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SURVIVAL OF HATCHERY-REARED CUTTHROAT

TROUT IN AN ALBERTA STREAM

BY

U.M. MANGAN

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THE UNIVERSITY OF ALBERTA

SURVIVAL OF HATCHERY-REARED CUTTHROAT
TROUT IN AN ALBERTA STREAM

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

FACULTY OF ARTS AND SCIENCE
DEPARTMENT OF ZOOLOGY

by

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Edmonton, Alberta,

April 1951.

ABSTRACT

Due to the poor returns to the angler from hatchery plantings a program was designed to determine the actual day by day survival of hatchery reared trout in a stream. Using a typical tributary stream of the Alberta east slope drainage, four hundred individually weighed and numbered cutthroat trout were planted in a section of the stream bounded by fish tight screens. The trout were of two size groups, one group of 12-15 inch fish, the other 6-8 inches. Throughout an experimental period of 100 days following planting, the surviving trout were caught by angling, weighed and returned to the stream. The fish that died drifted against the screen and were collected. The large trout showed a mortality of 30.15% for the first 100 days and were entering the winter in poor condition, while the smaller group showed a calculated percentage mortality of 85%. If the screens had not been present the experimental hatchery fish would have been carried out of the stream by the current in a matter of hours.

A rough measure of the efficiency of natural reproduction showed that the stream could build up its present population in three to four years. We tentatively conclude that the planting of hatchery reared trout in a stream already supporting a population of the same species is uneconomical and does not contribute to the brood stock of the stream.

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INTRODUCTION

During the past fifteen years the major problem confronting fisheries management has been the feasibility of restocking lakes and streams with hatchery-reared trout. Plantings have been made on a large scale in waters which have not produced meritable returns to the angler. The determination of fishermen and administrators to improve the trout fishing has, in some cases, borne fruit. New species have been introduced into areas which were previously barren. But with the exception of a few cases which fall into the above category, no noticeable improvement has been observed.

As early as 1900, a high official in the U. S. Fish Commission expressed doubt as to the outcome of the indiscriminate planting procedure. In the 1920's, the first Canadian experimental work was performed by Dr. R. E. Foerster (1936), of the Pacific Biological Station, Nanaimo, B. C. Foerster's experiment, conducted over a ten year period, offered conclusive proof that the salmon hatcheries of the Pacific Coast were not improving the commercial catch.

Foerster's work started a chain of research in Canada and the United States. Experiments were performed to determine the age group and the month best suited for maximum survival.

Nation-wide averages show that fry survival varies from one to four percent, while fingerling survival shows better results. Needham (1944) in California showed a gross survival of 63.7% for brown trout fingerlings (1.25-1.56 inches) over a five year period; also, a gross survival of 44.2% for small rainbow fingerlings (1.32-1.69 inches). In the above instances, the recorded period varied from 89-151 days. Needham's most significant work in respect to our study, is seen in the gross survival of 49.8% for large rainbow fingerlings# during a 123 day recorded period.

Shetter and Hazzard (1938) found a survival of 1.8% for spring-planted brook trout and a 17.5% survival for rainbow. Shetter (1942) found in Michigan trout streams that 25.7% of the rainbow trout planted in the open season were caught by anglers. Nation-wide returns to the angler of planted legal-sized trout average about 25%.

Miller (1949) summarizes the existing data in these words, "This great body of evidence shows a return from spring-planted legal-sized fish of about 5-50%, average around 30%. From fall-planted fish the returns are, with few exceptions, negligible."

The problem then resolves itself into a question
#The large rainbow fingerlings are comparable in size to our lot #2 cutthroat trout.

of what causes this serious mortality of hatchery-reared trout when placed in natural waters. The fact that hatchery-reared trout are different from wild trout in their ability to take care of themselves is obvious. Schuck (1948) has listed ten possible causes of the low survivability of hatchery-reared trout; he states:

- " 1. High percentages of fats and carbohydrates in diets.
2. Overfeeding which leads to (among other things) detrimentally high growth rates.
3. Relative lack of exercise.
4. Artificial conditions where little or no foraging for food is necessary.
5. Relative freedom from predators.
6. Relative stability of water temperature the year round, a condition which does not exist in most trout streams. Hatchery trout, if reared in spring water, are usually subjected to neither the low temperature (approximately 32° F. during winter) nor the high temperature (above 75° F.) which trout in the wild must often endure. If trout have become accustomed to the rather stable temperatures of the hatchery, the more variable temperatures in the wild might contribute to their mortality.
7. Continued domestication of hatchery breeders.
8. Intentional or unintentional selection of brood fish for good performance in the hatchery, i.e., for rapid

growth rate, large production of eggs and like qualities. Such selection does not necessarily produce fish with the qualities to survive in the wild.

9. Relative absence of natural live food
10. Transportation and planting methods "

Poor survival of hatchery-reared trout in streams is not necessarily due to any one of the above causes, but is very likely a combination of several, perhaps all. Figuratively speaking, the survival chain is only as strong as its weakest link.

In Alberta, the trout streams on the east slope drainage are rated "fair" with regard to food and cover; they are capable of maintaining a year round population. Our anglers are not forced to follow the hatchery truck to obtain good fishing. However, anglers do insist on plantings, in the belief that they will contribute to the brood stock of the streams.

From the research reviewed above, it would seem that these plantings are largely wasted. It is important, then, to plan and carry out a number of experiments, under controlled conditions, which will tell us how effective the planting procedure may be; and, if it is not effective, to suggest ways in which it could be improved.

EXPERIMENT WITH CONFINED TROUT

A project was planned for the summer season, 1950, under the supervision of Dr. R. B. Miller, University of Alberta, Edmonton. The program was designed to determine the actual survival of hatchery-reared trout in a stream which contained a population of native trout. It was also hoped that this investigation would shed some light on the possible causes of mortality in planted stock.

The experiment was planned to illustrate the day by day fate of planted stock in a stream. This could be ascertained by erecting three fish-tight screens approximately one mile apart. The screens would form the boundaries of two enclosures. Planted stock would be confined within one enclosure; the other would serve as a control. Before planting, each fish would be weighed and marked with a numbered tag. Throughout the summer, the hatchery fish would be recaptured as often as possible by angling, weighed and returned to the stream. In this way a series of case histories could be built up from planting time until fall.

At the same time, a population estimate of the wild trout would be calculated for each enclosure by the usual method of clipping fins. This would further serve as a special check to indicate whether the hatchery fish

had caused any change in the condition of the wild trout, or vice versa. An auxiliary program was planned to determine the efficiency of natural reproduction. The experiment was completed in September, 1950, and the findings form the substance of this paper.

Experimental Area - Gorge Creek

The creek selected for the experiment is a small mountain stream, which arises in two branches, the main or south fork and the north fork. The main or south fork has its origin at the six thousand foot level of the northwest slopes of Blue Rock Mountain. The north fork begins on the northeastern slopes of Ware Mountain, approximately at the same altitude. Each branch flows about four miles before uniting to form the main stream. From the union of the two branches, the main stream descends four miles, to the 4,800 foot level where it enters the Sheep River. The junction is approximately a half mile west of the Bighorn Ranger Station.

The stream gradient of Gorge Creek is 150 feet per mile (Andrekson, 1949). During May and June when the spring run-off is at its maximum, the rate of flow is seven miles per hour. In the latter part of August and early September, the rate of flow drops to a summer level of 1.5-2 miles per hour.

The experimental area was located in the lower part of the main stream where it is ten to fifteen feet wide. It traverses a deep gorge with numerous sheer rock faces which are mainly loose shale and limestone. The stream twists and turns through the narrow gorge, forming well defined pools, under-cut banks, long stretches of rapids and gravelly riffles. The water temperature has an average variation of 14-16° F. per day. The lowest recorded temperature was 33° F.; the highest 67° F. Bottom food samples average 0.5 cc. per square foot (Andrekson, 1949).

Gorge Creek has been closed for the last five years and supports several hundred small cutthroat trout per mile. Generally speaking then, this stream is a typical tributary stream of the east slope drainage. It differs from other streams in that the temperature is somewhat warmer and the stream gradient is not quite as severe. These factors should increase the chances of survival in planted stock.

Fish-tight Screens

Approximately the first mile and a half of the main stream, known to contain a population of native trout, was chosen for the experimental area. Fish-tight screens were erected at both ends and in the middle. (The screens were about three-quarters of a mile apart.)*omit.*

Figure 1. DIAGRAM OF A SECTION OF SCREEN.

The screens were assembled in sections. A section consisted of 2 x 4 scantling made into a rectangular frame measuring 8 or 9 x 3 feet. The frames were strengthened by cross supports on each corner and covered with one inch chicken wire. An additional piece of chicken wire was attached to the bottom of each frame to form an apron. (Figure 1). In each case the chicken wire overlapped the frame to allow for connection with the adjoining section.

A sufficient number of these sections were placed across the stream to form a screen. The sections overlapped one another and were joined together by means of the overlapping wire mentioned above. Rocks were piled on the apron of chicken wire which lay flush with the stream bed and the sections were propped upright on the downstream side. (Figure 1). When each section had been fastened to its neighbour, the whole screen was covered with half inch netting on the upstream side. The netting hung over the top of the screen and was held in place along the stream bed by small rocks. The addition of the netting, besides rendering the screens fish-tight, also eased the task of daily cleaning.

These screens were found to be most effective when erected on hard bottom and could withstand extreme flooding. On one occasion the water rose within five inches of the top and the screens remained intact. For the first week after installation it was necessary to check each section of the screen for undercutting, that is, water flowing over the 2 x 4 on the stream bottom would cut a deep hole beneath the

Figure 2. MAP OF HATCHERY ENCLOSURE, GORGE CREEK

framework. An undercut frame would soon sink into the hole dug by the stream thereby weakening the whole structure.

The three screens were installed in the stream by June 15th. The lower enclosure bounded by No. 1 and No. 2 screens were called the hatchery enclosure, the upper enclosure bounded by No. 2 and No. 3 screens was called the native enclosure.

Description of the Enclosures

Hatchery Enclosure. The general layout of this enclosure is shown in Figure 2. No. 1 screen was located on an outcropping about 600 feet from the junctions of Gorge Creek and the Sheep River. Immediately upstream the banks of the creek rose rapidly forming the narrow gorge from which the whole stream is named.

The rock walls approached within two feet of one another forming a narrow slit or gap through which turbulent water flowed. These divided the hatchery enclosure into areas X, Y and Z. Due to the difficulty of negotiating these narrow places, they were termed Impasse 1 and Impasse 2.

Area "X". This was bounded by No. 1 screen and the lower end of the Impasse 1. The water was fairly smooth-flowing, with five excellent pools and a number of small rapids. On the eastern bank a few feet ^{Above} (about) No. 1 screen, Dead Horse Creek, a small tributary stream enters Gorge Creek.

Figure 3. GRAPH OF THE AVERAGE MAXIMUM AND MINIMUM TEMPERATURE READING OF GORGE CREEK FOR EACH TEN DAY INTERVAL OF THE EXPERIMENTAL PERIOD 1950.

Area "Y". This was the longest of the three areas, extended from the upper end of Impasse 1 to the lower end of Impasse 2. The water in this area flowed very rapidly with numerous shallow rapids and small waterfalls. The furthest upstream part of Area Y was characterized by a deep narrow channel. The few pools in this area were deep and relatively productive.

Area "Z". This shortest of the three areas, was bounded by the upper end of Impasse 2 and No. 2 screen. It was very similar to area "X", with small rapids and fairly productive pools. On the west bank immediately above Impasse 2, a small unnamed tributary stream enters Gorge Creek.

(Each of the major pools was numbered in all areas beginning downstream. (See map of hatchery enclosure).) *omit.*

Native Enclosure. An old log jam situated half way between No. 2 and No. 3 screen, divided the native enclosure into two parts. The section of the stream is not bordered by rock walls and the pools are wider and shallower. The narrow gorge which began in the hatchery enclosure is widened considerably and small trees and shrubs grow along the banks.

Figure 4. A TAGGED TROUT, showing the white, unnumbered disc; the red, numbered disc, on the other side, does not photograph properly.

METHODS AND PROCEDURES

Experimental Trout

Two separate lots of cutthroat trout were planted in the hatchery enclosure. These plantings were made by the staff of the Calgary Provincial Hatchery.

The trout were tagged at the hatchery by Mr. A. C. Sinclair the Provincial Hatchery Superintendent. The tags consisted of two celluloid discs, each about the size of a dime, one red and one white. A nickel plated steel pin was pushed through the hole in the centre of the tag, then through the body of the fish immediately below the dorsal fin. The remaining tag was placed on the protruding pin and the pin clinched. The red disc bore the number in black and the words Alberta Government Fisheries Branch, Edmonton. The red disc was placed on the left side of the fish, the white disc on the right. The fish were anaesthetized before tagging to facilitate the operation. As each fish was tagged the number and weight were recorded. This method of tagging does not seem to cause mortality as tagged fish kept in the hatchery ponds suffered no more deaths than untagged.

Lot One. This consisted of 199 three-year-old cutthroat trout numbered from 201-400, ^{except no. 303.} They were hatched in Calgary and reared in the ponds at Westmount and Raven river rearing stations. This group ranged from 3.5-11 oz. and were

12-15 inches long, considerably larger than the native wild trout in Gorge Creek. They were planted on June 16th, 63 being released in Area "X" and 136 in Area "Z". There was no mortality during the two hour trip from Calgary and all seemed to be in good condition when liberated.

Lot Two. This consisted of 201 two-year-old cutthroat trout numbered from 401-600. Number 303 was planted with this lot also. They were hatched and reared in the ponds at the Calgary Hatchery. These fish ranged from 1.5-3.5 oz. and were 5-8 inches long. The planting took place on July 5th. Numbers 401-500 were released in Area "Z" and numbers 303 and 501-600 were released in Area "X". This lot was smaller than the native wild trout in Gorge Creek. The fish were in exceptionally good condition when released. They were of the same size groups that the Alberta Government hatchery usually distributes in their restocking operations.

Catching and Reweighing

Hatchery Trout. Angling operations were commenced about four days after planting. The hatchery trout were caught by angling with light tackle and small artificial flies. Due to heavy concentrations of hatchery fish in certain pools at night we obtained large numbers of recaptures using a flashlight and long handled dip net. This procedure was carried out on four or five occasions.

Each fish when recaptured was weighed with a small

package scale and then liberated. The number and weight were recorded. Using this method weights could be accurately obtained to the nearest half ounce. A file was kept for each of the four hundred hatchery fish and entries made when the fish were recaptured.

By these means 142 fish of lot one were reweighed, many, several times, and 124 of lot two.

Native Trout. Native trout caught while angling were marked by fin clipping and released. The number of fish marked in this manner and the number of recaptures were recorded daily. Native wild trout in the hatchery enclosure were called Hatchery Natives and were marked by the removal of the right pelvic fin. Native Trout in the native enclosure were marked by the removal of the left pelvic fin. Recaptures of native trout from the enclosures enabled the calculation of the numbers present.

Periodically throughout the summer, wild trout from both enclosures were killed, weighed and measured. The data obtained in this way were used to calculate the condition or relative heaviness of the fish so that any effect of the hatchery fish on the native fish might be observed.

MORTALITY OF PLANTED FISH

Lot One. During the first twenty-four hours after planting the vast majority of the hatchery fish planted in Area "Z" and Area "X" had been carried downstream by the

current. They were observed in large numbers around No. 1 screen and the adjacent pool, and seemed to be in a state of semi-shock. The hatchery fish exhibited a definite preference for quiet water and were hopelessly baffled by the current. About forty fish endeavoured to hold their own against the current and were lined up side by side in front of the screen. If the screen had not been present the major portion of the planting would have been swept out of Gorge Creek in a matter of hours. The hatchery fish required two weeks to become accustomed to the current and were not observed in fast water until the 14th day after planting. This date coincides with the first record of upstream migration.

The planted fish also exhibited complete loss of their natural protective instincts during the first three weeks making them an easy mark for predators. It is surprising that only two fish were found dead; the loss of natural protective instinct was most evident during the first three days, when fish lying in shallow water in front of the screen could be picked up with little difficulty. On the 18th day after planting we noticed that movement along the banks caused the hatchery fish to scatter. By the 21st day they had regained their natural alertness.

The majority of the planted fish made little effort to feed at the surface until the eighth day. On many occasions we witnessed a small native trout obtain a morsel of food borne by the current before the large hatchery trout had reached it.

Mortality commenced on the second day after planting. The bodies of the dead fish were washed against the screen. The screen was examined daily and the dead fish were reweighed and stomach contents examined. Examination of the stomach contents yielded varying results. Within the first two days after planting, three of the five fish found dead against the screen showed evidence of stream feeding. All the remaining hatchery fish that died showed no evidence of food. In most cases, the stomachs were collapsed and the intestines transparent. The two fish that were killed by predators were badly mutilated and the examination of stomach contents was impossible.

The daily mortality was based on the number of dead fish washed against the screen in a twenty-four hour period. By the twentieth day, 23.1% of the planting had been washed against the screen. Mortality continued at a somewhat slower rate until the forty-fourth day, by which time 30% of the planted fish had died. From the forty-fifth to the hundredth day, only one fish was found dead. Thus, at the end of one hundred days, 30.1% or sixty fish had died. During this recorded period, only one wild trout was found dead in the hatchery enclosure (except for a few killed by a violent hailstorm on August 10th, 1950).

The true mortality cannot be calculated from the number of fish found dead against the screen. One would imagine that dead fish thrown into the stream in Area "Z"

would be borne downstream by the current and be deposited against No. 1 screen. This was tried and the dead fish were never found. An unknown number of hatchery fish may have died and failed to drift down to the screen. These were termed 'hidden loss' and the numbers ascertained in the following manner.

We considered that the surviving hatchery trout had gone wild by the 15th of August, i.e., that they had acclimatized themselves to their new environment, and had become as hard to catch as the wild trout. Therefore, the ratio of hatchery trout to wild trout caught by angling would be the same ratio as their numbers in the stream. From the period August 19th-September 22nd, 44 lot one hatchery trout and 106 wild trout were caught. It will be shown later in this paper that the number of wild trout in the hatchery enclosure was 287. Thus:

$$\frac{\text{number hatchery trout caught}}{\text{number wild trout caught}} = \frac{\text{population of hatchery trout}}{\text{population of wild trout}}$$

or $\frac{44}{106} = \frac{x}{287}$ x, or population of hatchery trout = 119.

If we add the total known dead to the remaining population, $119 + 60 = 179$, we are only 20 fish short of the number planted. Due to a violent hailstorm on August 10th flooding occurred and we lost a small number of lot one hatchery fish into the Sheep River. Anglers returned nine tags, and from our own observations we know that 2 more fish are still in the river. We presume that our hidden loss for

lot one is nine fish. Such a small number will not appreciably affect our percentage loss and we can accurately state that the estimate of 30.1% represents the true mortality. We must then assume that as the trout weakened, they drifted downstream and died against the screen.

Lot Two. This planting was made on July 5th and differed from lot one in many respects. The lot two fish were more active when planted and encountered little difficulty moving upstream. They commenced surface feeding a few minutes after planting and seemed undisturbed by their new environment. For the first twenty-four hours the majority moved upstream. They were not baffled by the current and did not line up side by side in front of the screen. The fish maintained their natural alertness and in some respects were wilder than the native trout. They preferred to remain in relatively fast water and deep pools and were seldom observed in shallow water. There seemed a distinct possibility that the survivability of lot two would be excellent. On the second and third day heavy rain made the water turbid and surface feeding was greatly reduced.

Mortality began on the first day when one fish died. As with lot one, the dead fish^{were} washed against the screen where they were picked up, weighed and stomach contents examined. Only six stomachs showed evidence of stream feeding, but over one-third of the dead fish had food remains in the intestines. Mortality continued at a slow

rate for two days, then suddenly increased on the fourth and fifth days. The death rate reached a maximum on the sixth day when twenty-two dead fish were removed from the screen. By the fourteenth day, the high rate of mortality had fallen off, but 46.77% of the planting had died. Mortality continued at a slower rate until the thirty-seventh day by which time 55.72% of lot two was dead. From the thirty-seventh to the eighty-fifth day, one fish was found dead against the screen. The known mortality of lot two fish for a recorded period of eighty-five days was 113 fish or 56.22% of the planting.

As has been discussed for lot one fish, the known percentage loss may not represent the true mortality. It is most probable that the dead lot two fish, being small, would not be carried downstream by the current. It is also possible that the small fish in weakened condition would be more vulnerable to predators. So it is likely that some of the hatchery fish which died would not drift down against the screen and our known percentage loss would be too low.

An estimate of the hidden loss for lot two was made in the same manner as previously outlined for lot one, i.e., by comparing the ratio of the numbers of lot two fish caught by angling to the number of wild trout caught by angling in the same period. This would be equal to the ratio of the population of lot two trout to the known popu-

lation of wild trout. The estimate depends on the hatchery fish being completely wild and as difficult to catch as the native fish. To obtain sufficient numbers for a reliable estimate, it was necessary to use all the fish caught after August 1st. This date is less than a month after planting and there is a danger that the lot two fish had not gone completely wild. If so, our estimate would err by being too great. From our observations it seems apparent that the hatchery fish were as difficult to catch as the native fish and the estimate should be reasonably accurate.

During the period August 1st to September 28th, 13 hatchery fish and 154 native trout were caught. Later in this paper it shall be shown that the population of wild trout was 287 fish. Therefore:

$$\frac{\text{No. of lot 2 fish caught by angling}}{\text{No. of wild fish caught by angling}} = \frac{\text{population of hatchery trout}}{\text{population of wild trout}}$$

$$\text{or } \frac{13}{154} = \frac{x}{287}$$

$$x \text{ or population of hatchery trout} = 24$$

The known loss (113) added to the remaining population (24), gives us a record of 137 fish out of the 201 planted. By subtracting (201 - 137), we find the hidden loss of lot two is 64 fish. This does not represent the actual hidden loss, because it includes some of the fish that escaped around the screen on August 10th. Escaped fish cannot be considered in the percentage mortality. If we use these figures to determine a total percentage loss (known loss 113 + hidden loss 64),

we see that the mortality of lot two would be 88%. This percentage is not accurate because it includes escaped fish and is too high. We must consider the percentage mortality of lot two fish as greater than 56.2% and less than 88%.

This rather large range may be reduced by calculating the number of lot two fish which escaped around the lower screen on August 10th. Such a calculation may be made by assuming that the proportion of lot two fish that escaped was the same as the proportion of lot one fish that escaped; and, further, that loss in both lots was proportional to the number of fish in the stream. Now, ~~20~~¹¹ of 139 lot one fish escaped, or approximately 8%. If the same proportion of lot two fish escaped, the loss is 8% of 88 known survivors, or approximately ~~six~~^{seven} fish.

This estimate is further substantiated by determining the percentage loss of the wild trout around the screen. Table XII (Appendix) shows the population of wild fish was 307 on August 10th. The population of the wild trout at the end of the recorded period was 287 fish. The difference between these populations indicates that 20 wild fish escaped. The number of escaped wild trout (20) to the number present (307), shows a 7% loss of native fish through the screen. These figures are significant because they show the loss for both groups was relatively similar.

The ~~known~~^{estimated} number of escapees (6) subtracted from the calculated hidden loss (64) indicates an actual hidden loss of 58 fish. The known loss (113) added to the actual loss (58) gives a total mortality of 171 lot two fish or a

percentage mortality of 85%.

WEIGHT LOSS OF PLANTED FISH

The weight loss of the planted fish was determined by catching, reweighing and releasing live fish and by weighing dead fish removed from the screen. In this way, weight checks were made of 142 lot one fish and 124 lot two fish.

A number of lot one fish were reweighed a second time and a few three and one four times. The fish weighed three and four times are of particular interest as they illustrate individual case histories. These and several that were checked twice, with a long time interval between are shown in Table 1.

Figure 5. WEIGHT LOSS AND MORTALITY OF LOT ONE PLANTED TROUT

The enclosed circles represent fish that died; the open circles are fish released alive after re-weighing. The continuous curve is drawn through the average percentage of planted weight for each ten day period. The broken curve represents survival in percent of total number planted.

Table 1. Record of weight checks of several lot one fish;
weights expressed as percentage of planted weights.

Tag No.	First Wt. Check		Second Wt. Check		Third Wt. Check		Fourth Wt. Check	
of Fish	Day Weight		Day Weight		Day Weight		Day Weight	
293	14	90	78	100	-	-	-	-
312	31	78	43	71	-	-	-	-
325	42	117	93	133	-	-	-	-
328	22	82	48	91	-	-	-	-
373	11	86	90	75	-	-	-	-
231	10	100	39	83	52	75	-	-
343	33	80	38	80	68	80	-	-
344	21	75	23	72	70	53	-	-
378	26	78	46	82	64	93	-	-
393	12	71	26	64	68	57	-	-
289	33	114	49	143	64	135	85	114

These individual records show a gradual weight loss with time, but three show gains and one shows no change. To get a comprehensive view of the changes in weight of the planted fish, all the weights obtained were expressed as percent of planted weight and grouped in ten day intervals. In Figure 5 the data are presented graphically for lot one fish. The continuous curve represents the average percent of planted weights for each ten day interval. It shows that the lot one

Figure 6. WEIGHT LOSS AND MORTALITY OF LOT TWO PLANTED TROUT

The closed circles represent fish that died; the open circles are fish released alive after re-weighing. The continuous curve is drawn through the average percentage of planted weight for each ten day period. The broken curve represents observed survival up to 30 days and, thereafter, calculated survival.

fish lost weight for the first forty-five days, by which time they had gradually decreased to 77% of their planted weight. A few individuals fell as low as 63% and one 45%. From the forty-fifth to the hundredth day, the fish as a whole, slowly regained their lost weight; by the end of the recorded period they were approaching their original planted weight.

The broken curve on Figure 5 is the curve of observed survival, drawn by plotting the percent of numbers planted and still alive against time. It is interesting that around the forty-fifth to the fiftieth day, the survival became constant, i.e., mortality ceased at the same time as the surviving fish began to regain their lost weight.

Figure 6 shows the same data for the small lot two fish. They steadily lost weight for the first forty-five days, and decreased to 65% of their planted weight. By this time only a few lot two fish remained in the stream and weight checks became too infrequent to determine whether they had commenced to regain their lost weight.

POPULATION OF WILD TROUT

The mortality previously recorded indicates that the native trout in the stream may have influenced the sur-

vival of the hatchery fish by consuming most of the available food. It is important, then, to know the number of wild trout in the hatchery and the native enclosures.

A population estimate of the wild trout in each of the hatchery and native enclosures was made, employing the marking technique of Peterson (1896). The fish were caught by angling, the right pelvic fin was removed from the wild trout in the hatchery enclosure, the left pelvic fin from the wild trout in the native enclosure. The estimates depended upon a daily record of the number of marked fish released and the number of recaptures.

Ricker's (1942) modification of the Schnabel (1938) formula was used. The formula is $P = \frac{\sum AB}{\sum C}$ where -

P is the daily estimated population;

A is the number of fish caught on any date;

B is the number of marked fish at large;

C is the number of recaptures on any day;

AB is the product of A and B;

$\sum AB$ is the sum of all the products of AB to date;

$\sum C$ is the sum of all the returns to date.

The complete estimate is obtained when the daily totals become constant.

In an estimate of this type, we must assume that the marked fish suffer no greater mortality than the unmarked fish and the marked fish are as vulnerable to capture as the unmarked fish. A small degree of error is found in natural

mortality and the recruitment of small fish into the size group marked.

Table Xll (Appendix) shows that the day by day estimates for the hatchery enclosure became constant during the first week of August, at which time the population was 307 fish. On August 10th a violent hailstorm caused a loss of some of the hatchery native fish around No. 1 screen. The population estimate was continued and by September 22nd, the figures had again become constant at 287 fish. Thus, the loss of wild fish around the screen on August 10th was 20.

The same hailstorm necessitated a new estimate for the native enclosure. This was completed on September 19th and showed that 255 wild trout were present in the native enclosure. (Table Xlll Appendix).

EFFECT OF HATCHERY TROUT ON WILD TROUT

The most convenient method of estimating the condition of a fish, i.e., whether it is in poor or good shape, is by use of the law that the weight of a solid body increases as the cube of its linear dimensions. In fish, the weight is roughly equivalent to the length cubed. The formula is expressed:

$$K = \frac{W}{L^3} \quad \text{where -}$$

K is the condition factor;

W is the weight of the fish;

L is the fork length.

If we divide the weight by the length cubed the answer will be approximately one. The number K, or the condition factor, is a good indication of the relative heaviness or condition of the fish. Generally speaking, a condition factor of one or greater indicates the fish is in good shape and a factor of less than one indicates poor condition.

Wild trout were removed from both enclosures during the early and late part of the summer and the condition factors calculated. All the hatchery fish that died were measured and the factors calculated. A comparison of the condition factors of wild trout from the two enclosures is shown in the following table.

Table 11. Condition factors of wild trout from the hatchery enclosure compared with those of trout from the native enclosure.

Date	Hatchery enclosure		Native enclosure	
	No. of fish	K factor	No. of fish	K factor
May & June	6	0.88	10	0.90
August	10	0.98	9	1.02

The table shows that the wild trout in both enclosures came out of the winter in poor shape (average condition factor of 0.88 and 0.90). As the food supply became plentiful, the wild trout slowly improved and by the end of the summer they were in good shape (average condition factors of 0.98 and 1.02). Thus, the wild trout in both areas regained ^{during the summer} (after wintering) and were now going into the winter in good shape. The wild trout in the control area showed no significant difference from those in the hatchery enclosure. Thus, we may conclude that the wild fish suffered little from competition with the introduced fish; in reality the wild trout consumed the majority of the food and the hatchery fish suffered.

A comparison of the condition factors for the hatchery fish at planting and at time of death is shown in Table III.

Table III. Condition factor of lot one fish at planting and time of death.

Fish No.	Length mm.	Planted Weight gm.	Planted Condition Factor	Dead Weight gm.	Condition Factor at Death	Days after Planting
224	228	142	1.2	99	0.85	16
248	286	255	1.09	213	0.91	43
259	251	184	1.16	133	0.84	43
264	241	170	1.23	127.5	0.92	12
323	255	170	1.02	142	0.85	14
338	261	213	1.19	156	0.87	13
278	229	142	1.18	99	0.82	20

The table shows that the hatchery fish were planted in good shape but due to loss in weight were in very poor condition at time of death. Condition factors calculated from surviving hatchery trout in August showed an average of 0.85, which is further proof that the surviving fish were approaching the winter in poor condition. It is not surprising then that few hatchery fish survive the winter following planting.

CAUSES OF MORTALITY

The data on the survival and mortality of the hatchery fish after planting invite speculation as to the causes of mortality. The data on K factors show that the planted fish were fat and healthy when placed in the stream; but soon after, a large percentage of each planting was lost. For the lot one fish, the mortality commenced on the second day and over half of the total mortality occurred during the first two weeks. By the 60th day 30.15% of lot one fish had died. The smaller lot two fish did not fare as well and over half of the total mortality occurred during the first fourteen days and continued until the 37th day, by which time 56.22% were dead. In both cases, the greatest loss was observed during the period immediately following planting. It must be concluded, then, that at

least half of the total mortality was due to the change from the rearing pond to the stream. For the lot one fish, the initial heavy mortality ceased on the 20th day, and on the 12th day for the second planting. It is evident that the initial mortality exceeded later mortality and, therefore, that the change from domestic to wild habitat accounts for a major share of the deaths.

Lot One. From our observations, we believe that the lot one fish possessed a considerable energy reserve. This fact was further substantiated when we found a large amount of fat tissue in all the dead fish. During the period of initial mortality, the hatchery fish did not actively feed and appeared to be in a state of semi-shock. They were therefore forced to rely on their large energy reserve to maintain life. The most pronounced effect of shock was evidenced in their complete loss of protective instinct. The temporary abnormal shock condition appears to be the most important cause of the initial mortality. It was accentuated by the change of environment from the quiet waters of the hatchery ponds to the current of the stream, the daily variation in stream temperatures and the turbidity of the water. The weight curve in Figure 5 shows that the fish lost weight consistently during the period of initial mortality; this is understandable when one considers the tremendous drain on their energy reserve. When the energy reserve became exhausted, the fish died. This also

explains why the fish planted in Area "Z" drifted downstream as they weakened and eventually died against the screen.

Two weeks after planting, the shock conditions had begun to decrease and by the 20th day the heavy initial mortality had ceased. The fish that survived were in a very weakened state and on the average were down to 83% of their planted weight. They were hungry and made continuous efforts to obtain food, but were hampered because they did not know how to feed (having been fed in the hatchery all their lives), and by the competition of the wild trout. As was previously mentioned, on numerous occasions we have observed the wild trout obtain a morsel of food borne by the current before the hatchery fish could reach it. They continued to die until the 60th day, by which time the surviving fish had become acclimatized and were slowly regaining their lost weight.

A daily temperature check of Gorge Creek showed that there is a range of 12-46⁰ F. during a 24-hour period. The lot one fish were kept in hatchery ponds which varied from 38-40⁰ F. Gorge Creek, during the month of June and early July, had an extreme temperature range of 36-60⁰ F., with a daily average of 45-55⁰ F. (Figure 3). It is possible that the change in temperatures was a cause of the shock condition and resultant mortality.

An unexplainable mortality of five lot one fish

occurred on the 43rd-44th day, when the water became very muddy. At this time, most of the hatchery fish were beginning to regain their lost weight and it seems evident that the extreme turbidity may have influenced the mortality. The stream was very turbid on the second, third and fourth days following planting and on four other occasions during the first three weeks. It is very likely that these conditions in some way affected the initial mortality.

It is difficult to say whether all the surviving fish would regain their lost weight before winter. But it is safe to assume that the hatchery fish were entering the period of food scarcity in poor condition and would not be able to maintain themselves over the winter. It is not surprising then that so few hatchery fish are found in streams during the season following planting.

Lot Two. The lot two fish were active when placed in the stream but seemed to possess a low energy reserve. They became acclimatized immediately and were attempting to feed soon after planting. We had hoped that the survival of this planting would be excellent as long as conditions remained appropriate for feeding and the fish were not forced to rely on their low reserve energy.

Heavy rain on the second and third day after planting reduced surface feeding to a minimum. The fish were forced to fall back on their reserve energy which was soon exhausted. It is not surprising then, that the heavy

mortality commenced on the third and fourth day, reaching a maximum on the sixth day when 22 fish died. The survival was hardly dependent upon weather and stream conditions, because the small fish were further hindered in their competition for food by the native trout. Examination of stomach contents showed that only six of the 113 fish had recently fed. Figure 6 shows that some of the hatchery fish that died during the period of initial mortality had lost weight while others had not. The fish that died and did not lose weight had little or no energy reserve to maintain them, while the others had a small energy reserve which was soon depleted. The loss of the small energy reserve resulted in a decrease in planted weight. Figure 6 further shows by the tenth day after planting the majority of the lot two fish had dropped to 77% of their planted weight. As shown by the large numbers of closed circles in the first ten day interval, these data are mainly based on dead fish and indicates that the average fish possessed an energy reserve equivalent to 23% of its weight. The severe initial mortality was the direct result of a low energy reserve, poor feeding conditions and the keen competition of the wild trout.

The surviving lot two fish were leading a meagre existence. Their life was dependent on the small amount of food obtained each day and their slowly diminishing

reserve of energy. If either of the two sources failed or was radically decreased due to environmental conditions, the fish died. Thus, from the 14th to 37th day, 21 fish died. Out of the 100 lot two fish planted in Area "Z", 55 drifted downstream and died against No. 1 screen. This is a good indication that the weak fish unable to fight the current drifted downstream and died against the screen. By the 37th day, 113 lot two fish had died. So few remained that our weight checks became too infrequent to determine whether the lot two fish were regaining their planted weight. In the meantime, the wild trout had been feeding all summer and were now prepared to enter the winter in good condition.

Thus, we can conclude that under the present hatchery policy it is impractical to plant hatchery-reared trout. The artificial environment of the hatchery does not produce fish that are conditioned to natural environment. The hand feeding to which they have become accustomed has not prepared them for foraging in the streams. As evidenced in both plantings, the weakened fish drifted downstream and would have been swept into the Sheep River had the screen not been present. It is not difficult to understand why the present policy of hatchery planting is not improving the sport fishing in Alberta streams.

EFFICIENCY OF NATURAL REPRODUCTION

Throughout the summer, information was gathered on the natural reproduction of the wild trout in Gorge Creek. Before spawning commenced, ripe female trout were caught and the number of eggs counted. After spawning, the redds were dug up and the number of fertile and infertile eggs were counted. When the fry had hatched, fry counts were made in the section of stream above the experimental area.

Egg Counts. Ten ripe female trout were caught above the experimental area during the period June 2nd-10th. The measurements, weights and number of eggs contained are shown in Table IV.

Table IV. Weights, lengths and number of eggs of female cutthroat trout caught in Gorge Creek immediately prior to spawning.

Fish No.	Weight (oz.)	Length (m.m.)	No. of Eggs
7	2½	205	299
11	3	204	293
12	3	208	323
13	2½	206	302
16	4	225	300
19	2½	190	300
20	3	210	300
21	6	246	562
25	2	198	210
26	3	222	309

The trout had an aggregate weight of 31.5 oz. and held 3,198 eggs or roughly 100 eggs per ounce of body weight. If we consider the average female trout weighs 3 oz., we can conclude that the average egg production is 300 per female.

Eggs in Redds. During the period May 23rd-June 11th, the lower four miles of Gorge Creek were examined several times weekly for the presence of spawning redds. The first eggs were recovered from redds on June 23rd. Examination of spawning areas was continued throughout July

and August and the results are shown in the following table.

Table V. Results of examination of spawning areas in Gorge Creek.

	Size of Area Examined	No. of Fertile Eggs	No. of Dead Unfertilized Eggs	Remarks
May 23-				
June 11	4 miles	-	-	-
June 12	4 sq.ft.	23	-	-
June 12	36 sq.ft.	-	-	-
June 12	8 sq.ft.	3	-	-
June 12	28 sq.ft.	-	-	-
June 14	Several pools	-	-	-
June 15	3 pools	-	-	-
June 17	1 mile	-	-	-
June 21	4 sq.ft.	19	-	-
June 24	1 pool	3	-	-
June 24	4 sq.ft.	20	-	-
June 24	4 sq.ft.	12	-	-
July 1	1 pool	146	1	-
July 1	1 pool	10	-	2 floating
July 11	8 sq.ft.	19(eyed)	-	6 shells
July 18	1 pool	-	-	-
July 18	4 sq.ft.	32	-	Recently deposited
Aug. 1	1 mile	-	-	-
Aug. 1	1 mile	-	-	Fry present

The aforementioned table shows that a total of 287 eggs were removed from redds and examined; of these 3 were dead, but only one was infertile. This indicates that 99% of the eggs deposited in the gravel are fertilized. The presence of six egg shells in a redd on July 11th indicates that hatching had already taken place. Fry were observed on July 29th and by the first week of August, large numbers were common in the stream.

Fry Counts. During the month of August fry counts were made by walking slowly along the stream and counting all the fry lying in the quiet water. It is evident that some of the fry would not be observed. It was therefore necessary to determine the ratio of the numbers observed to the actual numbers present. This was accomplished by enclosing an area of approximately 2.5 sq. ft. with fine screen and counting the numbers present. All the rocks and debris under which the fry were hiding were then removed from the enclosed area and the actual number present was determined. This procedure was repeated in six different areas and the results are presented in Table VI.

Table VI. Comparison of the number of fry observed to the number present in a screened area of $2\frac{1}{2}$ sq. ft.

Date	Area	No. Observed	No. Actually Present
Aug. 30	1	6	14
Aug. 30	2	1	3
Aug. 30	3	1	1
Sept. 14	4	4	9
Sept. 14	5	1	2
Sept. 14	6	2	5

The table shows that a total of 15 fry were observed and on removal of all hiding places, 34 were present; therefore approximately twice as many fry are present in an area (^{As} ~~than~~) one observes.

By counting the number of fry observed in a 300 yard area and then multiplying by two, we ^{CAN} ~~could~~ obtain an (~~accurate~~) estimate of the number present. As the fry are found on both sides of the stream and not in the middle, it is necessary to multiply the corrected figures by two for an accurate estimate. Table VII shows the results of fry counts made during August and the applied corrections.

Table VII. Results of fry counts on one side of a 300 yard section of Gorge Creek.

Date	No. Fry Observed	Estimated No. Present (Correction Applied)	Remarks
Aug. 15	15	30	Size $\frac{3}{4}$ -1 inch
Aug. 15	39	78	Size $\frac{3}{4}$ -1 inch
Aug. 24	70	140	2 with yolk sacs
Aug. 24	27	54	-

Note: The areas examined on August 24th had previously yielded large numbers of eggs.

The latter estimates are reasonably accurate, as most of the eggs were hatched by this date. A calculation based on the average of the numbers observed on August 24th shows that there were 1,136 fry in one mile of the stream above the experimental area.

Spawning Records. Examination of gonads of fish caught over the summer enabled us to determine the approximate date that spawning commenced. Examination of females killed during the period May 24th to June 14th showed that the ovaries were rapidly ripening, and on June 19th we caught the first spent female. As this estimate is based on random sampling, it is impossible to fix any set date, but we believe that spawning commenced around the 14th of June and continued until approximately August 15th, when the last spent female was caught. The daily maximum and minimum temperatures of the stream are presented graphically in Figure 1. During the approximate spawning season, the minimum temperature recorded was 41° F. and average daily minima $45-46^{\circ}$ F. The maximum daily temperature varied from $52-67^{\circ}$ F.

Efficiency of Natural Reproduction. We have seen that the average female cutthroat trout in Gorge Creek weighs 3 ounces and releases approximately 300 eggs during spawning. Of these, 99% are fertilized. The population estimates of the experimental enclosures show there is a native population of approximately 300 fish per mile. The upper part of Gorge Creek where this work was performed has a much heavier concentration and it is reasonably safe to assume that there are 600 wild trout per mile. Considering that half these fish are females, the average egg deposition would be 90,000 per mile. But 1,136 fry were counted per mile. The

efficiency is therefore about 1.26%. This enormous loss probably occurs at spawning when a large number of the eggs may be swept downstream. Even though the efficiency is 1.26%, 1,136 fry per mile are more than the stream can support, since the normal adult population of all age groups is approximately 600 fish.

Even though these figures are based on too few samples and can only be considered rough approximations, (it is obvious that a closed stream containing a brood stock could restock itself in a period of three to four years.) } omit.

SUMMARY

During the summer of 1950, Gorge Creek, a typical mountain stream of the east slope drainage in Alberta, was used for an experiment on the survival of four hundred hatchery-reared cutthroat trout. Two areas, each three quarters of a mile long and known to contain a population of wild trout, were marked off with fish tight screens. Into one of the areas, four hundred tagged and individually weighed hatchery-reared trout were planted; the other area served as a control. The experimental trout were of two size and age groups; lot one consisted of 199, 12-15 inch trout approximately three years old and were planted on June 16, 1950; lot two was of 201 6-8 inch trout approximately two years old; these fish were planted on July 5, 1950.

The lot one fish were considerably larger than the wild trout in the stream, while the lot two fish were somewhat smaller than the average wild trout.

Soon after planting, catching and reweighing operations were commenced. The hatchery fish were caught by angling with light tackle, weighed and returned to the stream. The planted fish that died were washed against the lower screen where they were collected and weighed, and the stomach contents examined. In this way individual records of the loss in weight of both surviving and dead fish were recorded. By this means 142 lot one fish were reweighed, many, several times, and 124 lot two fish were reweighed. Native trout caught while angling in the enclosures were marked by fin clipping and the number of recaptures obtained during the summer enabled a calculation of the population in each enclosure.

Within 24 hours after planting, the majority of the planted fish were swept downstream by the current and would have been lost into the Sheep River if the fish tight screens had not been present. The lot one fish were hopelessly baffled by the current and exhibited a complete loss of their protective instinct. The mortality commenced on the second day after planting. Over half of the total mortality of lot one fish occurred during the first twenty days following planting and then continued slowly until the 44th day, by which time 30% of the lot one fish had died.

The surviving fish lost weight until the 55th day and had decreased to an average 77% of their planted weight. Soon afterward, they began to regain their lost weight and by the 100th day were approaching their original planted weight.

The total number of dead fish removed from the screen each day represents the known mortality but does not account for fish that died upstream and did not drift down to the screen to be collected. This loss was termed 'hidden loss' and was calculated to consist of 20 fish. These twenty necessarily include fish lost around the screen on August 10th when heavy rains caused a wash around one side of the lower screen. Other calculations showed that 11 fish were lost around the screen and the actual hidden loss was only 9 fish. Such a small number would not appreciably affect the percentage mortality and it would be safe to assume that the mortality of lot one planting was 30.1% for the first 100 days following planting.

The lot two fish were more active when planted and seemingly became acclimatized immediately. Mortality commenced on the first day after planting and over half of the total mortality of lot two fish occurred during the first 12 days, by which time 47% had died. The mortality continued at a lesser rate until the 37th day by which time 113 fish or 56.2% were known to be dead. A population estimate of the lot two fish, showed that 24 remained in the enclosure at the end of the recorded period. The hidden

loss of 64 fish included the fish that died and were not retrieved and a number of fish lost around the screen due to flooding on August 10th. Further calculations showed that approximately six fish escaped around the screen and the actual hidden loss was 58 fish, resulting in a total mortality of 171 lot two fish or a calculated percentage mortality of 85%. Lot two represents the size group planted by the Alberta Government in their restocking operations during the last few years. It is not surprising then that the restocking program is not showing results to the angler.

The lot two fish steadily lost weight for the first forty-five days and decreased to 65% of their planted weight. By this time so few lot two fish remained that it was impossible to determine whether they would regain their lost weight before winter.

The results of the day by day population estimate showed that 307 wild trout were in the hatchery enclosure on August 10th and 287 on September 22nd. Thus approximately 20 wild trout were lost around the screen on August 10th. The population estimate for the control area showed that 255 wild trout were present on September 19th.

Examination of wild trout from the experimental and control area showed that they came out of the winter in poor condition (K factor of 0.88). After feeding all summer, their condition had improved and by August they were in good shape and were going into the winter with a condition factor

of 0.98. The condition of the wild trout in the hatchery enclosure and in the control area showed no significant difference. We must therefore conclude that the presence of the hatchery fish did not affect the wild fish.

The condition factor of two lot one fish in August was 0.81. Thus, in August, the planted fish were in the same condition as wild fish in the spring; their chances of wintering successfully lacking a reserve of fat do not appear very good.

The initial mortality of the lot one planted fish was attributed to a shock condition induced by a change of environment, variations in stream temperature and turbidity of the water. The effects of the shock were revealed in the loss of protective instinct and the cessation of feeding. From observations, it seems probable that the lot one fish did not know how to obtain food in natural surroundings and that a high energy reserve played a dominant role in their low mortality.

The lot two fish suffered a heavy initial mortality due to inability to obtain food under natural conditions and the competition with the wild trout. These combined factors slowly induced starvation. They were not as visibly affected by shock and their seemingly low energy reserve was rapidly consumed with a resultant heavy mortality.

A study of naturally spawned eggs in redds showed that 99% were fertile. Fry counts later in the season led

to an estimate of 1,136 fry per mile. This figure indicates that there is a large loss of eggs at some time during the spawning to fry stages of the life cycle; of the potential egg supply, 1,136 fry represent only 1.2%.

CONCLUSIONS

1. If the fish tight screens had not been present, the current would have swept the majority of the hatchery-reared trout out of the stream in the first twenty-four hours following planting.
2. Trout raised in the artificial environment of a hatchery do not possess the ability to maintain themselves when planted with wild trout.
3. Hatchery-reared trout, due to their failure to compete with wild trout for food, begin to lose weight soon after planting.
4. The mortality of 6-8 inch planted trout is almost three times that of 12-15 inch trout.
5. The wild trout in the stream are relatively unaffected by the presence of planted fish.
6. The planting of hatchery-reared trout in a stream already supporting a population of wild trout of the same species is uneconomical and does not contribute to the brood stock of the stream. Hatchery plantings made in

open streams will only benefit angling for a short while after planting.

7. Natural reproduction in Gorge Creek produced, in 1950, approximately eleven hundred fry per mile; while this quantity is only 1.2% of the potential egg supply, it is considerably more fish than the stream can support to adult size.

ACKNOWLEDGMENTS

This work was carried out as the major part of the 1950 programme of the Alberta Biological Station. I am grateful to the Department of Lands and Forests, Province of Alberta, and to the University of Alberta (the two organizations which sponsored this station) for the opportunity to participate in this study.

I am particularly indebted to Mr. H. B. Watkins, Superintendent of Fisheries, and to various members of his staff who had a share in the work; to Mr. W. H. Macdonald, Inspector of Fisheries, for his continued assistance and guidance throughout the summer; to Mr. A. C. Sinclair, Alberta Government Superintendent of Hatcheries, who completed the enormous task of weighing and tagging the experimental fish; and to the staff of the Calgary Hatchery who completed the plantings without loss; to Ranger J. E. Butler, Bighorn Station, and his staff who assisted on numerous occasions.

I wish to express my sincere gratitude to my partner in the field, Mr. M. Paetz, who helped collect the data and unsparingly put forth every effort to make the experiment a success; and to Mrs. L. Morris and Miss M. O'Byrne, for their aid in typing the manuscript.

I am also indebted to Dr. R. B. Miller, Department of Zoology, University of Alberta, for his assistance in organizing the experiment, interpreting the data and presenting the results.

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APPENDIX

Table VIII:	Known mortality of lot one fish planted on June 16th, 1950.
Table IX :	Known mortality of lot two fish planted on July 5th, 1950.
Table X :	Record of weight checks of lot one fish expressed as percentage of planted weights.
Table XI :	Record of weight checks of lot two fish expressed as percentage of planted weights.
Table XII :	Population estimate of wild trout in the hatchery enclosure.
Table XIII:	Population estimate of the wild trout in the native enclosure.

Table VIII

KNOWN MORTALITY OF LOT ONE FISH PLANTED JUNE 16th, 1950.

Date	No. Days After Planting	No. Dying per Day	Total Known Dead	Known Percent Loss
June 16th	-	-	-	-
17th	1	-	-	-
18th	2	3	3	-
19th	3	2	5	2.51
20th	4	-	5	2.51
21st	5	1	6	3.02
22nd	6	-	6	3.02
23rd	7	-	6	3.02
24th	8	-	6	3.02
25th	9	2	8	4.02
26th	10	2	10	5.03
27th	11	3	13	6.53
28th	12	5	18	9.05
29th	13	5	23	11.06
30th	14	7	30	15.08
July 1st	15	3	33	16.58
2nd	16	4	37	18.69
3rd	17	2	39	19.59
4th	18	4	43	21.60
5th	19	1	44	22.11
6th	20	2	46	23.11
7th	21	-	46	23.11
8th	22	-	46	23.11
9th	23	-	46	23.11
10th	24	1	47	23.60
11th	25	1	48	24.12
12th	26	1	49	24.63
13th	27	-	49	24.63
14th	28	-	49	24.63
15th	29	1	50	25.12
16th	30	1	51	25.62
17th	31	1	52	26.12
18th	32	-	52	26.12
19th	33	-	52	26.12
20th	34	-	52	26.12
21st	35	1	53	26.63
22nd	36	1	54	27.14
23rd	37	-	54	27.14
24th	38	-	54	27.14
25th	39	-	54	27.14

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Table VIII (cont.)

Date	No. Days After Planting	No. Dying per Day	Total Known Dead	Known Percent Loss
July 26th	40	-	54	27.14
27th	41	-	54	27.14
28th	42	-	54	27.14
29th	43	4	58	29.14
30th	44	1	59	29.64
31st	45	-	59	29.64
Aug. 1st	46	-	59	29.64
2nd	47	-	59	29.64
3rd	48	-	59	29.64
4th	49	-	59	29.64
5th	50	-	59	29.64
6th	51	-	59	29.64
7th	52	-	59	29.64
8th	53	-	59	29.64
9th	54	-	59	29.64
10th	55	1	60	30.15
11th	56	-	60	30.15
12th	57	-	60	30.15
13th	58	1#	61	
14th	59	1#	62	
15th	60	1#	63	
16th	61	-	63	
17th	62	-	63	
18th	63	-	63	
19th	64	-	63	
20th	65	-	63	
21st	66	1#	64	
22nd	67	-	64	
23rd	68	-	64	
24th	69	-	64	
25th	70	-	64	
26th	71	-	64	
27th	72	1#	65	
28th	73	-	65	
29th	74	-	65	
30th	75	-	65	
31st	76	-	65	
Sept. 1st	77	-	65	
2nd	78	1#	66	
17th	93	2#	68	
28th	104	-	68	

#Fish which escaped from hatchery enclosure on August 10th and recaptured in the Sheep River.

Table IX

KNOWN MORTALITY OF LOT TWO FISH PLANTED JULY 5th, 1950.

Date	No. Days After Planting	No. Dying per Day	Total Known Dead	Known Percent Loss
July 6th	1	1	1	-
7th	2	1	2	-
8th	3	3	5	2.49
9th	4	11	16	7.96
10th	5	16	32	15.92
11th	6	22	54	26.86
12th	7	13	67	33.33
13th	8	10	77	38.31
14th	9	6	83	41.29
15th	10	4	87	43.28
16th	11	2	89	44.28
17th	12	3	92	45.77
18th	13	-	92	45.77
19th	14	2	94	46.77
20th	15	-	94	46.77
21st	16	2	96	47.76
22nd	17	-	96	47.76
23rd	18	1	97	48.25
24th	19	-	97	48.25
25th	20	-	97	48.25
26th	21	1	98	48.76
27th	22	-	98	48.76
28th	23	2	100	49.75
29th	24	1	101	50.25
30th	25	7	108	53.73
31st	26	-	108	53.73
Aug. 1st	27	1	109	54.23
2nd	28	-	109	54.23
3rd	29	-	109	54.23
4th	30	-	109	54.23
5th	31	2	111	55.22
6th	32	-	111	55.22
7th	33	-	111	55.22
8th	34	1	112	55.72
9th	35	-	112	55.72
10th	36	-	112	55.72
11th	37	1	113	56.22
12th	38	-	113	-
13th	39	-	113	-
14th	40	-	113	-
Sept. 28th	85	-	113	-

Table X

RECORD OF WEIGHT CHECKS OF LOT ONE FISH EXPRESSED AS
PERCENTAGE OF PLANTED WEIGHTS.

Tag No.	First Wt. Check	Second Wt. Check	Third Wt. Check	Fourth Wt. Check
of Fish	Day Weight	Day Weight	Day Weight	Day Weight
201	15 100			
203	16 92			
206	11 92	33 83		
208	42 91			
209	11 83	33 75		
210	58 81			
211	18 100#			
212	38 100			
213	54 57			
214	73 87.5			
215	60 82			
218	21 64			
222	9 78	42 57		
223	75 106#			
224	16 70#			
226	11 87	39 100#		
227	9 85	18 - #		
228	12 90#			
229	48 82			
230	19 77#			
231	10 100	39 83#	52 75	
232	19 87	20 87#		
233	21 86	33 71		
235	69 71			
237	79 -			
238	33 112	64 137		
239	11 87			
242	18 100#			
243	11 100#			
244	9 112	15 100	28 100	
245	26 100			
246	38 80	102 - #		
248	11 89	43 83#		
249	9 78	22 75#		
250	15 94			
251	16 78#			
253	9 112#			

Table X (cont.)

Tag No.	First Wt. Check		Second Wt. Check		Third Wt. Check		Fourth Wt. Check	
of Fish	Day Weight		Day Weight		Day Weight		Day Weight	
255	33	67						
257	2	91#						
259	42	80	43	73#				
261	48	110	88	100				
262	3	100#						
263	22	75	33	80	35	89#		
264	12	75#						
265	14	87#						
266	73	87						
268	22	75	44	69				
269	38	110	59	110				
270	33	89	37	89#				
271	21	83	23	83				
272	12	100#						
275	23	94	25	94#				
277	88	67						
278	13	70	20	70#				
279	22	74	42	79				
280	21	75	23	75				
281	48	100						
282	13	90#						
284	14	100#						
286	3	86#						
287	11	87.5						
288	33	117						
289	33	114	49	143	64	135	85	114
291	18	87.5#						
292	70	125	73	125				
293	14	90	78	100				
294	14	45						
296	13	122						
297	26	132						
298	26	70						
299	2	100#						
301	15	91	48	94				
304	42	86						
305	68	86						
306	14	82						
307	11	100						
310	19	83	52	83				
311	72	90						

Table X (cont.)

Tag No.	First Wt. Check		Second Wt. Check		Third Wt. Check		Fourth Wt. Check	
of Fish	Day Weight		Day Weight		Day Weight		Day Weight	
312	31	78	43	71 [#]				
314	66	72	73	72				
315	78	85	80	80				
316	16	90 [#]						
318	14	83 [#]						
319	10	100 [#]						
321	22	75						
322	12	81 [#]						
323	14	83 [#]						
324	14	72 [#]						
325	42	117	93	133				
327	66	115	88	115				
328	22	82	48	91				
330	9	108						
332	10	75						
333	38	50						
334	14	89 [#]						
336	12	93	30	93 [#]				
338	13	73 [#]						
339	42	65						
340	23	86						
342	80	75						
343	33	80	38	80	68	80		
344	21	75	23	72	70	53		
345	22	62	23	62				
346	15	91 [#]						
347	9	92 [#]						
348	52	75	85	83				
349	43	75 [#]						
351	22	75	23	75				
352	12	67 [#]						
353	27	61	70	67				
354	48	91						
355	43	67 [#]						
356	70	61						
357	17	77 [#]						
358	13	77 [#]						
359	10	90 [#]						
360	73	84						
362	66	105	70	105				
363	73	92	85	92				

Date	Time	Location	Weather	Wind	Sea
10/10/2023	14:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	15:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	15:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	16:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	16:30	Port of Call	Sunny	10 knots	Calm

Date	Time	Location	Weather	Wind	Sea
10/10/2023	17:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	17:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	18:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	18:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	19:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	19:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	20:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	20:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	21:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	21:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	22:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	22:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	23:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	23:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	00:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	00:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	01:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	01:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	02:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	02:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	03:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	03:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	04:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	04:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	05:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	05:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	06:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	06:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	07:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	07:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	08:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	08:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	09:00	Port of Call	Sunny	10 knots	Calm
10/10/2023	09:30	Port of Call	Sunny	10 knots	Calm
10/10/2023	10:00	Port of Call	Sunny	10 knots	Calm

Table X (cont.)

Tag No.	First Wt. Check		Second Wt. Check		Third Wt. Check		Fourth Wt. Check	
of Fish	Day Weight		Day Weight		Day Weight		Day Weight	
364	49	78						
365	11	85#						
366	13	86#						
367	70	71						
370	42	67	55	80#				
371	13	83#						
372	11	75#						
373	11	86	90	75				
374	13	81	21	87				
375	22	76						
376	2	- #						
377	14	83#						
378	26	78	46	82	64	93		
383	48	70						
386	73	77	98	81				
387	23	73	24	80				
390	33	82						
391	21	71	29	75#				
393	12	71	26	64	68	57		
395	73	77						
396	16	75#						
397	5	100#						
399	38	73	70	73				

#Fish found dead against the screen.

Note: In cases where there is no entry in the weight column, the tags only were found, or no weight obtained.

Table XI

RECORD OF WEIGHT CHECKS OF LOT TWO FISH EXPRESSED AS
PERCENTAGE OF PLANTED WEIGHTS.

Tag No.	First Wt. Check		Second Wt. Check		Third Wt. Check		Fourth Wt. Check	
of Fish	Day Weight		Day Weight		Day Weight		Day Weight	
402	20	100	24	75#				
403	7	66#						
404	4	100#						
407	35	66						
408	10	75#						
409	8	87#						
410	24	75#						
411	11	40#						
412	23	50						
416	7	80#						
417	10	75#						
419	5	100#						
420	6	75#						
422	20	66						
426	7	85#						
430	4	64#						
431	20	42	24	55#				
432	7	80#						
433	4	71#						
435	6	66#						
437	6	58#						
438	7	80#						
439	14	50	25	100#				
440	8	83#						
441	6	50#						
442	6	80#						
443	7	100#						
445	36	83						
446	3	70	4	70	8	80#		
447	11	50#						
449	6	75#						
451	4	75#						
452	8	80#						
453	5	66#						
455	14	50						
456	8	58#						
458	8	66#						

Table XI (cont.)

Tag No.	First Wt. Check	Second Wt. Check	Third Wt. Check	Fourth Wt. Check
of Fish	Day Weight	Day Weight	Day Weight	Day Weight
459	31	- #		
461	5	87#		
462	6	58#		
464	6	58#		
465	5	70#		
467	6	66#		
468	3	81	4	81#
471	25	80#		
473	7	83#		
474	4	87#		
475	5	83#		
476	5	80#		
478	6	50#		
481	7	83#		
482	3	62#		
483	23	- #		
485	4	57#		
487	7	83#		
490	14	58	33	50
491	8	62#		35
493	5	75#		83#
494	9	66#		
495	6	71#		
496	12	64#		
497	6	87#		
499	37	41#		
502	23	75#		
503	27	60#		
504	6	75#		
505	14	80#		
507	14	70#		
508	24	75#		
509	12	75#		
512	9	83#		
513	7	83#		
515	14	87	17	87#
516	10	66#		
518	19	57		
520	3	50#		
521	24	75#		
522	6	87#		

 
Q3 2122	21,150,000

Table XI (cont.)

Tag No.	First Wt. Check	Second Wt. Check	Third Wt. Check	Fourth Wt. Check
of Fish	Day Weight	Day Weight	Day Weight	Day Weight
526	5	83#		
527	6	70#		
528	6	75#		
529	33	80		
530	9	87#		
532	5	100#		
533	6	80#		
534	66	80		
535	18	56#		
536	14	50#		
537	2	100#		
539	18	42#		
544	6	80#		
546	4	75#		
547	6	83#		
548	8	87#		
549	19	50	21	87#
550	12	85#		
552	4	90#		
553	25	75#		
554	3	87#		
555	5	100#		
556	7	100#		
557	5	100#		
558	4	75#		
559	6	80#		
560	5	50#		
561	5	75#		
562	8	66#		
563	8	75#		
564	10	75#		
568	5	100#		
569	5	100#		
571	5	100#		
573	14	71	17	85
574	7	80#		
578	9	50#		
579	7	80#		
581	8	100#		
586	6	62#		
587	6	58#		

Table XI (cont.)

Tag No.	First Wt. Check	Second Wt. Check	Third Wt. Check	Fourth Wt. Check
of Fish	Day Weight	Day Weight	Day Weight	Day Weight
591	14	80#		
594	20	100#		
597	47	66		
598	6	80#		
600	9	75#		

#Fish found dead against the screen.

Note: In cases where there is no entry in the weight column the tags only were found, or no weight obtained.

Table XII.

POPULATION ESTIMATE OF WILD TROUT IN THE HATCHERY ENCLOSURE

Date	A	No. Marked and Ret'd	B	AB	Σ AB	C	Σ C	No. Killed Not Marked	P
June 17	1	1	-	-	-	-	-	-	
21	1	1	2	2	2	-	-	-	
22	5	4	6	30	32	-	-	1	
23	2	1	7	14	46	-	-	1	
25	2	2	9	18	64	-	-	-	
26	3	3	12	36	100	-	-	-	
27	4	2	14	56	156	-	-	2	
28	3	3	17	51	207	-	-	-	
30	8	7	24	192	399	1	1	-	
July 2	1	1	25	25	424	0	1	-	
4	6	6	31	186	610	0	1	-	
6	3	3	34	102	712	0	1	-	
7	1	0	34	34	746	1	2	-	
8	2	2	36	72	818	0	2	-	
12	9	7	43	387	1,205	2	4	-	
13	8	7	50	400	1,605	1	5	-	
14	1	1	51	51	1,656	0	5	-	331
15	1	0	50	50	1,706	1 (dead)	6	-	284
17	2	2	52	104	1,810	0	6	-	301
18	1	1	53	53	1,863	0	6	-	310
19	16	9	60	960	2,823	5 (2 killed)	11	2	256
20	2	2	62	124	2,947	0	11	-	267
21	1	1	63	63	3,010	0	11	-	273
24	5	3	66	330	3,340	1	12	1	278
25	2	2	68	136	3,476	0	12	-	289
28	3	2	70	210	3,686	1	13	-	283
29	3	2	72	216	3,902	0	13	1	300
30	1	0	72	72	3,974	0	13	1	305
Aug. 1	1	0	72	72	4,046	0	13	1	311
3	13	9	81	1,053	5,099	4	17	-	299
3	13	9	81	1,053	5,099	4	17	-	299
7	10	8	89	890	5,989	2	19	-	315
9	3	1	90	270	6,259	2	21	-	298
10	12	0	90	1,080	7,339	2 (killed)	23	10	319

Average
307

 

Table XII (cont.)

Date	A	No. Marked and Ret'd	B	AB	Σ AB	C	Σ C	No. Killed Not Marked	P	
Aug.	14	6	0	90	540	7,879	0	23	-	342
	17	3	0	90	270	8,149	1	24	-	339
	19	5	0	87	435	8,584	3(all killed)	27	-	318
	21	1	-	87	87	8,671	0	27	-	321
	23	5	-	87	435	9,106	0	27	-	337
	24	1	-	86	86	9,192	1 (killed)	28	-	328
	25	6	-	84	504	9,696	2 (killed)	30	-	323
	28	19	-	80	1,520	11,216	9	39	4	287
	30	4	-	80	320	11,536	0	39	-	295
Sept.	2	5	-	80	400	11,936	3	42	-	284
	4	4	-	80	320	12,256	1	43	-	285
	9	14	-	80	1,120	13,376	3	46	-	290
	10	5	-	80	400	13,776	4	50	-	275
	12	17	-	79	1,343	15,119	4 (1 dead)	54	-	280
	13	6	-	79	474	15,593	1	55	-	283
	14	3	-	79	237	15,830	0	55	-	287
	15	2	-	79	158	15,988	1	56	-	285
	18	5	-	79	395	16,383	1	57	-	287
	19	1	-	79	79	16,462	0	57	-	288
	20	1	-	79	79	16,541	0	57	-	290
	22	2	-	79	158	16,699	1	58	-	287
Average									287	

The population is estimated by the following formula:

$$P = \frac{\Sigma AB}{\Sigma C}$$

where

P is the estimated population on any date;

A is the number of fish caught on any date;

B is the number of marked fish present in the enclosure on any date;

C is the number of returns on any date;

AB is the product of A and B;

Σ AB is the sum of all products (AB) calculated to date;

Σ C is the sum of all returns to date.

Table XIII

POPULATION ESTIMATE OF WILD TROUT IN THE NATIVE ENCLOSURE

Date	A	No. Marked and Ret'd	B	AB	Σ AB	C	Σ C	No. Killed Not Marked	P
June	24	1	1	1	-	-	-	-	
	26	10	10	11	110	-	-	-	
	28	8	7	18	144	1	1	-	
	30	11	9	27	297	2	3	-	
July	8	7	6	33	231	1	4	-	
	13	3	2	35	105	1	5	-	
	17	9	7	42	378	2	7	-	
	20	15	14	56	840	1	8	-	
	24	1	1	57	57	0	8	-	
	28	11	9	66	726	2	10	-	
Aug.	3	1	0	66	66	1	11	-	
	8	7	6	72	504	1	12	-	
	15	4	0	72	288	0	12	-	312
	18	3	0	72	216	0	12	-	330
	21	14	0	68	952	4	16	4	307
	23	4	0	68	272	0	16	-	324
	25	8	0	66	528	2	18	2	318
	28	3	0	65	195	1 (dead)	19	1	311
	30	5	0	65	325	2	21	-	297
Sept.	2	4	0	65	260	2	23	-	282
	4	1	0	65	65	1	24	-	273
	12	7	0	64	448	3 (killed)	27	-	260
	13	13	0	64	832	3	30	-	261
	14	5	0	64	320	1	31	-	263
	17	5	0	64	320	3	34	-	249
	19	16	0	64	1,024	5	39	-	244

Sept. 12th-19th: average population 255 wild trout.

THEORY OF THE EARTH AND ITS HISTORY

No.	Name of the place	Date	Time	Wind	Weather	Temperature	Remarks
1	London	1850	10	S	C	50	
2	Paris	1850	15	N	C	55	
3	Berlin	1850	20	E	C	50	
4	Vienna	1850	25	S	C	55	
5	Rome	1850	30	S	C	60	
6	Naples	1850	35	S	C	65	
7	Genoa	1850	40	S	C	70	
8	Lyon	1850	45	N	C	55	
9	Marseilles	1850	50	S	C	60	
10	Algiers	1850	55	N	C	65	
11	Tunis	1850	60	N	C	70	
12	Cairo	1850	65	N	C	75	
13	Alexandria	1850	70	N	C	80	
14	Suez	1850	75	N	C	85	
15	Port Said	1850	80	N	C	90	
16	Constantinople	1850	85	N	C	95	
17	Istanbul	1850	90	N	C	100	
18	Edinburgh	1850	95	N	C	50	
19	Glasgow	1850	100	N	C	55	
20	Belfast	1850	105	N	C	60	

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