MONTANA FISH AND GAME DEPARTMENT
FISHERIES DIVISION

JOB PROGRESS REPORT

State Montana

Project No. F-9-R-19 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, 1970 to June 30, 1971

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, 1968, and 1969. 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 and 1970. 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), 8.8 widths two years following construction (1969), and 7.8 widths in 1970.

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. Both parameters remained unchanged in 1970. 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, 5.3 widths two years following construction, and 5.5 widths in 1970. Of the 30 jetties installed in the channel, 53.3% (16) remained in 1969, with an additional 26.7% (8) partially washed out. By 1970, only 11 (36.7%) remained functional, with an additional 30.0% 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. An estimate of total population number and weight was not possible in 1970, due to low recapture efficiency of longnose suckers. Standing crops of trout for the same sampling periods were: 36, 17 and 19 pounds per acre, respectively, and 16 pounds per acre in 1970. 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. In 1970, standing crops were 837 pounds per acre for rough fish and 39 pounds per acre for game fish.

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. A 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 (Elser, 1970).

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

PROCEDURES

Stream morophology of the original channels was measured in 1967, and on both relocated channels in 1968, 1969, and 1970, to evaluate 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 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. Parameters were adjusted for differences in flow from year to year on the basis of measurements taken in the control sections.

Fish populations were censured by electrofishing. Estimates of the fish populations (fish greater than 4.0 inches in total length) were based on Chapman's modification of the Peterson formula described by Vincent (1969). Confidence intervals at the 95% level were calculated by formula 6 of the Michigan Institute for Fisheries Research (1960).

FINDINGS

Stream Morphology

The analysis of the field data showed that the channel length for Prickly Pear Creek was retained, and was actually increased in the area of construction by 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, and 1970, with the exception of a slight increase in the average thalweg.

TABLE 1. Channel measurements obtained from Prickly Pear Creek prior to (1967), one year following (1968), two years following (1969), and three years following (1970), relocation.

Parameter	1967	1968	1969	1970
Length (ft.)	3150	3250	3250	3250
Average depth (ft.)	1.4	1.0	1.0	1.0
Average thalweg depth (ft.)	2.3	1.8	1.8	2.0
Average width (ft.)	26	25	25	25
Pool-riffle periodicity 1/	6.6	15.7	8.8	7.8

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

The bed profile along the thalweg was plotted to show changes in the pool-riffle periodicity. 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. In 1970, the stream had adjusted to a periodicity of 7.8 widths (a pool every 196 feet).

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 produce meanders. Average stream depth and average thalweg depth of the realigned channel 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%. All three parameters remained unchanged in 1971. (Table 2)

TABLE 2. Channel measurements obtained from the East Gallatin River prior to (1967), one year following (1968), two years following, (1969) and three years following (1970) construction.

Parameter	1967	1968	1969	1970
Length (ft.)	2,200	1,650	1,650	1,650
Average depth (ft.)	0.7	1.0	1.1	1.1
Average thalweg depth (ft.)	1.3	1.5	1.9	1.9
Average width (ft.)	27	29	23	23
Pool-riffle periodicity 1/	5.6	3.9	5.3	5.5

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

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, and 1970, periodicity had adjusted to 5.3 and 5.5 widths, respectively, 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 in 1968. In 1969, 53.3% (16) of the original structures remained functional, with an additional 26.7% (8) partially washed out. By 1970, only 36.7% (11) remained functional, with 30.0% (9) partially washed out. Scouring of pools generally occurred in association with every other structure in 1968, increased to 75.0% in 1969 and further adjusted to 81.8% of the remaining structures in 1970. 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.

Fish Populations

The ultimate measure of the effects of channel alterations on the stream fisheries lies in the response of the fish populations to changes in the habitat. It was shown that changes in morphology did occur to 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.

TABLE 3. Estimated fish populations for Prickly Pear Creek, pre- (1967) and post-construction (1968, 1969, 1970), expressed as number per acre, with pounds per acre in parentheses. Confidence intervals at 95% level.

Species	1967	1968	1969	1970
Rainbow trout	98 (12)	31 (4)	19 (4)	37 (5)
Brown trout	61 (24)	47 (13)	55 (15)	41 (11)
Longnose sucker	234 (125)	128 (59)	147 (53)	*
White sucker	39 (7)	28 (6)	7 (6)	-
Total Trout	159 (36)	78 (17)	74 (19)	78 (16)
Confidence interval (+)	38	11	18	22
Total non-trout	264 (132)	156 (65)	154 (54)	*
Confidence interval (+)	62	30	28	
Grand Total	423 (168)	234 (82)	228 (73)	

* Longnose sucker estimate not possible due to low efficiency.

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 the sampling periods 1967-1969, comprising over 54% of the total number and over 72% of the total weight. An estimate of longnose suckers was not possible in 1970, due to low sampling efficiency. However, visual observations indicated that longnose suckers still dominated the population.

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 also the predominate game fish in 1970. By weight, brown trout were the dominant game fish during the years 1968-1970.

Federal fish hatcheries suffered a cut back in funds during the 1970 season and were unable to carry out all their programs. Since the Bozeman National Fish Development Center normally supplies the catchable rainbow plant for Prickly Pear Creek, the state system made the plant. Due to lack of communication, a portion of the plant was made immediately above the study section. At the time the estimate was made, there were an estimated 55 hatchery rainbow per acre weighing 16 pounds in the section.

1/ Common names used in this report correspond to those reported in Special Publication No. 6 of the American Fisheries Society, 1970.

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%. No total estimate was possible in 1970 since longnose suckers could not be estimated with any degree of confidence. 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. The game fish population showed a slight increase (5.1%) from 1969 to 1970. No white suckers were collected in the 1970 sample.

The fish population of the study area on the East Gallatin River was dominated by rough fish prior to and following relocation. Rough fish made up 89.2 and 91.8% of the total number and weight, respectively in 1967 (pre-construction), 85.9 and 97.2%, respectively in 1969 (two years post-construction), and 92.5 and 95.5%, respectively in 1970 (Table 4). The longnose sucker was the most abundant species collected all three years.

Game fish contributed 10.8, 14.1 and 7.5% of the total number plus 8.2, 12.8 and 4.5% of the total weight in 1967, 1969, and 1970, respectively. Rainbow trout were the most abundant game fish prior to and following construction.

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. In 1970, the total weight had increased to 876 pounds which represents an increase of 47.0%. The weight of the rough fish population was reduced by 56.2% as compared to a 29.2 decrease for the game fish from 1967 to 1969. Rough fish numbers increased 2.6 times from 1969 to 1970, while game fish numbers increased by 1.3 times numerically. The rainbow trout increased from 59 in 1969, to 95 in 1970 (1.6 times).

RECOMMENDATIONS

It is recommended that stream morphology and fish populations of the relocated channel on Prickly Pear Creek be remeasured in 1971. Since the continuous erosion of the steep allevial slopes of the artificial 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 rock material. Top soil material should also be utilized in existing rip-rap to further encourage revegetation. Rooted, native brushy vegetation, sod, willow cuttings and grass seeding will be planted and evaluated, along with the berm, as to their effectiveness.

It is further recommended that the East Gallatin River segment be dropped from the project. The structures continue to erode and become ineffective. However, physical properties of the channel appear to have stabilized. Changes in the fish populations and stream morphology should be evaluated in the future.

TABLE 4. Estimated fish populations for the East Gallatin River, 1967 (pre-construction), 1969 (two years post-construction), 1969 (two years post-construction), and 1970 (three years post-construction), expressed as numbers per acre with pounds per acre in parentheses. Confidence intervals at the 95% level.

Species	1967	1969	1970
Rainbow trout	76 (25)	59 (16)	95 (25)
Brook trout	2 (1)	12 (2)	3 (1)
Brown trout	10 (15)	10 (7)	14 (8)
Mountain whitefish	6 (7)	13 (9)	7 (5)
Longnose sucker	528 (468)	304 (188)	1039 (753)
Mountain sucker	158 (30)	263 (50)	322 (43)
White sucker	104 (50)	5 (2)	104 (41)
Total game fish	94 (48)	94 (34)	119 (39)
Confidence interval (±)	27	15	21
Total non-game fish	790 (548)	573 (240)	1465 (837)
Confidence interval (±)	286	234	991
Grand total	884 (596)	667 (274)	1584 (876)

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