OBSERVATIONS ON THE FISH POPULATION OF WILLOW CREEK RESERVOIR, MONTANA

by

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A THESIS

Submitted to the Graduate Faculty

in

partial fulfillment of the requirements

for the degree of

Master of Science in Fish and Wildlife Management

at

Montana State College

Approved:

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Head, Major Department

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Bozeman, Montana
March, 1960

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I was born in Sheboygan, Wisconsin on March 6, 1935 and completed my elementary and high school education there. In September, 1953 I entered Montana State College where I completed requirements for a Bachelor of Science degree in Fish and Wildlife Management in 1957. For two summers, I was employed by the Montana Fish and Game Department; one as an assistant to a district fish manager, and one as foreman of a fish shocking crew. I was employed for one summer as party leader for a fish collecting crew from Montana State College. In November of 1957 I entered military service and served two years with the United States Army, 15 months of which were spent in Germany. I was married to Helen Vidal in May, 1958 and we now have two sons. In September, 1959 I was accepted as a graduate student in Fish and Wildlife Management at Montana State College. This thesis is submitted as partial fulfillment of the requirements for the Master of Science degree in Fish and Wildlife Management

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Abstract

Observations were made on the spawning, growth, distribution, harvest and movement of trout in Willow Creek Reservoir from March through November, 1960. Successful reproduction was observed only in Willow Creek. Rainbow trout taken in 1960 showed a decline in average size and slower growth rate than the same species taken in previous years. Distribution of trout in the reservoir appeared to be correlated with water temperatures. Rainbow trout were most evenly distributed in the reservoir when water temperatures were warmest, but were concentrated near the surface when water temperatures were cool. Brown trout were always more abundant near the bottom, and at maximum temperatures were restricted to deeper areas. Game fish caught by gill nets included 69.05 percent rainbow trout, 30.04 percent brown trout, 0.68 percent brook trout and 0.23 percent mountain whitefish. Anglers harvested an estimated 14,868 trout during the 1960 (six week) fishing season. The catch was composed of 97.27 percent rainbow trout, 2.47 percent brown trout and 0.26 percent brook trout. Recoveries of marked fish indicated a wide dispersal of fish marked in the tributaries during spawning, and of those planted in 1960.

Introduction

A large number of investigations have been made on fish populations of reservoirs but few concern cold water fish. Studies on cold water fish populations in Colorado were made by Nelson (1955) and Sharpe (1958). The present investigation was conducted from March through November, 1960. It included observations on the life history, distribution and harvest of rainbow trout (Salmo gairdneri) and brown trout (Salmo trutta) in a cold water impoundment.

Acknowledgements. Grateful acknowledgement is due to Dr. C. J. D. Brown who directed the project and aided in the preparation of the manuscript. Thanks are due to several members of the Montana Fish and Game Department for help in the field. John R. Heaton assisted with the age and growth analysis and Tom Leik gave advice regarding the collection and analysis of creel data. Thanks are also due to Charles Quesenbury who suggested and outlined the design for the harvest estimate. The Montana Fish and Game Department provided financial support under the Federal Aid to Fish Restoration Act (Project number F-9-R-9).

Description of Area. Willow Creek Reservoir is formed by an earth filled dam athwart Willow Creek, a tributary of the Jefferson River which in turn is one of three primary headwater tributaries of the Missouri River. This impoundment is located 4 miles east of Harrison, Madison County, Montana. It was filled for the first time in 1938. When full, it has a surface area of 868 acres, a storage capacity of 17,760 acre feet, and a maximum depth of 74 feet. The spillway elevation is 4,736 feet above

sea level. During summer and early autumn of the study period, water levels in the impoundment decreased about 15 feet due to irrigation draw-down. The reservoir is situated in an open rolling grassland and has a drainage area of approximately 160 square miles located on the east slopes of the Tobacco Root Mountains. The tributaries which enter the reservoir are: Willow Creek with a drainage area of 88.4 square miles and an average flow of 43.1 c.f.s.; Norwegian Creek with a drainage area of 34.6 square miles and an average flow of 7.5 c.f.s.; and Dry Hollow Creek which is a very small intermittent stream.

The water in the reservoir is relatively clear, even during run-off. In the study period, water temperatures ranged from 78° (July 22) to 32° F. (ice cover, December through March). The greatest daily variation occurred on July 22 with a maximum of 78° and a minimum of 63° F. No marked thermal stratification was observed.

Chemical analyses of water from the impoundment showed the following: phenolphthalein alkalinity 13 p.p.m.; methyl orange alkalinity 127 p.p.m.; pH 7.3. Chemical analyses of water from the two major tributary streams (Table 1) were made by the Montana State Board of Health.

Rooted aquatic vegetation was present in areas of the reservoir with depths less than 10 feet but much of this area was exposed by draw-down.

Fish observed in the reservoir were rainbow trout, brown trout, brook trout (Salvelinus fontinalis), mountain whitefish (Prosopium williamsoni), white sucker (Catostomus commersoni), longnose sucker (Catostomus catostomus), longnose dace (Rhinichthys cataractae), and mottled sculpin (Cottus

Table 1. Chemical data for Willow and Norwegian Creeks, 1960.

Chemical analyses	Willow Creek p.p.m.	Norwegian Creek p.p.m.
Iron (Fe)	1.0	0.9
Calcium (Ca)	56.0	52.0
Magnesium	27.0	37.0
Sodium and Potassium Calc. (Na-K)	25.0	21.0
Carbonate radical (CO_3)	0.0	0.0
Bicarbonate radical (HCO_3)	293.0	317.0
Sulphate radical (SO_4)	49.0	27.0
Chloride (Cl)	8.0	28.0
Fluorine (F)	0.4	0.5
Nitrates (NO_3)	0.1	0.0
Hydroxide (OH)	0.0	0.0
Total hardness (as $CaCO_3$)	250	281
Total dissolved solids	370	385

bairdi). With the exception of the first three, all are native to the drainage. No records were found regarding the original introduction of trout into the reservoir but stocking records since 1953 are available (Table 2).

Table 2. Willow Creek Reservoir rainbow trout stocking records.

Year	Size in inches	Number	Total weight in pounds
1953	6-9	2,700	360
1954	1	113,175	85
1954	6-9	2,599	769
1955	3	85,966	490
1957	3	46,124	708
1958	3	58,144	705
1959	6-9	29,988	9,630
1959	6-9	25,083	4,810
1960	6-9	29,976	7,847
1960	6-9	25,000	5,000

Rainbow trout have produced spawning runs in the tributary streams and a trap in Willow Creek has been operated since 1950 for the purpose of obtaining eggs of this species (Table 3).

Table 3. Data from the Willow Creek egg taking operation.

Year	Number of females stripped	Number of eggs taken
1950	----	1,289,680
1951	----	2,267,136
1952	----	1,746,810
1953	----	3,585,600
1954	----	2,642,164
1955	1830	2,432,960
1956	1139	3,615,744
1957	1771	2,493,102
1958	988	1,773,552
1959*	335	629,748
1960	239	279,800

* In 1959 an additional 443 females and 935,088 eggs were taken from Norwegian Creek.

Observations on Spawning and Fry Production in Tributaries

The tributary streams provide spawning areas for most fishes in the reservoir. Spawning fish in Norwegian and Dry Hollow Creeks were collected by electrofishing, using a 220 volt D.C. generator. A section of 300 feet was established in each stream and practically all adult fish were captured in these areas on each collection date. The spawning fish in Willow Creek were taken in a trap which blocked the entire stream. This trap was installed previous to this study, by the Montana Fish and Game Department for the purpose of obtaining rainbow trout eggs.

The tributaries were first visited on March 27 and at that time adult

rainbow trout, presumably from the reservoir, were observed in Norwegian and Dry Hollow Creeks, no fish were seen in Willow Creek. Seven samples were taken on Norwegian Creek as follows: two on March 30, and one each on April 1, 4, 8, 11, and May 7. A total of 207 male and 124 female rainbow trout was collected (Table 4). Four samples were taken on Dry Hollow Creek; one each on April 1, 8, 11, and May 7. A total of 71 male and 31 female rainbow trout was collected (Table 4).

Table 4. Number, average length, and average weight of rainbow trout taken electrofishing in Norwegian and Dry Hollow Creeks, 1960.

Date	Norwegian Creek		Dry Hollow Creek	
	Males	Females	Males	Females
March 30	22	10	--	--
March 30	25	21	--	--
April 1	33	13	15	4
April 4	37	45	--	--
April 8	29	7	26	13
April 11	16	11	17	7
May 7	45	17	13	7
Total number	207	124	71	31
Average length	13.48	16.80	13.18	14.84
Average weight	0.98	1.62	0.81	1.10

The trap on Willow Creek was put into operation on March 29, and the first rainbow trout was captured along with seven suckers on April 1. The first eggs were taken on April 13, and spawn-taking continued at irregular intervals through May 8. During this period a total of 474 rainbow trout, including 235 males and 239 females, was trapped. A total of 270,800 eggs was taken in this spawn-taking operation (Table 5).

Lengths and weights were taken on rainbow trout in the 1960 spawning run in Willow Creek. Lengths and weights were also available for spawning

Table 5. Rainbow trout captured and eggs obtained during the spawn-taking operation in Willow Creek, 1960.

Date	Males taken	Females taken	Eggs obtained
April 13	90	48	64,960
April 19	92	45	46,400
April 20	14	14	113,920
May 3	22	113	26,680
May 8	17	19	27,840
May 17	Station closed		

In addition to the rainbow trout, 82 adult brown trout were also taken in the trap; 72 on April 13, 3 on April 20, and 7 on May 11. One adult brook trout was taken on April 20.

fish taken in 1953 through 1958, except for 1956. The tabulation of this material shows a decline in the size of fish taken over this period (Table 6).

Table 6. Lengths and weights of rainbow trout from the spawning runs in Willow Creek, 1953 - 1960.

Year	Sex	Number	Average length in inches	Average weight in pounds
1953	Male	50	———	3.90
	Female	50	———	3.40
1954	Male	14	20.6	3.00
	Female	87	20.4	3.10
1955	Male	157	17.6	———
	Female	368	19.4	———
1955	Male	6	18.1	1.61
	Female	62	19.0	2.21
1957	Male	53	18.7	2.21
	Female	54	19.1	2.62
1958	Male	18	18.3	1.99
	Female	57	18.8	2.16
1960	Male	61	13.6	0.93
	Female	105	17.7	1.67

A length-frequency distribution was plotted for fish captured in the tributaries in 1960. The 12- and 13-inch groups were dominant with 130 and

154 specimens respectively. The 18- and 19-inch groups were next with 69 and 72 individuals respectively.

At least some of the rainbow trout planted in 1959 and 1960 could be identified by certain fin deformities. A total of 192 fish or 32 percent of those handled by the writer during the spawning-run were identified as hatchery fish. The majority of these were in the 12- and 13-inch groups and none were found to exceed 15.0 inches. Of the 130 fish in the 12-inch group, 72, or 55 percent possessed deformed fins, and of the 154 specimens in the 13-inch group, 81, or 52 percent showed similar deformities. The 18- and 19-inch groups were either from fish planted (mostly fingerlings) prior to 1959, or from wild fish.

A few observations were made on the spawning movement of suckers into the tributary streams. On April 13, 206 (143 white suckers and 63 longnose suckers) were removed from the Willow Creek trap, and on subsequent days large undetermined numbers were removed. A sample of 52 suckers from Willow Creek was weighed and measured. These had an average total length of 14.25 inches and an average weight of 1.24 pounds. Eight suckers were taken from Norwegian Creek on May 7, but none were found in Dry Hollow Creek. On June 2, a concentration of suckers and trout was observed on the first riffle above the reservoir in Willow Creek. A 150-foot section of this riffle was shocked. The fish taken included: 80 rainbow trout, 13 brown trout and about 150 suckers. Examination of four rainbow trout and three brown trout stomachs revealed that they had been feeding almost exclusively on sucker eggs.

Spawning Success. The tributary streams were kept under observation for trout fry and fingerlings from May 27 to September 8. Dry Hollow Creek was dewatered on May 28, except for a few scattered pools. These pools were inspected for fry but none were found. A fry trap, which had been used successfully in other Montana streams, was placed in Norwegian Creek in an attempt to capture fry. It was installed on June 3 and remained in the stream until August 17. During this period not one fry or fingerling trout was taken although several dace and sculpins were caught. Repeated seining ("common sense", 1/8-inch mesh) captured no trout and only a few sucker fry in Norwegian Creek, but a large number of fry and fingerling trout (brook, brown and rainbow) as well as suckers were taken in Willow Creek.

Autumn Spawning Activity. The tributaries were kept under observation through October and November for spawning brown trout, or their redds. Only Willow Creek revealed any spawning fish, although there was adequate water in all the tributaries. The first redd was found on October 4, and 10 redds were observed in approximately two miles of stream between October 4, and November 2.

A section of Willow Creek (approximately 300 feet) was sampled four times by electrofishing (October 6, 21, 24, and 28). Twenty male and three female brown trout were taken, along with 13 male and 11 female brook trout, and 6 male and 3 female whitefish. All of these fish were mature enough to spawn.

Two experimental gill nets were set near the mouth of Willow Creek on

November 2 and two on November 3. Ten female and four male brown trout over 15 inches in total length, and 11 smaller individuals of this species were taken. None of them showed evidence of having spawned or being mature enough to spawn, with the exception of one female. All the remaining females had remnants of eggs in the body cavity, presumably from the previous season.

Age and Growth

Age and growth determinations were made for rainbow trout and brown trout. Fish were collected from Willow Creek Reservoir by gill netting, and angling, and from the tributaries by electrofishing, seining, and the trap on Willow Creek. Fish were measured to the nearest 0.1 inch (total length). Scale samples were taken anterior to the dorsal fin above the lateral line, and annuli were determined from plastic impressions with the aid of a microprojector. Scale measurements were made from the center of the focus to the outer edge along the mid-anterior radius. Assuming a straight line relationship of scale length to body length, the length of the fish at the completion of each annulus was determined by use of a nomograph.

A considerable number of scale samples revealed patterns that were so irregular and diverse that they could not be interpreted. Most of these scale samples were from fish between 7 and 16 inches in total length that had deformed fins. Practically all of the fish taken between 9 and 15 inches total length had irregular patterns on their scales, these fish also had deformed fins.

The average calculated total lengths for rainbow trout at annuli I-VI were 3.29, 7.86, 12.93, 16.53, 18.82, and 18.1. The largest individual in the collection was 21.0 inches in total length, weighed 3.02 pounds and had five annuli. No rainbow trout were found to have more than six annuli. The smallest rainbow trout taken was 3.6 inches in total length and was without annuli. Calculations from scales of previous collections in Willow Creek Reservoir (1949, 1954, and 1955) generally showed greater total lengths than those of the 1960 collection (Table 7). The largest rainbow trout was taken in 1954. It was 24.3 inches in total length, weighed 4.62 pounds and had five annuli.

Table 7. Comparison of rainbow trout age and growth determinations for Montana (number of specimens in parenthesis).

Location	Year	I	II	III	IV	V	VI
Willow Creek Res.	1960	3.29 (258)	7.86 (246)	12.93 (233)	16.53 (152)	18.82 (68)	18.10 (2)
	1955	3.2 (55)	8.4 (55)	13.7 (53)	17.8 (28)	20.5 (1)	
	1954	4.0 (96)	10.2 (96)	15.6 (95)	19.4 (87)	21.6 (30)	21.0 (3)
	1949	3.3 (18)	8.6 (18)	14.9 (18)	17.7 (13)	18.3 (3)	
Canyon Ferry Res.	1959	3.4 (13)	7.2 (12)	13.8 (10)	17.1 (1)	19.0 (1)	
Prickley Pear Cr.	1955	3.5 (747)	6.6 (270)	9.4 (63)	11.8 (10)	16.7 (1)	
Missouri River	1950	3.2 (478)	7.9 (371)	11.1 (168)	13.5 (40)	15.9 (4)	16.6 (2)

Several age and growth studies have been made on rainbow trout in Montana. Growth was similar for ages I and II except for Prickley Pear Creek (Bishop, 1955) which was less than that of Willow Creek Reservoir at age II. In fish older than two years, growth was greatest in Canyon Ferry

Reservoir (Graham, 1959), next in Willow Creek Reservoir, next in the Missouri River (Kathrein, 1951), and least in Prickley Pear Creek.

The average calculated total lengths for brown trout at annuli I-VIII were 3.38, 8.29, 12.99, 15.69, 17.29, 19.13, 22.90, and 24.40. The largest and oldest specimen in the collection was 25.0 inches in total length, weighed 7.50 pounds and had eight annuli. The smallest brown trout in the collection was 3.2 inches in total length and was without annuli. The brown trout growth rate for Willow Creek Reservoir was greater than that reported by Bishop (1955) for ages II-VII, comparable to that found by Kathrein (1951), but not as great as that given by Graham (1959) (Table 8).

Table 8. Comparison of brown trout age and growth determinations for Montana (number of specimens in parenthesis).

Location	Year	I	II	III	IV	V	VI	VII	VIII
Willow Creek Res.	1960	3.38 (140)	8.29 (125)	12.99 (113)	15.69 (91)	17.29 (35)	19.13 (9)	22.90 (3)	24.40 (1)
Canyon Ferry Res.	1959	4.2 (67)	10.4 (67)	14.3 (35)	17.2 (34)	20.7 (9)	23.6 (3)		
Prickley Pear Cr.	1955	3.8 (908)	7.7 (375)	11.1 (229)	13.7 (80)	16.5 (19)	20.2 (5)	22.2 (1)	
Missouri River	1950	3.9 (127)	8.1 (103)	12.0 (71)	15.3 (47)	18.2 (19)	20.0 (5)	21.7 (3)	22.2 (2)

Gill Netting Results

Three gill net series, consisting of 20 overnight sets each, were made in Willow Creek Reservoir in 1960. One series was conducted in June (7-12), one in July (19-22), and one in September (13-14). Nets used were 125 feet long and 6 feet deep with graded mesh sizes ranging from 3/4- to 2-inch (bar measure). Twenty netting stations were established (Figure 1).

June Series. The water in the reservoir was at maximum level and all

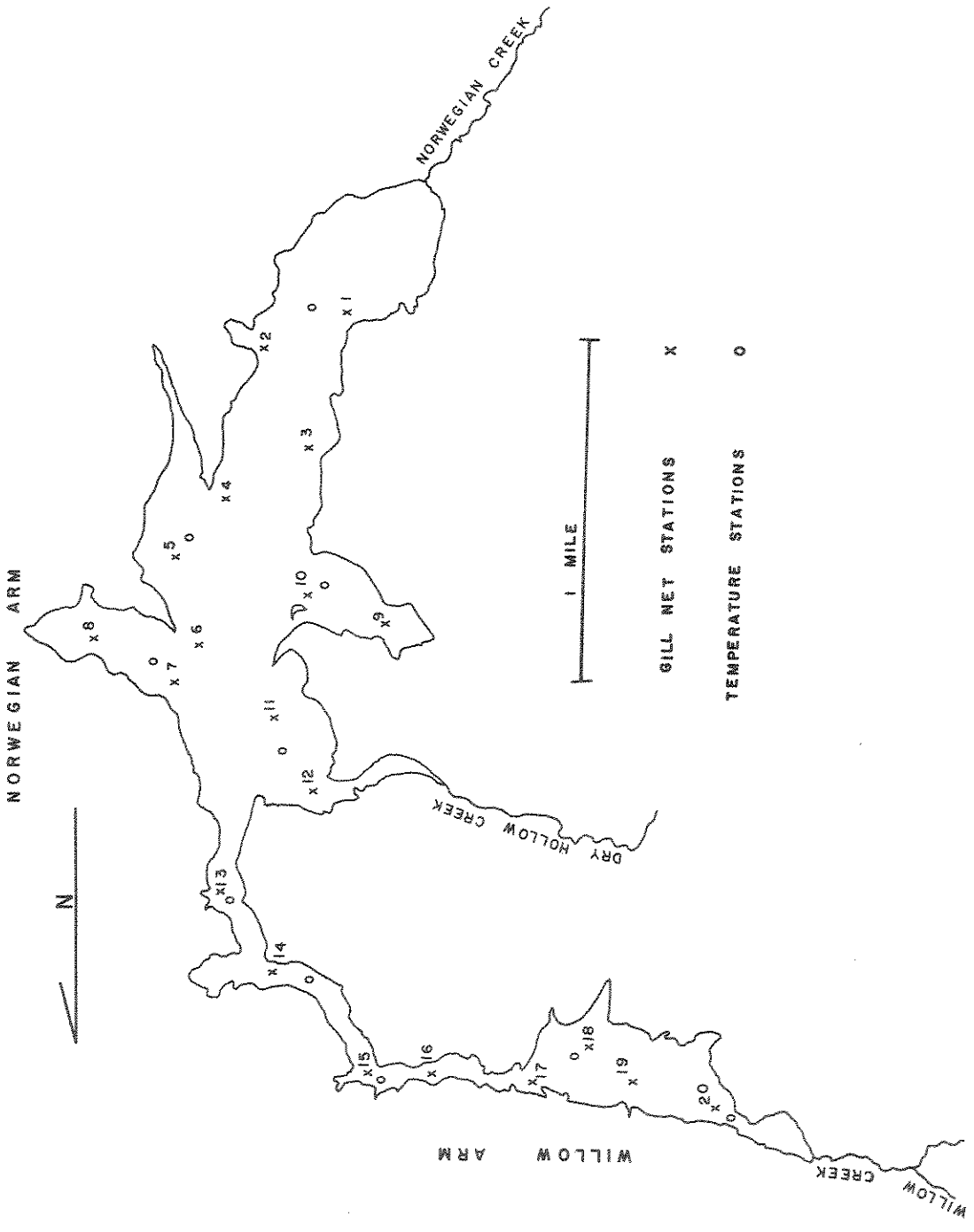

Figure 1. Willow Creek Reservoir showing netting and temperature stations.

nets were set on the bottom at depths varying from 10 to 50 feet. The following fish were taken: 118 brown trout, 48 rainbow trout, 2 brook trout, 2 mountain whitefish and 1595 white and longnose suckers (Table 9).

Table 9. Fish taken in the June gill net series, Willow Creek Reservoir, 1960.

Set number	Rainbow trout	Brown trout	Brook trout	White-fish	Suckers	Maximum depth in feet
1	1	3	-	-	89	15
2	4	7	-	-	96	15
3	4	7	-	-	76	20
4	4	3	-	-	96	20
5	1	6	-	-	71	20
6	7	1	-	-	185	20
7	-	3	1	-	86	20
8	2	1	-	-	84	25
9	2	1	-	-	132	15
10	1	-	-	-	128	25
11	-	3	-	-	48	20
12	-	4	-	-	98	15
13	-	10	-	-	50	50
14	1	9	1	-	50	50
15	1	-	-	-	21	45
16	3	24	-	-	41	30
17	3	19	-	1	44	30
18	3	6	-	1	31	20
19	7	8	-	-	86	15
20	4	3	-	-	83	10
Totals	48	118	2	2	1595	

Brown trout were taken in all areas of the reservoir, but were more abundant at depths below 30 feet, where 25 percent of the nets captured 52 percent of this species. Rainbow trout were taken in most areas of the reservoir and showed no marked concentrations. Suckers outnumbered all other fish in all sets regardless of location.

July Series. The water level in the reservoir was six feet below the spillway. Nets at 10 stations were set on the bottom while the other 10

were set at the surface. The following fish were taken: 227 rainbow trout, 46 brown trout, 4 brook trout, and 1237 suckers (Table 10). The 10 bottom

Table 10. Fish taken in the July gill net series, Willow Creek Reservoir, 1960.

Set number	Set type	Rainbow trout	Brown trout	Brook trout	Suckers	Station depth in feet
3	Surface	13	-	-	84	15
4	"	4	-	-	10	15
6	"	23	-	-	70	20
8	"	4	-	-	8	20
10	"	4	-	-	3	20
11	"	24	-	-	2	15
13	"	4	-	-	4	40
15	"	38	7	-	7	40
18	"	1	-	-	2	15
19	"	11	-	-	42	10
Total	Surface	126	7	-	232	
1	Bottom	4	-	-	116	7
2	"	2	-	-	86	7
5	"	19	2	-	82	15
7	"	11	-	-	114	10
9	"	24	2	1	104	10
12	"	7	-	-	89	10
14	"	6	16	-	27	50
16	"	4	4	-	75	25
17	"	10	11	-	91	25
20	"	14	4	3	221	8
Total	Bottom	101	39	4	1005	
Grand Total		227	46	4	1237	

sets captured 101 rainbow trout, 39 brown trout, 4 brook trout, and 1005 suckers, while the surface sets took 126 rainbow trout, 7 brown trout, and 232 suckers. Rainbow trout were taken throughout the reservoir with the surface sets capturing 56 percent. Only 15 percent of the brown trout were taken in surface sets, and all of these were in the same net (set 15) which floated over 40 feet of water. In the bottom sets, 30 percent of the nets

took 79 percent of the brown trout. These nets were set at depths below 24 feet. The 10 bottom sets captured 81 percent of the suckers taken in this series.

September Series. The water was at minimum level; 15 feet below the spillway. Only 10 of the original stations were suitable for gill netting and one net was set at the surface and one on the bottom at each of these. The following fish were taken: 334 rainbow trout, 101 brown trout, and 1742 suckers (table 11). The bottom sets captured 70 rainbow trout, 69

Table 11. Fish taken in the September gill net series, Willow Creek Reservoir, 1960.

Set number	Set type	Rainbow trout	Brown trout	Suckers	Station depth in feet
4	Surface	35	-	88	15
8	"	33	3	168	15
10	"	50	2	65	15
11	"	29	-	72	24
13	"	26	1	31	42
14	"	-	1	14	42
15	"	16	1	25	40
16	"	8	13	94	25
17	"	33	5	52	25
19	"	34	6	68	20
Total	Surface	264	32	677	
4	Bottom	13	1	133	15
8	"	14	1	189	15
10	"	4	5	154	15
11	"	8	9	107	24
13	"	5	14	60	42
14	"	-	5	18	42
15	"	1	7	45	40
16	"	3	12	176	25
17	"	15	2	94	25
19	"	7	13	89	20
Total	Bottom	70	69	1065	
Grand Total		334	101	1742	

brown trout, and 1065 suckers, while the surface sets took 264 rainbow trout, 32 brown trout, and 677 suckers. Although rainbow trout were taken in all depths and areas of the reservoir 79 percent of them were captured in surface sets. Brown trout were also taken throughout the reservoir, but 68 percent of them were captured in bottom sets. The bottom sets took 61 percent of the suckers in this series.

Fish Distribution in Relation to Temperature and Water Levels. Some observations were made on temperature fluctuations and water levels. Temperatures were secured with a resistance thermometer at 10 stations in the reservoir (Figure 1). Readings were taken at three-foot intervals from surface to bottom (Table 12). Water level data were secured from the Montana State Water Board.

During the June gill net series, water levels were maximum. Surface temperatures ranged from 63.0° to 64.0° F., with an average of 63.7°. Bottom temperatures ranged from 54.0° at 60 feet to 60.5° F. at 15 feet, with an average of 56.4°. Brown trout were distributed over the entire bottom of the reservoir, appearing in 90 percent of the nets. This species was more abundant at depths below 30 feet, however there was no apparent relationship between brown trout distribution and water temperatures. Rainbow trout were not abundant but were widely distributed, appearing in 80 percent of the nets.

During the July gill net series water levels were down six feet. Surface temperatures ranged from 75.0° to 78.0° F., with an average of 76.3°. Bottom temperatures ranged from 63.0° at 54 feet to 74.5° F. at 3 feet,

Table 12. Water temperatures in Willow Creek Reservoir, 1960.

Depth in feet	Average temperatures in degrees Fahrenheit for all stations		
	Date		
	June 14	July 22	September 12
Surface	63.7	76.3	63.7
3	63.5	74.1	61.1
6	62.3	72.9	60.1
9	61.7	71.7	59.4
12	62.0	70.6	59.3
15	61.3	69.6	59.0
18	59.9	69.9	58.9
21	59.4	68.3	59.0
24	58.2	67.4	59.0
27	57.1	66.9	59.0
30	56.5	65.7	59.0
33	55.5	65.0	59.0
36	55.0	65.0	59.0
39	55.0	64.7	58.3
42	55.0	64.3	58.3
45	54.6	64.2	58.3
48	54.3	63.8	
51	54.3	63.7	
54	54.3	63.3	
57	54.3		
60	54.3		

with an average of 68.1°. Brown trout were taken in only 35 percent of the nets. Bottom sets captured 85 percent of the brown trout taken in this series. They were particularly abundant in nets set at depths below 24 feet, where water temperatures averaged less than 68° F. Rainbow trout appeared in all nets with surface sets capturing 56 percent of the total.

During the September gill net series water levels were at a minimum (-15 feet). Surface temperatures ranged from 62.5° to 65.5° F., with an average of 64.0°. Bottom temperatures ranged from 58.0° at 45 feet to 60.0° F. at 3 feet, with an average of 58.9°. Brown trout appeared in 90 percent of the nets. They were taken most frequently in bottom sets where

68 percent was captured. There were no concentrations that could be attributed to temperatures. Rainbow trout also appeared in 90 percent of the nets, 79 percent being taken in surface sets. Suckers showed wider dispersion in September than in July.

While water levels dropped progressively from June through September, no relationship was observed between declining water levels and fish distribution, other than a general overall restriction.

Species Composition. The gill nets took a total of 5,456 fish. The most abundant fishes were the suckers, which constituted 4,574 individuals comprising 83.83 percent of the total. Of the remaining 882 fish: rainbow trout made up 69.05 percent (609 individuals), brown trout 30.04 percent (265 individuals), brook trout 0.68 percent (6 individuals) and mountain whitefish 0.23 percent (2 individuals). Of all the rainbow trout taken, 488 or 80.1 percent had deformed fins and were presumed to be hatchery fish of the 1959 and 1960 plants.

Length-Frequencies of Rainbow and Brown Trout. A length-frequency distribution was plotted for rainbow trout taken in the three gill net series (Figure 2). The 11-inch group was dominant, having 132 individuals. This group was followed by the 13-inch group with 117 individuals, and the 14-inch group with 113 individuals. Rainbow trout taken by anglers showed the 13-inch group to be the most numerous with 619 individuals. The 14-inch group was next with 454 specimens, followed by the 10-inch group with 206 individuals.

A length-frequency distribution was plotted for brown trout taken in the three gill net series (Figure 3). The 16-inch group was dominant,

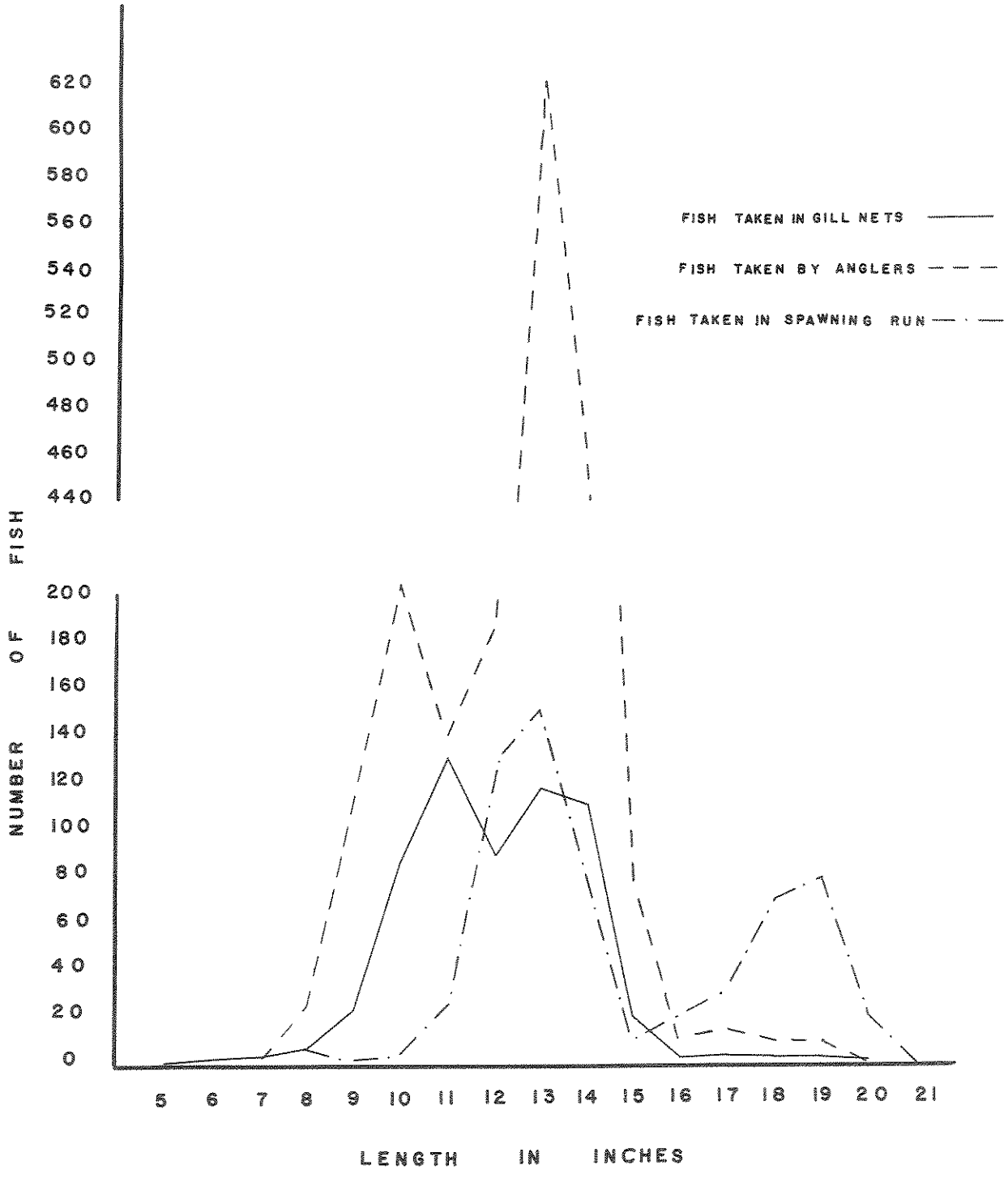

Figure 2. Length-frequency distribution of rainbow trout in the spawning, run, gill nets and creel, 1960.

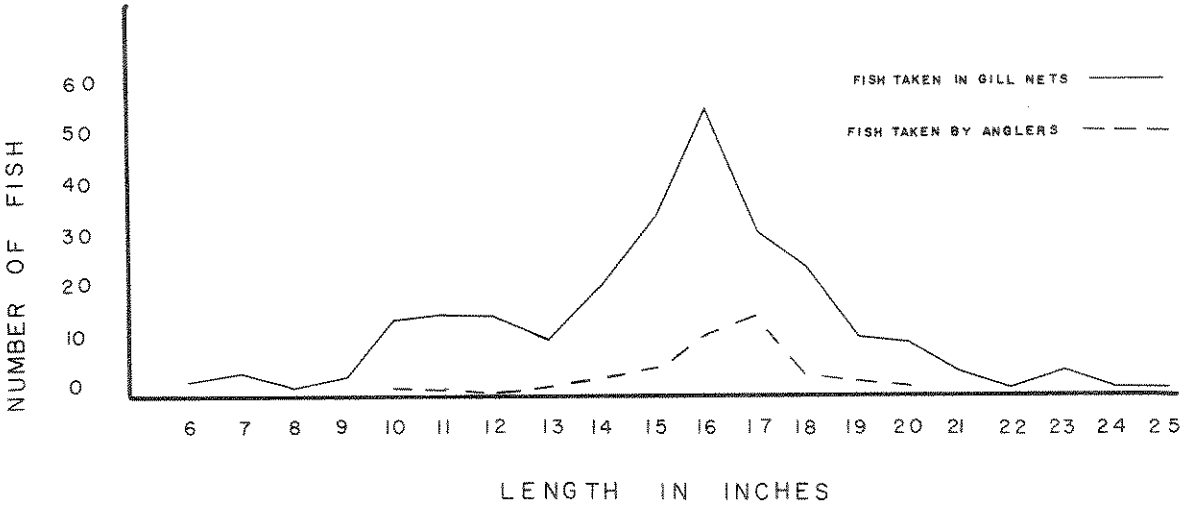

Figure 3. Length frequency distribution of brown trout in the gillnets and creel, 1960.

having 56 individuals. This group was followed by the 15-inch group with 34 individuals, and 17-inch group with 32 individuals. Brown trout taken by anglers showed the 17-inch group to be dominant with 15 specimens. This was followed by the 16-inch group with 12 individuals and 15-inch group with 6 individuals.

Harvest

Willow Creek Reservoir was open to angling from May 22 through July 15, 1960. Angling was permitted only in that portion of Willow Creek Reservoir known as Norwegian Arm (Figure 2). An attempt was made to con-

tact one-half of the anglers, and inventory their catch. Anglers were interviewed at a checking station located on the only access road. The following information was taken from each fishing party; number of fishermen, number of hours fished, number of fish taken, and method of fishing (from a boat or from shore).

The sampling period was divided into three strata: stratum I opening day; stratum II, weekend days and holidays; and stratum III, weekdays. An actual count was obtained for the first stratum. In stratum II one-half of the Saturdays, one-half of the Sundays, and one of the two holidays were censused. In stratum III one-half of the Mondays, Tuesdays, Wednesdays, Thursdays, and Fridays were censused.

Fishing Success. An estimate of total catch was made from the census data. Estimated total catch with 90 percent confidence limits for strata II and III were determined to supplement the actual count of stratum I. The method outlined by Cochran (1953, pp. 72-73) was used to make this estimate and obtain confidence limits. The above estimate was combined with the total number of fish inventoried in stratum I for the estimated total catch (Table 13).

Table 13. Estimated number of fish taken by anglers from Willow Creek Reservoir, 1960.

Strata	Lower confidence limit	Estimate	Upper confidence limit
I	1,854	1,854	1,854
II and III	9,377	13,014	16,651
Total	11,231	14,868	18,505

A total of 2,076 anglers was interviewed, and 1,725 of these fished from boats while 351 fished from shore. The boat fishermen caught 7,436 fish for an average of 4.31 fish per fisherman, at the rate of 0.850 fish per hour, while the shore fishermen took 937 fish for an average of 2.67 fish per fisherman at the rate of 0.455 fish per hour. Boat and shore fishermen combined took an average of 4.03 fish per fisherman, at the rate of 0.775 fish per hour.

Composition of the Catch. Of the total fish taken by anglers from Willow Creek Reservoir, 1,941 were examined. Fish were identified, measured and fin condition noted. There were 1,888 rainbow trout (97.27 percent), 48 brown trout (2.47 percent), and 5 brook trout (0.26 percent) in the catch. Rainbow trout averaged 12.96 inches in total length, brown trout 16.73 inches, and brook trout 9.88 inches. Fish with deformed fins made up 71.4 percent of the rainbow trout examined in the creel census.

Marked Fish Recovery

A total of 3,210 fish was marked either by fin clipping or jaw tagging to obtain information on distribution and movement of fish in the spawning runs, and on those planted in 1960. Of these, 2,500 were from a hatchery and 710 were captured in the tributaries. Marked fish were recovered by angling, gill netting and electrofishing. Recovery of fin-clipped fish from angler catches was practically nil, as all fish were cleaned and fins were often lost prior to examination.

Recovery of Fish Marked in Norwegian Creek. A total of 339 fish was captured, marked and released in Norwegian Creek between March 30 and May 7.

These included 331 rainbow trout (71 with jaw tags), 5 brook trout, and 3 brown trout. Only 11 rainbow trout were recovered. Seven of these were tagged fish taken by anglers; six in the reservoir and one about two miles above the reservoir in Norwegian Creek. Four of the 11 were fin-clip recoveries. Two of these fin-clipped fish were taken by anglers and one by a gill net (station 1) in the reservoir. The other was captured in Willow Creek on June 2, by electrofishing.

Recovery of Fish Marked in Willow Creek. A total of 249 fish was captured, marked and released in Willow Creek between April 13 and May 11. These included 166 rainbow trout (17 with jaw tags), 82 brown trout (11 with jaw tags) and 1 brook trout. Fourteen of these were recovered; five were tagged and nine were clipped. Four of the tagged fish were rainbow trout taken by anglers in the reservoir and one was a brown trout taken by an angler approximately 1½ miles above the reservoir in North Willow Creek. Eight fin-clipped rainbow trout and one brown trout were recovered. Of the rainbow trout, one was taken by angling, and six were caught in gill nets (stations 5, 7, 14, 15, 16, and 20) in the reservoir. One was captured (June 2) by electro-fishing in Willow Creek. The single brown trout was taken by electrofishing (October 21) in the same creek.

Recovery of Fish Marked in Dry Hollow Creek. A total of 122 fish was captured, marked, and released in Dry Hollow Creek between April 1 and May 7. These included 102 rainbow trout (38 with jaw tags), 10 brown trout and 10 brook trout. Only six recoveries were made and all were taken in the reservoir. Three tagged rainbow trout were taken by anglers. One fin-

clipped fish was recovered by an angler and two were taken gill netting (station 9).

Recovery of Marked Hatchery Fish. On May 16, 2,500 fin-clipped (6-9 inch) rainbow trout were planted in Willow Arm of Willow Creek Reservoir. Only 23 of these were recovered. Two were taken by electrofishing in Willow Creek; one on October 21 and one on October 24. The remaining 21 fish were taken by gill netting in the reservoir. The number taken at each station were as follows: 1 fish at station 4, 2 at 8, 1 at 9, 2 at 10, 4 at 11, 1 at 13, 1 at 14, 1 at 15, 4 at 17, 1 at 18, and 3 at 19.

Only 31 of the 710 fish that were marked in the tributaries during the spawning season were recovered. These were widely distributed in the reservoir. One individual fin-clipped in Norwegian Creek sometime between March 30 and May 7, was taken by electrofishing in Willow Creek on June 2. This fish traveled approximately $4\frac{1}{2}$ miles which was the greatest distance recorded for any fish.

All marked hatchery fish were planted in Willow Arm of the reservoir near the inlet. Two of the recoveries were made in Willow Creek, 10 in Willow Arm, and 11 in Norwegian Arm.

Summary

1. Observations were made on the spawning, growth, distribution, movement, and harvest of trout in Willow Creek Reservoir from March 27, through November 5, 1960.

2. The only successful reproduction was observed in Willow Creek. Average size of rainbow trout taken in the spawning trap on Willow Creek

has declined from 20.42 inches total length and 3.08 pounds in 1954, to 16.19 inches total length and 1.38 pounds in 1960.

3. Of rainbow trout observed in spawning runs, 32 percent were identified as fish planted in 1959 or 1960.
4. Growth rate of rainbow trout was less in 1960 than in previous years (1949, 1954, and 1955).
5. Distribution of trout in the reservoir appeared to be correlated with water temperatures. Rainbow trout were most evenly distributed in the reservoir when water temperatures were warmest, but were concentrated near the surface when water temperatures were cool.
6. Brown trout were most restricted at maximum water temperatures, and were most abundant near the bottom in all gill net series.
7. The game fish caught by gill nets included, 69.05 percent rainbow trout, 30.04 percent brown trout, 0.68 percent brook trout, and 0.23 percent mountain whitefish.
8. A total of 80.1 percent of rainbow trout taken in gill nets was believed to be fish planted in 1959 and 1960.
9. Anglers took an estimated 14, 868 fish from Willow Creek Reservoir during the six week fishing season in 1960, with an average of 4.03 fish per fisherman at a rate of 0.775 fish per hour.
10. The anglers' catch was composed of 97.27 percent rainbow trout, 2.47 percent brown trout and 0.26 percent brook trout.
11. Of rainbow trout taken by anglers, 71.4 percent were identified as fish planted in 1959 and 1960.

12. Thirty-one of 710 fish marked in the tributaries were recovered and found to be widely distributed in the reservoir and tributaries.

13. Marked hatchery fish planted in Willow Arm were also widely distributed being recovered in both arms of the reservoir and in Willow Creek.

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