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EFFECT OF WATER REDUCTIONS ON FISH MOVEMENT IN IRRIGATION DIVERSIONS

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EFFECT OF WATER REDUCTIONS ON FISH MOVEMENT IN IRRIGATION DIVERSIONS [1]

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Data collected from the Low Line Canal during a study of irrigation fish loss and movement in Gallatin Valley, Montana, 1950–1951, showed a direct correlation between severe water reductions and the movement of 36.87 pounds of legal game fish back into the West Gallatin River (Clothier, 1952). This phenomenon has not been entirely overlooked with respect to saving fish lost in irrigation ditches. Dr. Richard B. Miller states, "There now exists a sort of agreement (in Alberta) whereby headgates are shut slowly." (Correspondence, November 24, 1951). For several years in the present study area, the volume of flow in the Kleinschmidt Canal has been decreased a few days before headgate closure solely to stimulate fish to return to the river. Despite the general recognition that water reductions save fish, little quantitative information is available.

To verify and enlarge upon previous findings, four West Gallatin River canals (Middle Creek Supply, Farmers, Kleinschmidt and Spain-Ferris) were studied in 1952. A series of 500-foot sections within approximately one mile behind the headgate of each canal were qualitatively sampled during the regular irrigation season with a "shocker" powered by a 500-watt alternating-current generator. Trout, whitefish, and suckers were weighed, measured, marked by distinctive fin-clips, and returned to the water within the sections where found. There were two marking periods in two of the canals, the first in connection with a related study.

Three days prior to headgate closure at the end of the irrigation season, the volume of flow in the Middle Creek Supply, Farmers, and Kleinschmidt Canals was reduced abruptly to the lowest level capable of supporting fish movement. The Spain-Ferris Canal served as a control. Its water supply was turned off without a preliminary period of decreased flow.

Each 300-foot section of all canals from the headgates downstream to the last section in which fish were marked was blocked by nets and shocked after the water was turned off. Distances traveled by marked fish were measured with a 100-foot steel tape.

Middle Creek Supply Canal (decreed right 76.2 c.f.s.)

Fish from four 500-foot sections of the Middle Creek Supply Canal were marked and released (Table 1) on August 20 several days after the volume of flow had been reduced to 41.9 c.f.s.

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TABLE 1.—TROUT AND WHITEFISH MARKED AND RELEASED IN THE MIDDLE CREEK SUPPLY CANAL

Species	Number	Weight (pounds)	Length in inches	
			Average	Range
Rainbow	58	20.24	8.8	6.2 - 15.1
Brook	19	4.96	7.7	3.4 - 14.4
Brown	12	11.68	12.1	3.3 - 18.7
Whitefish	8	0.75	4.6	3.4 - 11.9
Total	97	37.63		

TABLE 2.—NUMBERS AND WEIGHTS OF TROUT, WHITEFISH, AND SUCKERS TAKEN FROM THE 4900-FOOT STUDY SECTION OF THE MIDDLE CREEK SUPPLY CANAL

Species	Number	Weight (pounds)	Percentage composition	
			By number	By weight
Rainbow	249	39.35	46.4	47.9
Brook	126	11.97	23.4	14.6
Brown	58	24.50	10.8	29.8
Cutthroat	5	0.76	0.9	0.9
Whitefish	97	5.47	18.1	6.7
Suckers	2	0.09	0.4	0.1
Total	537	82.14	100.0	100.0

from decreed right. There were no further major water cuts until October 8 when flow was reduced to 7.7 c.f.s. This water flowed under the headgate through a space approximately 1–1/2 inches high. Within five minutes two eight-inch trout moved rapidly upstream to the headgate. The increased water pressure and the narrow opening possibly impeded fish movement out of the canal.

Rainbow trout was the most abundant game species in the 4900-foot study section following headgate closure on October 11 (Table 2). Eastern brook trout, brown trout, cutthroat trout, whitefish, and suckers comprised the remaining 53.6 per cent. Approximately 63.5 per cent of the trout and 79.4 per cent of the whitefish were less than seven inches in total length; the two longnose suckers less than six inches.

Fish concentrations were found behind the headgate and wherever brush, undercut banks, and pools furnished concealment. These areas of concentration were often small and widely separated, suggesting that the reduced flow had effected a redistribution of the population. There were 21.75 pounds of trout and 0.59 of a pound of whitefish found on a 15-foot cement ramp immediately behind the headgate. Only 1.04 pounds, all trout, were taken from the remaining 285 feet of this first section. Game fish poundage in Section 1 represented 28.5 per cent of the total pounds taken in the entire study area (Fig. 1).

About 11 per cent of the poundage (all trout) was taken from a shallow 20-foot pool in Section 2 near one bank under overhanging willows. Sections 3 to 5, inclusive, had few pounds of fish.

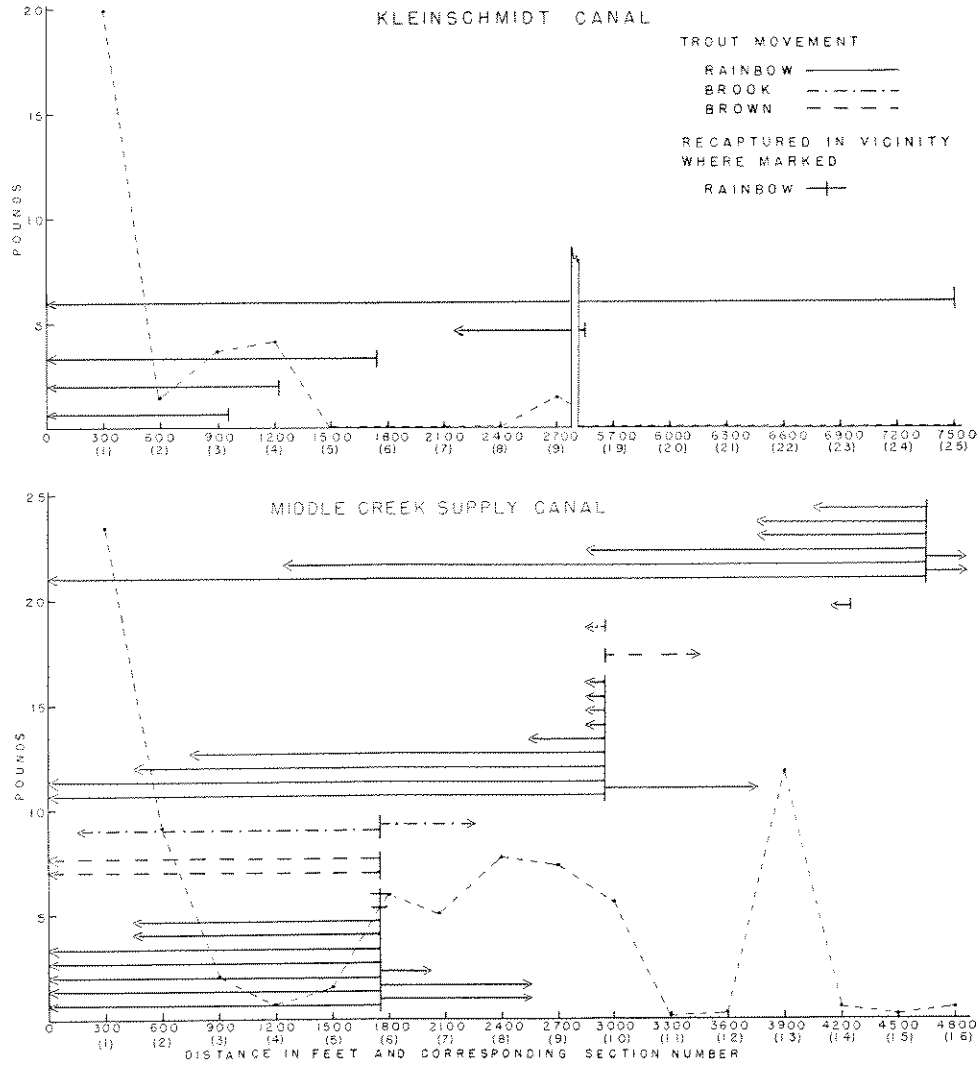

FIG. 1. Pounds of trout and whitefish taken in each 300-foot section of Kleinschmidt and Middle Creek Supply Canals (superimposed broken line), and direction and distance marked recoveries traveled from point of release (vertical bars). Zero feet at the headgate. Each symbol signifies an individual fish.

This area was characterized by rubble and very shallow water. A fairly uniform distribution of poundage (38.9 per cent of the total) was taken from Sections 6 through 10. This entire area was a continuous pool 12 to 18 inches deep. The water in Sections 11 through 16 was generally less than 10 inches deep. Few pounds were taken in this part of the ditch except in Section 13, which contained 11.84 pounds of game fish (14.4 per cent of total poundage captured).

Most of these were found in shallow water beneath a pile of leaves and brush accumulated on fence wires.

Approximately 41.6 per cent of 89 marked trout in the Middle Creek Supply Canal were recovered. None of the marked whitefish were retaken. Sixty-one days elapsed from date of marking to date of headgate closure.

Of the marked trout recovered, 73 per cent had moved upstream for distances ranging from 150 to 4850 feet (Fig. 1). Eight were found between 200 and 800 feet downstream from the point of release, and two were recovered in the area where marked. There was no distinct difference shown in direction of movement by individual species of marked trout.

Two marked trout less than seven inches in total length were recovered. One 4.3-inch brook trout found at the headgate had moved 1750 feet up the canal, and a 6.9-inch rainbow trout recovered some distance from the headgate had gone upstream 450 feet. The trout that traveled the greatest distance upstream was a 10.0-inch rainbow (Fig. 1).

Marked fish that did not reach the headgate were found in areas affording concealment suggesting that exposure resulting from water removal stimulated fish to seek cover. Perhaps they would travel longer distances if cover were not available. Exposure may stimulate fish to move more readily than does the actual process or amount of flow reduction. A few water reductions in the Keughen Canal during the 1950–1951 fish movement investigation equaled the present reduction in volume without stimulating an up-canal movement of fish into a weir. Only about half of the water was turned out of the Keughen Canal by these reductions leaving sufficient water depths for concealment.

KLEINSCHMIDT CANAL
(DECREED RIGHT 151.0 C.F.S.)

The Kleinschmidt Canal carried about 50.5 c.f.s. of water when fish were taken from the canal and marked August 5 and 17 (Table 3). Flow remained relatively constant from these dates until it was decreased abruptly to 13.3 c.f.s. October 14. All water was turned off October 17. A time lapse of 74 and 64 days occurred between the two dates of marking and headgate closure.

Excluding sculpins, rainbow trout and whitefish were the dominant species in the study area (Table 4). There were no cutthroat trout or suckers captured. Six of the 19 whitefish and 29 of the 59

TABLE 3.—TROUT AND WHITEFISH MARKED AND RELEASED IN THE KLEINSCHMIDT CANAL DURING TWO SHOCKING PERIODS (AUGUST 5 AND 17).

Species	Number	Weight (pounds)	Length in inches	
			Average	Range
Rainbow	18	5.71	8.4	4.6 - 13.9
Brook	1	0.41	10.3	.... - ....
Brown	2	0.41	7.9	7.8 - 8.0
Cutthroat	3	0.43	7.5	7.0 - 8.0
Whitefish	3	1.42	12.3	11.5 - 13.0
Total	27	8.38		

TABLE 4.—NUMBERS AND WEIGHTS OF TROUT AND WHITEFISH TAKEN FROM THE 7500-FOOT STUDY SECTION OF THE KLEINSCHMIDT CANAL

Species	Number	Weight (pounds)	Percentage composition By number	By weight
Rainbow	42	15.10	53.8	49.4
Brook	14	2.44	18.0	8.0
Brown	3	1.13	3.8	3.7
Whitefish	19	11.90	24.4	38.9
Total	78	30.57	100.0	100.0

trout taken were less than seven inches in total length.

Trout and whitefish located immediately behind the diversion headgate comprised 65.2 per cent of the total poundage taken in the entire study area (Fig. 1). These fish were concentrated similar to those taken at the Middle Creek Supply Canal headgate. The remaining 10.64 pounds of game fish taken from the Kleinschmidt Canal were divided among Sections 2, 3, 4 and 9, which were predominantly rubble and gravel with a few isolated areas of water three to six inches deep. Water depths throughout the remainder of the study area did not exceed 14 inches in depth. Sparse vegetative cover and a smooth channel bottom provided little concealment for fish in this lower area.

Of the fin-clipped trout, only five rainbow (20.8 per cent) were recovered (Fig. 1). Each had moved upstream for distances ranging from 950 to 7500 feet. All but one swam under the downstream headgate to reach the headgate at the canal intake. The smallest recaptured rainbow trout (5.5 inches in total length) traveled 950 feet. A 12.9-inch rainbow trout moved the maximum distance of 7500 feet.

No marked whitefish were retaken.

FARMERS CANAL
(DECREED RIGHT 268 C.F.S.)

Fish were marked (Table 5) and recovered on two occasions in the Farmers Canal. Trout marked in the 900 feet immediately behind the second headgate on August 4 totaled 28. This number

TABLE 5.—FISH MARKED AND RELEASED IN THE FARMERS CANAL DURING TWO MARKING PERIODS (AUGUST 4 AND 20)

Species	Number	Weight (pounds)	Length in inches Average	Range
Rainbow	38	15.81	9.5	4.6 - 14.0
Brook	84	17.08	7.6	2.7 - 12.0
Brown	7	8.10	13.0	7.5 - 20.2
Cutthroat	2	0.33	7.9	7.6 - 8.2
Whitefish	3	0.03	3.3	3.1 - 3.4
Suckers	9	15.97	16.5	7.7 - 19.8
Total	143	57.32		

was added to on August 20 when 103 trout, three fingerling whitefish and nine longnose suckers were fin-clipped and released in three additional sections (total length 1500 feet). The latter sections represented the area from the first headgate to 4800 feet downstream. Subsequent recoveries included 49.6 per cent of the trout, none of the whitefish, and 43.0 per cent of the suckers. The marked fish that traveled the greatest distance (4500 feet upstream) was a 7.3-inch eastern brook trout.

Volume of flow during the two marking periods was near 51 c.f.s. A gradual decrease to approximately eight c.f.s. occurred after the fish were marked and coincidental with the natural lowering of river level. This gradual reduction had not been anticipated, and by September 24 it appeared advisable to reshock the area behind and adjacent to the first headgate and the one immediately in front of the second headgate. Each area was a favorable fish habitat with water depths up to four feet. This water is constantly freshened by seepage from springs. Marked fish moving from other parts of the canal as a result of slowly diminished flow were likely to be retained in one of the two pools.

A few days subsequent to September 24, the ditch company adjusted the canal intake and increased volume of flow to 16.3 c.f.s. Arrangements were then made to have the water cut sharply three days before headgate closure as originally planned. Thus on October 10 the flow was reduced to 4.0 c.f.s., and completely turned off October 13. The second recovery shocking proceeded immediately after headgate closure, and included the entire area from the first headgate to 4800 feet downstream.

Eastern brook trout was the most abundant species taken during the two recovery periods (Table 6). All other species comprised 45.7 per cent of the total. Of 403 trout taken, 33.5 per cent were less than seven inches in total length. No adult whitefish were captured. Suckers ranged from 6.6 to 18.5 inches in total length, and mean length was 14.5 inches.

A total of 27.13 pounds of trout, 0.80 of a pound of whitefish and 6.25 pounds of suckers were taken in Sections 1, 2 and 3 behind the first headgate on September 24 (Fig. 2). There were 35.17 pounds of trout and 0.34 of a pound of whitefish removed from Section 8 in front of the second headgate. None of

TABLE 6.—NUMBERS AND WEIGHTS OF TROUT, WHITEFISH, AND SUCKERS TAKEN DURING TWO RECOVERY PERIODS FROM THE 4800-FOOT STUDY SECTION OF THE FARMERS CANAL

Species	Number	Weight (pounds)	Percentage composition By number	Percentage composition By weight
Rainbow	87	32.25	15.9	26.5
Brook	298	60.68	54.3	49.9
Brown	15	13.33	2.7	11.0
Cutthroat	3	1.36	0.5	1.1
Whitefish	139	3.21	25.3	2.6
Suckers	7	10.83	1.3	8.9
Total	549	121.66	100.0	100.0

the fish was returned to the canal, and all but suckers were transported to other waters.

There were 46 marked trout and two marked suckers taken during this first recovery period (Fig. 2). Most of these fish were found in the same two pools where fin-clipped, which suggests that gradually decreased flow had little effect on fish movement when deeper water afforded concealment. Seven of the trout marked in the shallow 900-foot area ad-

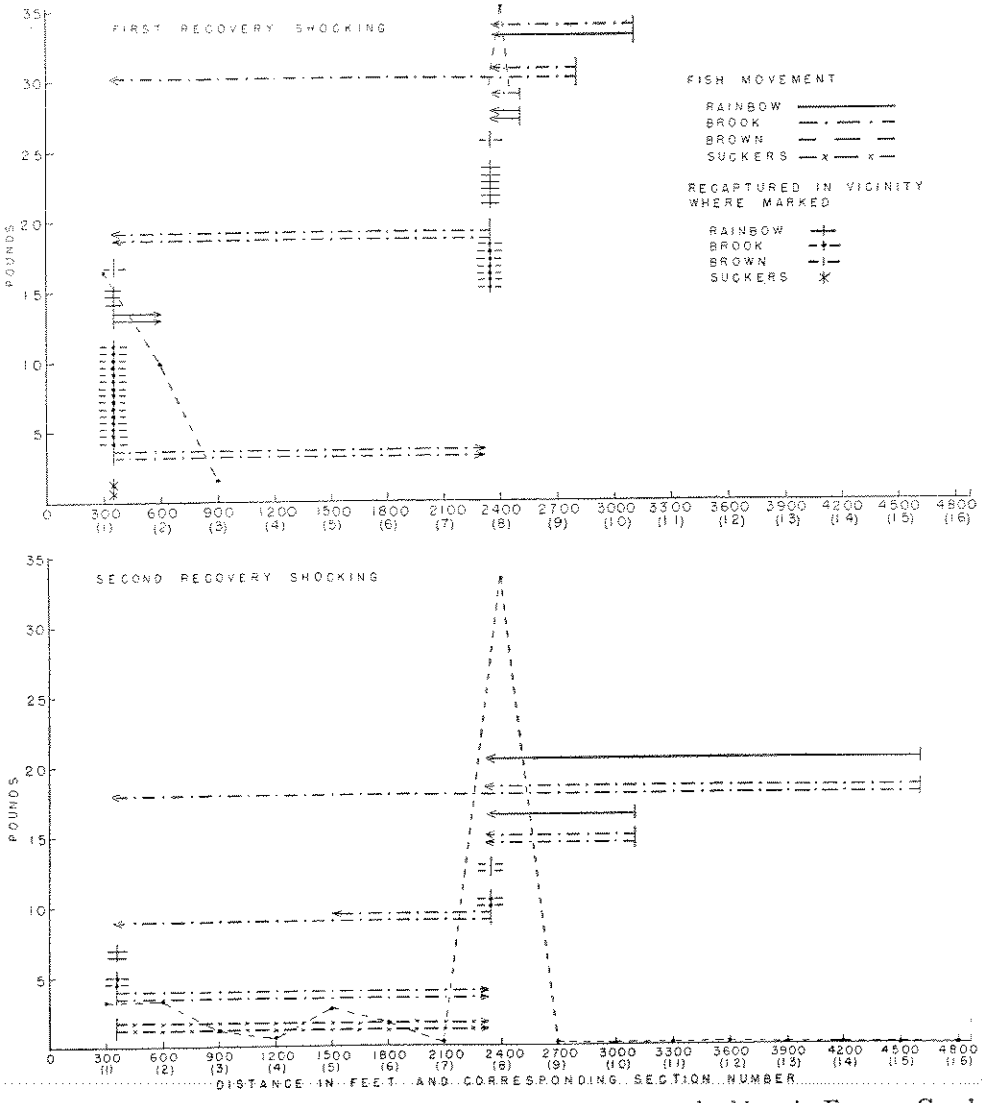

FIG. 2. Pounds of trout and whitefish taken during two recovery shockings in Farmers Canal (superimposed broken line), and direction and distance marked recoveries traveled from point of release (vertical bars). Zero feet at the headgate. Each symbol signifies an individual fish.

jacent and downstream from the second headgate had moved up the canal to one or the other protective pool in Sections 1, 2 and 8.

During the second recovery period, only 47.39 pounds of trout and whitefish were taken from the entire 4800-foot study area (Fig. 2). Almost 70.5 per cent of this poundage was found in the pool immediately in front of the second headgate (Section 8), which nearly equaled the amount previously removed from the same section. Less than a pound of trout and whitefish were found downstream in Sections 9 through 16, and these were all fingerlings.

Eighteen marked trout and two marked suckers were taken during this second recovery period (Fig. 2). All movement of fish marked downstream from the second headgate was in an up-canal direction. Apparently the sharp decrease in flow to 4.0 c.f.s. had a part in stimulating these fish to move upstream and contributed to the void in Section 8.

SPAIN-FERRIS CANAL
(DECREED RIGHT 121.3 C.F.S.)

Water in the Spain-Ferris Canal was turned off without a preliminary three-day period of reduced flow to establish whether many marked fish move in an up-canal direction despite a sharp water cut. Flow in this ditch diminished from 30.0 c.f.s. to 20.4 c.f.s. between the marking period and the water turn-off-date (September 12 to November 4). The time lapse between these two dates was 53 days. Actual censusing was begun November 6.

Within 15 minutes after headgate closure four brown trout, one rainbow trout, two small unidentified trout, and two adult whitefish responded to reduced flow by moving upstream to the headgate. The identified trout ranged in size from an estimated 1 to 2-1/2 pounds each. Probably these fish subsequently swam a short distance downstream to deeper water. About 1500 feet behind the headgate another trout (estimated length eight inches) was observed struggling upstream over a shallow riffle.

Whitefish was the most abundant game species taken in the 4200 feet adjacent and downstream from the headgate (Table 7). Brown trout comprised 56.9 per cent of the total number of trout captured. Longnose suckers were found in greater numbers than in any of the canals investigated. Game

TABLE 7.—NUMBERS AND WEIGHTS OF TROUT, WHITEFISH, AND SUCKERS TAKEN FROM THE 4200-FOOT STUDY SECTION OF THE SPAIN-FERRIS CANAL

Species	Number	Weight (pounds)	Percentage composition By number	Percentage composition By weight
Rainbow	67	30.91	6.6	6.8
Brook	43	14.19	4.2	3.1
Brown	174	101.60	17.0	22.5
Cutthroat	22	5.40	2.2	1.2
Whitefish	541	203.10	52.9	44.9
Suckers	175	97.37	17.1	21.5
Total	1022	452.57	100.0	100.0

fish less than seven inches in total length included 31.8 per cent of the whitefish and 5.2 per cent of the trout. Suckers averaged 9.2 inches in total length (4.3 to 19.5 inches).

Fish concentrated wherever cover furnished concealment much the same as in the canals which had an abrupt decrease in flow before headgate closure. Only 12.8 per cent of the total trout and whitefish poundage taken in the Spain-Ferris Canal was found in Section 1 behind the headgate (Fig. 3), which is considerably less than 28.5 per cent found in Section 1 of the Middle Creek Supply Canal or the 65.2 per cent for the same section of the Kleinschmidt Canal. Practically all of the poundage taken in this first section of the Spain-Ferris Canal was located in a 40-foot pool (maximum depth 30 inches) about 260 feet downstream from the headgate. A 75-foot pool (maximum depth 14 inches) held all of the fish taken from Section 2. Three-fourths of the fish in Section 3 were found in a 25-foot pool (maximum depth 30 inches), and the remaining 1/4 were taken from two adjacent and shallower pools. These first 900 feet of the canal more closely resemble a natural stream than a diversion ditch. Pools are separated by riffles, bottom materials are predominantly rubble and gravel, and channel banks are well covered by willows and smaller shrubs.

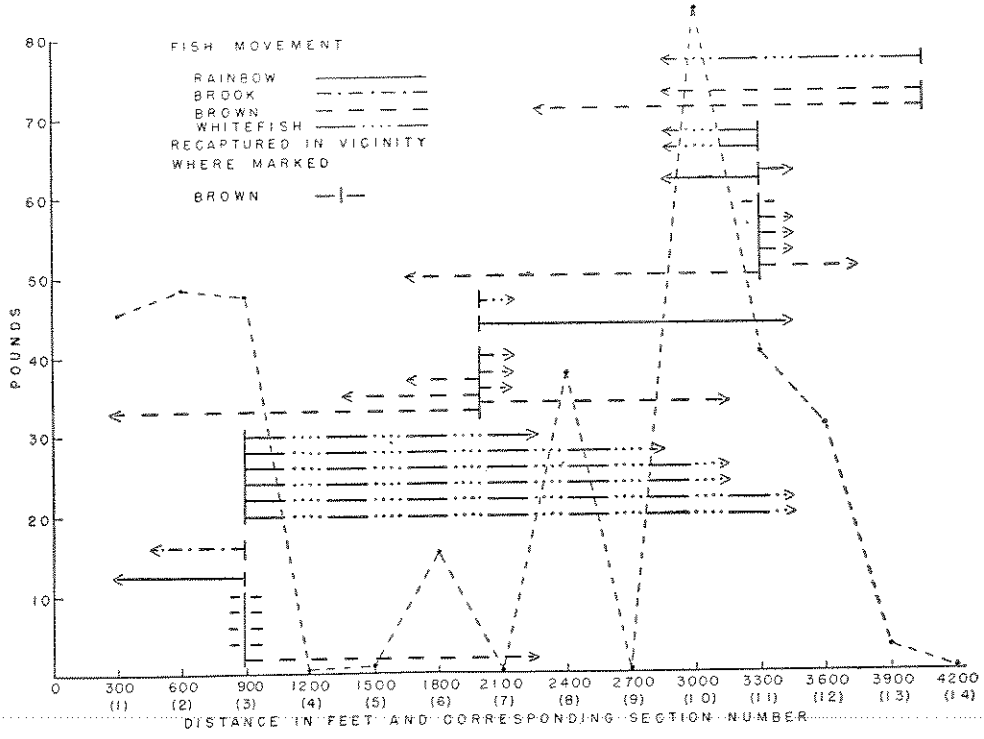

FIG. 3. Pounds of trout and whitefish taken in each 300-foot section of Spain-Ferris Canal (superimposed broken line), and direction and distance marked recoveries traveled from point of release (vertical bars). Zero feet at the headgate. Each symbol signifies an individual fish.

Less than one per cent of the total game fish poundage was taken from Sections 4 and 5, each of which contained two to eight inches of water. Trout and whitefish taken from Sections 6 through 12 (2100 feet) represented 58.7 per cent of the total game fish poundage captured (Fig. 3). Standing water depths increased gradually from 12 inches in Section 6 to 24 inches in Section 9, and remained deep through Section 12. Cottonwood trees and willows shaded Sections 6 through 8, and continuous islands of *Ranunculus aquatilis* gave cover in Sections 9 through 12. The remaining sections in the study area (13 and 14) were shallow because of an increased gradient. Only a few fish were taken in this 600-foot section of ditch and most of these were found under a bridge in Section 13.

Four 500-foot sections were shocked during the marking period, and 85 fish were fin-clipped (Table 8). Subsequent recoveries included 49.0 per cent of the trout, 47.6 per cent of the whitefish and none of the suckers. Only one fish (a trout) less than seven inches in length was retaken.

Most of the recoveries (51.4 per cent of total) were recaptured as far as 2550 feet downstream from the point of release (Fig. 3). Recoveries which moved upstream (34.3 per cent of total) had traveled from 350 to 1800 feet. No movement was shown by 14.3 per cent of recoveries. This down-canal trend is opposite to the trend of movement found in canals where distinct water reductions were made before headgate closure.

SUMMARY

1. Four canals from the West Gallatin River, Montana, were selected for a study of trout, whitefish, and sucker movement following abrupt water reductions.

2. Fish taken from each canal during the regular irrigation season were marked and returned to the water within the section where caught.

3. The entire distance from the headgate to the last section in which fish were marked (4200 to 7500 feet) was censused in each canal after the water was turned off. Elapsed time between dates of marking and dates of headgate closure ranged from 51 to 74 days.

4. Water in three canals was decreased three days prior to headgate closure. One of these ditches had a period of reduced flow coincidental with the natural lowering of river level. The fourth canal served as a control, and it was turned off with-

TABLE 8.—FISH MARKED AND RELEASED IN THE SPAIN-FERRIS CANAL, SEPTEMBER 12

Species	Number	Weight (pounds)	Length in inches	
			Average	Range
Rainbow	10	3.13	8.4	6.4 - 12.7
Brook	3	0.52	7.9	7.2 - 8.4
Brown	37	15.11	9.6	6.9 - 21.4
Cutthroat	1	0.12	7.6	... - ....
Whitefish	21	3.78	7.0	3.6 - 12.6
Suckers	13	5.86	9.0	4.7 - 17.8
Total	85	28.52		

out a preliminary reduction period.

5. Fish concentrations were found wherever brush, undercut banks, and pools furnished concealment. These areas of concentration were often small and widely separated, suggesting that reduced flow effected a redistribution of the fish population.

6. Game fish concentrations were found immediately behind the headgate in the two canals having one period of decreased flow before headgate closure. Of the marked recoveries, 73 per cent in one canal and 100 per cent in the other were recaptured upstream from point of release for distances varying from 150 to 7500 feet.

7. The smallest marked fish (a 4.3-inch eastern brook trout) which moved upstream traveled 1750 feet. A 12.9-inch rainbow trout traveled a maximum distance of 7500 feet.

8. Only 12.1 per cent of the game fish poundage in the control canal was found in the section immediately behind the headgate, and 51.4 per cent of the marked recoveries were recaptured as far as 2550 feet downstream from the point of release.

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