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Abundance, Movements, Harvest, and Survival of Brown Trout and Mountain Whitefish in a Section of Logan River, Utah

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ABUNDANCE, MOVEMENTS, HARVEST, AND SURVIVAL OF BROWN TROUT AND MOUNTAIN WHITEFISH IN A SECTION OF LOGAN RIVER, UTAH

by

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David Wilder Bridges

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INTRODUCTION

Comprehensive population studies in the field of fisheries are in great demand. Many of our fishable waters are being changed, and we need to be able to predict the results of these habitat alterations. We must know how to include beneficial modifications in readjustments of habitat in order to create a fishery or prevent destruction of an existing one.

The acceptable situations for good fish production in large mountain streams are not well-known. A fishery can be properly managed only if the manager has sufficient knowledge of the carrying capacity of the habitat, the survival and mortality of the population, and the movements of the fish within the population. My study is an attempt to answer some of these questions about the self-sustaining populations of brown trout (*Salmo trutta fario* Linnaeus) and mountain whitefish (*Prosopium williamsoni* Girard) in a 5-mile section of Logan River, Utah.

REVIEW OF LITERATURE

Logan River

Clark (1958) found in studying the planktors of Logan River that most of the biota taken in drift nets in the river were fragmented or dislocated periphyton. No planktors existed. McConnell (1958), by extracting the chlorophyll from periphytic communities, estimated the average quantity of chlorophyll per M^2 of bottom of the canyon section of the Logan River at 0.30 grams.

Thoreson (1949), Pechecek (1950), and Regenthal (1952a) all studied the trout stocking program and creel censusing techniques in Logan River. Regenthal (1952b) summarized and analyzed all of the information that had been gathered on the Logan River between 1948 and 1950. Perhaps the most significant finding was that about 80 percent of the stocked rainbow were caught the same season that they were stocked. Sigler (1951a,b) did an age and growth study on brown trout and a life history study of the mountain whitefish in the Logan River.

Sampling

Shetter and Hazzard (1938) in studying stream fish populations in Michigan concluded that blocking and seining small sections of a stream repeatedly and using this information for an estimate of the total population was not accurate. Total actual fish populations in identical sections varied from month to month.

Cleary and Greenbank (1954) in analyzing stream fish studying techniques stated that no set method by which one may sample a stream population exists. Until new techniques are worked out and the inefficiencies removed from the known techniques, reasonably accurate trends in river populations can be obtained if studies are continuous so that annual data can be compared. Of the present methods available poisoning and electrofishing are about equal in efficiency, but electrofishing can be made much more pliable to fit many situations where poisoning would be impossible.

Using a power supply of 110-220 volts, 60-cycle, alternating-current in a section of Crystal Creek, New York, which was 20-30 feet wide, 15 inches deep, and had a flow of 40 c.f.s., Haskell (1939) obtained an 83.5 percent recapture in a mark and recovery experiment.

Pratt (1951) measured the efficiency of sampling brook and brown trout with alternating and direct-current. He used a 110 volt, 60-cycle power supply in the alternating current test and a 230 volt, 2500 watt power supply for the direct-current. He used a ground return arrangement with a copper plate for the negative electrode when testing the direct-current apparatus. He achieved an average in percentage recovery of 50.2 using the direct current and 31.85 using alternating current.

Pratt (1955) tested the mortality caused by alternating-current and direct-current with brown, brook, and rainbow trout. By combining brown, brook, and rainbow trout he determined that 110 volts of alternating-current killed 11.1 percent of the fish, while 230 volts of direct-current killed 2.0 percent of the fish. He found no relationship between size of fish or species of trout tested and mortality.

Marking

Heacox (1942) clipped fins from brown trout and checked the amount of regeneration which occurred over a 3-month period. He found that 0.2 percent of the paired fins grew back to normal length.

Eschmeyer (1959) investigated the effects of tagging on lake trout (Salvelinus namaycusch). He found by testing groups of 100 lake trout 8.5 inches total length that after a year 85 cheek tags remained, 86 Petersen tags remained, 91 monel metal strap tags on the lower jaw remained, and 25 adipose fin clips remained. Growth decreased 25 percent with the first three types of tags but did not decrease with the adipose fin clip.

Population Estimation

Cooper and Lagler (1956) tested the various common methods of estimating fish populations by using marked and unmarked beans as fish in a minnow bucket as a lake. The DeLury, Petersen, Schnabel, and Schumacher-Eschmeyer methods were tested; and it was found that the Petersen estimate gave the least reliable estimate. The estimate becomes much better when the empirical data are grouped according to length of fish. Data from Cooper (1952) were used to exemplify this point. When all fish were grouped together (lengths 2.0-12.9 inches), the population estimate was an underestimate of 30.2 percent. Sullivan (1956) also emphasizes the importance of grouping the fish by size when making population estimates especially if the population was sampled with electrofishing equipment which is selective for larger fish.

Brown Trout

Age and growth

Zarneki (1958) measured certain parameters about the spawning population of brown trout in the Silesian Vistula. He discovered that 89.3 percent of the 272 fish studied had already formed their winter rings by October. Of those participating in spawning 1 percent were 2 years old, 63 percent were 3 years old, 32 percent were 4 years old, and 2.5 percent were 5 years old. The oldest fish found was 8 years old. The length of the fish after completing 1 year of life was 9.4 cm., after 2 years it was 17.2 cm., after 3 years it was 23.2 cm., and after 4 years it was 27.5 cm.

Schuck (1943) reported age and growth figures for the brown trout population in Crystal Creek, New York. Fingerlings in fast water were significantly longer than those in slow water (3.24 inches and 2.92 inches respectively). The length obtained by September for the various ages is as follows: 0 age group, 3.09; I age group, 5.69; II age group, 7.56; III age group, 10.15; IV age group, 11.65; V age group, 14.02 inches.

In comparing six Eastern streams, McFadden and Cooper (1962) computed the instantaneous growth rates of brown trout in each stream. Correlation with significance at the .05 level of probability between water conductivity (as a measure of fertility) and instantaneous growth rates was high.

Purkett (1950) reported on the growth and condition (C) of rainbow and cutthroat trout in relation to elevation and temperature in the West Gallatin River and Bridger Creek. In the Gallatin River yearly length increments decreased as one proceeded upstream. A marked seasonal difference and wide daily fluctuations in water temperature existed in the West Gallatin River. The growth data from fish in Bridger Creek showed no consistent differences in length increments and no great temperature differences.

Steffan (1957) compared the growth of brown trout in boggy ponds against that in brooks and found that growth of young trout was greater in ponds, and growth of older trout was greater in streams. The reason given was that ephemeroptera, the preferred food for the larger fish, was lacking in the pond but was available in the streams.

Ball and Jones (1960) found in studying brown trout in Llyn Tegid that winter rings occurred in scales by September-October and that growth was confined to that period between February-March and September-October. There was an increase in growth rate when trout migrated from tributary streams into the lake. The mean specific growth rate in the lake and streams declined with age, and its negative acceleration decreased with age.

Sigler (1951b) found mean total lengths of 4.0, 6.9, 9.7, 12.1, 15.6, 18.3, 25.5, and 27.7 inches for brown trout in Logan River from ages I-VIII respectively.

Abundance

Cooper (1952) studied a 4.8-mile section of the Pigeon River, Michigan, in 1949 and 1950. He found that the brown trout gave a yield to fishermen of 8.2 and 10.6 fish 7 inches and larger per acre for the 2 years of the study. He determined the population in the study section in 1949 as follows: 1426.72 browns 2-4.9 inches, 175.93 trout 5-6 inches, and 573.58 trout 7 inches and above. In 1950 the population was as follows: 1556.86 trout from 2-4.9 inches, 310.89 browns 5-6 inches, and 667.57 browns 7 inches and above. He also found that brown trout less than 9 inches were rarely mature.

Schuck (1943) found in Crystal Creek, New York, that an estimated 1053 trout were in fast water in the stream as compared to 481 in slow water. Trout under 8.4 inches total length were more numerous in slow water. An average of 421 fingerlings, 106 yearlings, 48.6 two-year-olds, 31.1 three-year-olds, 11.2 four-year-olds, and 5.0 five-year-olds occurred per mile each year.

Needham, Moffett, and Slater (1945) reported fluctuations in the brown trout populations in two sections of Convict Creek, California. One section was fished, and one was closed to fishing. They found that trends in the two populations were parallel and apparently cyclic. The number and weight of fish at various times was highly unstable. Natural reproduction (recruitment at the lower end of the age scale) was variable, and the reason for a variable number of fish reaching catchable size was attributed to variable survival conditions rather than variable numbers of young produced. The fished section of the stream contained 3818 fish per mile, 83.3 lbs. per mile, or 68.7 lbs. per acre. The closed section contained 5438 fish per mile, 360.3 lbs. per mile, or 297.1 lbs. per acre of brown trout.

Burnet (1959) found evidence of 4-year cycles of abundance in two New Zealand streams. He attributed the cycle to increased survival of a brood due to lessened predation by older fish. The number of large fish reached a low point which permitted an increase in survival of small fish.

McFadden and Cooper (1962) compared the brown trout populations in six Eastern streams. Population estimates were from 1080 fish or 137 lbs. per acre to 104 fish or 13 lbs. per acre. The vicissitudes of the environment made the occurrence of a fish of age IV very rare. There was some difference in the year-class strength between 1958 and 1957.

Movement

Schuck (1943) showed that movement of brown trout from September to September was slight. Most fish ascended the stream in October and November but returned to their original locations.

Maciolek and Needham (1951) found that during the winter brown trout in Convict Creek were quite active, but they spent most of their time under shelf-ice and among willow roots and brush along the side of the stream. The trout would suddenly appear midstream when the sun took effect on the sub-surface ice. The trout were seen feeding at all water temperatures.

Cobb (1933) investigated the residency and migration of planted brook and brown trout by tagging the fish when they were released. Sixty-six and one-half percent of the brown trout and 79.7 percent of the brook trout remained in the same area where they had been planted. Six and nine-tenths percent of the brook trout were taken above the release section, and 6.8 percent of the browns were taken above the release section. Only 9.1 percent of the brook trout were taken downstream; whereas, 26.6 percent of the browns were taken below the release section. Four and one-tenth percent of the brook trout moved into tributaries, while only 0.1 percent of the browns did.

Needham and Cramer (1943) operated a two-way fish trap on Convict Creek for 2 years. During the week of May 11-18 of both years, a large downstream movement of brown trout about 6 inches long, or in their second year of growth, took place. The authors postulated that the rising water level may have had an effect on fish of this size in that the environment was rendered intolerable by it. Water level did not peak until June, however.

Ball and Jones (1962) found that mass movement of stream and lake brown trout was inferred by the construction of the scales. They found that 60 percent of the fish entered the lake from nursery tributary streams when they were 3-years-old, 20 percent entered when they were 2-years-old, and 20 percent entered when they were 1-year-old. Within an age group this lakeward migration appeared to be related to the attainment of a certain size. They found within the lake a summer movement of fish from shallow to deep water. Most fish left the littoral zone in April-June and returned in the winter beginning in September. The spawners ran to the tributaries in October and November.

<u>Survival</u>

Schuck (1943) studied the brown trout population in Crystal Creek for 4 years. The survival in percent of age group 0 trout in later years was 24.1 for age I, 11.0 for age II, 5.49 for age III, 1.25 for age IV, and 0.48 for age V. As the number of legal sized brown trout decreased, the catch per angler decreased.

Schuck and Kingsbury (1945) found that both survival and growth of hatchery brown trout raised under different hatchery conditions were better in fast water than in slow water of Crystal Creek, New York.

Needham, Moffett, and Slater (1945) found in Convict Creek that during the first 18 months of life, each yearly brood of brown trout decreased 85 percent. For all ages of fish the over-winter mortality was 60 percent. For fish under 4 inches in total length it was 80 percent, and for fish greater than 4 inches total length it was 62 percent.

Maciolek and Needham (1951) found that over-winter mortality in Convict Creek was 50 percent as indicated by recovery of marks in April

1951, which were put on in November 1950.

McFadden and Cooper (1962) in comparing six brown trout populations found that annual survival rates from ages I-IV figured by the weighted Jackson method were: Ceder River, .436; Spring Creek, .197; Spruce Creek, .337; Young Woman's Creek, .557; Kettle Creek, .189; and Shaver Creek, .433. They concluded that

> If the hypothesis of relatively constant recruitment in these populations is accepted, it appears that substantially smaller than expected broods (magnitude of one-third or less) occur in about 17 percent of cases.

Ball and Jones (1962) found that brown trout in the lake Llyn Tegid had an average annual survival rate over ages I to IV of 29 percent.

Whitefish

Rawson and Elsey (1948) computed age and growth figures on 51 Pyramid Lake, Alberta, mountain whitefish. In consecutive years from age I-X the total length attained by the fish was 2.5, 4.0, 6.0, 7.7, 9.3, 10.7, 12.1, 13.0, 14.0, 15.5 inches. Fish from age III-X attained weights of 1.0, 2.8, 5.0, 7.6, 11.0, 14.1, 19.0, 26.0 ounces.

Godfrey (1955) in studying the whitefishes in the Skeena River system found the mountain whitefish in all of the lakes and many of the rivers and streams sampled. He stated that they were the most abundant in eutrophic lakes which had large populations of bottom organisms. He found one specimen in each of two lakes which had completed 9 years of growth. They had attained fork lengths of 13.3 inches and 14.37 inches.

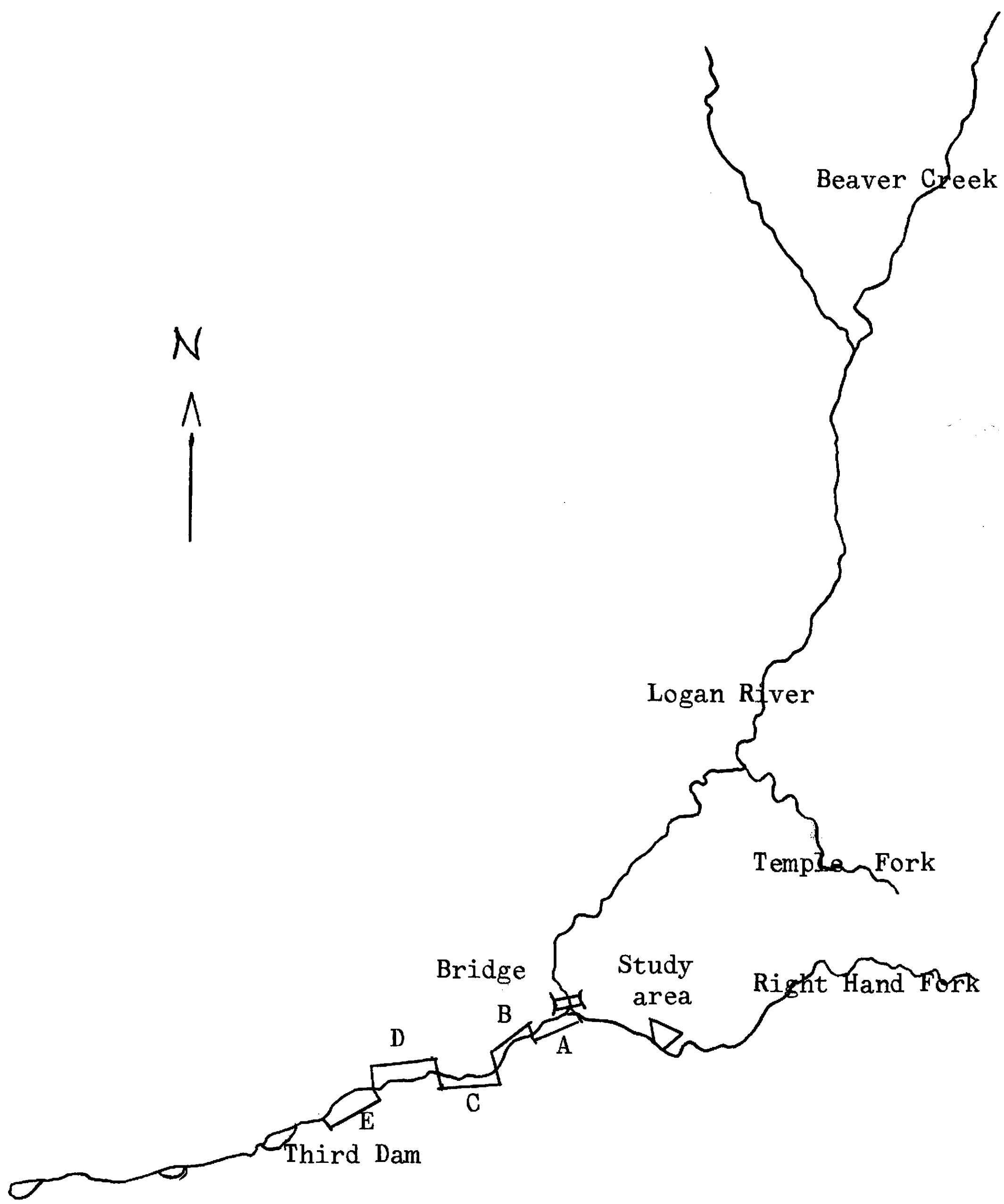
Sigler (1951a) determined that Logan River whitefish from age I-IX attained total lengths of 4.6, 8.1, 10.2, 11.6, 12.8, 14.1, 15.4, 16.4, 17.4 inches respectively. Seventy percent of the 3-year-old and 97 percent of the 4-year-old whitefish were mature.

DESCRIPTION OF THE AREA

The Logan River originates in the Bear River Mountains in the northeastern part of Cache County, Utah, and flows some 30 miles southwest down Logan Canyon to join the Bear River in Cache Valley, Utah. The Logan River is a swift, rather large mountain stream with violently fluctuating water flows dependent upon spring run-off. Brown (1935) said that prior to his study the minimum water flow recorded for the Logan River at the canyon mouth was 90 c.f.s. The first year of this study was very dry. The minimum mean monthly flow recorded for January 1962, was 74.5 c.f.s. with a minimum daily flow of 60 c.f.s. on December 11, 1961. The maximum daily flow of 390 c.f.s. occurred on May 28, 1961, as compared to the maximum of 1080 c.f.s. on May 9, 1962. The water temperature varies about 10 F per day the entire year. The yearly fluctuation is between 32 F and about 60 F. The highest temperature recorded during 1961 and 1962 in the river was 61 F during the period from June 1961, to October 1962. The gradient of the canyon portion of Logan River is as high as 200 feet per mile in the head waters and averages 40 feet per mile in the study area (Water Supply Paper 420, 1916).

Hatchery reared rainbows (*Salmo gairdneri irideus* Gibbons) are found the length of the river. Cutthroat trout (*Salmo clarki lewisi* (Girard)) are found primarily in the river above and including Temple Fork between elevations of 5900 feet and 8500 feet. At one time brook trout (*Salvelinus fontinalis* (Mitchill)) existed in Beaver Creek and the beaver ponds near Franklin Basin; however, they have not appeared in sampling collections in recent years. The mountain whitefish is found from the mouth of the river up to 7300 feet elevation (Regenthal, 1952a). Brown trout comprise the bulk of the trout population below and in Right Hand Fork and exist up to about the level of Temple Fork. The species overlap in distribution between 5400 and 6000 feet according to Regenthal (1952a); however, the overlap of cutthroats, browns, and whitefish occurs to the third dam at 5000 feet elevation.

This study was made on that portion of the river between Right Hand Fork and .5 miles above the third dam (Figure 1).



Scale: 1" = 2.3 miles

Figure 1. Map of Logan River and tributaries showing study areas and sections for 1961-1962 (taken from Regenthal, 1952a).

METHODS

Population Estimation

Capture techniques

During the period from April 17-22, 1961, the 5-mile section of Logan River from the east edge of DeWitt camp up to 0.1 mile above the mouth of Right Hand Fork was shocked, and each brown trout and whitefish was marked by removal of the adipose and right pelvic fins. A total of 405 brown trout and 517 whitefish was marked. Subsequent samples including, from three to ten 0.1 mile stations chosen at random, were taken in May, August, October, December, and January. The marking program was repeated in 1962 beginning on February 24 and ending on March 9. A total of 2301 brown trout and 2264 whitefish was marked. Subsequent samples were taken in March, May, August, September, October, November, and December. The total length and mark of each fish was recorded at each sampling station.

Formerly I had been using an Onan 300 volt, 27 amp. capacity, direct-current, generator. I changed the power supply to a 115 volt, 13.5 amp. capacity, 60-cycle, Homelite, portable, generator and ran the alternating-current through a half-wave rectifier and pulsator, so that I was using a pulsed direct-current. The duty cycle was .5; that is, the time that the current was on equaled the time the current was off each second. The number of pulses per second was 60.

Three methods of electrofishing were tried. In 1961 one positive electrode and one negative electrode were moved upstream at the same time. The negative electrode was a 36 inch by 12 inch electrical conduit oval with 1-inch square heavy wire gridwork inside the oval attached to a 5-foot, insulated, conduit handle. The positive electrode was an 18-inch, oval, metal conduit, dip net. One or two men netted fish at the positive electrode. The negative electrode was always upstream from the positive electrode; and a station, which was one-tenth of a mile, was worked moving upstream. This arrangement utilized the Onan 300 volt, 27 amp. capacity power supply.

The second arrangement utilized three positive electrodes, two oval grids with a dip net between them, moving downstream toward a stationary negative electrode, which was a woven wire fence across the width of the river tied to each bank and weighted on the bottom. The negative electrical field around the fence served as a block to fish which ran ahead of the positive electrodes. The fish appeared to have been turned back when they ran into the fringe of the negative field and swam in circles between the positive and negative poles. When the positive electrodes approached the negative, these fish were forced into either of the fields. The Onan generator supplied the power.

The third technique utilized the second electrode arrangement with pulsed direct-current.

The second electrode arrangement was the most satisfactory. The pulsed direct-current power supply, while it did work, still needed some improvement.

Sampling techniques

Estimates of the number of brown trout and whitefish in the study area were made by a mark and recapture technique. The Petersen single census method was used to calculate actual numbers.

One of the basic assumptions which must be made according to Ricker

(1958) is that the marked fish must be distributed randomly in the population so that there is an equal chance of capturing marked and unmarked individuals. In order that this be accomplished, fish were marked throughout the entire study area. The mark used in 1961 was the complete removal of the adipose and right pelvic fins. In 1962 the marking was done over again using a different fin-clip within each 1-mile section of river. Approximately 2 weeks after the marking was completed, the first sample of fish was taken for population estimation at the time of marking. Subsequent sampling between marking times was done to obtain survival information.

According to Cochran (1953), I could expect a coefficient of variation of 34 percent with a sample of 8 one-tenth mile stations. The number of brown trout per station increased downstream, so two stations were chosen at random from each 1-mile segment of the river to insure equal sampling. Because of an improvement in the efficiency of the sampling gear, the coefficient of variation decreased to 10 percent in August 1961. I felt that one station per mile of stream was sufficiently representative of the river, so our sampling was cut in half, and the resulting coefficient of variation was 34 percent in October 1961.

Since the Petersen method was used to estimate the population number, and since it is essentially a single census technique, any population estimate made subsequent to marking was an estimate of the population at the time of marking. I allowed for the growth of the fish. No fish which would have been smaller than the smallest marked fish was included in any sample after marking. The survival for the segment of the population which contained the marked individuals was determined by the number of fish surviving to successive ages (Robson and Chapman, 1961).

From the work of Schuck (1945) and Cooper and Lagler (1956), it became evident that a serious bias might occur if the population estimates were made over the entire population giving no compensation for the selection of larger fish by the sampling gear. Determination of the relative selectivity of the gear with respect to length of the fish became necessary. The percentage recapture by 1 inch length groups was used as a measure of gear selectivity.

By the preceding procedures fish were marked in April of 1961 and again in late February and early March of 1962. Population estimates of brown trout and whitefish were made at the first sampling after marking for the number of fish present at the time of marking.

Survival and Mortality

Annual survival estimation

The annual estimated survival of a portion of the population was estimated by the Robson and Chapman method (1961). This method is essentially comparing one age-class to another, but it includes a weighting technique which reduces the influence of weak or strong year-class strength on the annual survival rate.

Fishing mortality estimation

Fishing mortality was obtained in 1962 from creel census data on the study area. Methods of sampling and analysis were patterned after those set forth by Regenthal (1952b) and Neuhold and Lu (1957).

Age determination by length

In order to compute the annual survival rates, it was necessary to age the fish accurately according to length at various times of the year. The age and growth data of Sigler (1951a,b) were used to furnish the basic increments of growth in length. The age and growth for whitefish and brown trout was determined from a sample in the study area in January 1961. The data were practically identical to those of Sigler. The actual total length frequencies obtained during this study were used to formulate the ranges in length for the first 3 years in the brown trout. The length frequencies of the whitefish did not clearly indicate where the age groups existed in relation to length. Peaks occurred which represented frequency modes within ages, but the length groups were not apparent. Combining the actual length of the brown trout and the annual increment of growth as determined by Sigler (1951a), the maximum and minimum length for each age was extended according to the time of the year. The average monthly increment of growth was the adjustment for each length each month. A fish of the minimum length to be included in age class I in February 1961, would be of the minimum length of age class II by February 1962.

In some waters growth is the most rapid during the summer months (Beyerle and Cooper, 1960; Ball and Jones, 1960). I did not know what the growth pattern in length was for the trout or the whitefish in Logan River, so I did not make the growth differential according to season. I took an equal increment each month by dividing the average annual increment by 12 and added this increment to each maximum and minimum length for each age class each month of the year.

Movements

Gross patterns in the study area

Movements of the entire population of brown trout and whitefish in the study area of Logan River were determined by using a system of area marks when the 1962 marking was done. The study area was divided into five sections. Sections A, B, C, and D were each 10 one-tenth mile stations; and section E was 12 one-tenth mile stations. A different fin was clipped in each section. Field data sheets contained a column for each mark used. Gross movements could be determined from the periodic sampling.

Minute moves of brown trout in Right Hand Fork

The more minute movements of brown trout were investigated during the summer of 1962 on the Right Hand Fork of the Logan River. A 404-foot section of the stream about 2 miles above its mouth was selected for study. The section contained areas of dense bank cover, open pools, and a long area of very turbulent water. One hundred and five fish were marked in the area. A modified binary system of holes punched in the fins was used to mark each fish individually. The area was sampled three times during July and August and a final sample was taken in October to obtain the information necessary to determine the lesser movements of brown trout in the summer and fall before they were influenced by the effects of reproduction.

RESULTS

Abundance

The first sample after marking was used to obtain an estimate of the populations of brown trout and mountain whitefish. The Petersen single census technique (Ricker, 1958) was employed.

Since the type of sampling gear used was selective for larger fish, a corrective measure was applied to the recapture data. The sample was divided into 1 inch length groups, and the percentage recapture within each group was plotted. A straight line fit by least squares was applied to each scattergram (Figures 2-5), and the calculated percentage recapture for each length was used as a correction factor. Following the method of Cooper and Lagler (1956) and Schuck (1945), a Petersen estimate based on the corrected number of fish sampled was made for each 1 inch length group (Table 1 and Figures 6 and 7).

Recovery was different between the 2 years of the study. A greater percentage of the fish was marked in 1962 than in 1961.

Population estimates were quite similar between the two years for both species of fish. The estimates become practically identical beyond a total length of 13 inches for brown trout and 12 inches for whitefish.

Movement

Logan River

In 1962 the entire study area was divided into five 1-mile study sections and a different fin clip was used in each section. I was able

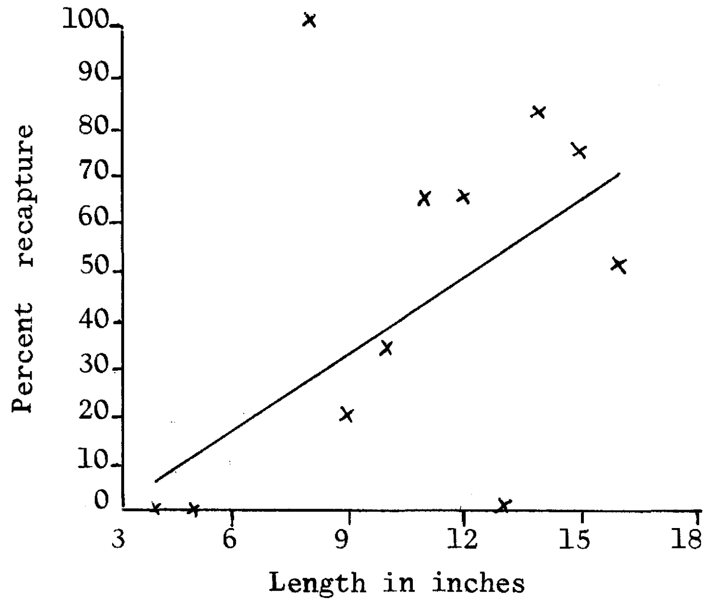


Figure 2. Relationship between the percent of recaptured tagged whitefish and each 1 inch length group for March 1962. Estimating equation: $\hat{y} = -7.15 + 4.88X$.

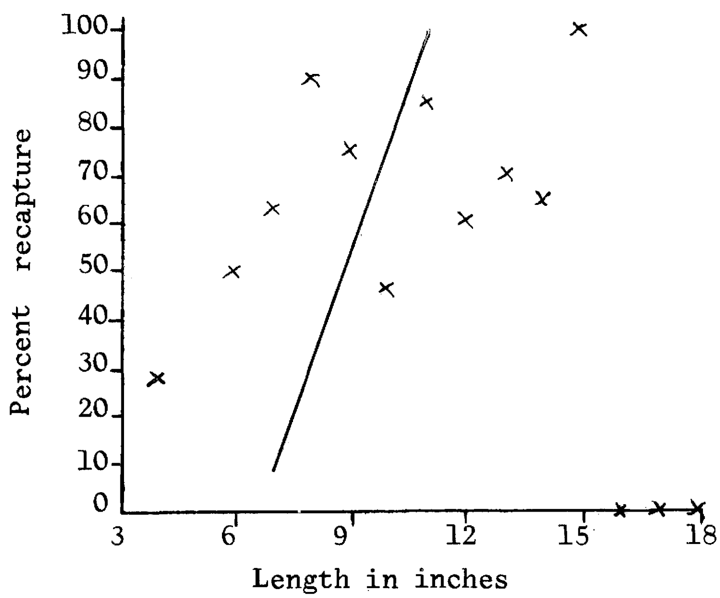


Figure 3. Relationship between the percent of recaptured tagged brown trout and each 1 inch length group for March 1962. Estimating equation: $\hat{y} = -.150.5 + 22.75X$.

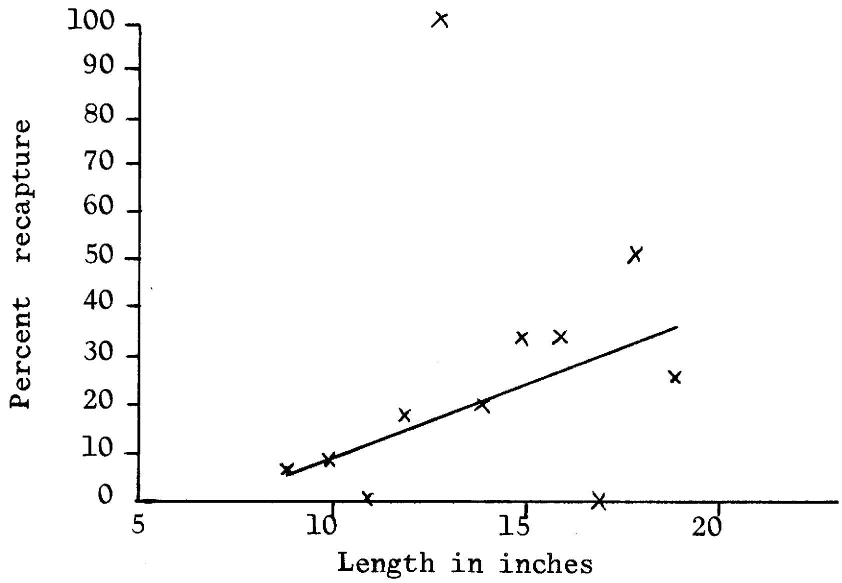


Figure 4. Relationship between the percent of recaptured tagged whitefish and each 1 inch length group for May 1961. Estimating equation: $\hat{y} = -22.8 + 3.1X$.

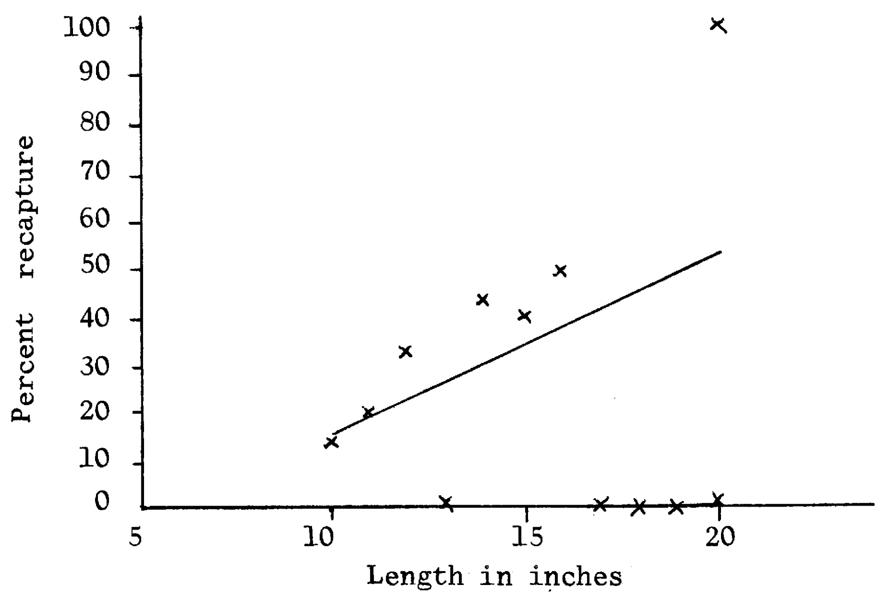


Figure 5. Relationship between the percent of recaptured tagged brown trout and each 1 inch length group for May 1961. Estimating equation: $\hat{y} = -25.05 + 4.10X$.

Table 1. Estimated number of whitefish and brown trout within each 1 inch length group

Inches	1961		1962	
	Whitefish	Brown trout	Whitefish	Brown trout
7				2019
8			100	485
9	1515		271	360
10	310	124	2339	320
11	41	108	1212	203
12	283	148	340	112
13	148	42	131	94
14	99	90	121	85
15	154	76	141	53
16	116	49	92	29
17	24	12	24	4
18	8	4	10	3
19	5	4	5	
20		3	0	
21			1	
22			1	
Totals	2703	658	4417	3731

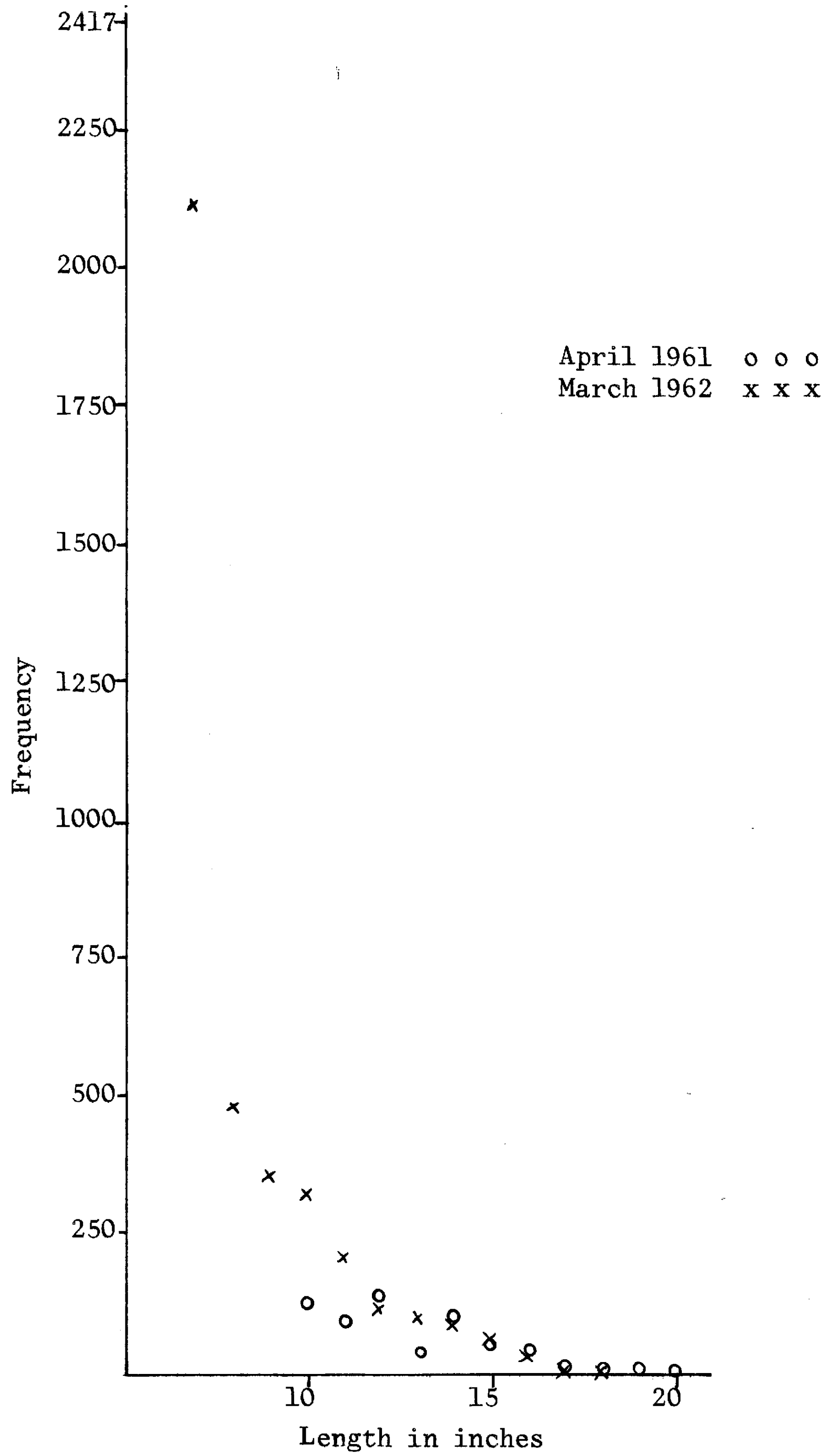


Figure 6. Frequency of brown trout at 1 inch length groups computed for April 1961, and March 1962.

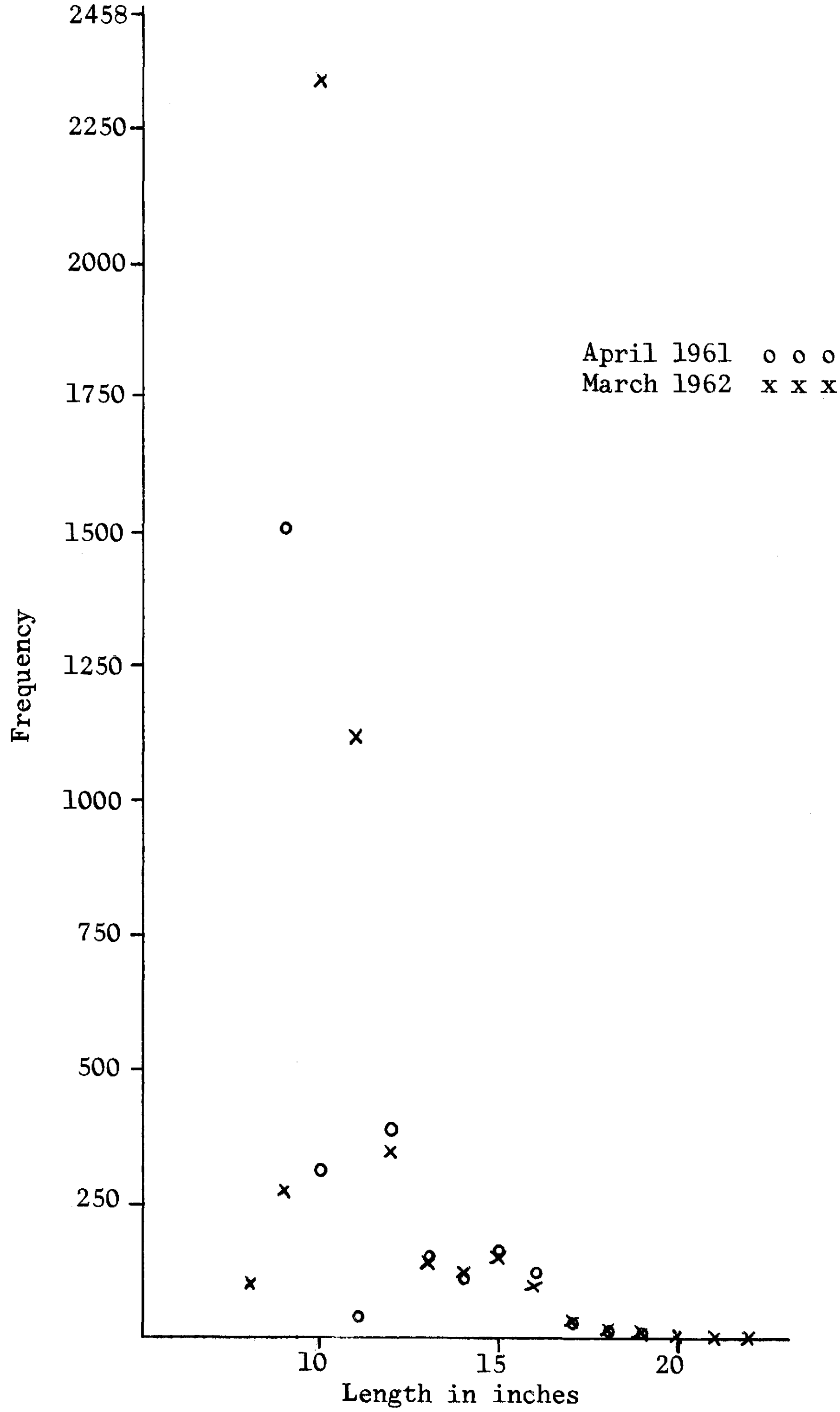


Figure 7. Frequency of whitefish at 1 inch length groups computed for April 1961, and March 1962.

to measure the gross movements of the whitefish and brown trout by subsequent sampling.

Five 0.1 mile stations were chosen at random selecting one station from each section of river for each sample. A sample of five stations was taken monthly from March through December, 1962, with the exception of April when no sample was taken. Four stations made up the sample in October. The extent of movement is presented in Figures 8-10.

The percentage of movement for brown trout regardless of direction (Figure 8) reached an immediate peak by October with no gradual increase and then declined until in December it was at the same level as in July. The percentage of nondirectional movement for whitefish (Figure 8) reached a peak in November with a more gradual increase exhibited in September and October.

The directional movement for brown trout is shown in Figure 9. Little difference appeared in the amount of upstream movement between months. A slight depression in upstream movement occurred in November and an increase occurred in December. Downstream movement appeared in only the two samples of October and November. The figure for October was quite high. In November downstream movement was little more than one-half of what it had been in October. The only outstanding difference in the distance that brown trout moved appeared in November when the mean distance per downstream move was seven times greater than the mean distance per upstream move.

The directional movement of whitefish is presented in Figure 10. Upstream movement varied between 3 and 14.5 percent of the marked fish in each sample. The greatest amount of upstream movement occurred in May and the least occurred in March. Downstream movement was almost the

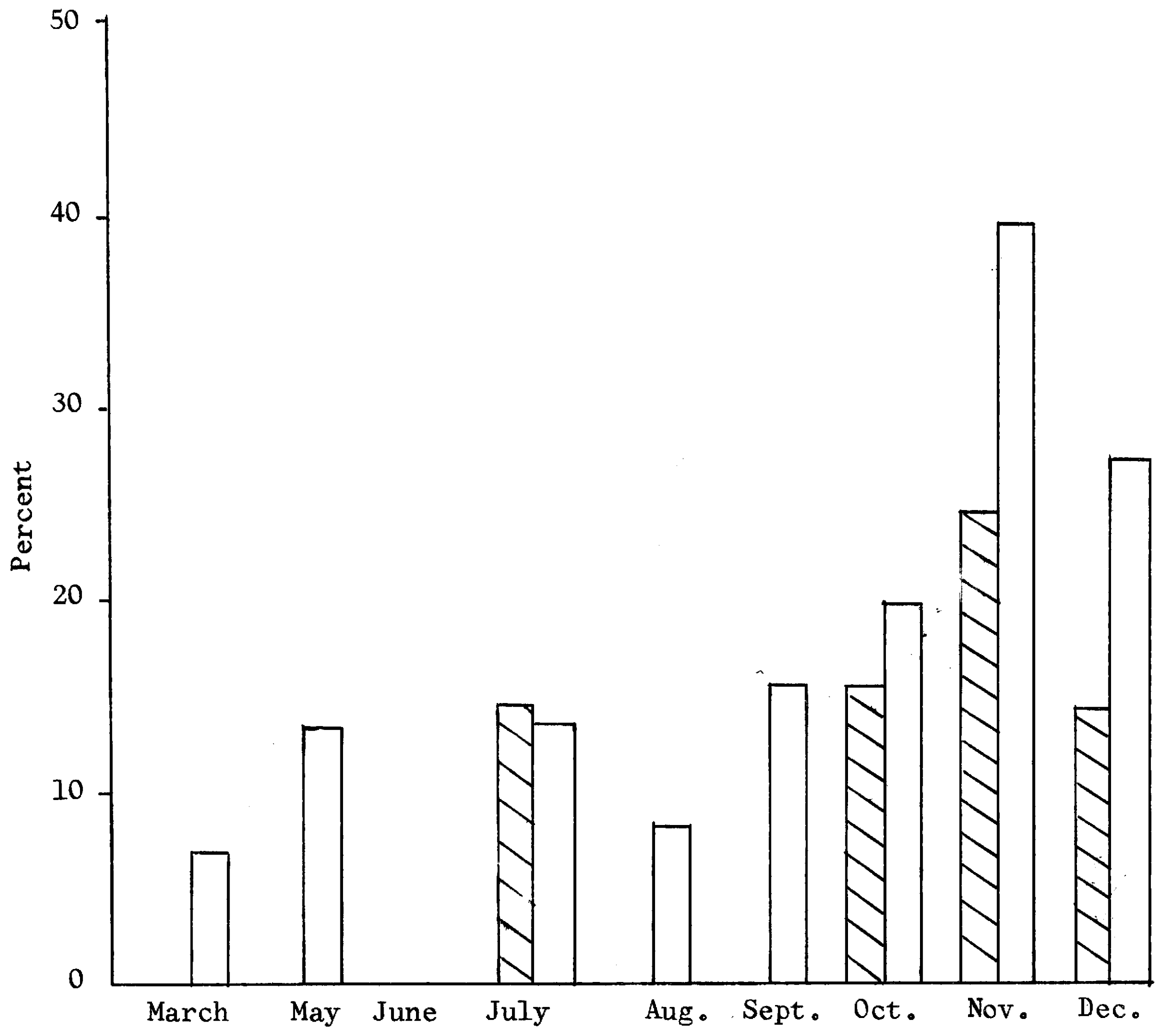


Figure 8. Percent of the sample of marked brown trout (hatched) and whitefish (open) which moved after being marked.

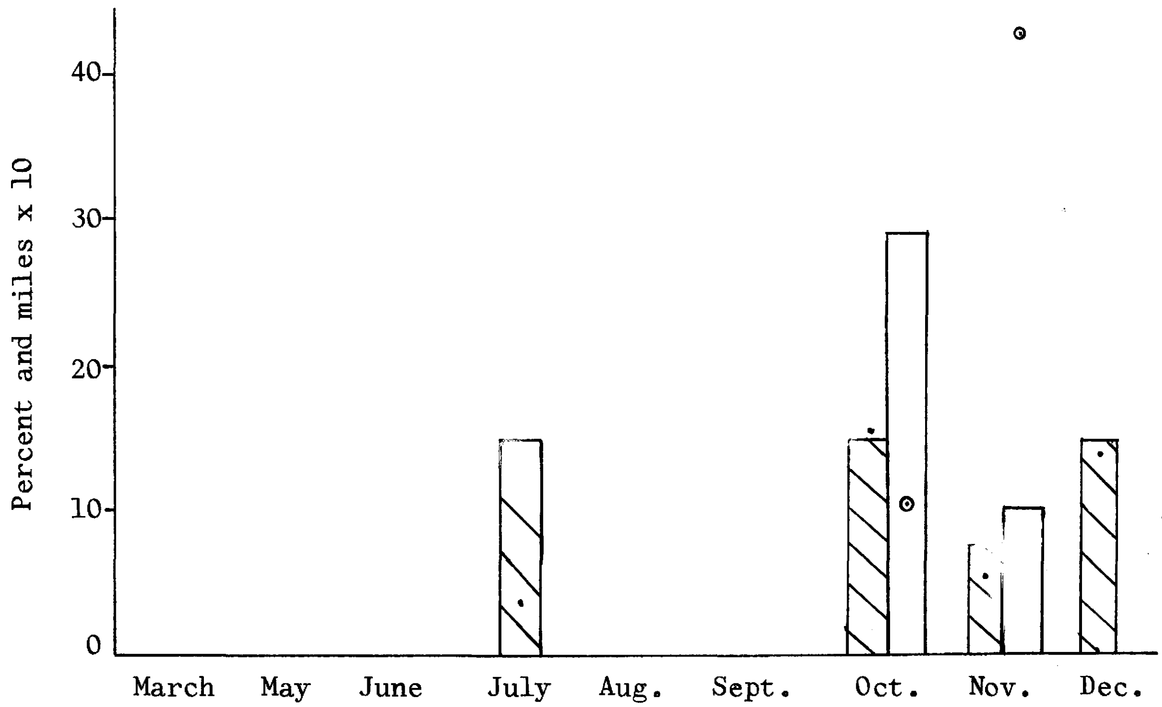


Figure 9. Percent of each sample of brown trout which moved upstream (hatched) or downstream (open) and the mean distance per move upstream (dot) or downstream (circled dot).

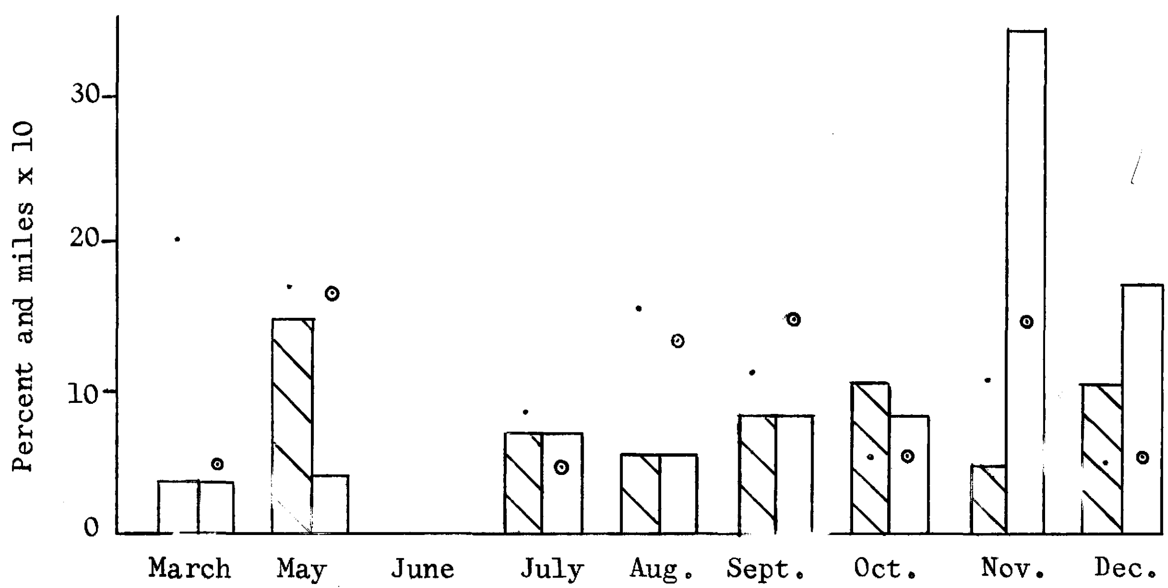


Figure 10. Percent of each sample of whitefish which moved upstream (hatched) or downstream (open) and the mean distance per move upstream (dot) or downstream (circled dot).

same magnitude as upstream movement until November. Downstream movement reached a high peak in November and then dropped in December to one-half of the peak value. The distance covered per move varied little between upstream and downstream movements except in March when upstream moves were much longer than downstream moves. There is no evident pattern to the distance which the whitefish moved in relation to time of year.

Right Hand Fork

The Right Hand Fork study area was sampled four times between July and October. The fish were marked individually. The area was divided into stream units each constituting a pool or a riffle. Each unit was measured to the nearest foot. The area sampled was extended beyond the 404-foot study area 80 feet upstream and 295 feet downstream. These limits were decided upon because no marked fish were found above or below this distance away from the marking section.

Thirty-eight and one-half percent of the fish sampled had moved after they had been marked. Of those that moved, 59 percent went upstream and 41 percent went downstream. Those that moved upstream went an average of 258 feet ranging from 95 to 429 feet per move. Those fish which went downstream moved an average of 155 feet ranging from 50 to 360 feet per move. They transversed an average of three stream units ranging up to six per move.

Harvest

A creel census was performed on the study area of Logan River during the fishing season of 1962. The analysis was divided into weekdays and holidays which included weekends (Table 2).

The sample taken on weekdays consisted of 59 counting trips through

Table 2. Summary of data from creel census in 1962 fishing season. Pressure expressed as fisherman hours, success expressed as fish per hour per fisherman, and harvest expressed as the number of fish

	Weekdays	Holidays	Total	Mean
Browns:				
Pressure	6093	8508	14601	
Success	.118	.035		.076
Harvest	609	298	907	
Rainbows:				
Pressure	6093	8508	14601	
Success	.699	.470		.585
Harvest	4265	3999	8262	
Whitefish:				
Pressure			14601	
Success				.013
Harvest			204	
Cutthroat:				
Pressure			14601	
Success				.004
Harvest			62	

the study area. Out of 164 fishermen counted 146 were interviewed. The fishing season consisted of 2176 fishable hours. The mean number of fishermen per count was 2.8, so fishing pressure exerted on weekdays was an estimated 6093 fisherman hours.

The sample taken on holidays was composed of 44 counts with 364 fishermen interviewed out of 399 counted. The fishing season on holidays consisted of 935 fishable hours. The mean number of fishermen per count was 9.1, so the estimated pressure on holidays was 8508.5 fisherman hours.

The estimated total harvest for brown trout was 907. The estimated total harvest for rainbow trout was 8262. The estimated total harvest for whitefish was 204 and for cutthroat it was 62. The estimates for whitefish and cutthroat were not divided into weekdays and holidays. Samples were so small that further division would have seriously decreased the precision of the estimates. Since there were 10,103 rainbow trout stocked in the study section of the river, the return to the creel for the season was 82 percent.

Survival

Age determination

The brown trout and whitefish were aged according to length. The samples were taken over a period of several months, so one length-age relationship was inadequate since the fish grew between samples. The effect of growth had to be eliminated. The length groups were increased by the average monthly increment of linear growth explained earlier. Tables 3 and 4 show the lengths included in each age for each month of a year. I could then age all of the samples throughout the year. Tables 5 and 6 show the number of brown trout and whitefish in each age for each

Table 3. Mean length interval for brown trout by age for each month of the year

Month	I[a] Min	I[a] Max	II[a] Min	II[a] Max	III[a] Min	III[a] Max	IV[b] Min	IV[b] Max	V[b] Min	V[b] Max	VI[b] Min	VI[b] Max
Feb.	3.0	5.75	5.25	8.75	8.25	11.25	11.00	13.75	14.00	17.00	17.25	21.75
March	3.25	6.00	5.50	9.00	8.45	11.45	11.25	14.00	14.25	17.25	17.50	22.00
April	3.50	6.25	5.75	9.25	8.65	11.65	11.50	14.25	14.50	17.50	17.75	22.25
May	3.75	6.50	6.00	9.50	8.85	11.85	11.75	14.50	14.75	17.75	18.00	22.50
June	4.00	6.75	6.25	9.75	9.05	12.05	12.00	14.75	15.00	18.00	18.25	22.75
July	4.25	7.00	6.50	10.00	9.25	12.25	12.25	15.00	15.25	18.25	18.50	23.00
Aug.	4.50	7.25	6.75	10.25	9.45	12.45	12.50	15.25	15.50	18.50	18.75	23.25
Sept.	4.75	7.50	7.00	10.50	9.65	12.65	12.75	15.50	15.75	18.75	19.00	23.50
Oct.	5.00	7.75	7.25	10.75	9.85	12.85	13.00	15.75	16.00	19.00	19.25	23.75
Nov.	5.25	8.00	7.50	11.00	10.05	13.05	13.25	16.00	16.25	19.25	19.50	24.00
Dec.	5.50	8.25	7.75	11.25	10.25	13.25	13.50	16.25	16.50	19.50	19.75	24.25
Jan.	5.75	8.50	8.00	11.50	10.45	13.45	13.75	16.50	16.75	19.75	20.00	24.50
Mean monthly increment	0.25		0.25		0.20		0.25		0.25		0.25	

[a]Maximum and minimum lengths determed empirically.
[b]Maximum and minimum lengths taken from Sigler (1951a).

Table 4. Mean lenth interval for whitefish by age for each month of the year

Month	Age class									
	I		II		III		IV		V	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Feb.	2.75	6.50	6.75	9.25	9.50	11.25	11.25	12.25	12.50	13.50
March	3.13	6.79	7.04	9.42	9.67	11.35	11.35	12.35	12.60	13.60
April	3.51	7.08	7.33	9.59	9.84	11.46	11.46	12.46	12.71	13.71
May	3.89	7.37	7.62	9.76	10.01	11.56	11.56	12.56	12.81	13.81
June	4.27	7.66	7.91	9.93	10.18	11.66	11.66	12.66	12.91	13.91
July	4.65	7.95	8.20	10.10	10.35	11.76	11.76	12.76	13.01	14.01
August	5.03	8.24	8.49	10.27	10.52	11.87	11.87	12.87	13.12	14.12
Sept.	5.41	8.53	8.78	10.44	10.69	11.97	11.97	12.97	13.22	14.22
Oct.	5.79	8.82	9.07	10.61	10.86	12.07	12.07	13.07	13.32	14.32
Nov.	6.17	9.11	9.36	10.78	11.03	12.17	12.17	13.17	13.42	14.42
Dec.	6.55	9.40	9.65	10.95	11.20	12.28	12.28	13.28	13.53	14.53
Jan.	6.93	9.69	9.94	11.12	11.37	12.38	12.38	13.38	13.63	14.63
Mean Monthly Increment	0.38		0.29		0.17		0.1025		0.1025	

Table 4. Continued

Month	Age class								
	VI		VII		VIII		IX		Older
	Min	Max	Min	Max	Min	Max	Min	Max	
Feb.	13.75	15.00	15.25	16.50	16.75	18.00	18.25	19.25	19.50
March	13.85	15.10	15.35	16.60	16.85	18.10	18.35	19.35	19.60
April	13.96	15.21	15.46	16.71	16.95	18.21	18.46	19.46	19.71
May	14.06	15.31	15.56	16.81	17.06	18.31	18.56	19.56	19.81
June	14.16	15.41	15.66	16.91	17.16	18.41	18.66	19.66	19.91
July	14.26	15.51	15.76	17.01	17.26	18.51	18.76	19.76	20.01
August	14.37	15.62	15.87	17.12	17.37	18.62	18.87	19.87	20.12
Sept.	14.47	15.72	15.97	17.22	17.47	18.72	18.97	19.97	20.22
Oct.	14.57	15.82	16.07	17.32	17.57	18.82	19.07	20.07	20.32
Nov.	14.67	15.92	16.17	17.42	17.67	18.92	19.17	20.17	20.42
Dec.	14.78	16.03	16.28	17.53	17.78	19.03	19.28	20.28	20.53
Jan.	14.88	16.13	16.38	17.63	17.88	19.13	19.38	20.38	20.63
Mean Monthly Increment	0.1025		0.1025		0.1025		0.1025		0.1025

Table 5. Corrected number of brown trout in each age-class at each sampling time

Month	Number in each age-class						
	0	I	II	III	IV	V	VI
April 1961	0	18	97	66	122	86	16
May	0	6	18	14	17	9	1
August	0	1	22	22	22	2	2
October	33	21	41	62	29	13	0
December	35	41	80	50	25	5	1
January 1962	47	11	29	30	12	0	0
February	0	788	434	503	409	168	11
March	0	80	38	43	31	13	1
May	0	22	5	10	3	0	1
August	0	19	17	13	20	2	0
September	0	19	18	14	7	1	0
October	0	12	12	6	5	1	0
November	6	45	36	34	15	5	0
December	6	67	21	19	17	4	0

Table 6. Corrected number of whitefish in each age-class at each sampling time

Month	Number in each age-class										
	0	I	II	III	IV	V	VI	VII	VIII	IX	Older
April 1961	0	10	155	88	57	44	93	41	28	1	0
May	0	3	47	24	11	1	8	8	4	1	3
August	0	17	111	16	11	20	4	6	3	0	0
October	0	8	52	72	35	10	23	6	12	0	1
December	0	18	21	64	48	22	28	29	6	215	.05
January 1962	0	0	38	70	21	9	10	2	0	0	0
February	0	98	94	1478	305	198	142	117	42	7	3
March	0	3	2	79	11	10	8	10	0	0	0
May	0	12	12	59	10	8	5	0	0	0	0
August	0	2	8	26	25	8	8	6	1	0	0
September	0	2	5	25	22	4	1	5	1	0	0
October	0	1	2	17	19	5	5	7	1	0	0
November	0	11	23	120	59	21	17	10	0	0	0
December	1	1	8	49	38	14	8	5	1	0	0

sample.

Survival estimation

Survival was computed by the Robson-Chapman method (1961). The survival of year-class 1958 and then the survival of age-class III and older regardless of year-class was computed. The results are shown in Figures 11-14.

The least squares method was used to fit lines to each of the graphs. Since the change in mortality of one year-class was desired in the data of year-class 1958, a line was fitted over the entire period of study for both the whitefish and brown trout. A separate line was fitted to each year's data for the survival of the population of age-class III and older.

A test which would convey the proper information for the survival of year-class 1958 was that of testing for regression of survival on time of year. Survival showed a definite negative relationship with time for the brown trout at the 95 percent level of confidence (Figure 11). The whitefish data showed that there was no regression at the 50 percent level of confidence (Figure 12).

Figure 13 shows the population survival of brown trout for the 2 years of the study. In order to compare the survival between the two time intervals, I fit a line to each year's data. Significant regression occurred at the 95 percent level of confidence. There is a steeper slope to the line fitted to the 1961 data as indicated by the larger negative "b" value. I tested the null hypothesis that the slope of the line for 1961 was equal to the slope of the line for 1962. This test was significant at the 60 percent level of confidence. Figure 14 reveals the whitefish data. Using the same tests as used on the brown trout, I

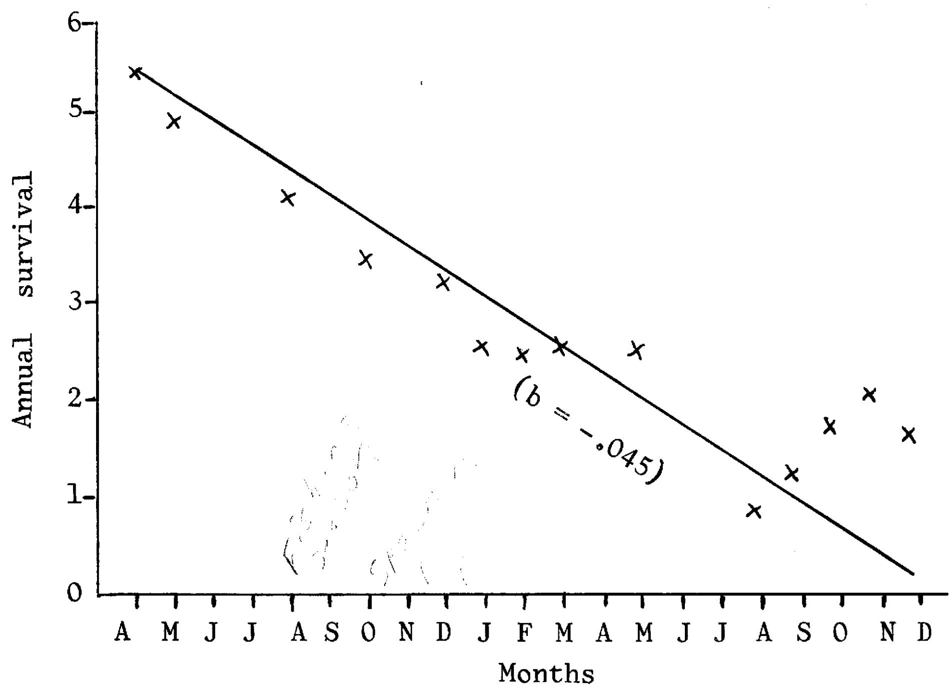


Figure 11. Regression of annual survival of year-class 1958 brown trout on time in 1961 and 1962.

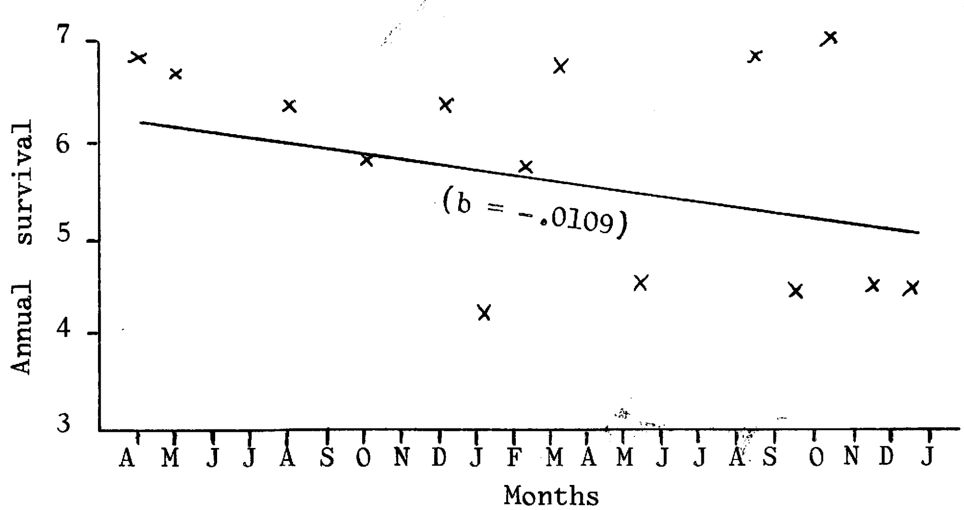


Figure 12. Regression of annual survival of year-class 1958 whitefish on time in 1961 and 1962.

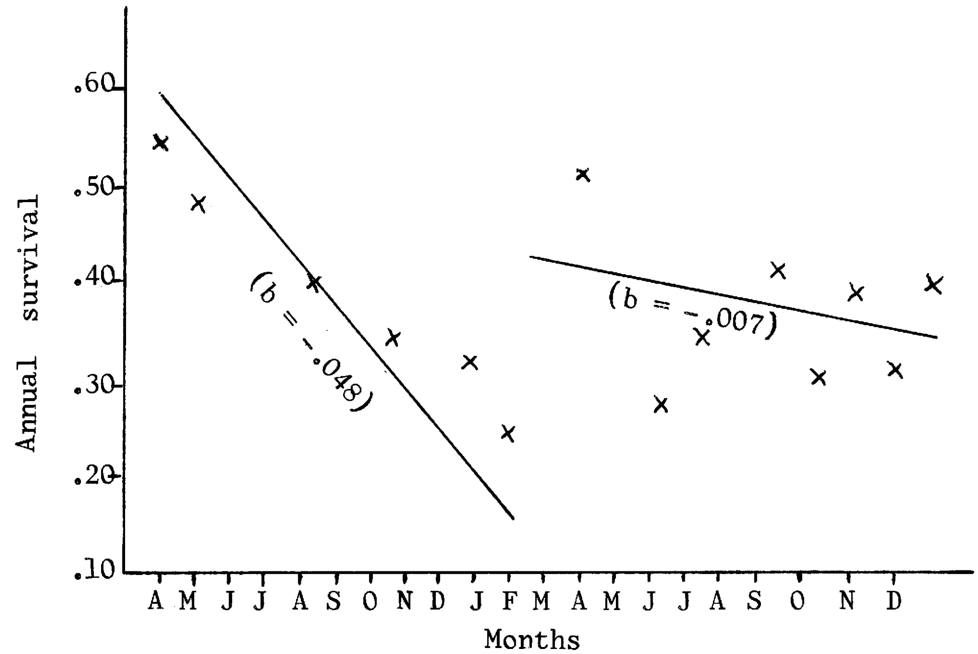


Figure 13. Regression of annual survival of age-class III and older brown trout on time in 1961 and 1962.

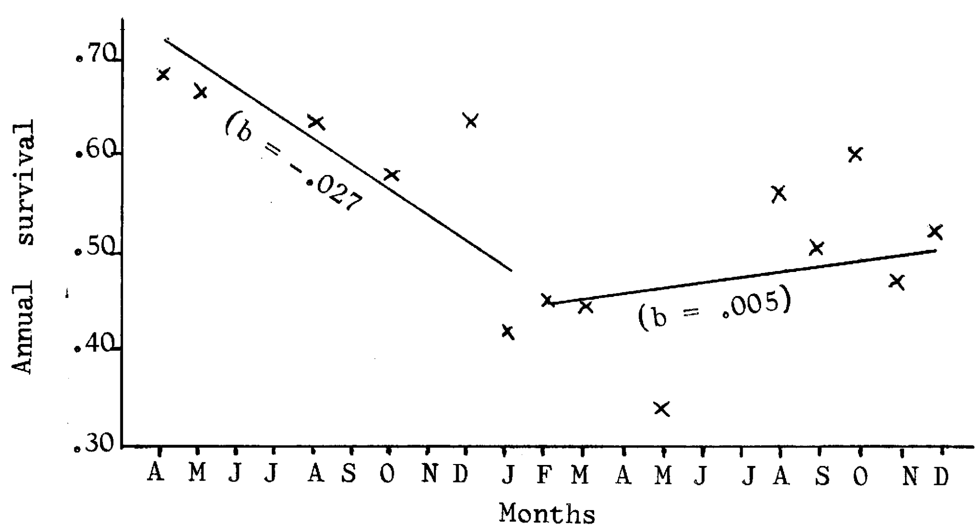


Figure 14. Regression of annual survival of age-class III and older whitefish on time in 1961 and 1962.

found regression at the 95 percent level of confidence for both years' data. The test to determine similarity between the two lines was administered. The test showed that the two lines were different at the 80 percent level of confidence.

DISCUSSION

Abundance

The population estimates of brown trout made for April 1961, and for late February 1962, are quite similar (Figures 6 and 7). The estimates could not be extended below 10 inches in 1961 because there were no recaptures below 10 inches. This was in part due to the small number of fish marked in 1961 and in part due to an increased water flow at the time of sampling. The flow increased approximately 100 c.f.s. There was virtually no change in the river in 1962 between marking and the time that the first sample was taken. The sampling gear used was selective for larger fish. Any change in river conditions which affected sampling would have affected the sampling of smaller fish more than the sampling of larger fish. The electrical current was apparently sufficient to attract and hold large fish when the river was high. The velocity of flow in the river would have swept a smaller fish downstream.

As the brown trout became larger, the number in each length group seems to stabilize. The 1961 and 1962 estimates differ through the 13 inch group (Figure 6). Some of this variation may be due to sampling. Brown trout survival could be variable until browns become about 14 inches in total length. A brown this length would be either a large 4-year-old or a small 5-year-old fish.

On the basis of 2 years' data, the brown trout population appears to be stable. The estimated numbers vary somewhat between the 2 years. No evidence for cycles of abundance exists. Burnet (1959) suggested that survival in younger ages created cycles of abundance in two New Zealand streams. Burnet attributed a cyclic pattern of abundance to decreased predation caused by a depletion of the older fish which prey on the young. Survival of older fish seems to be very stable in Logan River.

On further inspection of the pattern of Figure 6, it may be suggested that the population as it exists may be close to the carrying capacity of the river for brown trout. This is particularly in evidence with trout over 13 inches total length. Almost exactly the same number of fish in each length group existed in the two estimates 1 year apart. Variation is slight between the estimates at each inch group for both years and between inch groups within either year. These data suggest a stable population maintaining itself at about the same level from year to year.

Figure 7 displays the population estimates at 1 inch groups for whitefish in April 1961, and late February 1962. The estimates for April 1961, follow the pattern of the brown trout in 1962. Over a 1 inch group, from 9-10 inches, the survival decreases tremendously. Survival drops at a decreasing rate until the end of the life span.

The 1962 population estimates for whitefish present a different situation. I was able to obtain an estimate of 8 inch fish in 1962; whereas, I was not able to in 1961. In 1961 the peak of abundance occurred at 9 inches. The major decrease in number occurred between lengths 9 and 10 inches. Beyond a length of 12 inches the number surviving decreased with little variation. In 1962 lengths 8 and 9 inches contained small numbers. The peak numbers occurred at 10 inches. They decreased very abruptly over two 1 inch groups and reached the bottom of the curve at 12 inches. Beyond 12 inches the number in each length group decreased at a lessening rate with little variation.

The small number of fish at 8 and 9 inches (Figure 7) for 1962 indicates that the number does not extend on upward in the manner indicated. The number drops very low. The explanation could lie in the existence of a peak year-class. A whitefish between 9 and 10 inches total length, which is the length interval included in length group 9, would be either a large 2-year-old or a small 3-year-old (Table 4) in April 1961. A whitefish which was between 10 and 11 inches long would be a large 3-year-old in February 1962. The two peaks shown in Figure 7 occur within consecutive inch groups. The 1 inch discrepancy is probably real and may be the result of most of a year's growth having occurred between estimates.

Some discrepancy exists between the 2 years' data on the height of the peak and the number of length groups over which the peak expresses itself. Both of these discrepancies can probably be attributed to the measurement techniques. In 1961 the total length was estimated to the nearest inch. Measurements in 1962 were made to the nearest 0.25 inch on a standard measuring board. Errors made in measuring during 1961 may have been sufficient to cause the differences mentioned.

If the existence of a large year-class is actually true, the phenomenon does not appear to be cyclic. No lesser peaks of abundance appear later. Another peak could occur after this one has disappeared as a dominant portion of the population. In this manner it could be a cyclic phenomenon. The effect of a large year-class other than the existing one has either been damped out, or the dominant year-class has passed out of the population and is being replaced by the one at length group 10.

Movement

Figure 8 shows that at least 10 percent of the whitefish are moving upstream or downstream most of the time. In every case where movement is in evidence, the mean distance per move is at least 0.4 miles (Figure 10). In 9 cases out of 16 the mean distance per move exceeded 1 mile for whitefish (Figure 10). If whitefish group by size or age, with the amount of movement displayed they could move in or out of a station and seriously misrepresent the actual age distribution within the population at the time of sampling.

The more extensive movements of both species follow a general pattern of little movement until around the time of spawning (Figure 8). The increased movement persisted until at least the first part of December when the last sample was taken.

Several authors have noted upstream migrations of brown trout at spawning time (Schuck, 1945; Ball and Jones, 1960). Redds appeared in the river in October. In Figure 8 brown trout reached their peak movement in October. Figure 9 shows that most of the movement was directed downstream. Spawning had begun in Right Hand Fork by November 8. It could have commenced prior to this since there was no constant observation made on this stream. Several marked fish were found on redds in Right Hand Fork near its mouth on November 19 and 28 of 1962. Two of the fish came from section A in Logan River proper. The mouth of Right Hand Fork is only 0.1 miles below the upper limit of the study area. These fish need not have moved far. Three fish were from section C, so they had to have moved at least 1.9 miles. One fish from section E would have had to move at least 3.9 miles upstream. Figure 9 shows that by the first week of November when the sample was obtained in the river proper, downstream movement had decreased in percent of the population; but the average distance per move had increased very markedly. By the fifth of December all downstream movement had stopped and a peak in upstream movement occurred. At this time two instances of migration from the third dam occurred. The fish had been marked on October 9, 1962.

The apparent reversal in spawning migration patterns can be explained if there could be two different spawning runs occurring at about the same time. Right Hand Fork is utilized quite heavily for spawning, but the area is very limited. Access to upper water is blocked by a natural log and rock dam about a half of a mile above the mouth. A large portion of the browns may run downstream to the area just above the third dam which has a very high trout population and which is utilized for spawning. I counted 12 redds in about one-half of a mile of stream on November 3, 1962. The increased upstream migration early in December would reflect the return of the brown trout upstream.

The pattern of whitefish movement is very similar to that of brown trout. The peak movement occurred in November rather than October. The whitefish did not utilize Right Hand Fork as a spawning area. Fishermen have reported that whitefish in the third dam run up into the river and spawn in the riffles. Whitefish were abundant in the river above the dam in November. This concentration may not have been entirely due to third dam fish moving upstream. Whitefish from the upper river apparently migrate downward and may congregate in this area to create what appears to be an upstream movement. The peak movement agrees with the time of spawning for Logan River whitefish (Sigler, 1951b). Upstream migration very likely was not completed between the time the samples were taken October 18 and November 5. Spawning probably takes more than 2 weeks;

and if the whitefish had moved upstream, I would have determined this in the November sample.

The study of movements of brown trout in Right Hand Fork was designed to obtain a measure of the amount of movement and not the reasons for moving. I can only speculate as to why the fish moved short distances. Foraging for food is probably the primary reason. Most of the fish were found in the section of river that was deep, narrow, and heavily shaded. Conditions were not conducive to invertebrate growth. There were riffle areas above and below this section which probably contained invertebrate food items for the trout found in the deep, shaded areas. The fish would obviously have had to move out of the shaded area to reach feeding grounds.

Harvest

The harvest data (Table 2) require little discussion. The precision of my estimates is supported by the fact that the return to the creel of hatchery rainbow which is around 80 percent is the same as it was 15 years ago (Regenthal, 1952a). Regenthal found for the 1948, 1949, and 1950 fishing seasons a return to the creel of 77.26, 78.28, and 86.63 percent of the rainbow stocked the same year that they were caught. The brown trout harvest estimate of 24 percent of the catchable population is well within reason and lends support to the accuracy of the creel census data.

Most of the brown trout harvested were of older age-classes. A great increase in mortality of browns of the 1958 year-class or age-class IV is apparent (Figure 11) during the heaviest part of the fishing season in June and July. The cause of the increased mortality could be selective fishing for large fish at that time.

Survival

When considering the population of brown trout or whitefish at only one point in time as shown in Figures 6 and 7, the survival may appear to be constant over a year's time. Approximately equal numbers of fish exist at the same ages a year apart. Survival at several times may be quite different for the same group of fish. A straight line expresses the regression of survival of year-class 1958 brown trout on time for the period from April 1961, through December 1962 (Figure 11). The fitted line does not completely describe the situation; however, I determined that regression exists.

From April 1961, the survival of age-class III brown trout decreases until January 1962. Survival then levels off and remains constant until some time between May and August of 1962. Survival increases through November and drops somewhat in December. The leveling off occurs at the time when the fish have reached the beginning of their fourth year.

The very low survival in August indicates that many of the 4-year-old brown trout are harvested during the fishing season. Fish are recruited to this portion of the population by growth in length until the void is filled. If brown trout which reside in the third dam below the study area run upstream to spawn during the fall, the survival estimates made for October and November are too high.

Movement shown in Figure 8 was not occurring upstream to any abnormal extent at spawning time but was occurring in a downstream direction. The increase in survival could not have been caused by downstream movement. Fish of spawning size should all move in at the same rate. This would increase the number in each age-class but not affect the age-classes in relation to each other. Since the survival estimates are based on relative numbers at successive ages, there would be no change in the estimated survival.

From the data described in Figure 12 for year-class 1958 mountain whitefish, a decrease in survival with time is suggested similar to the decrease for brown trout shown in Figure 11. The survival estimates for whitefish are more variable between months, so no precise inferences can be drawn from the estimates.

The reason for the high degree of discrepancy between survival estimates for whitefish most likely is the result of biased sampling. This is directly related to the habits of these fish. The preferred habitat of whitefish appeared to be open water. I can recall no instance where whitefish utilized overhanging banks, brush, or roots directly as cover. They were taken most frequently in long deep riffles or pools. Whitefish seemed to be gregarious. I could expect to get several of them at a time. A group of whitefish usually included few sizes. This was especially evident with small fish. On one occasion at Chokecherry picnic area a dozen or so young-of-the-year whitefish were taken under the bridge at practically the same instant.

Whitefish may congregate in groups according to age or size. A population grouped in such a manner could be inadequately sampled. I made the assumption that one station of 0.1 mile would include all of the habitats in any mile section of the river. This assumption may have been made in error regarding whitefish. Perhaps other factors need to be considered besides the habitat type to obtain an adequate sample of whitefish; such as, movements according to time of day or time of year.

Testing the null hypothesis for the data presented in Figure 13, I found that the two estimates of the slope became different at the 60 percent level of confidence. The chances are slight that a change did occur. The vicissitudes of the environment could have caused the small change in survival rate.

During the 2 years of this study, water levels fluctuated violently and abnormally in Logan River. In 1961 very little run-off was experienced in the spring. The maximum mean monthly flow in May 1961, measured at the canyon mouth was 293 c.f.s. as compared to a maximum of 673 c.f.s. in May 1962. The water level remained low until the spring run-off in 1962. A low mean monthly flow of 74.5 c.f.s. was reached in January 1962.

The very low water could have decreased the survival in 1961 and early 1962 by forcing the fish into competition for space or habitat. Brown trout utilized the over-hanging brush and roots along the river banks extensively as cover. As the river dropped to a very low level, habitat was reduced and the carrying capacity of the river was thereby decreased. Brown trout were probably forced to occupy positions in the river which had marginal habitat conditions. Since brown trout in Logan River are found usually beneath brush hanging in the water or under the bank, the presentation of a lure to them is difficult. If the fish were forced into the open areas in 1961, they may have been more vulnerable to fishing.

If water flow affects survival, too great a flow is apparently as bad as too small a flow. A very high water flow which occurred in 1962 accompanied by a rather cool spring resulted in continued high water through most of July. The continued high water may have interferred with food production. The high water could have created disturbed bottom conditions through molar action, thereby reducing invertebrate production in the river. High water conditions may also have destroyed or removed brown trout occupying marginal habitat. This is based on the assumption that brown trout must have adequate protection from relatively high water velocity. Marginal habitat would not have provided adequate protection during the high water.

The decrease in rate of survival over the 2-year period could conceivably be the result of a fluctuation or oscillation in the population abundance. A population existing at the upper limit of its environment will oscillate above and below that limit.

In Figure 14 for whitefish the slopes b_1 and b_2 are different. The null hypothesis that the slopes are equal can be rejected at the 80 percent level of confidence.

These data indicate that survival of the whitefish population changed with time. The change from a negative to a positive trend would have been the result of the fluctuating water level, or the result of one peak year-class passing out of existence and another coming into existence.

The decrease in survival rate through January 1961, and the increase in survival rate from February through December 1962, in general follow the yearly pattern of flow for Logan River. The river was low until May 1962. The water level then increased to a peak of 1080 c.f.s. and declined slowly over the summer of 1962. The whitefish seem to be able to survive better when Logan River is high.

The survival estimates do not coincide exactly with the volume of flow for Logan River. Perhaps the change in survival rate is due to the presence of a dominant year-class cycle. The decrease in survival could have been created by a dominant year-class which was dying out at the upper end of the age scale. Another dominant year-class could not influence the population survival estimates until February 1962. By late summer in 1962 all of the former dominant year-class was apparently gone and the new dominant year-class was exerting its influence on the population's survival estimate.

SUMMARY AND CONCLUSIONS

The number of brown trout is somewhat variable up to a length of 14 inches at which time it becomes stable between years. The number of whitefish in each inch group is unpredictable because of the apparent existence of a dominant year-class.

Brown trout move downstream more than upstream at spawning time. Brown trout which had been marked in the river spawned in all areas including the tributary to the study area of Logan River.

Whitefish did much more extensive moving than brown trout throughout the year except during the spawning season from October through December. Large aggregations of whitefish were found in the lower section of the study area when downstream movement was greatest. The aggregations were, at least in part, made up of downstream migrants.

The rainbow trout "put and take" fishing is operating at about the same level of efficiency that it was 15 years ago. The superimposed rainbow population probably does not compete with brown trout or whitefish during the winter months.

The annual survival of the 1958 year-class of brown trout is affected by time and apparently fishing pressure. Increased survival after fishing season apparently compensated for the loss of large fish due to selective harvesting of older and larger fish by angling.

Survival of the 1958 year-class of whitefish was not related to time. Precise interpretation of these data was hampered by sampling complications caused by movement habits of the whitefish population.

The annual survival of 3-years-old and older brown trout decreased at about the same rate in 1961 as in 1962. The decrease could be the result of normal population fluctuation.

The rate of survival for whitefish of age III and older changed between the two years of this study. Absolute survival was low in 1962. The decrease could have been the result of a dominant year-class passing out of the population at the upper end of the age scale.

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