MONTANA FISH AND GAME DEPARTMENT
FISHERIES DIVISION

JOB PROGRESS REPORT

State Montana

Project No. F-9-R-18 Title Southwestern Montana Fishery Study

Job No. II-a Title Evaluation of Stream Improvement Structures on Prickly Pear Creek and the East Gallatin River.

Period Covered July 1, 1969, to June 30, 1970

ABSTRACT

The physical parameters and fish populations were measured in the relocated channels of Prickly Pear Creek and the East Gallatin River and compared with measurements made in 1967 and 1968. The artificial channel on Prickly Pear Creek was meandered in the floodplain to retain original length, while approximately 2,200 feet of the East Gallatin River was replaced with a straight, 1,650-foot channel with rock jetties. Prior to construction, the average depth and width of Prickly Pear Creek was 1.4 and 26.4 feet, respectively. Average depth was reduced by 28.6% (1:4 to 1:0) in 1968, and remained unchanged in 1969. Pool-riffle periodicity, or the spacing of successive pools, was 6.6 times the average width before construction (1967), 15.7 widths one year following construction (1968), and 8.8 widths two years following construction (1969). Willow shoots were planted to compensate for vegetation lost during construction, but survival was poor.

Average stream depth and average thalweg depth of the realigned channel on the East Gallatin River were increased by 42.9 and 15.4%, respectively, in 1968 and by an additional 10.0 and 26.7%, respectively, in 1969. The average stream width increased by 7.4% (27 to 29 feet) in 1968 and decreased by 17.2% (29 to 23 feet) in 1969. Pools were spaced at intervals of 5.6 widths prior to construction, 3.9 widths one year after construction and 5.3 widths two years following construction. Of the 30 jetties installed in the channel, 53.3% (16) remained in 1969, with an additional 26.7% (8) partially washed out.

Fish populations were estimated by means of a simple mark-and-recapture census in both channels. Rough fish predominated in both channels, pre- and post-construction, contributing over 62 and 77% of the total number and weight, respectively, in Prickly Pear Creek and over 85 and 87%, respectively, in the East Gallatin River. Longnose suckers were the most abundant fish collected in both channels. Total standing crops in Prickly Pear Creek were: 169, 81 and 74 pounds per acre prior to construction, one year and two years following construction. Standing crops of trout for the same sampling periods were: 36, 17 and 19 pounds per acre, respectively. The East Gallatin River segment supported total standing crops of 596 pounds per acre prior to construction and 274 pounds per acre two years after alteration.

BACKGROUND

In the mountainous regions of the Western United States, major transportation lines have long followed water level routes. The natural courses laid out by streams and rivers most often offered least resistance because of alignment and grade. When it became a question of preserving the stream or the right-of-way, the railroad or highway generally won out at the expense of the waterway. In the past, construction of highways and railroads left shorter, straight channels for the roadside stream and stripped the willows and other streamside vegetation.

The ultimate result of forcing a naturally meandering stream into a straight channel is a loss of valuable stream length. A study of channel alterations on 13 Montana streams revealed that their total length was shortened by 68 miles when 137 miles of natural stream was rerouted into 69 miles of inferior man-made channel (Alvord and Peters, 1963). Such channel disturbances are undoubtedly detrimental to the indigenous fish populations. Following habitat alteration of a small stream for highway construction, Whitney and Bailey (1959) showed a 94% reduction in number and weight of trout greater than 6.0 inches in length. In Little Prickly Pear Creek, Elser (1968) reported the number and weight of brown and rainbow trout were about 78% less in a segment of stream straightened by railroad construction than in a natural section.

A great aid in preventing losses to fish habitat by channel alterations in Montana has been the Stream Preservation Law. Since 1963, this law has required agencies of the state and local government to notify the Fish and Game Department of any construction activity that encroaches in any manner on a river or stream. If the construction activities are judged detrimental to the stream, alternate plans or recommendations for mitigating habitat losses are presented, as was the case in this study. A 3,300-foot channel change to Prickly Pear Creek was meandered in the floodplain to retain original channel length and rock jetties were installed in a realigned segment of the East Gallatin River to constrict the flow and create meanders. The objective of this study was to evaluate the effectiveness of such mitigative measures.

OBJECTIVES

The Prickly Pear Creek segment of the study is designed to determine the effectiveness of artificially meandering a stream when the natural channel is altered by highway construction. The construction of Interstate Highway 15 near Montana City resulted in a continuous 3,300-foot channel change to Prickly Pear Creek. A new channel was built with meanders to retain pre-construction channel length (Figure 1). The new sinuous channel was supposed to be constructed alongside existing brushy vegetation to retain streamside cover. However, most existing woody vegetation in the floodplain was removed by mistake during the construction process. Willow shoots were planted to help stabilize the banks and re-establish woody vegetation lost to construction.

The purpose of the East Gallatin River portion of the study is to measure and evaluate changes in stream morphology and the fish population resulting from artificially meandering a realigned channel by constructing rock jetties. Over 2,200 feet of natural channel was replaced by a straight channel 1,650 feet in length as the result of construction of Interstate Highway 90 near Bozeman.

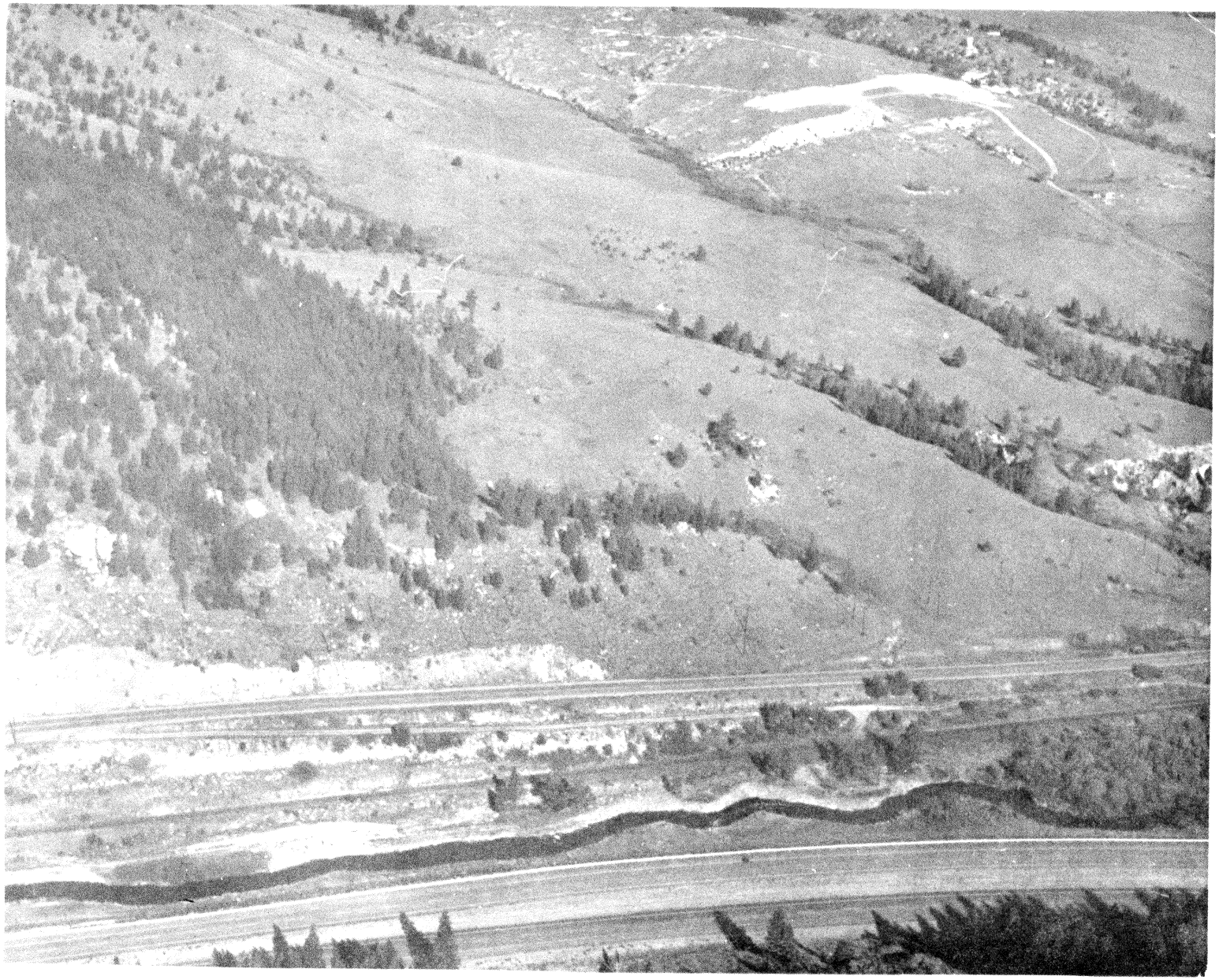

FIGURE 1. Photograph of artificial channel on Prickly Pear Creek showing man-made meanders.

Rock jetties were installed in the new channel on alternate banks at 50-foot intervals to constrict the current and create meanders (Figure 2).

PROCEDURES

Stream morphology of the original channels was measured in 1967 and on both relocated channels in 1968 and 1969 to determine differences following alteration. Transects were established perpendicular to the main current at 50-foot intervals on Prickly Pear Creek, and at 25-foot intervals on the East Gallatin River. Depths were measured to the nearest 0.1 foot at 2-foot intervals on each transect. Pool-riffle periodicity was determined by plotting the bed profile along the thalweg, or the line connecting the deepest points of the channel. A pool was arbitrarily defined as a vertical drop in the streambed greater than the average thalweg depth. Sinuosity, or the ratio of thalweg length to mean down-valley distance, was measured prior to and following alteration.

Fish populations were censused by electrofishing. Estimates of the fish populations (fish greater than 4.0 inches in total length) were based on Chapman's modification of the Petersen formula described by Vincent (1969). Confidence intervals at the 95% level were calculated for each estimate by formula 6 of the Michigan Institute for Fisheries Research (1960). Coefficient of condition was calculated for the Prickly Pear Creek fish populations using the formula $K = W \times 10^5/L^3$; where W = weight in pounds and L = length in inches.

FINDINGS

Stream Morphology

The analysis of field data showed that the channel length for Prickly Pear Creek was retained, and was actually increased in the area of construction by approximately 3% (Table 1). Average stream depth and average thalweg depth were reduced by 28.6 and 21.7%, respectively, in 1968 and remained unchanged in 1969.

In natural stream conditions, the thalweg tends to wander back and forth across the channel opposite the bars, even in straight reaches. The degree of wandering is indicated by the sinuosity. This ratio of thalweg length to mean down-valley distance for the natural channel was 1.05, indicating an almost non-sinuous channel. The ratio increased to 1.09 in 1968 and 1.10 in 1969.

The bed profile along the thalweg was plotted to show changes in the pool-riffle periodicity (Figure 3). Prior to construction, there was a pool every 180 feet of stream for a periodicity of 6.6 times the average stream width. Leopold and Langbein (1966) reported the spacing of successive pools as ordinarily in the magnitude of from 5 to 7 stream widths. In 1968, the spacing of successive pools was increased to a pool every 380 feet or a periodicity of 15.7 widths. Two years following construction, the periodicity had adjusted to 8.8 widths or a pool every 210 feet.

Willow shoots were planted along the realigned channel in 1968 to compensate for woody vegetation lost during construction. Total survival of the shoots was low; 36.8% for willows planted in double rows and 8.7% for shoots planted in single rows (Elser, 1969). A total of 1,723 willow shoots and 32 red dogwood shoots were planted in single rows along the stream bank in 1969. Although these

FIGURE 2. Photograph of realigned channel on the East Gallatin River showing locations of rock jetties.

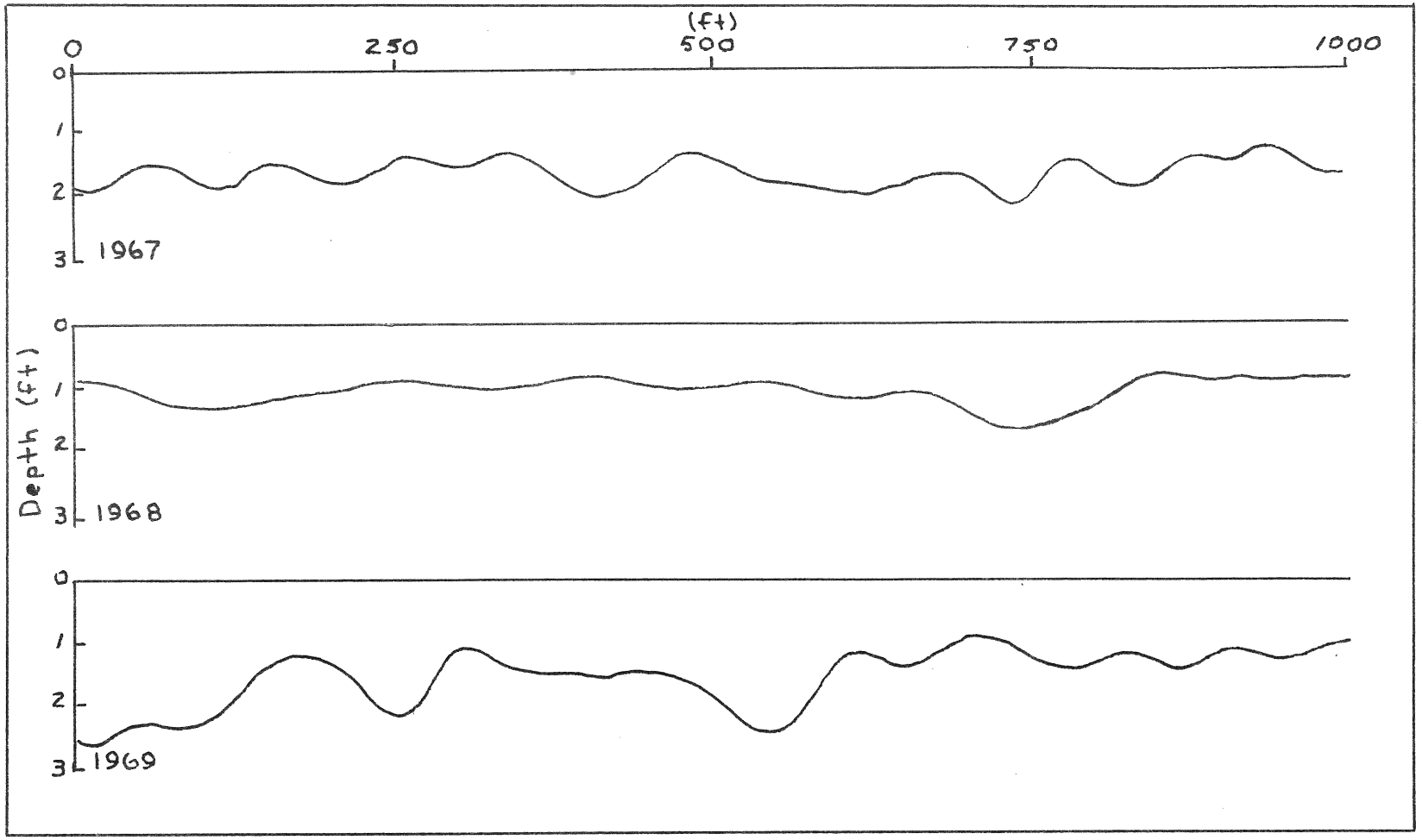

FIGURE 3. Bed profile along the thalweg for a portion of Prickly Pear Creek, showing the pool-riffle periodicity; pre-construction (1967), one year post-construction (1968), and two years post-construction (1969).

TABLE 1. Channel measurements obtained from Prickly Pear Creek prior to (1967), one year following (1968) and two years following relocation (1969)

Parameter	1967	1968	1969
Length (ft.)	3,150	3,250	3,250
Average depth (ft.)	1.4	1.0	1.0
Average thalweg depth (ft.)	2.3	1.8	1.8
Average width (ft.)	26	25	25
Sinuosity	1.05	1.09	1.10
Pool-riffle periodicity 1/	6.6	15.7	8.8

1/ Average distance between successive pools divided by average width, expressed in widths.

plantings were not evaluated, streamside observations indicated poor survival. It was felt that the major reason for failure of the two plantings was the lack of a stable bank. The artificial channel was constructed with the conventional engineering design of 1½:1 slopes. Except where rip-rap was placed, these steep allevial slopes have not stabilized, and erosion continues to wash away the toe of the slope.

Approximately 2,200 feet of natural channel of the East Gallatin River near Bozeman was replaced by 1,650 feet of straight channel. Rock jetties were installed in the realigned channel at 50-foot intervals on alternate banks to constrict the current and create meanders. Average stream depth and average thalweg depth of the realigned channel were increased by 42.9 and 15.4%, respectively, in 1968, while the average width remained about the same. In 1969, the average depth and average thalweg depth increased by an additional 10.0 and 26.7%, while the average width decreased by 17.2% (Table 2).

The periodicity of pools prior to construction was one pool each 5.6 stream widths, or a pool every 150 feet. One year following construction, there was a pool every 125 feet, for a periodicity of 3.9 widths. In 1969, periodicity had adjusted to 5.3 widths, nearly the same as prior to construction.

Deflectors, or jetties, are designed to make a narrower, swifter and deeper channel. Early uses of deflectors were to improve on natural conditions, producing better fish habitat and thereby increasing the yield. Recently, jetties have been used effectively to improve the habitat quality of streams altered by highway construction. A total of 30 jetties were installed in the realigned channel (1968). In 1969, 53.3% (16) of the original jetties remained, with an additional 26.7% (8) partially washed out since 1968. Scouring of pools generally occurred in association with every other structure in 1968, and increased to 75% of the remaining jetties in 1969. The jetties may have been more effective had they been installed at greater distances apart, since not all structures are forcing the stream to scour.

TABLE 2. Channel measurements obtained from the East Gallatin River prior to (1967), one year following (1968) and two years following construction (1969)

Parameter	1967	1968	1969
Length (ft.)	2,200	1,650	1,650
Average depth (ft.)	0.7	1.0	1.1
Average thalweg depth (ft.)	1.3	1.5	1.9
Average width (ft.)	27	29	23
Sinuosity	1.38	1.13	1.15
Pool-riffle periodicity 1/	5.6	3.9	5.3

1/ Average distance between successive pools divided by average width, expressed in widths.

Fish Populations

The ultimate measure of the effects of channel alterations of the stream fishery lies in the response of the fish populations to changes in the habitat. It was shown that changes in morphology did occur in both streams with channel relocation. Changes in the fish populations following alteration must be evaluated in terms of the populations that were present prior to construction.

Rough fish dominated the population prior to and following construction in Prickly Pear Creek, contributing from 62.4 to 67.6% of the total number and from 74.0 to 79.3% of the total weight (Table 3). The longnose sucker[1/] was the most abundant species collected in all three sampling periods, comprising over 54% of the total number and over 72% of the total weight.

Game fish made up approximately one-third of the total population number both before and after construction. Numerically, rainbow trout were the most abundant game fish prior to alteration, contributing 23.2% of the total. Following construction, predominance shifted to brown trout, which made up 20.1 and 24.1% of the total number in 1968 and 1969, respectively. Brown trout were the dominant game fish by weight all three years.

The study section supported an estimated standing crop of 168 pounds per acre prior to construction. One year after alteration, the biomass was reduced by 51.2% to 82 pounds per acre. In 1969, it was reduced by an additional 11.0%. The total weight of rough fish was reduced from 1967 to 1969 by 59.1% as compared to a 47.2% decrease for the game fish population. Rainbow trout showed the greatest decline for the two-year period following alteration, with an 80.6% reduction in numbers. Numerically, white and longnose suckers decreased 82.1 and 37.2%, respectively, while brown trout were reduced by 9.8%.

1/ Common names used in this report correspond to those reported in Special Publication No. 2 of the Amer. Fish. Soc.

TABLE 3. Estimated fish populations for Prickly Pear Creek, pre- (1967) and post-construction (1968 and 1969), expressed as numbers per acre with pounds per acre in parentheses. Confidence intervals at 95% level

Species	1967	1968	1969
Rainbow trout	98 (12)	31 (4)	19 (4)
Brown trout	61 (24)	47 (13)	55 (15)
Longnose sucker	234 (125)	128 (59)	147 (53)
White sucker	39 (7)	28 (6)	7 (1)
Total trout	159 (36)	78 (17)	74 (19)
Confidence interval ($\pm$)	38	11	78
Total non-trout	264 (132)	156 (65)	154 (54)
Confidence interval ($\pm$)	62	30	28
Grand total	423 (168)	234 (82)	228 (73)

A comparison of calculated confidence intervals at the 95% level indicates that the rainbow trout and longnose sucker populations were significantly reduced following channel alteration in 1968 (Figure 4). However, population changes found in 1969 could not be considered significant. The white sucker population demonstrated the only significant change from 1968 to 1969.

The coefficient of condition is a useful parameter for comparing the well-being of a fish. Condition factors were computed for each species of the fish population as another measure of the effects of channel alteration on the fish population. Since populations were sampled at nearly the same time each year, seasonal differences were eliminated. The mean condition factor for each species decreased the first year following alteration (Table 4). The brown trout population showed the least change (2.7%) and the white sucker population demonstrated the greatest (11.3%). Two years following alteration, the brown trout and the longnose sucker populations showed an improved condition and an increase in numbers. The mean condition factor of the rainbow trout population was further reduced, as were population numbers. Inspection of the data indicates that differences between mean condition factors from year to year for any one species are statistically significant.

The fish population of the study area on the East Gallatin River was dominated by rough fish prior to and following relocation, which comprised 89.2 and 91.8% of the total number and weight, respectively, in 1967 (pre-construction) and 85.9 and 87.2%, respectively, in 1969 (Table 5). The longnose sucker was the most abundant species collected both years. A population estimate was not possible in 1968 due to construction activities.

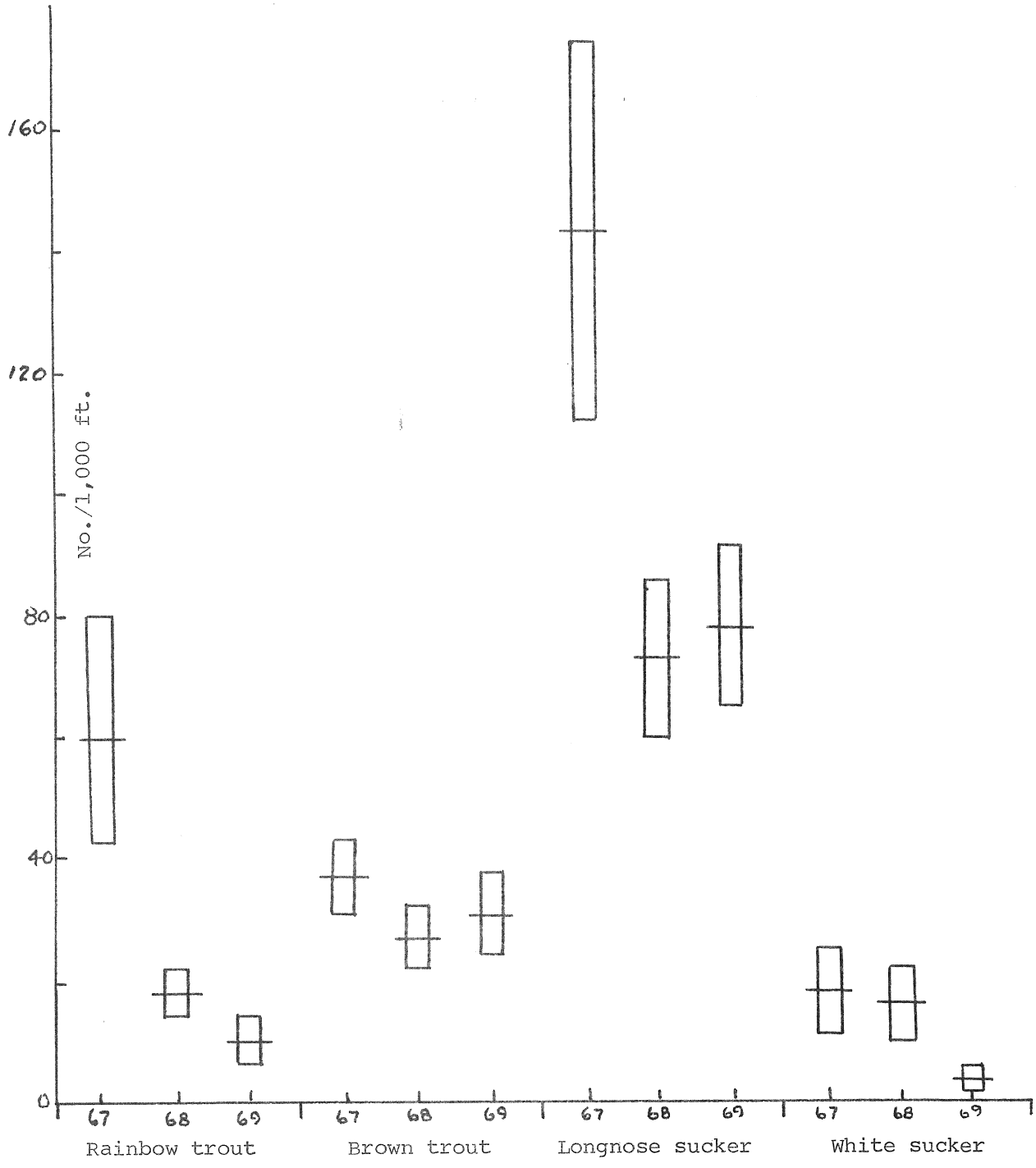

FIGURE 4. Comparison of population estimates (horizontal line) and calculated confidence intervals (vertical bar) for Prickly Pear Creek, pre-construction (1967), one year post-construction (1968) and two years post-construction (1969).

TABLE 4. Change in mean condition factor of fish from Prickly Pear Creek, prior to (1967), one year (1968) and two years (1969) following channel alteration

Species	Year	Mean	Standard deviation of sample mean	Range
Rainbow trout	1967	38.5	1.25	21.0-70.4
	1968	36.1	0.57	28.6-47.3
	1969	34.9	0.63	28.6-42.6
Brown trout	1967	33.8	0.47	23.7-52.8
	1968	32.9	0.54	25.4-41.7
	1969	36.0	0.77	22.5-60.0
Longnose sucker	1967	36.0	0.38	20.5-62.5
	1968	34.6	0.39	24.7-45.8
	1969	37.6	0.33	27.2-49.2
White sucker	1967	42.6	2.08	32.7-79.3
	1968	37.6	0.98	29.0-43.8
	1969	38.2	1.23	33.6-43.4

TABLE 5. Estimated fish populations for the East Gallatin River, 1967 (pre-construction) and 1969 (two years post-construction), expressed as numbers per acre with pounds per acre in parentheses. Confidence intervals at 95% level

Species	1967	1969
Rainbow trout	76 (25)	59 (16)
Eastern brook trout	2 (1)	12 (2)
Brown trout	10 (15)	10 (7)
Mountain whitefish	6 (7)	13 (9)
Longnose sucker	528 (468)	304 (188)
Mountain sucker	158 (30)	263 (50)
White sucker	104 (50)	5 (2)
Total game fish	94 (48)	94 (34)
Confidence interval (±)	27	15
Total non-game fish	790 (548)	573 (240)
Confidence interval (±)	286	234
Grand total	884 (596)	667 (274)

Game fish contributed 10.8 and 14.1% of the total number plus 8.2 and 12.8% of the total weight prior to and following alteration, respectively. Rainbow trout were the most abundant game fish before and after alteration, comprising over 8% of the total number and over 5% of the total population weight.

The study section supported an estimated standing crop of 596 pounds per acre in 1967. Two years after construction, the biomass was reduced by 54.2% to 274 pounds per acre. The weight of the rough fish population was reduced by 56.2% for the two-year period compared to a 29.2% decrease for the game fish population. White suckers showed the greatest decline, with a 95.2% reduction in numbers for the two-year period. Longnose suckers and rainbow trout decreased 42.4 and 22.4%, respectively. Mountain suckers showed an increase of 72.8% in number, while the brook trout and whitefish populations both more than doubled their numbers. A comparison of calculated confidence intervals indicates that no significant change occurred for the total game or rough fish population numbers following channel relocation.

RECOMMENDATIONS

It is recommended that stream morphology and fish populations of the relocated channels be remeasured in 1970. Since the continuous erosion of the steep allevial slopes of the Prickly Pear Creek channel has prevented streamside vegetation from becoming re-established, a berm, or artificial bank, should be built within the channel. A berm would provide a stable toe for the steep slopes and a suitable substrate for vegetation. Construction of the berm will attempt to stabilize the eroding slopes by primarily using soil with a minimum of rock material. Rooted, native brushy vegetation, sod, willow cuttings and grass seeding will be planted and evaluated, along with the berm, as to their effectiveness.

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East Gallatin River - 09-1710-01

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