Montana Fish and Game Report

In Cooperation with U. S. Army Corps of Engineers

Contract No. DACW 67-70-C-0001

Fisheries Division

Job Progress Report

ANNUAL PROGRESS REPORT

EVALUATION OF MITIGATION MEASURES IN FISHER RIVER, WOLF CREEK, AND FORTINE CREEK, 1970 - 1971

by

Bruce May

Reservoir Investigation Project

July 1971

TABLE OF CONTENTS

MONTANA FISH AND GAME DEPARTMENT

FISHERIES DIVISION
JOB PROGRESS REPORT

Project Title: Evaluation of Mitigative Measures in Fisher River, Wolf Creek and Fortine Creek

Job Title: Status of water quality, erosion, aquatic insect and fish populations as related to road and railroad relocation. July 1, 1970 - June 30, 1971

ABSTRACT

Data are presented for Fisher River, Wolf Creek and Fortine Creek concerning the effect on the aquatic environment of road and railroad relocation.

Sediment pollution from the railroad grade is lowering water quality and probably limiting trout populations in Fortine Creek. Additional erosion control is needed to stabilize soils along the grade.

Problem erosion areas still exist along the railroad grade from the mouth of Wolf Creek upstream to Fairview. In addition, nearly all channel changes are in dire need of riparian vegetation to provide bank stability and cover for trout. Aquatic insect populations in a control section of Wolf Creek averaged over 200 lbs. per surface acre of riffle, indicating they have recovered to some degree from construction related lows. The altered section had a deeper, wider channel with more pool development than the control section. The impounding effect of the groins has produced a backwater type habitat which is infested with longnose suckers (Catostomus catostomus) and largescale suckers (Catostomus macrocheilus). Suckers were over 14 times as abundant in the channel change than in the control area. Rainbow trout (Salmo gairdneri) populations were slightly higher in the control than in the altered section.

Aquatic insect populations in the control section of the Fisher River were over twice as large as in the altered area. It appears that unsuitable substrate in the channel changes is the limiting factor. Resident fish population data indicated: (1) suckers are much more abundant in altered than control sections, (2) mountain whitefish (Prosopium williamsoni) are the dominant game fish in the control but are rare in the altered section, and (3) rainbow trout are more numerous in the altered section than in the control.

A spawning run of 2,640 mountain whitefish with a total fecundity of 2,800,000 eggs migrated from the Kootenai River into the Fisher River. Groins were not barriers to their movement and spawning occurred in some channel changes.

Recommendations are presented to minimize damage to aquatic environment during construction, control erosion and produce more trout habitat in channel changes.

INTRODUCTION

Dam construction, reservoir clearing, relocation of villages, highways and railroads were initiated in 1965. Relocating the Burlington-Northern Railroad involved the channelization of parts of the Fisher River, Wolf Creek and Fortine Creek. Construction activities increased erosion in the watersheds by denuding large land areas and creating steep slopes along the railroad grade which are quite susceptible to erosion.

The changes in stream environment caused by construction activities are often harmful to aquatic life. Whitney and Bailey (1959), Johnson (1964) and Elser (1968) documented the detrimental effect of stream channelization upon fish populations in three Montana trout streams. Silt desposition greatly alters the aquatic environment by blanketing spawning areas, killing and reducing production of benthic organisms and preventing light penetration (Apmann and Oatis, 1965). Long periods of slow accumulation of fine sediment are especially harmful. Cordone and Kelly (1961) summarized "Our failure to recognize that even small amounts of sediment may be harmful, may well result in the gradual destruction of the majority of our streams".

Apmann and Oatis (1965) pointed out that caution must be exercised when altering streams because the channels are in delicate adjustment with water discharge channel length. This causes channel instability because the stream will attempt to equalize the slope in the new channel with the upstream and downstream slope. It is obvious that if damage to the aquatic environment is to be prevented, stream alterations must be founded on the principles of stream dynamics in conjunction with hydraulic regime of stream being altered, and great care must be exercised to prevent erosion during and after construction.

The purpose of this study is to evaluate the effects of construction activities associated with the relocation of the railroad upon the aquatic environment and biomass in the Fisher River, Wolf Creek and Fortine Creek. Parameters under investigation include: water quality, sediments, turbidity, stream morphology, aquatic insect and fish populations.

Initial data collected during the 1969-70 fiscal year were presented in an annual report, July 1970. In summary, field inspection documented by photographs showed that considerable erosion occurred along the railroad grade from Wolf Creek Junction upstream to approximately three miles north of the Fairview Overpass. In the Fortine Creek drainage, erosion from the right-of-way is serious from the north portal of the Flathead tunnel downstream to about four miles below Swamp Creek. The susceptibility of the unconsolidated glacio-lacustrine soils to erosion has intensified the problem in both drainages.

Resident fish populations were sampled in the three study streams. It appears that sediment loading from construction activities is limiting trout production in Fortine Creek. Initial data from the meadow area of Wolf Creek suggest that suitable game fish habitat is available in the man made channel meandered through the willows in the flood plain. The altered section of lower Wolf Creek contained less trout and more suckers and redside shiners (Richardsonius balteatus) than the unaltered section. The altered sections of the Fisher River contained less whitefish and more suckers and redsided shiners than the unaltered areas. Trout populations in the two sections were comparable.

Data were gathered on migratory fish entering the Fisher River to spawn from the Kootenai. A total of 1,131 mountain whitefish with a potential fecundity of 1,500,000 eggs was passed through traps in the mouth of the Fisher River during October, 1969. Thirteen of these fish migrated upstream as far as 14 miles, indicating that the groin structures in channel changes are not barriers to whitefish movement. The majority of spawning activity appeared to occur in the lower mile of the Fisher River. Attempts to sample spring spawning rainbow and cutthroat trout were unsuccessful because of high discharges coupled with large amounts of debris.

OBJECTIVES

The specific objectives of this project are to (1) determine sediment loads and turbidities in altered and control areas in the Fisher River drainage, (2) to monitor water quality in influenced and control areas in the Fisher River drainage, (3) to determine physical characteristics of the stream channel in altered and natural sections in the Fisher River and Wolf Creek, (4) to determine the abundance of aquatic insects in altered and control areas of the Fisher River and Wolf Creek, and correlate with changes in the physical and chemical environment caused by construction activities, (5) to determine species composition and standing crops of resident fish in altered and control areas in the Fisher River, Wolf Creek and Fortine Creek, and to correlate fish population with changes in the physical and chemical environment caused by construction activities, (6) to determine the effect of altered habitat upon migratory game fish from the Kootenai River which enter the Fisher River to spawn, and (7) to recommend measures which will alleviate damage to the aquatic environment.

PROCEDURES

Sediments and Water Quality

A description of sampling techniques is given by May (1970). Analysis was accomplished by the U. S. Geological Survey under a contract with the Corps of Engineers and the data are on file at the Libby Field Station.

Aquatic Insects

Aquatic insect sampling was initiated in the Fisher River and Wolf Creek by the Corps of Engineers in 1967. Insects were collected with a modified square foot sampler designed by Waters and Knapp (1961). A collection consisted of three samples at each station. Sample stations were located near the mouth of Wolf Creek, near the mouth of the Fisher and in the Fisher above the mouth of Wolf Creek (Figure 1).

LEGEND

11 - fish population sections.

Δ - aquatic insect stations.

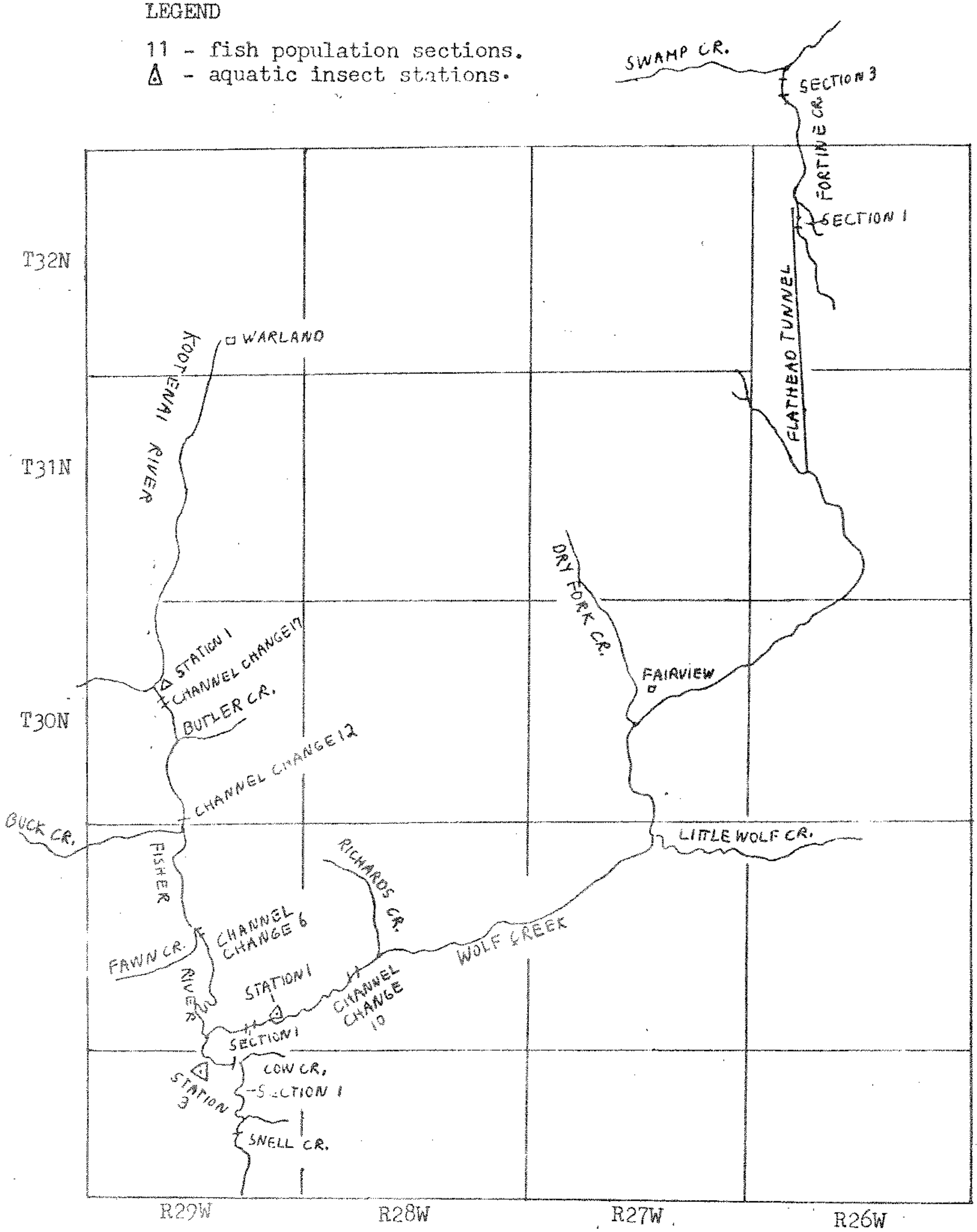


Figure 1. Map of Project Area Showing Sampling Sections for Fish and Aquatic Insects.

Organisms were preserved in 70 percent methyl alcohol, sorted from debris in the laboratory and screened through a 30 mesh screen. Indentification to genus, enumeration and weighing of organisms was accomplished under contract by a graduate student, Mr. Thurston Dotson, of the University of Montana. Insects were identified to genera except for the Diptera which were identified to family.

The data are presented as the average number and weight of organisms per collection for each month and totaled for the year.

Stream Morphology

Stream length, gradient and length of stream channeled were determined from Corps of Engineer maps where available (scale: one inch= 400 feet). Contour maps from the U. S. Geological Survey (scale: one inch= 1,320 feet) were utilized for gradient determinations on Wolf Creek upstream from Little Wolf Creek and most of Fortine Creek.

Transects were established at 20 foot intervals and depths measured every two feet in Wolf Creek sample sections. Pools were defined as areas having a smooth water surface with low water velocities and with a thalweg depth greater than the average thalweg depth. Riffles were defined as areas having a choppy water surface with an intermediate to high water velocity and a thalweg depth less than the average thalweg depth.

Fish Populations

Resident fish populations were sampled with electrofishing gear. Captured fish were anesthetized with MS-222, measured, weighed, fin-clipped, scales collected and released. In general, methods outlined by Vincent (1969) were followed during electrofishing operations. Mark and recapture data were utilized to make population estimates for each species. A computer program was employed to carry out the mathematical limits, condition factors and age and growth data.

Fall spawning fish migrating from the Kootenai River into the Fisher River were collected with box traps utilizing poultry netting leads. A cone shaped fyke net was fished in the spring to sample spring-spawning rainbow and cutthroat trout. Fish were released upstream after being marked, measured, weighed and scale samples collected.

Fry traps similar to those used by Northcote (1969) were placed in the mouth of the Fisher during July to sample outmigrant trout fry.

The Fisher River was sampled for whitefish eggs at approximately one-and-a-half mile intervals from the mouth upstream to Cow Creek. If eggs were located, a series of ten samples were taken to determine relative abundance. Eggs were collected by stirring gravel and collecting the eggs in a small net as they drifted downstream.

FINDINGS

Fortine Creek Drainage

Background.- A general description of the Fortine drainage was presented by May (1970). Fortine Creek rises on the east slopes of the Salish Mountains in Lincoln County, Montana and flows approximately 40 miles north to its confluence with Graves Creek to form the Tobacco River. This creek drains a watershed of about 180 square miles with timber production and ranching being the primary land use in the drainage. Soils in the drainage are composed of glacial deposited drift overlain by unconsolidated, glacio-lacustrine silt.

Fortine Creek, in the study area, is a small mountain trout stream flowing through a narrow valley from the north portal of Flathead Tunnel downstream to Swamp Creek (Figure 1). Gradients in this section average between 44 to 49 feet per mile. A total of 4,560 feet of natural channel has been replaced by 3,831 feet of altered channel resulting in a loss of 729 feet of channel length. Downstream from the mouth of Swamp Creek, Fortine Creek has not been altered but has been subject to sediment loading from construction activities.

Erosion.- Field inspection in April of 1970 revealed a serious erosion problem along the railroad right-of-way from the north portal of Flathead Tunnel downstream to about four miles below Swamp Creek. Silt deposition in pools and riffles was quite evident in the stream. Erosion control measures were initiated by the Corps of Engineers along the right-of-way in the summer of 1970. Inspection of the right-of-way during spring run-off in 1971 indicated that the stabilization methods had succeeded in reducing sediment loads but problem erosion areas still exist. Areas contributing noticeable sediment include: (1) above Cedar Creek where run-off is eroding a ditch along the west side of the grade, (2) above Channel Change 2918, (3) below Channel Change 2898 and (4) from Channel Change 2893 downstream to Channel Change 2827. This section of the grade consists mostly of deep fill material. The upper part of the grade has been stabilized by covering but the lower part adjacent to the stream has not been stabilized in many areas and is eroding directly into Fortine Creek.

Stream Morphology.- The locations of sample sections in Fortine Creek are presented in Figure 1. Section 1 located approximately 0.8 miles upstream from the north portal is 1,200 feet long and has an average width of 13 feet. This section appears to possess fair trout habitat. Washed out beaver dams in the upper 400 feet cause some sediment loading. The lower 800 feet has good bank stability coupled with fair cover and shade. Section 3 located immediately upstream from the mouth of Swamp Creek is 2,000 feet long and averages 13 feet in width. This section appeared to possess the best trout habitat because of stable banks, excellent willow cover and good pool development. Section 1 has not been influenced by construction, whereas Section 3 has received considerable sediment pollution from the construction activities and erosion from railroad right-of-way.

Fish Populations.- The fish population data for Fortine Creek are summarized in Tables 1, 2 and 3. Marked difference are apparent between the fish populations in Section 1 and 3. Cutthroat trout comprise 81 percent of the fish Age I+ and older in Section 1 with brook trout constituting the remaining 19 percent - only four rainbow were collected. In contrast, rainbow comprised 63 percent of Age I+ and older fish in Section 3 followed by cutthroat (33 percent) and brook trout (6 percent).

The age composition of the individual species suggest low reproductive success for rainbow and cutthroat trout in Section 3 in 1967 and 1968. Only eleven percent of the rainbow were older than Age I+ and none of the cutthroat were older than Age I+. The weak 1967 and 1968 year classes were probably caused by the heavy sediment pollution resulting from peak construction activities along the railroad per acre indicates reproduction of cutthroat in Section 1 approaches expected with 19 percent being Age II+ and older.

A strong year class of brook trout, 983 per acre, was produced in Section 1 in 1970. These large numbers of Age 0+ brook trout indicate that severe competition may occur between juvenile brook trout and cutthroat. Brook trout also reproduced successfully in Section 3 in 1970 as indicated by the estimate of 251 Age 0+ fingerlings per surface acre. Age II+ and III+ brook trout were over five times more abundant in Section 1 than Section 3.

Growth of trout is comparatively slow and little difference in growth rates occur between the two sections. A few rainbow and cutthroat trout reach a harvestable size of seven inches in their third growing season but most attain a harvestable size in their fourth growing season. Brook trout growth is somewhat faster with most fish reaching seven inches in their third growing season. All species are short lived - trout older than Age III were not collected.

The total standing crop of trout in Section 1 was 82 percent larger by number and 34 percent heavier by weight than in Section 3, even though Section 3 had the better physical habitat. Since the confidence limits don't overlap for the number estimate, the difference can be considered significant. The larger standing crop of trout in Section 1 was accounted for by more Age 0+ brook trout and by more Age II+ and III+ brook and cutthroat trout than in Section 3. Sediment loading from the railroad grade is the most probably factor limiting trout in Section 3.

Wolf Creek

Background.- Wolf Creek rises on the west slopes of the Salish Mountains in Lincoln County, Montana and flows approximately 39 miles to its confluence with the Fisher River. The upper 15 miles sector is a small mountain stream with an average gradient of 40 feet per mile. A total of 4,600 feet of natural channel has been replaced by 2,975 feet of altered channel; a net loss of 1,625 feet of stream. From Fairview to about one mile below the mouth of Little Wolf Creek, Wolf Creek meanders for approximately 8 miles through a meadow. This section has good pool development, stable banks with good willow cover and a gradient of about 10 feet per mile. Stream channelization in the meadow has accounted for 4,410 feet of stream being replaced by 4,690

Table 1. Population estimates by age class for trout from Section 1 of Fortine Creek, August 1970

Age Class	Average Length (inches)	Average Weight (pounds)	Percent Age Composition	Number Per Acre	Pounds Per Acre
		Cutthroat Trout			
I+	4.0	.03	81	328	8.4
II+	6.0	.06	16	65	4.2
III+	7.5	.13	3	12	1.4
		Brook Trout	1/		
0+	2.9	.01		983	11.2
I+	5.4	.04	56	50	2.2
II+	7.2	.13	40	36	4.7
III+	10.3	.35	4	6	1.5

1/ Based on Age I and older fish.

Table 2. Population estimates by age classes for trout from Section 3 of Fortine Creek, August 1970

Age Class	Average Length (inches)	Average Weight (pounds)	Percent Age Composition	Number Per Acre	Pounds Per Acre
		Rainbow Trout			
I+	4.2	.03	89	303	10.0
II+	6.3	.08	9	32	2.5
III+	7.2	.12	2	7	.9
		Cutthroat Trout			
I+	4.1	.03	100	186	5.0
		Brook Trout	1/		
0+	2.9	.01		251	3.4
I+	5.5	.05	75	25	1.2
II+	8.9	.26	25	8	2.1

1/ Based on Age I and older fish.

Table 3. Numbers and standing crop in pounds of trout per surface acre for Sections 1 and 3 of Fortine Creek, 1970. Confidence intervals at the 95 percent level.

Species	Number		Pounds		Confidence Interval	
	Section 1	Section 3	Section 1	Section 3	Section 1	Section 3
Rainbow	-	342	-	13.4	-	± 34%
Cutthroat	405	186	14.0	5.0	± 20%	± 37%
Brook	1,075	284	19.6	6.7	± 34%	± 60%
Total	1,480	812	33.6	25.1	± 25%	± 27%

Table 4. Comparison of physical parameters of the stream channel from Section 1 and channel change 10, Wolf Creek, September 1970

Section	Average Depth	Thalweg Average Depth	Average Width	Periodicity 1/	%-Stream Length in Riffle	%-Stream Length in Pools
Section 1	.66	1.2	25.5	6.4	68	32
Channel Change 10	.92	1.5	30.6	4.5	58	42

1/ Average distance between successive pools divided by average stream width.

feet of altered channel; a net gain of 280 feet of channel. Below the meadow, Wolf Creek flows through a narrow valley for approximately 16 miles to its mouth. Approximately 21 percent of this section has been channeled, 17,136 feet of altered channel has replaced 20,640 feet of natural channel resulting in a loss of 3,504 feet of stream.

Three thousand feet of the channel change 10 were sampled to estimate fish populations and 1,500 feet were measured for stream morphology. Section 1 is a 2,000 foot long unaltered channel located approximately two miles upstream from the mouth of Wolf Creek. Fifteen hundred feet of this section was measured for stream morphology information.

Erosion and Water Quality.- Water samples were collected throughout the 1970 water year. This data will be analyzed by the Corps of Engineers Biologist.

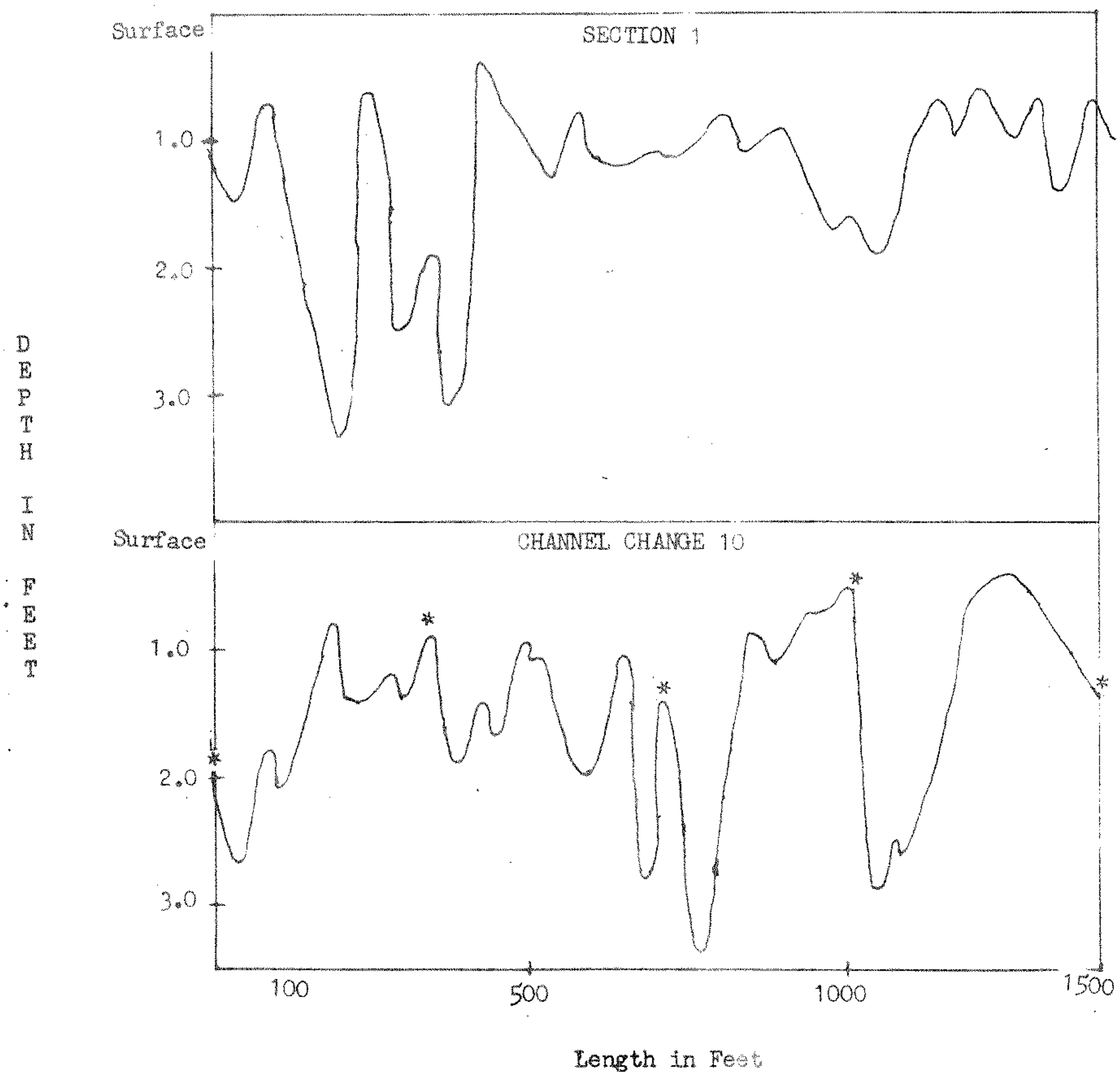
Soil stabilization methods accomplished in the summer of 1970 appeared to have reduced the erosion problem in many areas but more erosion control is needed. Especially important is the need for the establishment of riparian vegetation in the channel changes to reduce erosion and provide cover for trout. The more obvious erosion areas include: (1) opposite channel change 1 (Ariana Creek to Jennings Contract), (2) opposite Calx Mountain Road, (3) below Richards Creek and (4) above Redemption Ridge Road.

Stream Morphology.- Stream morphology data collected from Section 1 and channel change 10 are presented in Table 4 and Figure 2. Marked differences exist between the stream morphology of the control and altered section. The average depth and average thalweg depth in channel change 10 are 39 and 25 percent deeper, respectively, than in Section 1. The periodicity of pools in the latered channel was one every 4.5 stream widths, whereas the periodicity in Section 1 was one pool every 6.4 stream widths. Pool development in channel change 10 occurred immediately below each groin and along the rip-rapped banks above one of the groins. Water velocity in pool areas was apparent only in the upper ends of pools immediately below the groins and was not noticeable in pools above the groins.

The average width in channel change 10 was 20 percent greater than in Section 1. The increase in average width coupled with the impounding effect of the groins has produced a backwater type habitat upstream from the groins.

The primary effect of the groins is to create a deeper, wider, channel with increased pool development and large areas of standing or backwater type habitat. A deeper channel with more pool development when coupled with more cover provides excellent habitat for trout (hunt). Lewis (1967) found that current velocity was the most significant factor positively influencing rainbow populations in pools. Fast water pools utilized by rainbows had large amounts of cover. Cover associated with current is critical because trout require security near their food supply which occurs primarily in the current as aquatic insect drift. This combination of cover and current is only found in the groins and immediately below the groins along rip-rapped banks associated with current.

Figure 2. Profiles along the thalweg in two st_eam sections of Wolf Creek showing pool-riffle periodicity. Asterisk indicate groins.



Aquatic Insects.- The insect data collected from the Fisher River drainage in 1970 are summarized in Tables 5 and 6. The five orders of aquatic insects which were encountered at all stations in almost every collection are presented in these tables. Two individuals of the order Odonata and one individual of the order Hemiptera were collected and are listed in Table 7. These were not included in the analysis because of their insignificance in the collections.

In Wolf Creek, insects collected represented five families of Diptera and 29 genera in the remaining orders: Plecoptera, Ephemeroptera, Odonata, Coleoptera and Trichoptera. A large number of taxa is generally associated with clean waters because sensitive species are eliminated by pollution.

Considerable variation occurred in the numbers and biomass from one month to another. Maximal biomass occurred in April while maximal numbers occurred in August and September. Minimal numbers and biomass occurred in June and July. The largest biomass in April was 2.2 times greater than the lowest in June and July. These flucuations are a reflection of the life cycle of the insects and the amount of habitat available because insects disperse when discharge and velocities increase.

Trichoptera was the dominant order by number and weight comprising 46.5 percent and 39.3 percent, respectively, of the insects collected. Plecoptera was second by weight comprising 31.5 percent of the biomass, whereas Coleoptera was second in abundance comprising 19.9 percent of the total number. Diptera was the least abundant and Coleoptera had the lowest biomass.

The average biomass for the seven months was 2.37 grams per square feet or 227 pounds/acre of riffle. Following Usinger's (1968), productivity classification, Wolf Creek would fall into the category of a rich stream. This is in accord with the productivity index suggested by the total alkalinity range, 41 ppm - 116 ppm recorded in 1968-69. Bonde (1968) found a standing crop of .92 grams/square feet in Wolf Creek in 1967.

The large difference between the two years is probably the result of different sampling dates and/or adverse water quality during 1967-68 when railroad construction increased sediment loads. At any rate, it appears that insect populations in undisturbed channels have increased from lows in 1967. Cordone and Kelly (1961) found that in about one year after a dredge mine operation had ceased, silt was flushed from pools and riffles by freshets and bottom organisms had increased 8 to 10 fold.

Fish Populations.- Population estimates were calculated for trout and suckers collected in Section 1 and channel change 10 (Table 8 and 9). Rainbow was the only species of trout collected except for one cutthroat captured in Section 1. Growth rates of trout in both sections are similar with most fish reaching a harvestable size of seven inches in their third summer of life. Few trout live to older than Age III+. Age I+ fish comprised 77 percent of the fish in channel change 10 and 68 percent in Section 1. Section 1 has

Table 5. Relative abundance for each aquatic insect order expressed as percent of total numbers and biomass for each station, 1970

Aquatic Insect Order	Wolf Creek Station 1	Fisher River Station 1	Fisher River Station 3
Plecoptera			
Numbers	9.7%	17.7%	15.9%
Pounds	31.5	21.0	37.0
Ephemeroptera			
Numbers	17.1	41.5	26.8
Pounds	9.1	34.2	17.8
Coleoptera			
Numbers	19.9	1.3	18.5
Pounds	3.5	tr.	3.1
Trichoptera			
Numbers	46.5	21.6	29.6
Pounds	39.3	20.0	24.8
Diptera			
Numbers	6.8	17.9	9.2
Pounds	16.6	24.8	17.3

Table 6. Average [1] number/square feet and weight in grams of aquatic insects for Station 1, Wolf Creek and Stations 1 and 3, Fisher River, 1970

Date	Plecoptera No.	Plecoptera Wt.	Ephemeroptera No.	Ephemeroptera Wt.	Coleptera No.	Coleptera Wt.	Trichoptera No.	Trichoptera Wt.	Diptera No.	Diptera Wt.	Collection Average No.	Collection Average Wt.
Wolf Creek - Station 1												
3/13/70	31	.40	65	.23	116	.13	95	.60	38	.56	345	1.92
4/10/70	45	1.30	53	.30	47	.03	237	1.60	20	.35	402	3.58
6/24/70	18	.56	76	.24	56	.06	87	.55	22	.23	259	1.64
7/15/70	30	.72	49	.21	48	.08	109	.54	23	.18	259	1.73
8/12/70	43	.89	72	.15	101	.10	266	1.16	36	.51	518	2.81
9/17/70	43	.54	90	.21	115	.14	273	1.35	27	.56	548	2.80
10/27/70	44	.80	47	.18	42	.04	160	.70	14	.37	307	2.09
AVERAGE	36	.75	64	.22	76	.08	175	.93	26	.39	377	2.37
Fisher River - Station 1												
3/13/70	95	.53	152	.81	1	tr	51	.26	43	.30	342	1.90
4/10/70	11	.13	52	.25	-	-	47	.39	80	.14	190	.91
6/24/70	2	tr	15	.11	-	-	3	.01	9	.03	29	.15
7/15/70	15	.08	49	.47	6	tr	15	.15	23	.16	108	.86
8/12/70	37	.24	61	.11	1	tr	52	.18	17	.11	168	.64
9/17/70	21	.17	82	.14	7	tr	69	.13	18	.36	197	.80
10/27/70	29	.14	84	.21	1	tr	19	.09	24	.40	157	.84
AVERAGE	30	.18	71	.30	2	.01	37	.17	30	.21	170	.87
Fisher River - Station 3												
3/13/70	108	.86	127	1.24	61	.04	82	.51	34	.51	412	3.16
4/10/70	56	1.29	64	.33	34	.03	73	.39	6	.10	233	2.14
6/24/70	18	.14	31	.14	19	.02	29	.17	22	.17	119	.64
7/15/70	24	.28	52	.11	23	.02	43	.23	24	.16	166	.80
8/12/70	32	.43	90	.22	71	.09	57	.32	32	.41	282	1.47
9/17/70	50	.79	87	.21	62	.07	87	.44	33	.42	319	1.93
10/27/70	54	1.59	128	.36	129	.17	266	1.55	49	.74	626	4.41
AVERAGE	49	.77	83	.37	57	.06	91	.52	28	.36	308	2.08

1/ Average based on three samples for each collection date.

2/ Yearly average based on seven collections or 21 samples.

Table 7. List of genera of insects collected in each order from Fisher River drainage, 1970

	Wolf Creek Station 1	Fisher River Station 1	Fisher River Station 3
Plecoptera			
Pteronarcys	X	-	X
Pteronarcella	X	-	X
Capnia	X	X	X
Isogenus	X	X	X
Acrynoptery	X	-	X
Isoperla	X	X	X
Claaseenia	X	X	X
Acroneuria	X	X	X
Alloperla	X	X	X
Nemoura	X	X	-
Kathroperla	-	-	X
Brackyptera	-	X	X
Diura	-	-	X
Ephemeroptera			
Baetis	X	X	X
Ameletus	X	X	X
Ephemerella	X	X	X
Leptophlebia	X	-	-
Paraleptophlebia	X	X	X
Rithrogenia	X	X	X
Cinygmula	X	X	X
Epeorus	X	X	X
Hexagenia	-	X	-
Odonata			
Ophiogomphus	X	-	-
Coleoptera			
Zaitzeuia	X	X	X
Promoresia	-	-	X
Helichus	-	-	X
Hemiptera			
Rhagovelia	-	X	-
Trichoptera			
Hydropsyche	X	X	X
Polycentropus	X	X	X
Brachycentrus	X	X	X
Glossosoma	X	X	X

Table 7. Continued

	Wolf Creek Station 1	Fisher River Station 1	Fisher River Station 3
Rhyacophila	X	X	X
Psychomyia	X	X	X
Leptocerns	X	-	-
Dicosmoecus	X	-	-
Tinodes	X	X	X
Chimarra	-	X	-
Diptera			
Chironomidae	X	X	X
Tabanidae	X	-	X
Tipulidae	X	X	X
Simuliidae	X	X	X
Rhagionidae	X	X	X

Table 8. Population estimates by age classes for rainbow trout from Section 1 and channel change 10, Wolf Creek, August 1970. Confidence limits at the 95 percent level in parenthesis

Age Class	Average Length (inches)	Average Weight (pounds)	Percent Age Composition	Number Per Acre	Pounds Per Acre
		Section 1			
I+	5.1	.05	68	112	5.1
II+	7.3	.14	28	46	6.4
III+	10.9	.34	4	6	2.1
Totals	-	-	-	164	13.6 (± 28%)
		Channel Change 10			
I+	5.0	.05	77	111	5.6
II+	7.3	.14	22	33	4.6
III+	10.1	.33	1	1	.3
Totals	-	-	-	141	10.5 (± 16%)

Table 9. Population estimates for largescale suckers from Wolf Creek, August 1970. Confidence limits given at the 95 percent level in parenthesis

Size Group	Average Length (inches)	Average Weight (pounds)	Number Per Acre	Pounds Per Acre
		Section 1		
3.8 - 7.5	5.2	.07	51	3.4 (± 75%)
		Channel Change 10		
2.8 - 5.4	4.1	.03	695	20.9 (± 31%)

Table 10. Population estimates for suckers and mountain whitefish from Section 1 and channel change 6, Fisher River, September 1970. Confidence limits at the 95 percent level in parenthesis

Species	Size Group	Average Length (inches)	Average Weight (pounds)	Number Per 1000' Stream	Pounds Per 1000' Stream
		Section 1			
Mountain whitefish	7.6-17.1	11.5	.53	96	50.8 (± 80%)
		Channel Change 6			
Largescale sucker	3.1-11.8	5.1	.06	486	29.4 (± 29%)
Longnose sucker	3.9- 7.9	5.9	.07	26	1.9 (± 66%)
Total suckers	-	-	-	512	31.3 (± 24%)

50 percent more Age II+ and III+ trout per acre than channel change 10. The biomass estimate of 13.6 pounds/acre in Section 1 is 30 percent greater than in channel change 10 (10.5 pounds/acre). However, the overlap of confidence limits indicates that the difference may not be statistical significant. At any rate the biomass of 13.6 pounds per acre is much less than that recorded for Fortine Creek (25 to 32 pounds/acre) and is not in accord with the basic fertility of a medium-hard water stream. A standing crop of 227 pounds insects/acre of riffle indicates that food is not the limiting factor.

Marked differences occurred between the two sections with regard to the numbers and biomass of suckers per acre. Section 1 had a standing crop of 51 largescale suckers with a biomass of 3.4 pounds per acre whereas channel change 10 had 695 largescale suckers with a biomass of 20.9 pounds per acre. Channel change 10 had 14 times as many suckers as Section 1. This difference was significant as there was no overlap of confidence limits. The suckers in channel change 10 averaged almost one inch less in total length than those in Section 1. Analysis of scales indicated that fish under five inches long were less than three-years-old. Increased completion may be expected between the suckers and trout when the suckers mature. In addition to suckers, redside shiners were quite abundant in the channel changes.

The majority of trout were collected from those areas having a combination of cover associated with current. Areas having these characteristics are comparatively few in both the channel change and control section and their scarcity is probably the factor limiting trout populations. Gunderson (1968) stated that the amount of suitable cover limits numbers of stream trout at some point soon after the fingerling stage. Chapman and Bjornn (1969) concluded that distribution close to high velocity water is food related because the fast current transports more drifting insects than slow current.

Suckers and other rough fish were most likely to be collected from deeper waters of little or no velocity. In the channel change areas this type of habitat was quite abundant and rough fish were especially abundant in the riprapped areas which had little current. This is in accord with Lewis (1967) who stated that suckers preferred deep-slow pools with extensive cover.

The integration of the stream morphology and fish population data shows that considerably more habitat for suckers and other rough fish than for trout has been created by the groins. Changes in the groin structure which would reduce their impounding effect and increase the area where current is associated with cover would provide more trout habitat, while reducing the amount of rough fish habitat. Establishment of riparian vegetation would increase cover, reduce erosion and make the channel changes more in harmony with the surrounding environment.

Fisher River

Background.- The Fisher River drains a watershed of about 838 square miles of which 216 are in the Wolf Creek drainage. The primary land uses in the drainage include timber production and cattle ranching. These practices have increased erosion and destroyed riparian vegetation. Soils in the project area are primarily unconsolidated glacio-lacustrine silts, classified in soil erosion class III (U.S.D.A. 1970). The Fisher has been extensively channeled during relocation of the railroad from its mouth upstream to below Wolf Creek Junction. Approximately 44 percent of this portion of the stream has been channeled. A total of 27,440 feet of natural channel has been replaced by 22,625 feet of altered channel; a net loss of 4,815 feet of stream length. Gradient was increased from 31 feet per mile to 34 feet per mile.

The fish population study sections are shown in Figure 1; Section 1 is 15,840 foot long unaltered section located above the mouth of Wolf Creek. Channel change 6 is 2,650 long and is located downstream from the mouth of Wolf Creek.

Erosion and Water Quality.- Water samples were collected for the 1970 water year. Data will be analyzed by Corps of Engineers personnel.

Erosion from the railroad grade is not a serious problem in the Fisher below the mouth of Wolf Creek. Establishment of riparian vegetation is needed in most channel changes to provide cover and shade for trout and make the channel change more in harmony with the natural sections.

Aquatic Insects.- The insects collected from Station 3 (Control) represented five families of Diptera and 29 genera in the orders listed in Table 7. The insects from Station 1 (altered area) represented four families of Diptera and 26 genera in the other orders. The main difference in genera occurred in the order Plecoptera where Station 3 had 12 genera as compared to 8 for Station 1. A large number of taxa is indicative of unpolluted waters and suitable substrate.

Both stations exhibited similar seasonal flucuations in abundance and biomass of insects. Comparatively large populations existed in March and April followed by a sharp decline in June and July. A gradual increase throughout the late summer resulted in a maximum biomass at Station 3 in October. The largest biomass at Sections 1 and 3 were 12.6 and 6.9 fold greater, respectively, than the smallest.

A marked difference occurred between the two stations with regards to the relative abundance of the insect orders. The overall pattern consisted of an increase in Emphemeroptera and Diptera at Station 1 coupled with a decrease in Coleoptera, Plecoptera and Trichoptera. The smaller forms of Ephemeroptera such as Baetis were quite abundant. Trichoptera and Plecoptera comprised 62 percent of the biomass at Station 3 whereas the same two orders accounted for only 41 percent of the biomass at Station 1 in the Fisher. Trichoptera and Plecoptera comprised 70 percent of the biomass at the Wolf Creek station. Ephemeroptera and Diptera at Station 1 accounted for 59 percent of the biomass as compared to only 35 percent at Station 3. In addition, Coleoptera comprised only 1.3 percent of the numbers at Station 1 and 21.6 percent at Station 3. It appears that some forms of Ephemeroptera and Diptera are tolerant of adverse conditions caused by channelization and sediment pollution.

The average biomass for Station 1 was .87 grams/square feet or 84 pounds per acre of riffle. Station 3 had an average standing crop of 2.08 grams per square feet or 200 pounds/acre of riffle. This biomass would place Station 3 in the catagory of a rich stream, whereas Station 1 would be a poor stream. Total alkalinities collected in 1968-69 ranged between 35 ppm and 123 ppm, indicating that the Fisher should rank medium to high in productivity.

Environmental factors altered by the railroad construction which limit insect diversity and production includes increased sediment loads, channelization and increased temperatures resulting from removal of riparian vegetation and impounding effect of the groins. The Wolf Creek station was subject to increased sediment loads but insect production remained high in the unaltered section sampled. This suggests that unsuitable substrate in the channel changes is the primary factor limiting insect diversity and production in Station 1 (channel change 17) of the Fisher River.

Resident Fish Populations.- The resident fish population data for Section 1 (control) and channel change 6 are summarized in Table 10 and 11. Population estimates were not calculated for mountain whitefish from channel change 10 nor were they calculated for cutthroat trout or largescale suckers from Section 1 because low populations of these species precluded capture of sufficient numbers for estimates.

Growth rates of rainbow are similar in both sections with most fish achieving a harvestable size of 7.0 inches in their third summer of life (Age II+). The age structure of the rainbow population reveals that only one percent survive to Age III+ in Section 1 and two percent in channel change 10. The poor survival of older fish may be a result of habitat deficiencies, life cycle of the fish and/or migration to the Kootenai River. Inspection of rainbow trout gonads collected in March 1971 from Section 1 indicated that the majority of males mature at Age II, whereas the majority of females mature at Age III. The fact that these trout mature in the Fisher River suggest a non-migratory population. However, a more detailed study on trout movement is needed before it can be determined whether or not the rainbow trout in the Fisher are primarily resident or migratory.

A small population of cutthroat trout was found in channel change 6. The point estimate was 11 cutthroat per 100 feet/stream. It is possible that these fish are migratory cutthroat native to the Kootenai River drainage.

The point estimate for biomass of rainbow trout in channel change 6 (10.1 pounds/100 feet stream) is nearly 2.5 times greater than the rainbow biomass in Section 1 (4.0 pounds). Since the confidence limits don't overlap the difference is significant. The biomass of trout in both sections is considerably less than a medium to hard-water stream could support. It is doubtful if food is limiting trout because there are 200 pounds of insects per acre of riffle in the control area and 84 pounds of insects per acre of riffle in channel changes. It appears that poor physical habitat is limiting trout populations in the Fisher River. A paucity of streambank cover, bank deterioration and bed movement are caused by the scouring effect of high spring flows. These problems have been intensified by channelization, destruction of riparian vegetation by cattle, road building and intensive logging in the watershed.

Table 11. Population estimates by age class for trout from Fisher River, Section 1 and channel change 6, September 1970. Confidence limits at the 95 percent level in parenthesis

Species	Age Class	Average Length (inches)	Average Weight (pounds)	Percent Age Composition	Number Per 1000' Stream	Pounds Per 1000' Stream
			Channel Change 6			
Ct	I+	5.2	.05	84	9	.5
	II+-III+	9.1	.29	16	2	.5
Subtotal	-	-	-	-	11	1.0 (± 57%)
Rb	I	5.2	.05	68	77	3.8
	II	7.2	.14	30	33	4.7
	III	10.3	.36	2	2	.6
Subtotal	-	-	-	-	112	9.1 (± 26%)
Total	-	-	-	-	123	10.1 (± 24%)
			Section 1			
Rb	I	5.1	.05	90	67	3.2
	II	6.9	.11	9	7	.7
	III	9.9	.34	1	1	.1
Total	-	-	-	-	75	4.0 (± 62%)

Table 12. Summary of 1969 and 1970 mountain whitefish spawning runs from Kootenai River into Fisher River

Year	Average Size	Number Repeat Spawners	Total Number Spawners	Percent Female	Total Fecundity
1969					
Male	11.6	-	664		
Female	11.6	-	467	41	1,500,000
1970					
Male	10.6	377 1/	1,746		
Female	11.4	-	895	34	2,800,000

1/ Includes males and females.

The point estimate for sucker biomass in channel change 6 was approximately 31.3 pounds/1000 feet of stream. Largescale suckers were by far the more abundant followed by longnose suckers. Largescale suckers averaged 5.1 inches in total length. Scale analysis indicates that the majority of these fish were less than three years old. Suckers were comparatively rare in Section 1 as only seven were collected in three sampling runs.

Mountain whitefish were more abundant in Section 1 than any other fish. The point estimate numbered 96 whitefish and 50.8 pounds of whitefish per thousand feet of stream. This estimate in 1970 is approximately 40 percent less than in 1969. It appeared that whitefish density was less in 1970 than in 1969 but the overlap of confidence intervals for the point estimates indicates that the difference may not be significant.

The whitefish population is both resident and migratory. Trap data show that 105 whitefish from the Kootenai migrated as far as Section 1 to spawn in the fall of 1970. Large and presumable resident whitefish provided a good fishery throughout the winter in this section. Only four whitefish were collected in two sampling runs through channel change 6. This low population is most likely a result of unsuitable habitat, coupled with the migratory habits of whitefish in the lower part of the Fisher.

Trout in channel change 6 were most often collected from the groins and the rip-rapped banks associated with current. Suckers were most often collected in the rip-rapped areas with little or no current and from aquatic vegetation found in the backwater type habitat. These observations are identical to those recorded from channel change 10 in Wolf Creek. The similarity of the habitat produced by groins in the two streams has resulted in almost identical fish populations.

Migratory Fish Population.- Trapping of fall spawning fish commenced in September 24, 1970 and continued through October 29, 1970. Mountain whitefish was the only species taken in any number. Approximately 98 percent of the whitefish run was captured between October 1 and October 26. A summary of the 1970 data is compared to the 1969 data in Table 12. The total number of the 1970 run (2,641 fish) was 134 percent greater than the 1969 run. Females comprised 34 percent of the run in 1970 as compared to 41 percent in 1969.

Approximately 33 percent of the whitefish marked and passed through the trap in 1969 were recaptured in 1970. This high rate of repeat spawning indicates a strong homing tendency and a comparatively high annual survival rate. A strong homing tendency in migratory fish is generally indicative of a distinct racial strain of the species, because little gene flow occurs between populations homing to difference streams. Liebelt (1970) found that in season displacement homing of mountain whitefish to Mission Creek (tributary of the Yellowstone River) to be 10 percent in 1968 and 31 percent in 1969. Only 2.6 percent of 310 fish marked in 1968 returned to spawn in 1969.

Some preliminary data were obtained in September and October on the origin of the Kootenai River whitefish migrating up the Fisher River to spawn. Ninety-seven fish marked in the Kootenai within a mile of the Fisher River were captured in the Fisher traps. Three fish marked near Warland also were recpatured in the Fisher trap. The distance these latter fish travelled down the Kootenai River to the Fisher was approximately 12 miles.

Upstream fish traps operated in the mouth of Wolf Creek and in the Fisher River approximately 13 miles upstream from the mouth provided information on movement of Kootenai River whitefish within the Fisher drainage. Only 11 whitefish were taken in the Wolf Creek trap. None of these fish were from the Kootenai River. The catch at the upper Fisher trap totaled 1,400 fish of which 105 were known to have originated from the Kootenai River. The remainder had to originate from the Fisher below Cow Creek or from the Kootenai River before the traps were installed. This data indicate that the groins installed in channel changes in the Fisher River are not barriers to migratory whitefish.

Mountain whitefish eggs were collected in the Fisher River to determine areas utilized for spawning. The 14 mile section sample included all of the river containing channel changes and the control section near Cow Creek. In general, whitefish eggs were most commonly found in clean gravel and rubble at heads of riffles or tail end of pools. The information on the distribution of eggs is presented in Table 13. Eggs were most abundant near the mouth of the Fisher, averaging 29 per sample. Eggs were common in and above channel change 17 but were not collected from channel change 16, above channel change 16 and channel change 12. Eggs were common above channel change 12, in channel change 8 and above channel change 3 and in the control section.

The resident whitefish population is comparatively low in the Fisher River below channel change 2. It follows that most eggs present from channel change 2 downstream to the mouth are spawned by migratory whitefish from the Kootenai. The electrofishing data revealed a large resident whitefish population in the control section which may have been responsible for deposition of most of the eggs in this area. The reason for little spawning from channel change 16 upstream through channel change 12 is not clearly understood but it may be related to lack of spawning gravels. The fact that spawning did occur in some channel changes indicates the presence of spawning gravels in these areas.

The age and growth information for the 1970 whitefish run is presented in Table 14. Little difference in growth rates is apparent between males and females. The growth rates of fish collected in 1970 were interpreted to be somewhat faster for Age 4+ and older fish than in 1969. This is probably related to problems encountered in aging. Scales from Kootenai River whitefish form accessory checks or false annuli and fish older than Age IV are difficult to age.

Table 13. Distribution and relative abundance of mountain whitefish eggs in Fisher River, 1970

Station	Location	Average 1/ Per Sample	Range
1	Mouth of Fisher	29.4	1-93
2	Channel change 17	1.5	0- 4
3	Above channel change 17	1.8	0- 7
4	Channel change 16	-	-
5	Above channel change 16	-	-
6	Channel change 12	-	-
7	Above channel change 12	1.8	0- 5
8	Channel change 8	1.5	0- 4
9	Above channel change 3	5.2	0-11
10	Fisher - Cow Creek	5.2	0-15
11	Fisher - Snell Creek	5.0	0-15

1/ Based on ten samples.

Table 14. Growth and age composition of mountain whitefish spawning run, October 1970

Age	Number Aged ♂	Number Aged ♀	Average Length at Capture ♂	Average Length at Capture ♀	Percent Age 2/ Composition ♂	Percent Age 2/ Composition ♀
II+	48	26	9.6	9.9	54.7	22.3
III+	36	40	11.3	11.2	32.3	46.4
IV+	24	18	12.8	12.5	8.2	17.6
V+	20	15	13.9	13.4		
VI+	6	7	14.6	14.1	4.8 1/	13.7
VII+	3	1	14.3	14.8		

1/ For Age V - VII.

2/ The percent an age class, comprised of each one inch length group, was determined for fish aged. This percent was multiplied by the total number of fish in each inch group taken from the length frequency distribution of the spawning run. The numbers of an age class in each length group were summed to arrive at the total number an age class contributed to the spawning run.

The age and composition of the males and females is quite different. The majority of the males (54.7 percent) in the spawning run were Age II+ indicating that most males mature when two years old. The low percentage (22 percent) of Age II+ females in the run indicates females don't mature until Age III+.

An examination of the age structure of the spawning run reveals why the average length of fish in the 1969 run was larger than in 1970. The decrease in average length of the run from 11.6 for males and females in 1969 to 10.6 and 11.4, respectively, in 1970 was a result of more Age II fish spawning in 1970 than 1969. A total of 1,155 Age II fish spawned in 1970 as compared to 124 in 1969.

The data suggest that the 1968 year class was stronger than the 1967 year class. The weak 1967 year class could be construction related. The original cuts for channel changes were made in 1966. Considerable channel work took place in the fall of 1966 and winter of 1967. Construction activities coincided with spawning and incubation of the eggs of the 1967 year class of whitefish. The channel work was 85 percent complete by September, 1967.

Since data on the whitefish spawning run are not available before construction, it can not be determined if the 1968 year class is as strong as preconstruction year classes. In any case the weak 1967 year class points out the need to construct channels in the dry and work in them when game fish are not spawning or their eggs are not incubating in the gravels.

A fyke net was fished in the Fisher River above channel change 17 during May 1971 to monitor spawning migrations of cutthroat and rainbow trout. Only one adult cutthroat and one adult rainbow were captured. The capture of ripe largescale suckers moving up to spawn indicates that the majority of trout had moved up the Fisher before the fyke net was operating. Generally cutthroat trout migrate first, followed by rainbow trout and suckers move last. Water temperatures taken in the morning ranged between 43° F. and 51° F.. Cutthroat trout migrate when minimum daily temperatures are above 39° F..

Data on the movement of trout fry out of the Fisher River were not available for this report.

RECOMMENDATIONS

Future Construction

1. Channel changes should be construction in the dry and opened during periods of increasing discharge when game fish are not spawning or their eggs incubating in the gravel. In northwest Montana this would generally be in March.

2. Groins should be tied into the stream bottom and constructed in the dry. The height above the stream bottom should allow for constriction of the current during low discharge in summer and fall but the groin height should be low enough to minimize the impounding effect.

3. Openings in the groins should be alternated to facilitate meandering. Openings on the side where banks are rip-rapped should be placed in such a manner as to direct current along the rip-rap. Low head groins should alleviate the problem of undercutting the rip-rapped bank and endangering the railroad or highway grades.

Current Project Modifications

4. Openings in the groins should be alternated to facilitate meandering. Openings on the side where banks are rip-rapped should be placed in such a manner as to direct current along the rip-rap. Low head groins should alleviate the problem of undercutting the rip-rapped bank and endangering the railroad or highway grades.

5. Cover should be improved in areas below opening where water velocity is not associated with suitable hiding places for trout. Cover could be provided by a series of boulders and rubble, and riparian vegetation.

6. Areas with erosion problems designated in this report should be stabilized.

7. Riparian vegetation should be established immediately after heavy equipment is out of the area.

8. Willow shoots should be planted on banks and groins in channel change areas to provide cover for trout, increase bank stability, reduce erosion and provide shade. This would decrease temperatures and make the channel changes more in harmony with the surrounding environment.

Next Year's Study

9. Trout over six inches in length collected in the Fisher River and Wolf Creek should be tagged to provide information on movement.

10. Velocity and cover measurements should be taken at the same stations along with stream morphology data in Wolf Creek and Fisher River.

Prepared by Bruce May   Approved by Art Whitney

Date July 1971   Date September 21, 1971

REFERENCES

Apmann, R. P. and M. P. Oatis. 1965. Sedimentation and Stream Improvement, New York Fish and Game Journal 12(2): 117-126.

Bonde, T. J. 1969. Progress Report on the Libby Dam Project Water Quality Investigations. Seattle District, Corps of Engineers. Mimeo. pp1-20.

Chapman, D. W. and T. C. Bjornn. 1969. Distribution of Salmonids in Streams with Special Reference to Food and Feeding. H. R. MacMillan Lectures in Fisheries, Symposium on Salmon and Trout in Streams. pp153-176.

Cordone, A. J. and D. W. Kelly. 1961. The Influence of Inorganic Sediments on the Aquatic Life of Streams. California Fish and Game 47(2): 189-223.

Elser, A. A. 1968. Fish Populations of a Trout Stream in Relation to Major Habitat Zones and Channel Alterations. Trans. A. M. Fish Society. 97(4): 389-397.

Gunderson, D. R. 1968. Floodplain Use Related to Stream Morphology and Fish Populations, Journ. Wildl. Man. 32(3): 507-514.

Hunt, R. L. 1968. Effects of Habitat Alteration on Production, Standing Crops and Yield of Brook Trout in Lawrence Creek, Wis. Wis. Dept. of Natural Resources Research Report. No. 31, 45pp.

Johnson, R. L. 1964. Shields River Stream Channel Alteration Study, D. J. Report. Project F-9-R-12. Montana Fish and Game Dept. 4pp.

Lewis, S. L. 1967. Physical Factors Influencing Fish Populations in Pools of a Trout Stream. M. S. Thesis, Mont. State Univ., Bozeman 34pp.

Liebelt, J. E. 1970. Studies on the Behavior and Life History of the Mountain Whitefish (Prosopium williamsoni Girad). Ph D Thesis, Mont. State Univ., Bozeman pp44.

May, Bruce. 1970. Evaluation of Mitigation Measures in Fisher River, Wolf Creek and Fortine Creek. Job Progress Report. Contract DACW 67-70-C-0001. Mont. Fish & Game pp24.

Northcote, T. G. 1969. Lakewood Migration of Young Rainbow Trout (Salmo gairdneri) in the Upper Lardeau River, B. C., J. Fish Res. Bd. Canada 26: 33-45.

U. S. Department of Agriculture. 1970. Erosion Class Designation of Soils, BPA Libby - Loop Power Tranmission Line. U. S. Forest Service, Missoula, Mt. Unpublished Mimeo pp1-3.

Usinger, Robert L. 1968. Aquatic Insects of California. University of Calif. Press, Berkley and Los Angeles pp508.

Vincent, E. R. 1969. River Electrofishing and Fish Population Estimates, Mont. Fish and Game Methods, Mimeo. pp1-7.

Waters, T. F. and R. K. Knapp. 1961. An Improved Stream Bottom Fauna Sampler Trans. Am. Fish Soc. 90(2): 225-226.

Whitney, A. N. and J. E. Bailey. 1959. Detrimental Effects of Highway Construction on a Montana Stream. Trans. Am. Fish Soc. 88(1): 72-73.