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EFFECTS OF THE RIFLE RIVER WATERSHED DEVELOPMENT PROGRAM ON TROUT FISHING [1]

By Howard Gowing

Abstract

An extensive program of watershed and stream improvement was initiated in the upper portion of the Rifle River watershed in July 1950 to restore and maintain a high quality of trout fishing in the Rifle River. In this report, comparisons are made between angling records for streams in the Rifle River Area obtained for 6 years prior to the improvement program (1945-1950) and 6 years thereafter (1956-1961).

Angling records for the upper Rifle River (4.6 miles) during the pre-improvement period showed (1) an average fishing pressure of 185.4 hours per acre, (2) a total catch of 3,972 wild trout (96% brown trout) for an average annual yield of 29.0 fish per acre, and (3) an angling quality of 0.16 fish per hour. On the other hand, the post-improvement period disclosed: (1) an average fishing pressure of 299.7 hours per acre, (2) a total catch of 5,214 wild trout (99% brown trout) for a mean annual yield of 38.1 fish per acre, and (3) an angling quality of 0.13 fish per hour.

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[1] Contribution from Dingell-Johnson Project F-27-R, Michigan.

Comparisons of the salient features of the Rifle River fishery for both periods revealed: (1) the seasonal pattern of fishing pressure was nearly constant; (2) on the average, the cumulative percentage catch of wild trout each year showed little change; (3) no consistent change was observed in the total annual catches of wild brown trout during either period; (4) the length-frequency distribution of wild brown trout was similar for both periods and the mean length of fish was almost identical; and (5) observed differences between periods for both mean annual catch and angling quality were not significant statistically.

A complicating factor in this evaluation was the 60% increase in fishing pressure on the Rifle River in 1956-1961 over that of the pre-improvement period. This uncontrolled variable made it difficult to assess the role of the watershed improvement work on the fishery. More wild trout were caught in the post-improvement period than previously but this increase was matched by the rise in fishing pressure and is reflected in the similarity of the average catches per hour for both periods. If angling pressure could have been held down at the previous level, changes in the fishery could well be ascribed to the watershed work. Since pressure could not be controlled, we have no conclusive evidence that the increase in catch of trout was due to the watershed program.

The watersheds of two tributaries of the Rifle River that flow into the Rifle River Area also were included in the program. The interpretation of the fishing data for these streams (Houghton and Gamble

creeks) also is obscured by annual fluctuations and rising fishing pressures. There was no significant change in mean angling quality on Gamble Creek but a pronounced drop (58%) for Houghton Creek in the post-improvement period. The average annual catch was identical in Houghton Creek for each period but fishing pressure increased by 135% in 1956-1961. There was some evidence that the trout population in the lower part of Gamble Creek increased following the installation of channel deflectors. The summer water temperature of the upper Rifle River was lowered by diverting the flow of Gamble Creek directly into the Rifle River via a diversion channel instead of through Devoe Lake.

Introduction

During the past three decades the Michigan Department of Conservation has attempted to modify trout streams so as to improve the habitat for trout. Much of the impetus given to stream improvement in the early years was derived from the work of Hubbs, Greeley, and Tarzwell (1932) and Clark (1948). Stream improvement has been attempted in many states having trout streams. Gee (1952) reviewed the techniques used in the installation of stream improvement devices, and Leonard (1941) described two of the basic structures used in Michigan. Although widely used as a management tool, there is a paucity of information evaluating the benefits to fishing of stream improvement (Tarzwell, 1937, 1938; Madsen, 1938; Shetter, Clark, and Hazzard, 1949).

In Michigan fish habitat improvement evolved into resource management on a watershed basis. The former Lake and Stream Improvement Section of the Fish Division, Michigan Department of Conservation, initiated the Rifle River watershed development program in July 1950. This was a pilot, land-use, planning program for a watershed and incorporated both soil and water management practices. The program was outlined by Tody and Clark (1951).

The Rifle River was selected as a site for this program for two reasons. First, a biological survey of the Rifle River and its tributaries had been completed in 1941, indicating that in some areas conditions for trout were marginal (Locke, 1951). Secondly, 6 years (1945-1950) of creel census records were available for these waters which were located within the Rifle River Area, [2] a 4,318-acre tract of land within the upper watershed of this river which was used as a management and research area for fish and game. The objective of the program was to restore and maintain trout fishing on a high level in the Rifle River (Tody and Clark, 1951). Most of the effort of the program was concentrated in the headwater areas of the watershed under the assumption that, if improvement increased trout production in these headwater streams, the effect could be demonstrated by improvement of fishing quality in the Rifle River Area where a creel census was conducted.

The watershed program was begun in the summer of 1950 and most of the field work was completed in 1953. Evaluation of the program was based on creel census records for two 6-year periods. A

[2] Now known as the Rifle River Recreation Area.

pre-improvement period extended from 1945 to 1950. Since trout planting experiments were in progress in Area waters in 1954 and 1955, the post-improvement period used for the evaluation was 1956-1961. The criteria used were based largely on (1) angler harvest, (2) size of fish caught, and (3) quality of angling (catch per unit of effort).

Of the five trout streams in the Area, only the Rifle River, Gamble Creek, and Houghton Creek were included in the program. The watersheds of Vaughn and Oyster creeks were not altered, but the general fishing trends in these unmodified habitats are presented for comparative purposes. Only small segments of these tributaries lie within the Area, and few anglers fished them. Nevertheless, catch data for these streams are included as indicators of general changes in the stream fisheries of the Area. The Rifle River received between 86 and 96% of the total annual fishing effort, and 78 to 91% of the trout creeled were caught in the river between 1945 and 1961.

Description of watershed

The Rifle River watershed comprises an area of about 386 square miles. It is located in the eastern upper half of the lower peninsula and drains into Saginaw Bay on the north shore (Fig. 1). Only that portion of the drainage system north of highway M-55, an area of approximately 100,000 acres (156 square miles) was included in the program. About 30,000 acres of this area are in federal or

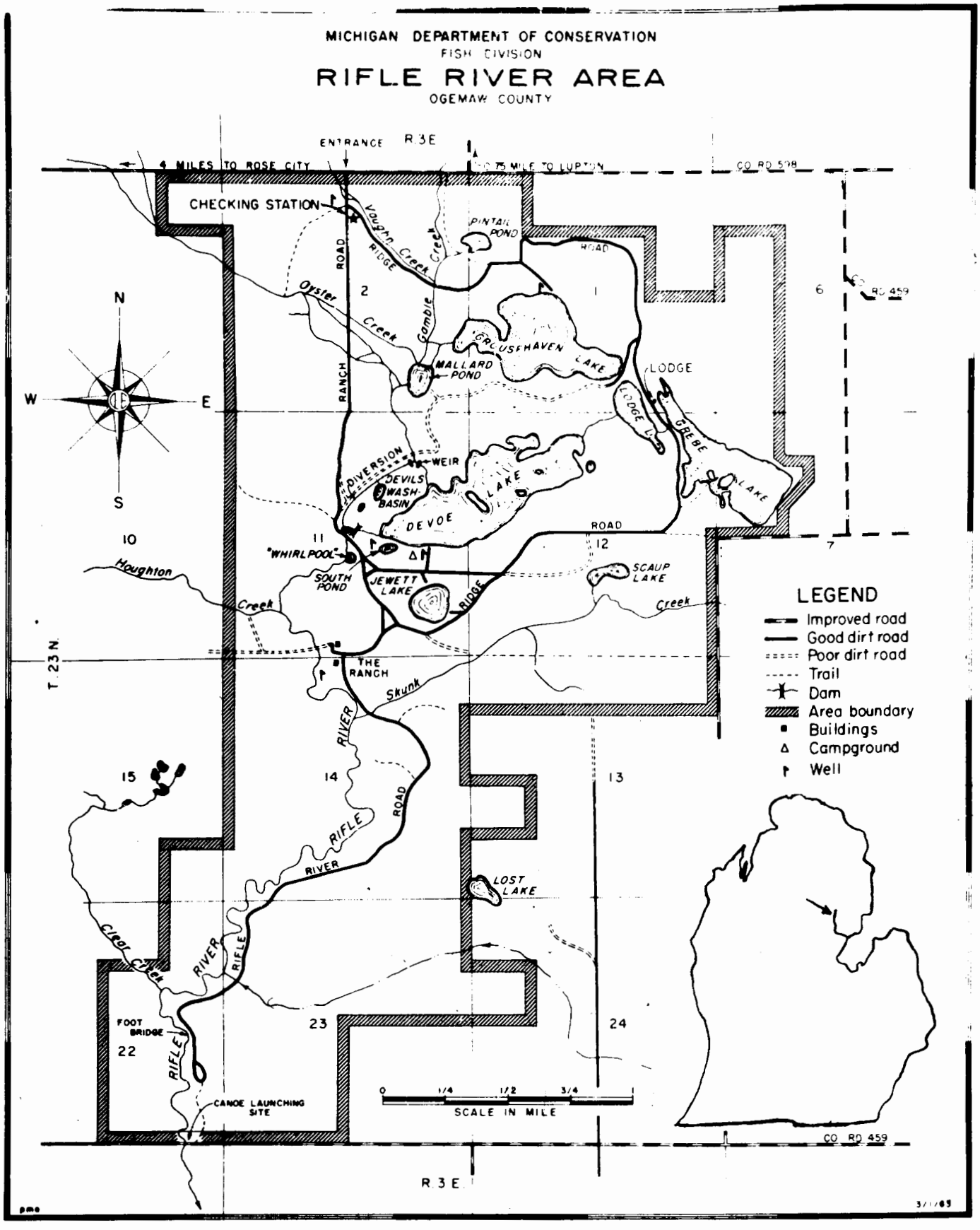

Figure 1.--Map of the Rifle River Area within which is the upper 4 miles of the Rifle River. See inset for location of the entire river in the lower peninsula.

state ownership (primarily forest lands), 50,000 acres are cultivated, and the remainder is largely wild lands.

The geology of the watershed was outlined briefly by Tody and Clark (1951). Soil types in the watershed range from light sand to heavy clay. Annual precipitation amounts to around 25-33 inches and the mean annual temperature is 42-45 F (1952-1957 U. S. Geological Survey records). The length of the frost-free growing season is between 100 and 110 days.

The Rifle River Area is located 4.5 miles east of Rose City in northeastern Ogemaw County (Fig. 1). It lies in the upper half of the drainage study area. There are five trout streams in the Area with an aggregate length of 9.1 miles and a combined area of 33.1 acres (Table A).[3] The streams meander through an area of relatively low ground and are readily subject to flooding. The surrounding forest type consists primarily of mature stands of aspen and cedar. Scattered stands of aspen, birch, balsam, spruce, and elm border the Rifle River. Borders of the smaller stream courses are chiefly cedar and alder. Streams in the Area are characterized by (1) relatively little ground water seepage, (2) predominantly sand bottoms, (3) gentle gradients, and (4) limited trout reproduction.

Among the salmonids, brown trout (Salmo trutta) is the predominant species. Brook trout (Salvelinus fontinalis) are found in the smaller streams and a few rainbow trout (Salmo gairdneri) are

[3] Lettered tables (and Fig. A) will be found in the Appendix; numbered tables and figures in body of report.

present. Among the Area streams, the Rifle River has the largest and most diverse fish fauna. Blacknose dace (Rhinichthys atratulus), creek chubs (Semotilus atromaculatus), pearl dace (Semotilus margarita), and common shiners (Notropis cornutus) are the most common cyprinids. Relatively large numbers of white suckers (Catostomus commersoni) are found and the mottled sculpin (Cottus bairdi) is common. Other species occasionally found include yellow perch (Perca flavescens), rock bass (Ambloplites rupestris), carp (Cyprinus carpio), northern pike (Esox lucius), bluegill (Lepomis macrochirus), brown bullhead (Ictalurus nebulosus), and black bullhead (Ictalurus melas); largemouth bass (Micropterus salmoides) are rare.

Methods of watershed improvement

Fisheries management of the Rifle River watershed based on the application of land use was summarized by Clark (1953). While the program involved both private (70%) and public (30%) lands, the major problems centered on the privately-owned agricultural land. Farm land improvements and management plans were formulated using ownership as a basic planning unit. These farm plans generally included (1) agricultural recommendations, (2) flood control reservoirs, (3) recharge areas, (4) tree plantations, (5) grass waterways, (6) wind breaks, (7) streamside tree plantings, (8) stream fencing, (9) stream bank and channel stabilization, and (10) channel structures for trout cover.

Most of the work was done outside the Rifle River Area on watersheds that drain into the Rifle River. These included Klacking

Creek, Prior Creek, Wilkins Creek, Houghton Creek, Bixby Creek, Barber Creek, and Gamble Creek. The watershed of Houghton Creek is the largest of this group and, because of its seasonally excessive flows, it received the most intensive development.

Within the Rifle River Area, management practices were confined to the Rifle River, Houghton Creek, and Gamble Creek. For the Rifle River these included (1) stabilization of several eroded banks and (2) construction of a series of deflectors and trout cover in the upper 1/2-mile and lower 1/4-mile of the river. To provide cover for trout in Houghton Creek, a few structures were placed in the stream channel.

The source of the Rifle River prior to 1951 was the outflow from Devoe Lake. From a detailed series of temperature observations in 1941, Locke (1951) recommended that Gamble Creek, a tributary of Devoe Lake, be diverted directly into the Rifle River to reduce water temperatures in the upper reaches of the river. In 1951, a 2,300-foot by-pass channel was dug (average width 15.7 feet) to link Gamble Creek with the Rifle River just below Devoe Lake dam (Fig. 1). Bulkheads were constructed at the confluence of Gamble Creek and this diversion channel which permitted the discharge of Gamble Creek either into the Rifle River or Devoe Lake or both.

Control of the annual flow for Gamble Creek was more or less fixed after 1951. During the fall, winter, and spring Gamble Creek was discharged into both lake and Diversion. During the

summer months the entire flow of Gamble Creek was shunted around the lake through the Diversion into the Rifle River.

Since July 1950, stream discharge rates and water temperatures have been recorded continuously for the Rifle River at the Ranch bridge 1/4 mile below Houghton Creek; for Houghton Creek, about 1/4 mile above its mouth.

In 1953, a series of long deflectors were installed in Gamble Creek below Mallard Pond to hasten the flow of water through this broad open stream and thereby prevent a rise in water temperature. A few deflectors also were placed in the stream immediately above Mallard Pond to create pools for cover.

Method of evaluation

The creel census operated at the Rifle River Area was virtually complete. All persons registered at the single entrance to the Area upon entering. Before they departed, information on the fishing activities of each angler was recorded. All trout were weighed and measured in the round, except for dressed fish which were measured only. The latter were assigned weights from a length-weight curve computed from local population data. A successful fishing trip was defined as one in which at least one legal-length trout was caught and kept. During the trout fishing season the Area was opened at 6 AM; the closing hour varied between 9 and 12 PM in the period 1945-1951, but it was set at 11 PM thereafter.

Between 1945 and 1961 several changes were made in the trout fishing regulations, as shown in Table B. Included in these changes was an experimental minimum size limit of 8.0 inches applied to the trout fishery on the Rifle River within the Area during 1948-1954. There was a 128-day season between 1945 and 1947; 137 days (on the average) thereafter. There were other species taken besides trout (mostly from the upper reaches of the Rifle River) but these fish are not discussed in this report.

Hatchery trout plantings made in the watershed streams and in Devoe Lake during the pre-improvement period were duplicated in the post-improvement period to facilitate comparisons between these periods. Devoe Lake was included in this planting schedule because trout often emigrate from the lake to the connecting streams and frequently contribute to the stream catch. An attempt was made to hold constant the number and species of hatchery trout planted in both periods. All stocked trout were given an identifying mark. Routine plantings made in the Rifle River within the Area were given the same mark as those planted in the river immediately below the Area. Thus, in a few instances it could not be determined whether or not fish in the Area catches had been planted within or outside the Area.

The population estimates computed for Gamble Creek were made from mark-and-recapture data acquired by electrofishing with d-c current. The Petersen formula, as modified by Bailey (1951), was used for the calculations.

Rifle River

The uppermost 4.6 miles of the Rifle River is within the Rifle River Area. Prior to 1951 its origin was the outlet of 130-acre Devoe Lake, an oligotrophic marl lake. The construction of the Diversion channel between Gamble Creek and the headwaters of the Rifle River in 1951 split the source of the river (Fig. 1). During the summer months the lake outlet is closed, however, and Gamble Creek is diverted around the lake and directly into the river. The Rifle River averages 44 feet in width and has an area of 22.8 acres. Discharge at base flow varies from 57 to 64 c.f.s. (1951-1952). Approximately 1/2 mile below Devoe Lake outlet, Houghton Creek empties into the river.

In the Rifle River Area the Rifle River has many deep pools and a few fast riffles with associated gravel bottom. Most of the stream bed consists of sand and sandy silt and much of the river is characterized as "flat" water.

Wild-trout fishery in the pre-improvement period

During this period, angling pressure increased from 129.3 hours per acre in 1945 to 273.1 in 1950 (Table 1). Mean annual angling effort for the entire period was 185.4 hours per acre. The annual catch increased from 14.3 trout per acre in 1945 to 42.1 in 1947, then leveled off at about 27 trout per acre. Of 3,972 trout

Table 1.--Angling pressure and catch of native trout in the Rifle River during the pre-improvement period (1945-1950) and the post-improvement period (1956-1961)

Year	Angling pressure		Catch						All trout	
			Brown trout		Rainbow trout		Brook trout			
	Trips per acre	Hours per acre	Number	Pounds	Number	Pounds	Number	Pounds	Number per acre	Pounds per acre
1945	53.8	129.3	316	167.4	10	3.9	1	0.3	14.3	7.5
1946	54.8	138.2	804	354.7	33	12.0	8	1.9	37.1	16.2
1947	76.6	195.0	938	503.0	14	6.1	9	2.3	42.1	22.4
1948	84.4	210.8	625	293.5	11	3.1	-	-	27.9	13.0
1949	67.8	166.0	587	258.1	37	11.0	2	0.8	27.4	11.3
1950	99.7	273.1	561	244.0	15	4.0	1	0.3	25.3	10.9
Total	-	-	3,831	1,820.7	120	40.1	21	5.6	-	-
Mean	72.8	185.4	638.5	303.4	20.0	6.7	3.5	0.9	29.0	13.6
1956	130.0	313.0	583	291.4	2	0.5	5	1.2	25.9	12.8
1957	98.8	237.2	783	388.4	1	0.2	7	2.0	34.7	17.1
1958	134.9	367.3	1,517	683.2	-	-	14	3.0	67.1	30.1
1959	112.4	280.4	516	292.5	-	-	4	1.0	22.8	12.9
1960	105.2	271.8	980	494.4	-	-	10	3.5	43.4	21.8
1961	119.5	328.7	782	362.3	-	-	10	2.4	34.7	16.0
Total	-	-	5,161	2,512.2	3	0.7	50	13.1	-	-
Mean	116.8	299.7	860.2	418.7	.05	0.1	8.3	2.2	38.1	18.5

caught during this period, 96.5% were brown, 3.0% rainbow, and 0.5% brook trout. The average yield of trout amounted to 29.0 fish per acre annually.

In 1945 the average catch per hour was 0.11 trout, rose to 0.27 in 1946, then declined to a low of 0.09 trout per hour in 1950 (Table C). In the pre-improvement period trout were caught at the average rate of 0.16 trout per hour. Angling quality varied from week to week.

The percentage of successful trips increased during the first 3 years but slowly diminished during the last 3 years of this period. For the entire period, 18.5% of the fishing trips were successful.

The length-frequency distribution of brown trout caught during these 6 years is shown in Figure 2. Fish between 7 and 26 inches were caught, but about 65% of the trout were between 8.0 and 10.9 inches long. The average length of these fish was 10.5 inches.

Wild-trout fishery in the post-improvement period

Annual fishing pressure during this period was greater than in 1945-1950, ranging between 237.2 and 367.3 hours per acre (Table 1). Angling effort averaged 299.7 hours per acre annually for the entire period and the annual harvest ranged between 22.8 and 67.1 fish per acre. During the 6 years, trout were harvested at the mean annual rate of 38.1 fish per acre. The peak catch occurred in 1958 when

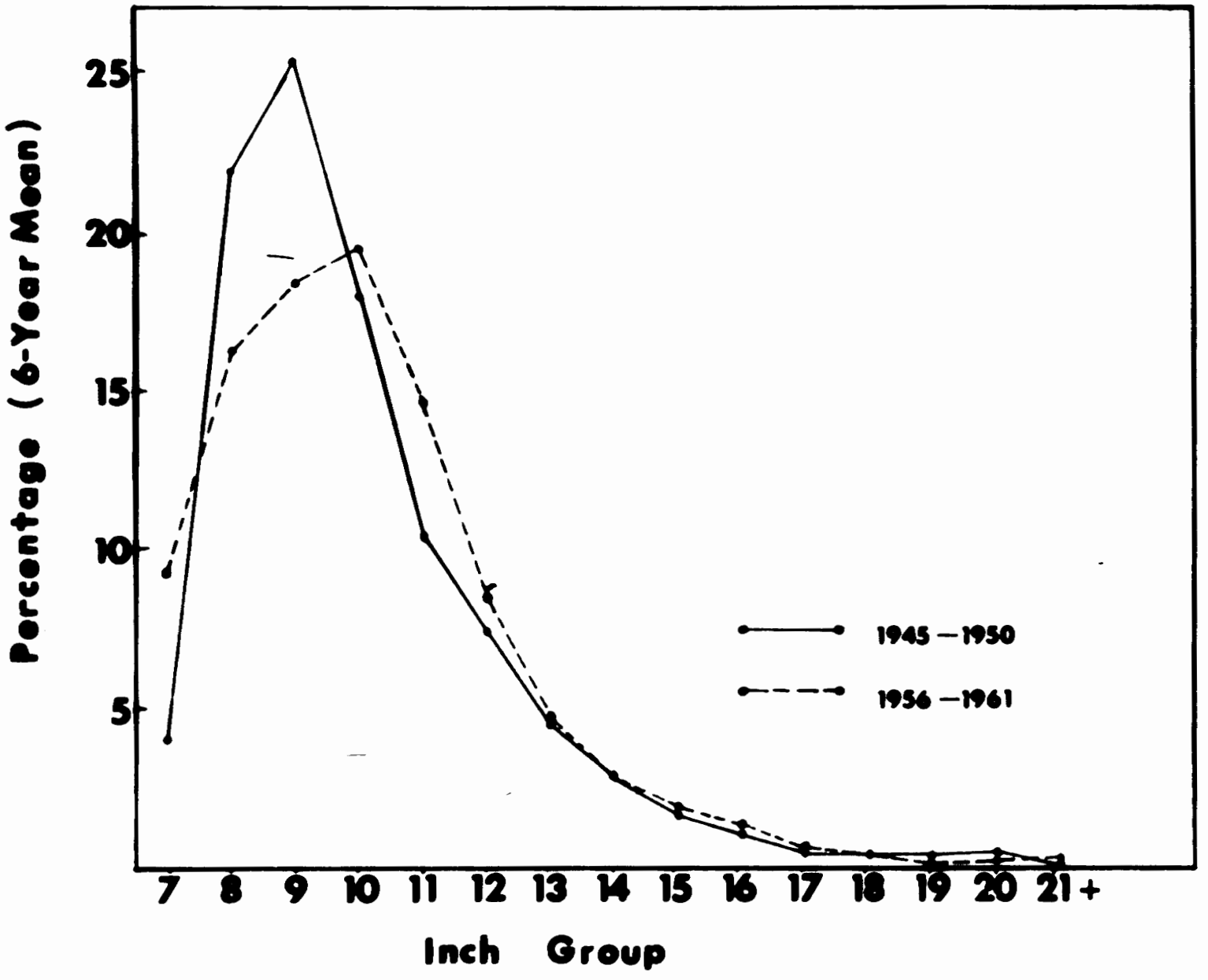

Figure 2. --Length-frequency distribution of angler-caught native brown trout in the Rifle River during the pre-improvement period (1945-1950) and post-improvement period (1956-1961).

1,531 trout were caught; only 520 trout were caught in 1959. Of the 5,214 trout caught during this period, 99% were brown trout.

Angling quality fluctuated between 0.08 trout per hour to 0.18 (Table C). On the average about 14% of the fishing trips were successful during this period. Between 9.7 and 19.5% of the trips were successful each year.

The length-frequency distribution of the total catch of brown trout (Fig. 2) reflects the size composition of the annual catches. The annual catch generally included trout between 7 and 20 inches but occasionally trout as large as 25 inches were caught. Fish between 8.0 and 10.9 inches comprised about 54% of the total harvest for this period. The mean length of the brown trout caught each year ranged between 10.5 (1958) and 11.0 inches (1959); for the entire period the average was 10.6 inches.

Comparison of wild-trout fisheries

Both the trend and level of fishing pressure during the pre- and post-improvement periods were dissimilar. During the pre-improvement period the general trend was one of increasing fishing pressure. Annual fishing effort during the post-improvement period was erratic but greater, averaging 299.7 hours per acre compared to 185.4 for the pre-improvement period. This represented a significant increase of 61.1% ($P < 0.05$) for the post-improvement period. Elsewhere in the state differences in fishing pressure also were demonstrated for these periods. From 1956 through 1961 average fishing pressure (hours per acre) on Hunt Creek increased

34.3% ($P<0.05$) over that for the years 1945-1950 (Alexander and Shetter, 1963). On a state-wide basis, a significant increase in the estimated number of trout fishermen was also noted for nearly comparable years (Shetter, et al., 1964). The average estimated number of trout fishermen for the period 1956-1961 exceeded by nearly 19% the number estimated for the years 1948-1950, an increase judged significant at the 5% level.

While the pre- and post-improvement periods reflected different levels of fishing effort, the seasonal pattern of fishing pressure during both periods was remarkably similar (Fig. 3). Fishing pressure was greatest on the opening weekend of the season followed by a rather sharp decline through the fourth week. A slight increase occurred during the fifth week (Memorial Day) and thereafter tapered off slowly. On the average, for both periods, between 44.5 and 46.5% of the fishing trips were completed by the fifth week; 68.5 to 72.2% by midseason (Table D and Fig. A).

There was no discernible trend in the annual catch of native trout during either period. During the pre-improvement period the annual catch varied from 315 to 938 brown trout (average, 639). For the post-improvement period the average annual catch was 860 brown trout (range: 516-1,517 fish). The length-frequency distribution of the catch was similar to that of the pre-improvement period, differing only in that the mode was slightly higher. The mean lengths of the brown trout caught in each period were nearly identical, differing by

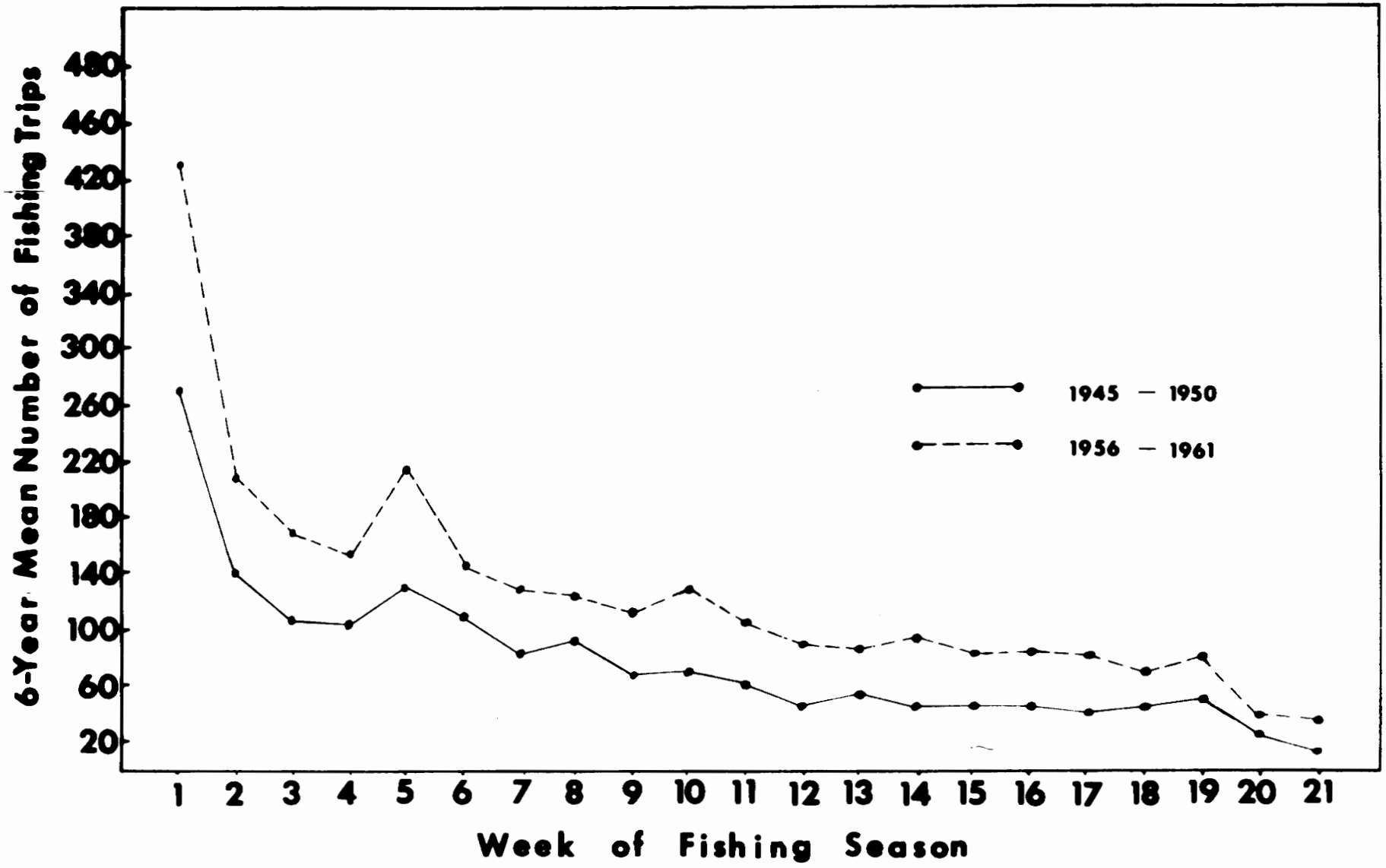

Figure 3. --Average number of fishing trips per week on the Rifle River during the pre-improvement period (1945-1950) and the post-improvement period (1956-1961).

only 0.1 inch. The cumulative rate of catch of native trout in an average season for the pre-improvement period closely resembled that for the post-improvement period (Table D and Fig. A). For the pre-improvement period, 44.4% of the total season's catch was harvested by the fifth week and 72.4% by the tenth week. Comparable values for the post-improvement period were 45.5 and 77.1%.

Native brown trout were harvested at the rate of 29.0 fish per acre during the pre-improvement period, compared to 38.1 for the post-improvement period. These yields were not significantly different ($P > 0.05$). Furthermore, there was no significant difference in the quality of fishing between the two periods ($P > 0.05$).

The effect of the extension of the fishing season (4 days on the average) during the last 3 years of the pre-improvement period upon the total catch for the period was negligible. Usually less than 1% of the total annual catch was made in the last week of the season. However, the change in size and creel limits during the latter half of the pre-improvement period did have a modest effect upon the over-all catch for this period. The increase in size limit from 7.0 inches in 1945-1947 to 8.0 inches during 1948-1950 reduced the catch by 7.6% (on the average) during the latter 3 years, but had little effect upon the average length of brown trout caught in these 3-year intervals. Brown trout caught during 1945-1947 averaged 10.5 inches as compared to 10.4 during 1948-1950.

The change in creel limit from 15 trout per day during 1945-1947 to 10 trout or 10 pounds and 1 fish per day for the years 1948-1950

also had a slight effect upon the total catch for the pre-improvement period in that 1.2% of the total catch in 1945-1947 can be attributed to the larger creel limit. For comparative purposes the total catch of the pre-improvement period should be reduced by this amount since the creel limit during the years 1948-1950 was the same as the post-improvement years. Therefore the adjusted total catch for the pre-improvement period is 3,941 brown trout and, exclusive of the effects of regulation changes on the harvest of brook and rainbow trout, the total catch was 4,082 native trout. The net effect of these changes would be to increase the yield from 29.0 to 29.8 trout per acre for the pre-improvement period. This adjusted yield is 27.8% less than the post-improvement yield of 38.1 trout per acre.

Hatchery-trout fishery on the pre-improvement period

During this period 3,023 legal-length trout were stocked in the Rifle River (see table below). In addition, 10,000 sub-legal rainbow trout were stocked in 1950. These rainbows ranged in length between 2.7 and 8.9 inches but 13.1% of these were at least 7.0 inches long.

Year	Brown trout	Rainbow trout
1946	200	325
1947	1,000	200
1948	1,198	-
1950	100	-

Of the 4,924 trout caught in the Rifle River during this period, 952 (19.3%) were hatchery fish (Table 2). Hatchery trout annually constituted between 0.9 (1945) and 36.0% (1950) of the total trout catch. The smallest catch of hatchery trout occurred in 1945 and 1949 when no trout were planted, but a few survivors from plantings made in previous years were taken. All but 1 of the 26 hatchery trout caught in 1946 presumably came from the 1946 planting of 525 trout in the river near the south boundary of the Area. Most of the 221 trout caught in 1947 were from the planting of 1,200 trout during the 1947 fishing season.

In 1948, 900 brown trout were planted in the river during the season and 298 in the fall after the fishing season closed. About 19% of the trout stocked during the season were caught. The rest of the 1948 catch came from plantings either in the river below the Area in 1948 or carryovers planted within the Area in 1947. None of the 100 brown trout planted in the river in 1950 were observed in the catch. Approximately 3% of the 10,000 rainbow trout stocked in the river in 1950 were caught in 1950.

Hatchery-trout fishery in the post-improvement period

Hatchery trout contributed between 10.1 and 52.7% of the total annual catch of trout during this period. Of the total catch of 7,674 trout, 32.1% were of hatchery origin. The 2,460 hatchery trout consisted of 51.8% rainbow trout, 47.9% brown trout, and 0.3% brook trout (Table 2).

Table 2.--Catch of hatchery trout in Rifle River during the pre-improvement period (1945-1950) and the post-improvement period (1956-1961)

Year	Catch					
	Brown trout		Rainbow trout		Brook trout	
	Number	Pounds	Number	Pounds	Number	Pounds
1945	-	-	3	0.6	-	-
1946	19	5.1	7	1.4	-	-
1947	132	35.0	86	19.3	3	1.1
1948	263	85.2	22	6.9	2	0.7
1949	66	23.4	30	21.5	-	-
1950	2	1.1	317	76.7	-	-
Total	482	149.8	465	126.4	5	1.8
1956	74	27.5	96	30.4	-	-
1957	91	25.9	202	46.4	3	0.8
1958	501	140.1	155	38.6	2	0.5
1959	330	83.8	248	67.6	1	0.3
1960	88	42.6	23	9.2	-	-
1961	95	22.2	550	91.0	1	0.2
Total	1,179	342.1	1,274	283.2	7	1.8

During this interval 2,200 legal-length brown trout were planted in the Rifle River within the Area during the fishing seasons. In addition, 300 legal-length brown trout were stocked in the river in the fall after the close of the 1959 fishing season. From these plantings about 43% (953 fish) were recovered by anglers during the same season of planting and 5% (124 fish) were caught in later years. Few trout were caught after two summers in the river. Twenty of the brown trout caught were planted outside the Area.

Also during this period, 525 rainbow trout (legal-size) were stocked in the river within the Area during the fishing seasons. Ultimately, 64.4% (338 fish) were recovered in the river during the same season as planted and 3.0% were caught the second season after planting. In addition, 343 rainbow trout were recovered from plantings made in other waters both in and outside the Area. Of these, 313 fish (91.2%) were from plantings of legal-length fish in Devoe Lake, 27 from the Rifle River below the Area, 2 from Houghton Creek above the Area, and 1 from an undetermined source outside the Area. About 80% of these trout were caught in the same season in which they were planted.

The 1950 planting of sublegal rainbow trout was repeated in the spring of 1961 when 9,996 fish (4.0-6.9 inches) were stocked. Anglers caught 506 (5.1%) of these fish.

Comparison of hatchery-trout fisheries

Although similar numbers of hatchery trout were stocked in Area waters during each 6-year period, more hatchery trout were available

in the early years of the post-improvement period than during the pre-improvement period. Trout plantings in Area waters in the years immediately preceding 1956 were larger than those stocked prior to 1945. During 1945-1950 four trout were recovered from plantings made prior to 1945. Thus the adjusted yield for the pre-improvement period was 948 trout or 6.9 fish per acre.

In contrast, 184 trout were caught from plantings made immediately preceding 1956. A scheduled fall planting of 1,000 rainbow trout in Devoe Lake in 1961 was inadvertently made in the spring. Six trout from this planting were caught in the Rifle River in 1961. Subtracting these 190 trout from the total catch of 1956-1961, the adjusted yield for this period was 2,270 trout or 16.6 fish per acre. These adjusted yields were significantly different at the 10% level of probability but not when P = 0.05. The adjusted catch per hour for the pre- and post-improvement periods was 0.04 and 0.06 fish per hour, respectively, a difference not statistically significant at the 0.05 probability level. However, there was a 1.6-fold increase in average fishing pressure during the post-improvement period.

One aspect of the trout planting program was not measurable. Emigration of hatchery trout out of Devoe Lake affected the catch from the Area streams to varying degrees. For example, a spring planting of 1,983 jaw-tagged rainbow trout was made in Devoe Lake in 1948. During the 1948 and 1949 seasons stream fishermen recovered 58 trout, 35 of which were caught in the Rifle River. A similar planting of 1,998

fin-clipped rainbow trout was made in the lake in the spring of 1959. After two fishing seasons 327 trout were caught in Area streams, 253 in the Rifle River.

Gamble Creek

Gamble Creek is a relatively small trout stream about 3 1/2 miles long which flows into Devoe Lake. The lowermost 1 1/2 miles of the stream lie within the boundaries of the Area (Fig. 1). There are two small tributaries to this stream within the Area. About 1/2 mile above its mouth, Gamble Creek flows through a shallow, 3.8-acre body of water known as Mallard Pond.

Above Mallard Pond and within the Area the stream bed is primarily sand with small areas of gravel in the stronger current. Below the pond a veneer of mostly silt and sand overlays a strata of marl. Some spawning occurs above the pond but none below it.

Below Mallard Pond the stream is about 40 to 50 feet wide, shallow, and typically flat water. A maximum water temperature of 75 F has been recorded for this portion of the stream.

Wild-trout fishery

Fishing pressure on Gamble Creek was comparatively light in 1945-1950, averaging about 30 hours per acre (Table 3). Starting in 1946, fishing effort slowly but steadily increased through 1950. The annual harvest of trout during the pre-improvement period was

Table 3.--Angling pressure and catch of native trout in Gamble Creek during the pre-improvement period (1945-1950) and the post-improvement period (1956-1961)

Year	Angling pressure		Catch						All trout	
			Brown trout		Rainbow trout		Brook trout			
	Trips per acre	Hours per acre	Number	Pounds	Number	Pounds	Number	Pounds	Number per acre	Pounds per acre
1945	22.9	40.8	24	8.4	-	-	2	0.7	4.4	1.5
1946	9.7	11.4	15	4.9	-	-	2	0.9	2.9	1.0
1947	11.7	16.9	6	1.8	-	-	1	0.1	1.2	0.3
1948	13.9	19.4	5	1.4	-	-	3	0.5	1.4	0.3
1949	23.6	36.4	46	17.2	-	-	5	1.0	8.6	3.1
1950	28.5	56.1	24	7.7	3	0.4	5	1.4	5.4	1.6
Total	-	-	120	41.4	3	0.4	18	4.6	-	-
Mean	18.4	30.1	20.0	6.9	0.5	0.1	3.0	0.8	4.0	1.3
1956	38.6	77.1	43	18.5	-	-	3	0.7	7.8	3.2
1957	36.3	68.0	57	20.9	-	-	7	1.5	10.8	3.8
1958	45.9	91.4	112	59.8	-	-	5	1.3	19.8	10.4
1959	33.6	57.4	29	15.1	-	-	6	2.1	5.9	2.9
1960	30.5	62.7	61	33.4	-	-	5	1.2	11.2	5.9
1961	28.1	62.4	67	23.1	-	-	3	0.8	11.9	4.1
Total	-	-	369	170.8	-	-	29	7.6	-	-
Mean	35.5	69.9	61.5	28.5	-	-	4.8	1.3	11.2	5.0

variable and light. The average catch was 4 trout, or 1.3 pounds, per acre. On the average, 15.5% of the fishing trips were successful and trout were caught at the rate of 0.13 fish per hour (Table C). Of the 141 trout caught during this period, about 85% were brown trout, 13% were brook trout, and 2% were rainbow trout.

Except in 1958 when fishing reached a peak of 91.4 hours per acre, angling pressure during the post-improvement period varied between 57.4 and 77.7 hours per acre (Table 3). Fishing pressure for the entire period averaged 69.9 hours per acre. A total of 398 trout were caught, consisting of 369 brown and 29 brook trout. Trout were caught at rates ranging from 5.9 to 19.8 fish per acre. For the entire period the mean yield was 11.2 fish or 5.0 pounds per acre.

There were differing trends in yield and levels of fishing pressure between the pre- and post-improvement periods. Fishing pressure was extremely light (30 hours per acre) at first, and like the early years of fishing on the Rifle River, 1945-1950 was a period of increasing fishing effort. During the post-improvement period, angling pressure (70 hours per acre, on the average) varied somewhat but averaged 132% greater than previously. Even at this significantly higher level, fishing pressure was comparatively light and represented only about one-quarter of the fishing pressure on the Rifle River for this same period (1956-1961). However, the yield increased 180%. This significantly greater yield ($P<0.05$) was offset by increased fishing effort. Consequently, angling quality for the post-improvement period (0.16 fish per hour) was not significantly different from that of 1945-1950.

Hatchery-trout fishery

Hatchery trout made a small contribution to the anglers' catch in 1945-1950 (Table 4). Altogether, 38 fish or about 21% of the total trout catch were of hatchery origin. Trout plantings consisted of (1) an in-season planting of 300 legal-length brown trout (jaw tagged) and (2) a fall planting of 1,000 brown trout fingerlings in each of 3 years, 1948-1950.

The numbers of brown trout planted in the post-improvement period were as follows: (1) 300 legal-length fish in the summer of 1958, (2) 998 fingerlings in the fall of 1959, (3) 996 fingerlings in the fall of 1960, and (4) 1,000 fingerlings in the fall of 1961. About 33% of the total trout catch were hatchery fish. Of the 200 hatchery trout caught, 74 were from plantings in the stream and 126 came from other sources (Table 4). Most of the trout caught came from the 1958 stocking of legal-length fish in the stream. The outside source of trout was mostly migrants from the plantings of legal-length rainbow trout in Devoe Lake.

The numbers of hatchery brown trout planted in Gamble Creek during the pre- and post-improvement periods were nearly identical. Only 20 brown trout were caught during the pre-improvement period whereas 69 fish, excluding the capture of survivors from plantings prior to 1956, were captured during the post-improvement period. This difference was due primarily to the catch of 57 trout from a planting of 300 legal-length fish in 1958 and the failure to exploit a similar planting in 1947. Of the 1,000 fingerling brown trout planted in Gamble Creek above Mallard Pond in the fall in each of the years 1948, 1949, and 1950,

Table 4. --Catch of hatchery trout in Gamble Creek during the pre-improvement period (1945-1950) and post-improvement period (1956-1961)

Year	Catch[1]			
	Brown trout		Rainbow trout	
	Number	Pounds	Number	Pounds
1945	-	-	-	-
1946	-	-	-	-
1947	4	1.0	-	-
1948	5	2.5	-	-
1949	9	3.1	16	12.0
1950	2	0.5	2	0.3
Total	20	7.1	18	12.3
1956	6	1.8	27	10.2
1957	6	2.2	1	2.3
1958	57	15.3	1	0.9
1959	2	0.4	42	12.7
1960	2	3.5	6	3.3
1961	9	1.6	40	9.2
Total	82	24.8	117	38.6

[1] In addition, one brook trout was caught in 1956.

none were caught within the pre-improvement period. However, 12 were eventually recovered by anglers between 1951 and 1954. A duplication of these plantings (2,994 fish) made in the fall of 1959, 1960, and 1961 resulted in a recovery of 1.2% through the 1961 fishing season.

The major source of rainbow trout in Gamble Creek was from plantings in Devoe Lake. Nearly equal numbers of rainbow trout were stocked in Devoe Lake during the pre- and post-improvement periods (3,983 and 3,998, respectively). However, the number of trout available to anglers in both periods was not equal as one planting was made in the fall of 1950 and its counterpart in the spring of 1961. During the post-improvement period 117 rainbow trout were caught, of which 29 were survivors from plantings made before 1956 in waters outside Gamble Creek and 12 trout from the 1961 spring planting (1,000 fish) in Devoe Lake. The adjusted catch of rainbow trout for the post-improvement period was 76 fish compared to 18 fish for the pre-improvement period.[4] The discrepancy in catch was largely the result of a greater catch of trout from plantings made in Devoe Lake in 1959 and 1960.

Houghton Creek

The lowermost 1/4 mile of Houghton Creek flows through the Area and empties into the Rifle River at a point about 1/2 mile below Devoe Lake dam (Fig. 1). This portion of the stream has an average width of about 30 feet and a surface area of 0.9 acre.

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[4] Same adjustment as for Rifle River catches.

Wild-trout fishery

Next to the Rifle River, Houghton Creek was the most intensively fished stream in the Area. Fishing pressure in 1945-1950 averaged 110.3 hours per acre. Fishing effort was lowest in 1945 (41.1 hours per acre) and reached a peak in 1950 (Table 5). The largest increase occurred between 1949 and 1950 when fishing pressure jumped from 89.4 to 295.5 hours per acre. More fish were caught in 1947 than in any other year on record but the greatest poundage was taken in 1950. The average yield for this period was 34.6 fish per acre.

The 187 native trout caught during this pre-improvement period consisted of 177 brown, 9 rainbow, and 1 brook trout for an average of about 31 trout per year. About 40% of the fishing trips were successful and trout were caught at the rate of 0.31 fish per hour.

From 1956 to 1960 annual fishing pressure fluctuated between about 133 and 273 hours per acre and then abruptly increased to 506 hours per acre in 1961. On the average, fishing effort amounted to 259 hours per acre. Peak yields occurred in 1958 and 1961 but remained at nearly identical levels in other years. The average yield for this post-improvement period was 33 fish per acre. Altogether, 177 brown and 1 brook trout were caught. About 14.5% of the fishing trips were successful. Angling quality ranged between 0.09 and 0.22 fish per hour; for the entire period it amounted to 0.13 fish per hour (Table C).

Average angling pressure during the post-improvement period was 134.8% greater than that during the pre-improvement period.

Table 5.--Angling pressure and catch of native trout in Houghton Creek during the pre-improvement period (1945-1950) and post-improvement period (1956-1961)

Year	Angling pressure		Catch						All trout	
			Brown trout		Rainbow trout		Brook trout			
	Trips per acre	Hours per acre	Number	Pounds	Number	Pounds	Number	Pounds	Number per acre	Pounds per acre
1945	13.3	41.1	14	4.7	-	-	-	-	15.6	5.2
1946	30.0	69.4	17	6.6	1	0.4	-	-	20.0	7.8
1947	31.1	62.8	60	18.0	1	0.1	-	-	67.8	20.1
1948	51.1	103.9	23	8.6	4	1.1	-	-	30.0	10.8
1949	38.9	89.4	35	10.6	3	1.5	1	0.1	43.3	13.6
1950	116.6	295.5	28	20.6	-	-	-	-	31.1	22.9
Total	-	-	177	69.1	9	3.1	1	0.1	-	-
Mean	46.9	110.3	29.5	11.5	1.5	0.5	0.2	.02	33.0	14.1
1956	107.8	205.6	21	7.2	-	-	1	0.1	24.4	8.1
1957	74.4	132.8	19	10.1	-	-	-	-	21.1	11.2
1958	142.2	236.7	47	18.7	-	-	-	-	52.2	20.8
1959	145.6	272.8	24	11.1	-	-	-	-	26.7	12.3
1960	84.4	200.0	26	12.3	-	-	-	-	28.9	13.7
1961	187.8	506.1	40	16.4	-	-	-	-	44.4	18.2
Total	-	-	177	75.8	-	-	1	0.1	-	-
Mean	123.7	259.0	29.5	12.6	-	-	0.2	.02	33.0	14.1

Accompanying this increase in fishing pressure was an average yield of 33.0 fish per acre, less than the pre-improvement average of 34.6. As a consequence, angling quality declined from 0.31 to 0.13 fish per hour between the pre- and post-improvement periods, respectively. A proportionately greater percentage of fishing trips were successful during the pre-improvement period.

The same number of native brown and brook trout were caught in each period. Nine rainbow trout were caught during the pre-improvement period; none were caught in 1956-1961.

Hatchery-trout fishery

No trout were planted in Houghton Creek. Nevertheless, 70 rainbow and 2 brown trout in the catch in 1945-1950 were of hatchery origin. The primary source of hatchery trout was from the 1950 planting of 10,000 rainbow trout in the Rifle River. These fish ranged in length between 2.7 and 8.9 inches when stocked. From this planting 67 trout were recovered in Houghton Creek in 1950.

About 40% of the total trout catch in 1956-1961 were hatchery trout. Of the 118 trout caught, 86 were rainbow trout and 32 were brown trout (Table 6). Brown trout came principally from a planting of legal-length trout in the Rifle River in 1959. Most of the rainbow trout were derived from the planting of 9,996 sublegal trout in the Rifle River in 1961.

Table 6.--Catch of hatchery trout in Houghton Creek during the pre-improvement period (1945-1950 and post-improvement period (1956-1961)

Year	Catch			
	Brown trout		Rainbow trout	
	Number	Pounds	Number	Pounds
1945	-	-	-	-
1946	-	-	-	-
1947	-	-	-	-
1948	-	-	3	0.8
1949	2	0.9	-	-
1950	-	-	67	11.3
Total	2	0.9	70	12.1
1956	1	0.3	-	-
1957	1	0.1	-	-
1958	6	1.8	-	-
1959	18	4.7	6	1.9
1960	-	-	3	1.5
1961	6	1.5	77	11.5
Total	32	8.4	86	14.9

Vaughn Creek

Vaughn Creek is a small tributary of Gamble Creek (Fig. 1). The lowermost 4,679 feet of stream within the Area flow through an alder and cedar swamp. The average width of the stream is about 9 feet. It has a surface area of 0.9 acre. This stream was not included in the watershed program.

Very few anglers fished this stream during 1945. Between 1946 and 1950, fishing pressure was relatively light and uniform (Table 7). During the 6-year period fishing pressure averaged 41.6 hours per acre. Except for the catch of 1 trout in 1945, the annual yield ranged between 12.2 and 38.9 native trout per acre--the average for the period being 17.6 trout per acre.

On the average, about 16 wild trout were caught each year in 1945-1950. The total catch for the period consisted of 53 brook trout and 42 brown trout. About 32% of the fishing trips were successful and wild trout were caught at the rate of 0.42 fish per hour (Table C).

During the 1956-1961 period, fishing pressure increased to a peak in 1958 before dropping to the low point in 1959. By 1961, fishing intensity approached the level found in 1958 (Table 7). The 6-year average was 157.6 hours per acre, an increase of 279% over the fishing pressure in 1945-1950. The annual yield for this period tended to follow the same trend as that for fishing pressure. The peak yield of 126.7 wild fish per acre occurred in 1958 and the poorest was in 1959 when 35.6 fish per acre were caught. The average yield was

Table 7.--Angling pressure and catch of native trout in Vaughn Creek during the pre-improvement period (1945-1950) and post-improvement period (1956-1961)

Year	Angling pressure		Catch						All trout	
			Brown trout		Rainbow trout		Brook trout			
	Trips per acre	Hours per acre	Number	Pounds	Number	Pounds	Number	Pounds	Number per acre	Pounds per acre
1945	8.8	10.0	1	0.1	-	-	-	-	1.1	0.1
1946	37.8	53.3	11	2.5	-	-	3	0.7	15.6	3.6
1947	38.9	53.9	8	2.4	-	-	27	6.4	38.9	9.8
1948	24.4	47.2	4	1.1	-	-	7	1.5	12.2	2.9
1949	15.6	30.6	7	2.3	-	-	15	3.1	24.4	6.0
1950	28.9	54.4	11	2.9	-	-	1	0.1	13.3	3.3
Total	-	-	42	11.3	-	-	53	11.8	-	-
Mean	25.8	41.6	7.0	1.9	-	-	8.8	2.0	17.6	4.3
1956	85.6	153.8	54	18.1	-	-	11	2.1	72.2	22.2
1957	84.4	163.8	82	34.6	-	-	8	1.7	100.0	40.3
1958	87.8	222.2	109	32.2	-	-	5	0.8	126.7	36.7
1959	61.1	82.8	24	6.4	-	-	8	1.4	35.6	8.7
1960	63.3	122.7	34	11.5	-	-	32	6.4	73.3	19.9
1961	71.1	199.4	85	22.9	-	-	15	2.8	111.1	28.6
Total	-	-	388	125.7	-	-	79	15.2	-	-
Mean	75.6	157.6	64.7	21.0	-	-	13.2	2.5	86.5	26.1

86.5 native trout per acre in 1956-1961, a 391% increase over 1945-1950. Altogether, 388 brown trout and 79 brook trout were caught for an average annual yield of about 78 fish. Anglers were successful on 37% of their fishing trips. Wild trout were caught at the rate of 0.55 fish per hour (Table C).

A comparison of the statistics for the two fishing periods shows that the percentage of successful trips was nearly identical and that there was no significant difference in angling quality ($t = 1.197$; $P > 0.05$). In 1945-1950, native brown and brook trout were taken in near y equal numbers but, after 1951, brown trout outnumbered brook trout 5 to 1 in the annual catches.

Trout were not planted in Vaughn Creek. However, 2 hatchery rainbow trout were caught during the pre-improvement period and 25 brown and 14 rainbow trout were caught during the post-improvement period. Most of the brown trout caught during the latter period came from a planting of legal-length fish in Gamble Creek in 1958 while the rainbow trout came from two plantings in Devoe Lake. Discounting 10 fish recovered from plantings made prior to 1956, the adjusted catch for the post-improvement period was 28 fish compared to 2 fish for the pre-improvement period.

Oyster Creek

Oyster Creek is about 10-12 feet wide where it enters the northwest corner of the Area. A short distance inside the Area the stream splits into a network of channels. It meanders in a southeasterly

direction through an area of low ground and empties into Gamble Creek in the vicinity of Mallard Pond (Fig. 1). Between 1945 and 1961 beaver worked on this stream almost annually. Over the years, slight changes in the drainage pattern of the stream in the Area were made by high water and beaver activity. Oyster Creek was not included in the watershed program.

Fishing activity on Oyster Creek during 1945-1950 was confined largely to a small beaver pond. The pond, in its early life, yielded modest numbers of brook trout of better-than-average size. The pond gradually deteriorated as a habitat for brook trout and the catch diminished. Fishing pressure and yield for the pond and creek were censused separately and are shown in Table 8. Between 1945 and 1947, the number of fishing trips was divided about evenly between pond and stream with the former producing a catch almost five times greater than the latter. By 1948, the pond apparently was overrun with a large number of creek chubs and fishermen sought these fish for bait minnows. Altogether, 210 chubs were caught that year. In 1949 and 1950, only three brook trout were caught; by 1951 the beaver pond ceased to exist. About 14% of the fishing trips were successful during this 1945-1950 period and trout were caught at the rate of 0.19 fish per hour (Table C).

In 1956-1961, fishing pressure and yield were extremely light. Annual fishing pressure ranged between 20 and 31 trips and from 21.5 to 61.0 hours. The total catch consisted of 15 wild brown and 1 brook trout (Table 8) which, together, weighed 6 lb. About 7.5% of the fishing trips were successful and trout were caught at the rate of 0.07 fish per hour (Table C).

Table 8.--Angling pressure and catch of native trout in Oyster Creek during the pre-improvement period (1945-1950) and post-improvement period (1956-1961)

Year	Oyster Creek			Oyster Creek beaver pond		
	Angling pressure	Catch		Angling pressure	Catch	
	Number of trips	Brook trout	Brown trout	Number of trips	Brook trout	Brown trout
1945	39	1	-	48	22[a]	2
1946	38	1	1	20	11	1
1947	29	7	1	41	21	5
1948	27	1	3	43	9	4
1949	12	1	1	5	3	-
1950	21	-	1	3	-	-
Total	166	11	7	160	66	12
1956	30	-	4			
1957	31	-	7			
1958	20	-	1			
1959	28	-	-			
1960	27	1	2			
1961	25	-	1			
Total	161	1	15			

[a] Includes one brook x brown hybrid.

The total number of hours fished decreased about 54% during the post-improvement period. In the same manner, the total catch of wild trout dropped from 96 to 16 fish (83%). This decline in catch coincided with the near disappearance of brook trout in this period. The existence of the beaver pond during the pre-improvement period created extra fishing interest in the brook trout. The mean lengths of 10.1 inches for the 21 brook trout caught in 1945 and 9.4 inches for a similar number caught in 1947 suggested that growth diminished as the pond aged.

Hatchery trout were not stocked in this stream. No hatchery trout were caught in Oyster Creek during the pre-improvement period but five were caught during the post-improvement period. Four originated from plantings in Devoe Lake and one from a planting in the Rifle River.

Diversion

Long-term water temperature records for the Rifle River prior to 1950 are not available for comparison with records accumulated since then. Thus, no quantitative measure of the influence of the Diversion upon water temperatures in the Rifle River is available. However, it is apparent that prior to 1950 the outflow of warm water from the epilimnion of Devoe Lake during the summer months was responsible for the high water temperatures in the Rifle River above Houghton Creek. On August 6, 1941, Locke recorded a series of hourly water temperatures over an 11-hour period at sites on the Rifle River and at the mouth of

Houghton Creek. His data showed that temperatures in the Rifle River above Houghton Creek ranged between 71 and 81 F and averaged 77.4 F. Temperatures in Houghton Creek averaged 16.4 F below this and, therefore, had the effect of depressing the water temperature of the Rifle River at the Ranch bridge by about 10 F on the average. The disparity between water temperatures in the Rifle River (Ranch bridge) and Houghton Creek varied from 4.5 to 7.5 F. The highest recorded water temperature for the Rifle River at the Ranch bridge since 1950 was 72 F, having occurred in July and August of 1955. Daily differences in maximum water temperatures between the Rifle River (Ranch bridge) and Houghton Creek ranged from 0 to 4 F during these months. Thus, by making Gamble Creek rather than Devoe Lake the direct source of the Rifle River, summer water temperatures were lowered in the Rifle River for at least some distance below the Ranch bridge.

While a secondary benefit of the Diversion is to provide means of storing Gamble Creek water in Devoe Lake to reduce flood crests on the Rifle River, the configuration of the lake basin and the low dam at the outlet limited the storage capacity of the lake.

In the first 4 years of its existence (1952-1955), the Diversion provided 226.5 hours of fishing and a catch of 24 brown trout and 1 brook trout in addition to 31 hatchery trout. In the following 6 years (1956-1961), 574 hours of fishing were spent on the Diversion for an average of 95.7 hours annually. A total of 57 brown and 5 brook trout were caught. In addition there was a catch of hatchery trout which consisted of 47 rainbow and 8 brown trout.

Discussion

Creel census data for the 6 years preceding (1945-1950) and following (1956-1961) the watershed improvement program represented distinctly different phases of angling on the Area streams. The pre-improvement period embraced the earliest history of public fishing in the Rifle River Area. Characteristic of this period was the general upward trend in fishing pressure noted also throughout the state. Exceptions to this trend were Vaughn Creek and Oyster Creek, two of five Area streams not included in the watershed program. During the post-improvement period, fishing pressure was noticeably more intensive (except on Oyster Creek) and included the peak years of fishing activity during the first 17 years of public use.

No consistent change was observed in the annual catches of native brown trout from the Rifle River during the pre- and post-improvement periods. Instead, the annual catch tended to fluctuate; the pre-improvement period showed slightly less variability in catch (coefficient of variation "C" = 33.6%) than the post-improvement period (C = 42.0%). Catch parameters such as length-frequency distribution, mode, and mean length of brown trout caught were very similar in both periods.

The annual catch of native trout from Gamble, Houghton and Vaughn creeks showed no discernible trend during either period. In the case of Oyster Creek, the catch tended to diminish during the pre-improvement period probably as a result of the deterioration of the beaver pond. Later, when fishing pressure was extremely light, the catch remained uniformly small.

The increased fishing pressure on the Rifle River during the post-improvement period was accompanied by an average yield and catch per hour not significantly different from that of the earlier period. Only Gamble and Vaughn creeks showed a significant increase in yield with an accompanying increase in fishing effort. In both instances fishing pressure and yield were light during the initial period of census, but, with a 2-fold increase in fishing pressure, the average yield for Gamble Creek increased from 4.0 to 11.2 trout per acre. A 5-fold increase in fishing effort on Vaughn Creek was accompanied by an increase in yield from 17.6 to 86.5 fish per acre.

Fall estimates of the brown trout populations in the upper 1/2 mile of Gamble Creek within the Area were obtained for the years 1947-1950 and 1956-1961, inclusively (Table 9). These annual total estimates are summations of estimates for the following three size groups: 2.0-3.9; 4.0-6.9; 7.0 inches and longer. Young-of-the-year trout accounted for much of the variability in the annual estimates. There was no significant difference ($P > 0.05$) between the average estimate for the years 1947-1950 and 1956-1961.

In the period 1947-1950, there were about 32 legal-length fish per acre in the fall. During these years the average yield to the angler was 3.8 trout per acre for the entire stream, suggesting a lightly exploited population during the pre-improvement period. Estimates in the fall for the post-improvement period averaged about 38 trout per acre, similar to that for the 4 years of the pre-improvement period. The anglers' catch of only 11.2 trout per acre again indicated this was a lightly exploited population.

Table 9.--Fall population estimates ($\hat{P}$), and their 90% confidence limits (L), of native brown trout in the upper 1/2 mile of Gamble Creek within the Rifle River Area

Year	Size range (inches)							
	2.0-3.9		4.0-6.9		7.0- larger		Total	
	$\hat{P}$	L	$\hat{P}$	L	$\hat{P}$	L	$\hat{P}$	L
1947	1,211	±482	484	±116	189	±39	1,884	±497
1948	631	±145	244	± 28	117	±15	992	±148
1949	382	± 86	459	±196	207	±20	1,048	±215
1950	120	-	219	± 44	245	±34	584	±191
Mean	586.0		351.5		189.5		1,127.0	
1956	1,187	±143	335	± 13	220	±18	1,742	±145
1957	766	± 89	447	± 34	265	±20	1,478	± 97
1958	1,435	±224	306	± 42	185	±22	1,926	±229
1959	232	± 74	319	± 44	125	±22	676	± 89
1960	179	± 62	129	± 23	243	±11	551	± 67
1961	236	± 77	138	± 28	317	±72	691	±109
Mean	672.5		279.0		225.8		1,177.3	

No estimates of the brown trout population in Gamble Creek below Mallard Pond were made during the pre-improvement period. When this open stretch of stream was sampled for sea lamprey ammocoetes (Petromyzon marinus) in 1952, observations indicated a relatively small population of brown trout. The stream undoubtedly supports a larger number of trout since the installation of a series of deflectors in 1953, as indicated by four fall population estimates between 1958-1961.

For Gamble Creek the improved yield in the post-improvement period would appear to be largely the result of increased fishing pressure over a reasonably stable but lightly exploited population. This point is corroborated to some extent by the early history of public fishing on this stream, wherein the annual yield tended to follow annual changes in fishing pressure ($r = 0.779$). The change in the fishery of Vaughn Creek, while of a greater magnitude, appeared to parallel that of Gamble Creek in that increased angling effort on an unexploited population resulted in a significantly greater yield. For both streams the increase in yield during the post-improvement period was accompanied by an increase in fishing pressure and, as a result, angling quality remained approximately at the pre-improvement level.

During the pre-improvement period the fishery on Houghton Creek was relatively more intense than on either Gamble or Vaughn creeks. Fishing pressure more than doubled during the post-improvement period but the annual catches were not increased. Consequently, angling quality dropped in the latter period.

The catch of hatchery trout in the Rifle River during both periods was, with few exceptions, the result of plantings in the Rifle River and, to a lesser extent, Devoe Lake. During the pre-improvement period 3,023 legal and 10,000 sublegal trout were stocked in the Rifle River and 2,983 trout (legal-length) in Devoe Lake. Nearly all of the 948 trout caught in the river came from these plantings. With a 1.6-fold increase in average fishing pressure, a comparable number of trout stocked during the post-improvement period resulted in the catch of 2,270 fish. There was no significant difference in the yields and in the quality of angling for the two periods.

For reasons largely unknown, rainbow trout planted in Devoe Lake during the post-improvement period enhanced the catch in the Rifle River more noticeably than similar plantings in the pre-improvement period. The catch from the river probably reflected differences in the number of trout that emigrated out of the lake and in fishing pressure between the two periods.

Gamble Creek was the only other Area stream that was stocked. In general, the fall plantings of brown trout fingerlings in Gamble Creek during the pre- and post-improvement periods resulted in relatively small returns to the anglers. Anglers failed to exploit a planting of 300 legal-length brown trout in Gamble Creek in the pre-improvement period whereas 19% were recovered from a similar planting in the post-improvement period. Comparable rainbow trout plantings in Devoe Lake during the pre- and post-improvement periods increased the total catch in Gamble Creek by about 13% and 20%, respectively.

The broadly stated objective of the watershed program was the restoration and maintenance of a high level of fishing on the Rifle River. Unfortunately, the large changes in fishing pressure complicated the evaluation of this program. With about a 60% increase in fishing pressure during the post-improvement period, the yield of native trout increased (though not significantly), but the catch per hour was not affected. It could not be determined whether or not the difference in yields was attributable to the watershed program, increase in fishing pressure, or possibly to both.

Aside from the cause-and-effect relationship in this study, the mean number of wild trout caught annually in the Rifle River during the post-improvement period (869 fish) was about 28% greater than that for the pre-improvement period (680 fish). Applying a test for sample size (Dixon and Massey, 1951), if the true difference had amounted to 57% (or 385 fish above the pre-improvement mean) this study would have had a 95% chance of detecting a significant difference at the 0.05 probability level. For increases of this magnitude, an experiment would have to be carried on for nearly 36 years to have a 95% chance of detecting a difference at the 0.05 probability level.

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Howard Gowing

Report approved by Mercer H. Patriarche

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Appendix

Table A. --Physical dimensions of streams in the Rifle River Area

Stream	Length (feet)	Average width (feet)	Surface area (acres)
Rifle River			
Upper	4, 139	42.1	4.0
Lower	20, 191	40.6	18.8
Gamble Creek			
Upper	2, 703	17.4	1.1
Lower	5, 238	40.4	4.8
Houghton Creek	1, 267	30.6	0.9
Vaughn Creek	4, 679	8.8	0.9
Oyster Creek	10, 222	11.0	2.6

Table B.--Trout fishing regulations during the years 1945-1961

Years	Season	Size limit (inches)	Creel limit
1945-1947	Last Saturday in April through Labor Day	7.0	15 trout per day
1948-1954	Last Saturday in April through 2nd Sunday in September	7.0[a]	10 trout, or 10 lb. and 1 trout per day
1955-1961	As above	7.0	As above

[a] An 8.0-inch size limit was imposed on the Rifle River trout within Area boundaries during this period.

Table C. --Indices of angling quality for the various trout streams on the Rifle River Area

	Pre-improvement period							Post-improvement period						
	1945	1946	1947	1948	1949	1950	Mean	1956	1957	1958	1959	1960	1961	Mean
Rifle River														
Percentage successful trips	12.3	20.3	22.7	19.3	18.3	17.0	18.5	11.4	14.6	19.5	9.7	16.1	13.3	14.2
Catch per hour	0.11	0.27	0.22	0.13	0.16	0.09	0.16	0.08	0.15	0.18	0.08	0.16	0.11	0.13
Gamble Creek														
Percentage successful trips	10.4	15.8	11.6	9.8	27.3	14.3	15.5	11.9	18.2	21.0	12.6	20.6	20.5	17.6
Catch per hour	0.11	0.25	0.07	0.07	0.24	0.10	0.13	0.10	0.16	0.22	0.10	0.18	0.19	0.16
Houghton Creek														
Percentage successful trips	83.3	31.0	57.1	30.4	51.4	32.4	39.9	11.3	17.9	17.2	10.7	17.1	14.2	14.4
Catch per hour	0.38	0.29	1.08	0.29	0.48	0.11	0.31	0.12	0.16	0.22	0.10	0.14	0.09	0.13
Vaughn Creek														
Percentage successful trips	12.5	35.3	45.7	18.2	42.8	23.1	32.4	31.2	40.8	44.3	27.3	45.6	40.6	37.0
Catch per hour	0.11	0.29	0.72	0.26	0.80	0.24	0.42	0.47	0.61	0.57	0.43	0.60	0.56	0.55
Oyster Creek														
Percentage successful trips	9.2	12.1	27.1	11.4	11.8	4.2	13.8	13.3	9.7	5.0	0.0	11.1	4.0	7.4
Catch per hour	0.14	0.18	0.33	0.16	0.18	0.04	0.19	0.10	0.11	0.05	0.00	0.08	0.03	0.07
Diversion														
Percentage successful trips	-	-	-	-	-	-	-	12.5	17.7	12.1	2.1	15.2	10.2	11.5
Catch per hour	-	-	-	-	-	-	-	0.16	0.11	0.14	0.01	0.23	0.07	0.11

Table 7. --Periodicity of fishing pressure and catch of native trout in the Rifle River for each 6-year period

Week of season	1945-1950				1956-1961			
	Angling trips		Trout caught		Angling trips		Trout caught	
	Number	Cumulative percentage	Number	Cumulative percentage	Number	Cumulative percentage	Number	Cumulative percentage
1	1,726	17.3	428	10.8	2,590	16.2	603	11.6
2	834	25.7	363	19.9	1,263	24.1	442	20.0
3	651	32.2	342	28.5	1,010	30.4	404	27.8
4	640	45.1	255	34.9	946	36.4	389	35.2
5	780	46.5	419	45.5	1,300	44.5	478	44.4
6	657	53.1	291	52.8	866	49.9	323	50.6
7	491	58.0	290	60.1	763	54.7	338	57.1
8	565	63.6	370	69.4	742	59.3	314	63.1
9	417	67.8	155	73.3	680	63.6	210	67.1
10	434	72.2	148	77.1	786	68.5	274	72.4
11	371	75.9	152	80.9	624	72.4	268	77.5
12	278	78.7	112	83.7	540	75.8	234	82.0
13	347	82.2	110	86.5	533	79.1	213	86.1
14	269	84.9	134	89.8	569	82.7	129	88.6
15	277	87.7	79	91.8	499	85.8	131	91.1
16	267	90.3	50	93.1	517	89.0	106	93.1
17	255	92.9	79	95.1	500	92.2	66	94.4
18	269	95.6	86	97.2	431	94.9	87	96.1
19	343	99.0	88	99.5	487	97.9	114	98.2
20	80	99.8	16	99.9	254	99.5	69	99.6
21	15	100.0	5	100.0	77	100.0	22	100.0
Totals	9,966		3,972		15,997		5,214	

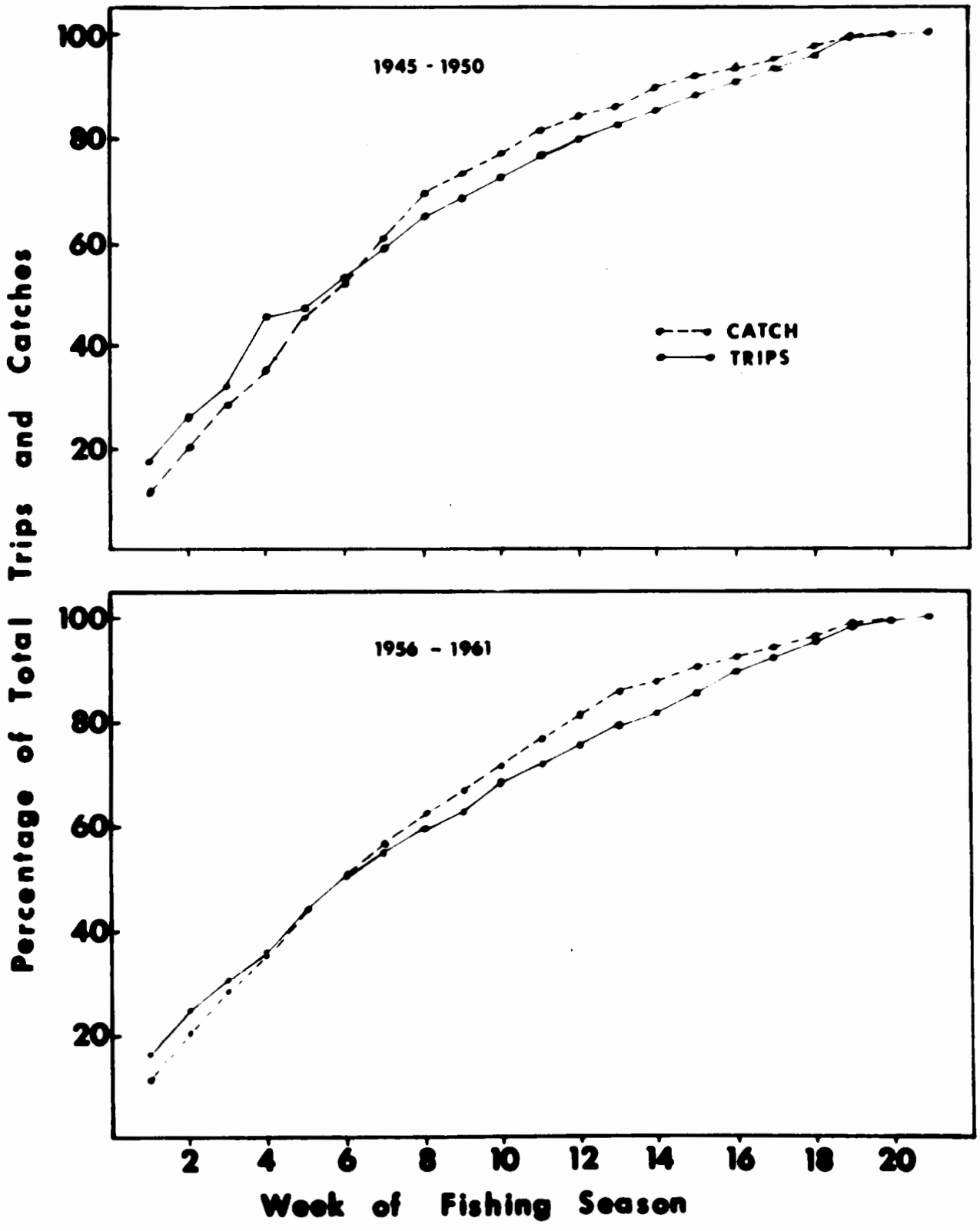

Figure A. --Cumulative percentages of fishing trips and number of native trout caught in the Rifle River in the pre- and post-improvement periods.