish captured in the entire canal, exclusive of weirs. Two 300-foot sections of the most favorable habitat between headgates in the Farmers Canal were sampled. This represented approximately one-fifth of the area. The 504 trout (88.4 pounds) and 120 whitefish (2.6 pounds) captured made up 92.9% of the total number and 84.7% of the weight of all game fish taken in the canal.

Fish observed in the Low Line Canal after it was turned off were predominantly small. Apparently most of the large trout had moved out through the weir during earlier water reductions. In the 5,165 feet sampled, only 21 trout ranging from 7 to 13 inches were taken. The average length for the 405 trout captured was 3.4 inches. All whitefish were less than 5 inches in length. Approximately 1640 lineal feet of canal was shocked in the first one-half mile behind the headgate. About 96% of the trout and whitefish were taken in this area, which was characterized by a series of pools.

Considerable variation was shown between the years of 1950 and 1951 in the pounds of game fish taken from the High Line Canal (table 5). Sampling the first year was limited to one 1245-foot section immediately behind the down-canal headgate. This area yielded 18 trout (13.7 pounds)

Table 5. Canals sampled, numbers and weights of game fish captured, and estimated numbers and weights of legal game fish

Name of canal	Flow decreed right (cfs)	Length of canal (miles)	Month and year sampled	Number of sections sampled	Percentage of length sampled	<u>Footage covered</u>			<u>Game fish captured</u>				<u>Estimated legal game fish loss</u>	
						Shocker	Poison	Canvassing	<u>Trout</u>		<u>Whitefish</u>		No.	Lb
									No.	Lb.	No.	Lb	No.	Lb
Farmers	268.0	10.4	8-9/51	16	9.0	4,140		1,000	547	104.66	125	2.76	537	242
Kleinschmidt	151.0	19.0	9/51	10	5.5	3,428		2,110	305	103.36	185	3.74	560	277
High Line	147.5	30.3	9/50	1	0.8	1,245			18	13.78	90	2.60		
			8/51	13	6.8	2,876	6,060	1,885	9	1.94	6	1.60	61	23
Low Line	147.5	31.6	8/51	7	3.1	3,265		1,900	405	12.11	462	9.21	132	71
Keughen	70.3	9.9	8-9/50	6	4.4	2,310			89	14.90	38	3.44	167	44
			7/51	3	2.2	1,160			9	1.94	6	2.74		
Beck and Border	50.0	7.6	8-9/51	8	24.0	9,610			235	93.13	22	1.27	368	176
Moreland	48.0	14.4	7/51	3	1.5	1,160			9	6.96	8	5.97		
Heeb-Duffin	—	—	7/51	4	—	705			61	26.10	25	2.71		
Creamery	20.0	2.5	7/51	3	8.7	1,150			8	2.95	1	0.10	44	33
Allison- Lewis	18.0	3.3	9/51	6	10.3	1,800			145	28.95	0	0.00	851	289
Clark	16.0	3.7	9/51	3	5.6	1,100			126	10.30	0	0.00	77	20
Gilmore-Todd	14.9	2.0	7/51	1	45.5		4,800		12	2.60	41	0.21	22	6
Cockrill	5.9	7.2	8/51	6	4.7	1,800			11	2.21	13	0.26	16	5
Total				90		35,749	10,860	6,895	1989	425.89	1022	36.61	2835	1186

and 90 whitefish (2.6 pounds). Only 9 trout (1.94 pounds) and 6 whitefish (1.60 pounds) were taken in over 2 miles of sections sampled in 1951. Although there were just two 300-foot sections shocked immediately behind the headgate the second year, it is probable that the variation was due to headgate manipulation. In 1950 the headgate was closed tightly without giving fish an opportunity to return to the river after they had been stimulated by reduced flow, whereas in 1951 flow had been reduced to approximately 7 cfs a few days before shocking.

Few game fish were found in the Gilmore-Todd and Cockrill Ditches (table 5). They were the smallest ditches sampled. A total of 4800 feet of the Gilmore-Todd Ditch adjacent and downstream from the headgate was poisoned. Twelve trout and 41 fingerling whitefish were taken from this area. They were widely distributed. The six 300-foot sections shocked in the Cockrill Ditch yielded 11 trout and 13 fingerling whitefish. There were no trout found beyond the first one-quarter mile below the headgate. The largest trout taken from either ditch was an 11-inch rainbow.

Creeks entered 3 of the canals studied (Fig. 1). In these instances water was usually released from the canal opposite the point of creek entrance in order to maintain a flow in the creek below. Brook trout were dominant and often abundant in the canals near creeks. The average length of all brook trout taken in the vicinity of creeks was over 9 inches. One brook trout measured 18.2 inches in length and weighed 3.02 pounds. The greatest concentrations of brook trout in the canals were found during the spawning season. On September 29 in the Kleinschmidt Canal, 138 brook trout (54.61 pounds) were found in a 320-foot section

around the entrance point of Wilson Creek. In the same canal and on the same date 66 brook trout and 1 rainbow trout (total weight 35.67 pounds) were taken from a 252-foot section located approximately 3.5 miles below the place where Cottonwood Creek enters the canal. The Beck and Border Canal, which is bisected by and receives much of its water from Hyalite Creek, contained 192 trout (80.3 pounds) in a 7260-foot section beginning approximately 2 miles below the place of bisection. These fish had entered the canal before September 23 and were blocked by an 8-foot falls from returning to the creek. Species composition consisted of 147 brook trout (55.78 pounds), 36 rainbow trout (19.60 pounds), 8 brown trout (4.48 pounds), 1 cutthroat trout (0.44 of a pound), and 6 whitefish (0.93 of a pound). A few brook trout were disbursed around Hyalite Creek in the Farmers Canal up to August 30 when the last samples were taken. No brook trout, or any game fish for that matter, were found in the lower one-half of any large canal not modified by a creek. One 16.1-inch whitefish moved down the High Line Canal for a maximum observed distance of approximately 15 miles.

The water in spring-fed ditches during the non-irrigation season is usually lost through seepage after flowing a short distance. However, it may, as observed in the Allison-Lewis Ditch, maintain a small flow in most of the channel all year. Six 300-foot sections of this ditch were shocked in mid-September. The headgate was open at the time to allow a flow of 6.9 cfs. A total of 145 trout, including 128 brook trout (24.89 pounds), 10 brown trout (1.43 pounds) and 7 rainbow trout (2.63 pounds), were taken. Trout less than 7 inches made up 43.4% of the total number. There were

66.4 pounds of trout per acre for the combined 6 sections. Three fingerling whitefish were captured.

The Heeb-Duffin and Creamery Ditches are located near the dewatered portion of the West Gallatin River (Fig. 1). There is no headgate on the Heeb-Duffin Ditch and flow into its intake ceases when the river reaches a low level. Water from another ditch enters the Heeb-Duffin 500 feet behind its intake, thus maintaining flow over much of its course for a longer period. An isolated 350-foot pool near the intake was shocked July 12. A total of 41 trout weighing 20.46 pounds was taken. Of these, 34 were brown trout, 4 were rainbow trout, and 3 were brook trout. Six whitefish weighing 1.80 pounds were also captured. The Creamery Ditch had a flow of 20 cfs at the time of sampling on July 19-20. This was almost one-half of the remaining river flow. Three sections were shocked (1150 feet) and these yielded 6 brown trout, 2 rainbow trout, and a 7-inch whitefish for a total weight of 3.05 pounds.

Several irrigated fields were inspected for stranded fish, but none was found. Many of the farmers in the area irrigated by the Gallatin canals were interviewed in both 1950 and 1951. They reported very little or no game fish movement into fields.

The species composition of all 1882 trout taken by sampling in 1951 was 46.1% brook trout, 37.6 brown trout, 16.2% rainbow trout, and 0.1% cutthroat trout. Fingerling trout comprised 54.7% of the total number. About 97.7% of the 894 whitefish were fingerlings. There was a progressive decrease in the number of brown trout and an increase in brook trout and rainbow trout in the canals going from the lower to the upper part of the

study area (table 6). Similar distribution was found in the 1949 and 1950 creel census of the West Gallatin River (Missouri River Basin Studies, 1951).

Table 6. The percentages of brown trout, brook trout, and rainbow trout in canals

<u>Location of canals</u>	<u>Brown</u>	<u>Brook</u>	<u>Rainbow</u>
Lower (3)	82.7	5.2	12.1
Middle (6)	27.1	55.7	17.2
Upper (4)	0.7	70.9	28.4

The greatest concentrations of trout and whitefish fingerlings were found near the headgates of 3 canals. Fingerling trout taken downstream adjacent to the headgate of the Low Line Canal totaled 384, of which 82.5% were brown trout. The number of whitefish fingerlings found in the same area was 461. There were 287 trout and 120 whitefish fingerlings taken between the headgates of the Farmers Canal. The dominant species in this case was brook trout (83%). In 1800 feet behind the headgate of the Kleinschmidt Canal, 63 trout (79% rainbow) and 185 whitefish fingerlings were captured. A few trout and whitefish fingerlings were found far down most canals. A maximum down-canal movement observed for any fingerling was approximately 14 miles.

Non-game species were found in all of the canals studied. Small longnose suckers were numerous in all but the spring-fed Allison-Lewis Ditch and in the 3 ditches which originated nearest the mouth of Gallatin Canyon. White suckers were rare except in the Beck and Border Canal. The average length for all suckers taken was approximately 6 inches. Only 5 of those captured in 1951 were over 15 inches in total length. Thousands

of sucker fry were observed in most of the canals. Adult sculpins and fry were also abundant, especially near the headgates. Dace were found in most ditches but not in large numbers.

Estimated legal game fish loss

Estimates of the total numbers and pounds of legal game fish (7 inches or over in total length) were made for 11 of the 13 canals studied (table 5). All estimates were based on the 1951 season, except for the Keughen Canal which was 1950. Each canal was divided into 3 sections for the purpose of making estimates. The first section included the one-half mile of canal immediately behind the headgate. The second included the upper one-half of the ditch adjacent to the first section, and the third the remainder or most distal part of the canal. Reasonable effort was made to secure representative samples in each of the 3 parts. No correction was made for fish movement into or out of the canals. The sections sampled in the 11 canals ranged from 3.1% to 45.5% of their entire lengths. Because of the small samples taken in the Moreland and Heeb-Duffin Canals, these were not used in the estimates. Only section 1 of the Clark Ditch was included because it was the only portion containing water at the time of shocking.

Fish loss showed little correlation with any of the usual physical conditions observed such as size or volume of flow. Both the High Line and Low Line Canals are large on the basis of length and volume of flow, yet the estimated 23 pounds of legal game fish in the High Line Canal and 71 pounds in the Low Line Canal are relatively small. On the other hand,

the Farmers and Kleinschmidt Canals, which had the greatest volumes of flow, attracted a large number of fish (estimated over 240 pounds each). These ditches had creeks entering them, and this rather than their size may have accounted for the abundance of fish. The Beck and Border Canal, in spite of its smaller size, had an estimated poundage of fish 4 times greater than the Keughen Canal. This canal is undoubtedly influenced by Hyalite Creek which enters it. The small spring-fed Allison-Lewis Ditch had an estimated 289 pounds of legal game fish. This is the largest for any canal studied. Losses estimated for other small canals ranged from 5 to 33 pounds.

A total of 866 legal game fish weighing 352.87 pounds were taken in all samples from the 11 canals. Using this as a basis, the total estimated loss in these ditches would be 2835 legal game fish weighing 1186 pounds. If these 11 canals are representative of the 52 West Gallatin River canals in the study area, the total estimated loss would be 13,400 legal game fish weighing 5600 pounds. This area of the West Gallatin River yielded an estimated 16,100 fish weighing 10,300 pounds to the fisherman in 1949 and 16,300 fish weighing 11,300 pounds in 1950 (Missouri River Basin Studies, 1951). Suckers made up slightly more than 1% of these numbers.

Summary

1. Fish loss and movement was investigated during 1950 and 1951 in irrigation canals from the West Gallatin River, Montana.
2. Two-way fish weirs were employed to study fish movement in the Keughen

and Low Line Canals. Debris-laden water prevented weir operation during the spring and fall segments of the irrigation seasons.

3. In the Keughen Canal there was a total of 502 initial down- and 322 initial up-canal migrants during 61 days in 1950. Trout comprised 3.5% of the total initial movement, whitefish 4.5%, and non-game species 92.0%. In 84 days of trap operation in 1951, 546 initial migrants moved down and 353 moved up the canal. Of this total movement, 6.1% were trout, 8.6% were whitefish, and 85.3% were non-game species.
4. The Low Line weir, which operated 41 days in 1951, showed an initial fish movement of 65 down- and 132 up-canal migrants. The total initial movement was 39.1% trout, 13.2% whitefish, and 47.7% non-game species.
5. All species of fish taken except cutthroat trout showed movement in both directions through either the Keughen or Low Line weirs.
6. A direct correlation existed between severe water fluctuations and trout movement upstream in the Low Line Canal. A total of 59 trout or 88% of all up-canal migrants for the entire season came out following 3 water reductions.
7. Fish loss (or gain) through the weirs while they operated was established by actual counts.
8. Thirteen canals were sampled in 1951 by shocking, poisoning or canvassing.
9. Game fish concentrations were found near headgates, near creeks where they entered a canal, and in 1 spring-fed ditch. Brook trout was the

dominant trout species in the vicinity of creeks and springs.

10. The species composition of 1882 trout taken by sampling in 1951 was 46.1% brook trout, 37.6% brown trout, 16.2% rainbow trout, and 0.1% cutthroat trout. Fingerling trout comprised 54.7% of the total number. About 97.7% of the 894 whitefish captured were fingerlings.
11. Non-game species were numerous in most of the canals studied. Suckers predominated; their average length was approximately 6 inches.
12. Fish loss did not seem to be correlated with length or volume of flow. It was estimated that 2835 legal game fish (7 or more inches in length) weighing 1186 pounds were lost to 11 canals in the study area.

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