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The Natural Reproduction of the Cutthroat Trout, Salmo Clarki Richardson, in Strawberry Reservoir, Utah

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THE NATURAL REPRODUCTION OF THE CUTTHROAT TROUT, *SALMO CLARKI* RICHARDSON, IN STRAWBERRY RESERVOIR, UTAH

by

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William S. Platts

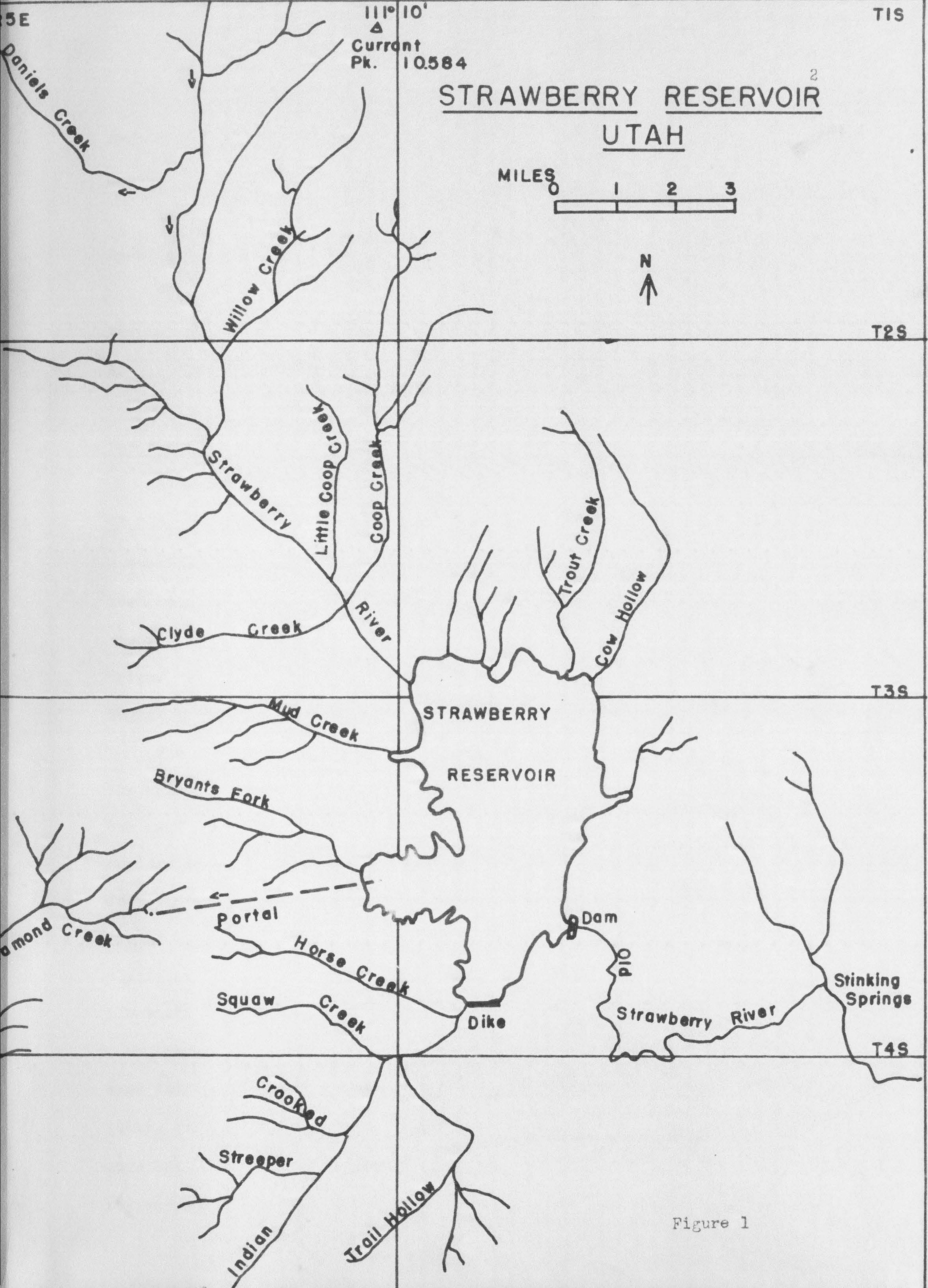
INTRODUCTION

Strawberry Reservoir, Utah is an 8,000 acre lake at the elevation of 7,550 feet; it has a maximum depth of 52 feet and an average depth of 18 feet. The supply of cutthroat trout eggs used to replenish and distribute this trout throughout the state are taken from two spawning traps located on reservoir tributaries. Because it has not proven economical to raise cutthroat to a larger size than newly hatched fry, it is at this stage they are planted. Because of competition, predation, and lack of space the planting back of fry to maintain the fishery and spawning run presents a serious problem. Tributaries are at carrying capacity from being closed to fishing and the reservoir supports a tremendous population of trash fish; mainly the Utah chub, Gila atraria (Girard); yellow perch, Perca flavescens (Mitchell); redside shiner, Richardsonius balteatus (Cope); mountain sucker, Pantosteus delphinus Cope; and dace, Rhinichthys osculus Cope. The rainbow trout, Salmo gairdneri Richardson, and the cutthroat trout dominate the game fish population.

It has been the policy of the Utah State Department of Fish and Game to trap and artificially spawn every possible fish, leaving most of the spawning ground unused. This cost, plus the unknown advantage, if any, of artificial over natural reproduction led to the study of the possibilities of natural reproduction for replenishment of the cutthroat trout in the reservoir.

Review of literature

Previous published studies on Strawberry Reservoir have been limited to Hazzard's (1934) limnological study. Carbine (1936) included the Utah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Trout Creek
Cow Hollow
STRAWBERRY
RESERVOIR
Mud Creek
Bryants Fork
amond Creek
Portal
Horse Creek
Squaw Creek
Dike
Dam
Old
Strawberry River
Stinking Springs
Crooked
Streeper
Indian
Trail Hollow

Figure 1

chub from Strawberry Reservoir in his study of the Utah chub in the Great Basin.

Studies on cutthroat trout include the following:

Spawning: Fleener (1952); Smith (1941, 1947); Cramer (1940); Welsh (1952); Cope (1956).

Population studies: Welsh (1952).

Beaver and cutthroat trout relationships: Huey and Wolfrum (1956); Grasse (1949); Rasmussen (1941).

Description of waters studied

Strawberry Reservoir was constructed in 1912 for storing water for 53,000 acres of irrigated land lying on the west side of the Wasatch Mountains. The surface area at full capacity is 8,000 acres; this has been reached only twice, the last time in 1952. The capacity of the reservoir is 280,000 acre-feet of which only 1,500 acre-feet cannot be withdrawn. The reservoir watershed drains 170 square miles. Inflow during August and September are less than loss through evaporation.

The basin of the lake is about six miles long and three miles wide. The bottom consists mainly of muck with sand, gravel, and boulders along the east side. The water is green in color, sometimes becoming greyish during fast abnormal runoffs. Secchi disk readings during the summer range from three to eight feet. The water is hard with a methyl-orange alkalinity of 142 to 197 parts per million and a pH of 7.8 to 8.2. Rooted aquatic plants are scarce in the lake, occurring only in shallow water. The fluctuations in water level prevent large areas of rooted aquatics.

Average annual precipitation is 12 inches, mostly in the form of snow falling between October and March. Summers are characterized by little rain, few clouds, and a constant daytime south wind. Days are warm but nights cold. Winters are very cold with the reservoir usually ice covered from late November to early May.

NATURAL REPRODUCTION

The effectiveness of artificial stocking as compared with natural propagation is one of the most fundamental problems in fish management. The actual advantage of each depends on the environment. The management program on Strawberry Reservoir was set up entirely in favor of artificial propagation. This program was carried on without taking into consideration the possibility that natural reproduction would be as efficient. Only spawners escaping the traps or entering untrapped streams have spawned naturally. This study was designed to measure the various elements of natural reproduction and survival so a comparison could be made with artificial propagation. The natural reproduction aspects studied were: fecundity, fertility, retained ova, and survival during the ova and alevin stages.

Fecundity

To determine fecundity of the Strawberry Reservoir cutthroat trout, 16 green female spawners were taken randomly from the spawning pens. A green female was opened and eggs in each ovary were counted individually to determine the number of eggs. The number increases with the size of fish (Table 1). The average number of eggs per female was 2,090, averaging from 290 to 318 per ounce. Leach (1939) found the fecundity of the Strawberry Reservoir female cutthroat was 2,000 eggs.

Spawning act (Appendix 4).

Fertility

Early reports of egg fertility must have been based on unsubstantiated beliefs, as Downing (1900) gave the opinion that not one egg in a

Table 1. Production of eggs by cutthroat trout spawners in Strawberry Reservoir, Utah, 1957

Number of fish	Standard length class (mm)	Average total length (mm)	Average weight in grams	Average ovary weight in grams	Average number of eggs per fish
1	250 - 399	282	448	65	1,215
1	301 - 350	337	458	93	1,391
5	351 - 400	392	555	98	1,461
5	401 - 450	430	831	137	2,341
3	451 - 500	466	1,044	165	2,786
1	501 - 550	533	-	-	3,459
Average eggs per female					2,090

thousand was fertilized naturally. Townsend and Smith (1924) were also confident a very low percentage of the eggs was fertilized. Moseley (1926) concluded that trout eggs left to themselves in the redds result in tremendous mortality.

Recent work on redds, dealing mostly with salmon, have proven the other extreme - that of high fertilization. Hazzard (1932) examined 21 redds of eastern brook trout, Salvelinus fontinalis fontinalis (Mitchell), in which fertility averaged 79.8 percent. The low fertility can probably be based on the fact that he considered only eyed eggs. Hobbs (1937), in his New Zealand study of introduced salmon, found an average natural fertilization of 98 percent. Cameron (1940) found a 98 percent fertilization in redds of salmon, Oncorhynchus nerka (Suckley). Cramer (1940) dug up four nests of coastal cutthroat, Salmo clarki clarki Richardson, and found fertilization varied from 93.0 to 98.6 percent.

To determine fertility of Strawberry cutthroat, 15 redds were set aside for fertility checks (Appendix 1). These redds were sampled at least 20 days from deposition, so fertile eggs could be easily detected. Average fertility of the 15 redds was 85 percent, which is lower than most studies. During artificial spawning of the Strawberry Reservoir cutthroat, fertility averages approximately 87 percent.

Ova lodging. No attempt was made to determine the actual percent of the eggs lodging and being covered. It was found that in favorable spawning areas a high percent lodged and were covered, but in the less favorable areas a low percentage lodged and were covered. Previous studies show that in favorable spawning areas approximately 95 percent lodge in the nest and are covered; Hobbs (1947), Taft and Shapovalov (1945). This figure was used in the Streeper Creek study.

Failure to release all eggs. To determine the number of ova not shed, 44 female spawners were sampled for retained eggs. Female spawners

Table 2. Eggs retained by cutthroat trout spawners after spawning naturally in Streeper Creek

Number of specimens	Length class in millimeters	Average total length in millimeters	Range of numbers of eggs retained	Total eggs retained	Average number of eggs retained per fish
1	350 - 369	356	-	48	48
2	370 - 389	381	2 - 3	5	3
3	390 - 409	406	18 - 44	92	31
3	410 - 429	421	0 - 230	230	77
13	430 - 449	437	0 - 965	1,859	143
12	450 - 469	456	0 - 24	63	5
5	470 - 489	478	1 - 775	925	185
1	490 - 509	495	-	5	5
1	510 - 529	508	-	1,162	1,162
1	530 - 549	546	-	9	9
1	570 - 589	572	-	0	0
1	650 - 669	660	-	11	11
Totals 44				4,409	
Average no. of eggs retained per spawner					100

were opened and ova counted from those returning downstream, those killed by disease and accidents, and those which chose to stay in the stream rather than return to the reservoir. The 44 spawners sampled (Table 2) retained 4,409 ova, an average of 100 eggs.

MORTALITY

Natural spawners released an average of 1,990 eggs into the redds. The next step was to determine how many of these eggs survived to contribute to the fishery. Mortality was recorded from the time the female entered the stream until the young migrated to the reservoir.

From natural spawning

Methods. Redds were checked at random throughout the tributaries during 1956; actual date of deposition was not known. During the 1957 spawning season, redds were not checked unless previously marked and dated as to time of deposition. Date of deposition was determined by actual observation. Spawning grounds were observed daily. When a pair was sighted and in the act of spawning the redd was marked. Twenty four hours later wire mesh was placed over the redd to prevent further spawning.

The ova and alevins were collected by placing a large nylon net downstream from the redd. By using the hands, the redd was dug up and contents sifted so ova and alevins were swept into the net. Immediately after taking the net from the stream live ova and alevins were separated from dead. The live specimens were separated into the different development stages, dead specimens in which exosmosis occurred were placed in a saturated NaCl solution. For dead eggs in which the chorion was still intact, the coagulation of the yolk was reversed so the embryo could be seen.

In most of the tributaries a large enough number of redds were marked to enable sampling one or more redds on each tributary every fifth day during the 50 day sampling period (Appendix 1). It was assumed that no fry emerge within 50 days after deposition. Redds were sampled when needed depending upon date of deposition. Spawners were released above the traps to make a natural reproduction study possible in streams where spawning runs were trapped.

Streeper Creek because of its small size, easy availability, and adequate spawning grounds, was studied more intensively than the other tributaries. Streeper Creek is a spring-fed stream that maintains a uniform flow of cool water favorable to spawning. The spawning area covers 5,200 feet of stream averaging 5 feet in width or $\frac{1}{2}$ acre of water. Approximately 25 percent of this area is unusable for spawning because of beaver dams and impondments. Because a spawning trap stopped cutthroat trout in the reservoir from entering the stream the number of spawners could be controlled.

During the 1957 spawning season 123 males and 129 females were released in Streeper Creek. Since the majority of the females were ripe, spawning took place soon after fish were released. With spawning taking place at the same time throughout the stream superimposition was kept at a minimum.

<u>During spawning</u>. The 129 female cutthroat trout released in Streeper Creek represent a potential 270,000 eggs available for deposition. Thirteen thousand of the 270,000 ova carried into the stream were not shed. This leaves a total of 257,000 eggs shed in the stream. Two hundred and fifty-three thousand of these ova lodged in the redd and were covered.

If fertility is as low as redd checks indicate, then approximately 39,000 eggs are wasted and have no chance of developing into fry. This leaves 215,000 fertilized ova deposited in the Streeper Creek spawning area. With 215,000 fertilized eggs in the redds, mortality takes its toll as the age of the ova increases.

Pre-eyed. In Streeper Creek during the pre-eyed stage 10 percent died leaving 193,000 eggs to develop to the eyed stage. Average pre-eyed mortality in the other tributaries entering the reservoir was 24 percent.

Eyed. Streeper Creek mortality in the eyed stage took approximately 3 percent leaving 187,000 specimens to develop into sac fry. Average eyed mortality in the other tributaries entering the reservoir was 27 percent.

Sac fry. Mortality to sac fry in Streeper Creek was negligible, thus close to 187,000 sac fry would survive to become fry. Average sac fry mortality in the other tributaries entering the reservoir was also negligible.

Buried fry. Five percent of the Streeper Creek fry died before emerging from the redd leaving an estimated 178,000 fry to emerge into the stream. Alevin mortality was also low in the other tributaries.

The 178,000 fry emerging might be lower than the actual number because fertility has entered twice, once in the initial fertility and once in the later stages of development when infertile eggs die. This would help to compensate for superimposition by subsequent spawners which was ignored because of the short period of spawning.

Each female cutthroat trout spawning in Streeper Creek produced an average of 1,330 free swimming fry or 66 percent survival.

Free swimming fry. From the Streeper Creek redds 178,000 free swimming fry emerged and 10,291 migrated from the stream within 98 days after deposition. This left approximately 167,500 fry that remained in the stream.

On September 23, 1957, two representative sample areas were checked with a portable AC electric shocker. The total area was 588 feet or over

10 percent of the total spawning area on Streeper Creek. From the samples (Appendix 2) it was determined approximately 4,050 fry remained in Streeper Creek 98 days after deposition. This left 163,500 free swimming fry that perished, or 92 percent perished before their first summer had ended. This high mortality of wild fry may indicate what happens to artificially propagated fry planted in the tributaries.

Differences between streams and in the same stream. Mortality of ova and alevins in the gravel was found to vary much from one stream to another. Even in the same stream some sections were very favorable for natural reproduction while other areas were poorly suited. Because of changing environmental conditions the same spawning area will differ from year to year. This is clearly shown on Bryants Fork and Mud Creeks. Only Streeper Creek has relatively uniform favorable spawning areas. Streams such as Sage and Charlie Chaplin Creeks were poor for natural reproduction because insufficient gravel resulted in the eggs failing to lodge and be covered. To show the differences in spawning areas and causes for these differences each tributary will be treated separately.

Tables 3 and 4 summarize the findings of the 1956 and 1957 redd checks, respectively. Appendix 1 gives the full data on each redd check. The high mortality of ova and alevins during 1956 in Bryants Fork, Mud, Indian, and Clyde Creeks can be attributed mainly to dynamiting of beaver dams and the resultant siltations of sampled redds. Beaver dams were not dynamited on Streeper and Trout Creeks.

Trout Creek. Trout Creek is a spring fed stream which varies little in flow throughout the year. It has the most favorable water temperatures for natural reproduction of any of the tributaries. The bottom of the stream is almost 100 percent gravel and boulders which offer ideal spawning beds.

There are two distinct spawning areas. The sagebrush area along the upper part of the creek was grazed by sheep; grassland along the lower part of the creek was pastured to cattle. Differences in mortalities in the two areas (Appendix 1) show the damage that cattle do when crossing or wading up and down the stream. In the upper area redds were clean; only the fine silt that the current carries down Trout Creek covered any of the redds. Redds in the lower area were silted because of cattle activities. Pre-eyed mortality was 45 percent as compared to 29 percent in the upper area. Although low, 29 percent is still high for a stream offering such ideal water temperatures and gravel.

Eyed eggs in the lower area suffered over 30 percent mortality as compared to 4.5 percent in the upper area. Alevin stages of development could not be compared as no eyed ova in the lower area were found to survive to this stage.

Two major reasons for high mortality were silt and concussion caused by cattle. The amount of silt and debris moving down the lower section of the stream is indicated by the fact that traps installed at the mouth of Trout Creek had to be abandoned because they plugged so frequently. I have observed these two traps plug up in just a little over an hour. Very few eggs deposited in the lower area will mature into free swimming fry if these conditions continue.

<u>Bryants Fork Creek.</u> Only a small percentage of Bryants Fork is accessible to lake spawners because of beaver dams.

The spawning beds (Appendix 1) in the lower section of Bryants Fork would be classified as dirty redds. A silt cover plus high water temperatures raised the mortality rate. Mortality in the pre-eyed stage was 16 percent, during the eyed stage it jumped to 47 percent, which is very high. No mortality was observed in the alevin stages. With this high rate of mortality an average sized female cutthroat spawning in the lower section would produce only 720 free swimming fry, minus those lost through superimposition. The upper section is more favorable but it is

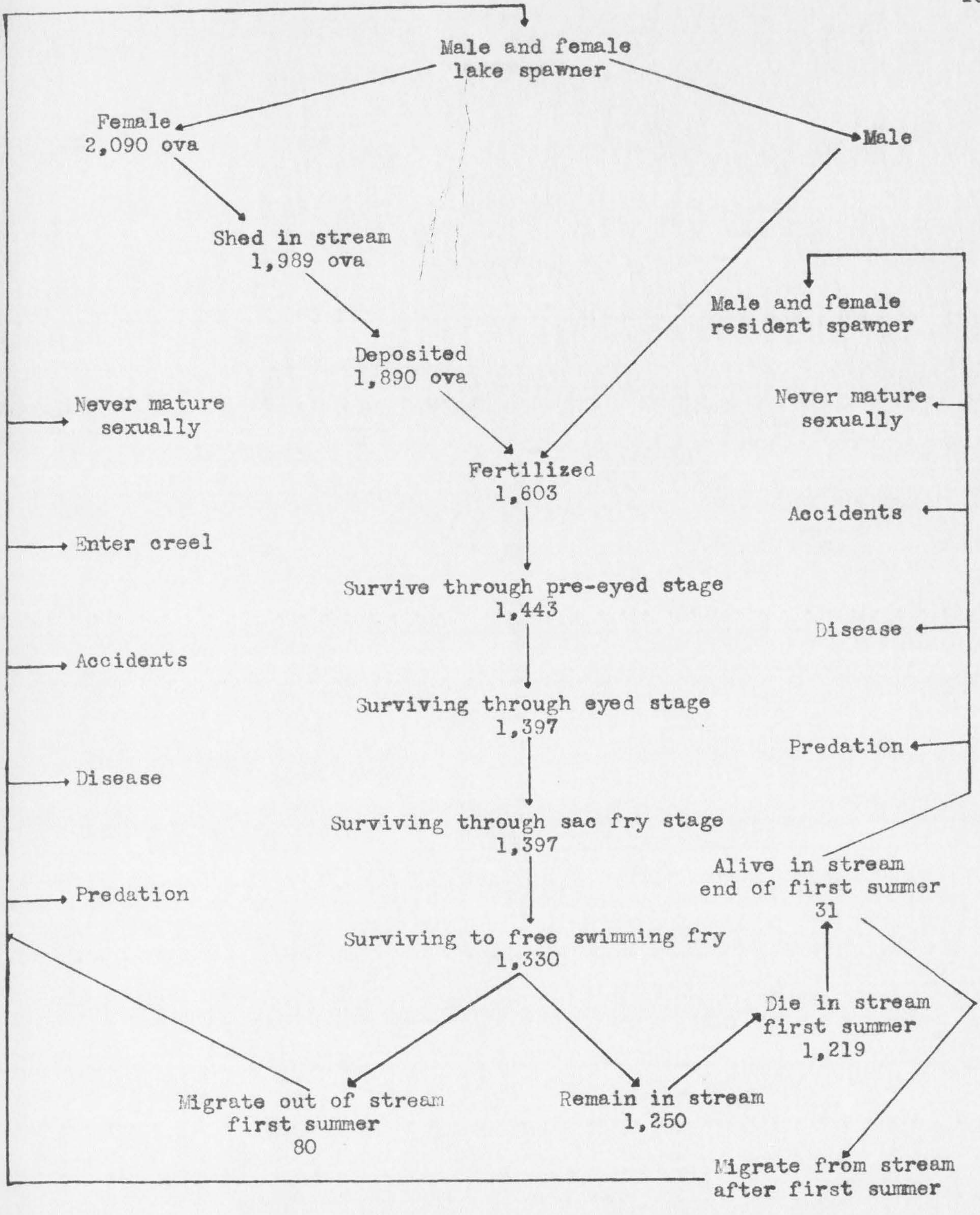

Figure 2. Results of an average male and female lake cutthroat spawning in Streeper Creek, 1957.

not readily accessible because of beaver activities.

Mud Creek. Although the sampling program did not show it, the lower section is poor for natural reproduction while the upper section is from good to excellent. In the lower section of Mud Creek the bottom becomes thickly covered with aquatic vegetation. Spirogyra is the most abundant form making a complete blanket around the sides and over the bottom.

Mud Creek redds do not become as dirty as Bryants Fork redds but they are not as clean as Streeper Creek redds. Mortality during the pre-eyed stage was 22 percent, in the eyed stage 8 percent, and in the alevin stages less than one percent.

Indian Creek. Although Indian Creek offers a plentiful supply of good spawning areas, not enough spawners were allowed to continue upstream to complete a sampling program. The 40 and 45 day checks were taken in a small diversion around a beaver dam.

Pre-eyed mortality amounted to 7 percent, while in the eyed stage mortality was 19 percent. Insufficient samples during the alevin stages make it impossible to estimate alevin mortality. Because of the favorable spawning areas it is assumed to be negligible.

Sage Creek. Sage Creek offers a poor environment for spawning because of its small size and inadequate gravel. When checking redds (Appendix 1) in Sage Creek the entire redd was dug up and well sifted. The small number of eggs per redd shows the percentage of eggs lodging in the shallow gravel was very low. Although redds were sampled up to 55 days after deposition no eggs were found to survive to the eyed stage.

During the 1956 sampling season approximately 600 spawners were counted in Sage Creek by Utah State Department of Fish and Game personnel. This would account for a loss of approximately 627,000 eggs. During the

1957 season I saw 125 spawners on one count. If all possible eggs were shed this would be a loss of 132,000 eggs. Nearly 100 percent of the eggs carried into the stream were not deposited and therefore wasted.

Charlie Chaplin Creek. This stream, like Sage Creek, offers a poor environment for spawning. Material for redds is scarce. The small number of specimens found shows the percentage of eggs lodging in the shallow gravel is low. One egg was found to survive to the pre-eyed stage.

It must be concluded that tributaries such as Sage and Charlie Chaplin Creeks should be made unavailable to spawners.

Causes of mortality

Losses before eggs are deposited. There are many possibilities for losses before the eggs are deposited in the redds. First, some fish may mature physically but not sexually. Scale reading of some 5, 6, and 7 year old cutthroat trout females, weighing up to 19 pounds, failed to show any spawning checks.

The effect of predation is felt as the spawner enters the stream in search of suitable spawning sites. Predation is assumed to be very slight in the tributaries entering the reservoir; but, 9 spawners were found in Trout Creek one morning that had been killed by blue herons. Poaching could be considered under this same heading. Spawners may also die from diseases, injuries, and accidents received from hazards that accompany spawning. Spawners have been found dead in the tributaries that have not shed any ova.

Spawners do not discharge all ova that mature. Hobbs (1948) found that 14 brown trout retained an average of 7 eggs per female. Welsh (1952) sampled 50 spent spawners and found an average of 3 eggs per female. Both figures are low because only spent spawners returning were sampled. I found an average of 100 retained eggs per female spawner.

This number takes into account the number of eggs retained by returning spent fish, plus spawners suffering mortality from disease, injuries, and accidents.

<u>Losses after eggs are shed.</u> The number of eggs lodging in the redd was not determined. It is known, from contents of stomachs taken from trout during the spawning season, that all eggs do not lodge. Fifteen cutthroat trout averaged 7 eggs per stomach.

The number of eggs lodging in the redd pocket depends upon the quality of the redd. If the pocket is deep enough so that currents in the bottom are traveling in an opposite direction of the downstream current it is likely that most of the eggs do lodge. The adhesiveness of the eggs, current traveling in opposite direction, and larger rocks forming crevices in the bottom of the redd pocket all favor retention of shed ova.

In areas with less favorable spawning sites the percentage of eggs lodging and being covered is low. The gravel in two streams, Sage and Charlie Chaplin Creeks, averages not more than $\frac{1}{2}$ inch in depth. This makes it impossible for the pit to be deep enough to develop a current flowing in the opposite direction to hold the eggs in the pit. Although eggs are slightly adhesive when first shed most are lost from these redds shortly after deposition. The remaining eggs are probably washed out when the female tries to cover the shallow pit with gravel.

<u>Losses from non-fertilization.</u> After ova are shed by the female they must be fertilized. The characteristics of the redd pit produce an ideal situation for fertilization of ova. Fifteen cutthroat redds were checked for fertility (Appendix 1) and the fertility ranged from 44.4 to 100 percent, with an average of 85 percent.

Hobbs (1937) concluded that if the total loss in a redd exceeded 3.3 percent then the explanation should be found in causes other than initial infertility.

Losses of ova after fertilization and burial. After the ova are covered they are left to the mercy of their environment. Probably only at this time during its life is the cutthroat trout relatively safe from predation.

Flooding. This is one factor that was unimportant during the study. Very little rain in summer with watersheds in good condition keeps flooding at a minimum. Only during high water in the spring is the flow enough to cause any damage to ova in the redds.

Superimposition. There is evidence that loss of eggs does occur during superimposition. Twenty-eight eyed eggs were found in the stomach of a spent spawner in Trout Creek at the end of the spawning run. These ova had been dug out of the redd by subsequent spawners. Redd checks show ova in different stages of development occupy the same redd. How much loss takes place from superimposition was undetermined. Observations indicate it is heavier in the lower sections of the streams and in the more favorable redd sites.

Late spawners take advantage of material already loosened by earlier spawners. On three different occasions I observed spawners utilize a redd just sampled. On all three occasions the female moved on to the redd and started digging in the short time it took me to sort and count the specimens taken from the redd.

Over a prolonged spawning season superimposition undoubtedly takes its toll. All ova washed from the redd die. Those moved during the tender stage, although still covered, die. The eggs surviving and still covered would benefit as the redd is once again in a clean state, this permits the maximum percolation of subsurface water around the ova.

There would be no loss from superimposition during the alevin stage because spawning activities have ceased.

Siltation. Siltation, in conjunction with high water temperatures, is the major cause of mortality in the ova and alevin stages.

silted redds suffered much greater mortality than clean ones.

A newly made redd is relatively clean. Surface diatomaceous growth and fine material have been removed and swept away by the current. Some fine material is redeposited during the burial action by the female. The clean redd starts immediately to resume the character of the surrounding bed. Silt gradually builds up, depending upon conditions in the stream, leaving a fine crust on top which gradually works down toward the egg pocket as the season progresses. The oxygen requirements of ova and alevins increase while total available oxygen percolating through the redd is gradually decreasing. As the silt crust deepens and water temperatures rise there is eventually a point when available oxygen is less than that required by ova and alevins. In a good spawning area this point is reached after the ova have developed into alevins and emerged from the gravel.

The effects of siltation are shown in the following discussion on mortality from beaver activities.

Effect of beaver. The role of the beaver in trout production is very controversial. Rasmussen (1940), Grasse (1949), and Huey (1956) found beaver to be beneficial, while Salyer (1935), and Nelson (1954) found beaver to be detrimental to fish production. Nelson (1954), in his study of the grayling in Montana, recommended that all beaver and beaver dams be removed from the tributaries of the Upper Red Rock Lake. Spawning areas were not accessible to grayling because of beaver dams.

Detrimental effects from beaver activity are clearly shown in most of the streams entering the reservoir. Since beaver were so common, their effects on trout reproduction were observed carefully. Redds were checked in stream areas inhabited by beaver to determine the detrimental effects produced on ova and alevins in the gravel. Redds were also checked to determine effects from dynamiting beaver dams. Blocking of migrations was determined from observations.

Table 3. Survival and mortality in eggs and fry in 33 redds sampled in the tributaries entering Strawberry Reservoir, Utah, in 1956

Tributary	Number of redds	Live Eggs	Live Sac fry	Live Fry	Dead Eggs	Mortality in percent
Bryants Fork	5	21	0	6	284	91
Indian	12	748	105	42	883	50
Mud	3	100	15	3	1,354	93
Streeper	11	691	303	156	794	27
Trout	1	64	0	0	0	0
Clyde	1	28	28	1	776	93
Totals	33	1,652	451	208	4,091	-

Table 4. Survival and mortality in eggs and fry in 109 redds checked in the tributaries entering Strawberry Reservoir, Utah, 1957

Tributary	Live				Dead			
	Pre-eyed eggs	Eyed eggs	Sac fry	Fry	Pre-eyed eggs	Eyed eggs	Sac fry	Fry
Streeper	1,858	91	243	59	361	11	-	3
Indian	451	225	1	2	53	12	-	-
Trout	1,954	346	117	45	1,444	73	-	-
Mud	1,750	284	56	244	652	51	-	2
Bryants Fork	1,130	98	16	13	347	103	-	-
Sage	271	-	-	-	102	-	-	-
Charlie Chaplin	4	1	-	-	17	-	-	-
Totals	7,418	1,045	433	363	2,976	250	0	5

Average pre-eyed mortality 23.8 percent

Average eyed mortality 11.95 percent

Average sac fry mortality 0 percent

Average fry mortality 1.4 percent

Average combined mortality 37.15 percent

Table 5. Summary of mortality (expressed in percent) of ova and alevins in redds in the tributaries entering Strawberry Reservoir, Utah, 1957

Tributary	Number of redds checked	Eggs		Alevins		Total mortality
		Pre-eyed stage	Eyed stage	Sac fry stage	Fry stage	
Streeper	20	10	3	0	5	18
Trout	26	37	18	-	-	55
Indian	15	7	19	0	0	26
Bryants Fork	18	16	47	0	0	63
Mud	27	22	8	0	1	31
Charlie Chaplin	5	81	0	-*	-*	100[x]
Sage	15	27	-*	-*	-*	100[x]

*No survival found to this stage.

[x]Estimated mortality.

Blocking of migrations. Beaver do the most harm to cutthroat trout when they block migrations. The better spawning areas and over 50 percent of the available spawning grounds are not accessible to spawners as a result of beaver. On Bryants Fork Creek which has over a mile of good gravel only 200 yards are readily available to spawners.

In observing migrations of marked cutthroat trout it was found they could traverse what seemed impassable beaver dams, but each high dam was a stumbling block and the size of the spawning run was greatly reduced. The spawners that passed over these dams and stayed until high water receded were trapped and most became diseased and died.

In the larger, deeper beaver dams marked spawners were observed to summer over in good shape. Three marked spawners were known to winter over in beaver dams on Indian Creek; however, these spawners are detrimental to migrating fry and other small resident fish. Also, spawners trapped in the stream are unavailable to fishermen.

By causing siltation. It has been the practice of the Utah State Department of Fish and Game to blast dams during and after the spawning season. Redds were checked on Bryants Fork and Mud Creeks during 1956 after beaver dams had been destroyed and also in 1957 when no beaver dams were destroyed. There was 91 percent overall combined mortality of ova and alevins in the 5 redds checked on Bryants Fork in 1956, compared with 26 percent in 18 redds checked during the 1957 spawning season when there was no blasting of beaver dams. There was 92 percent overall combined mortality of ova and alevins in the 3 redds checked on Mud Creek during the 1956 spawning season against 23 percent in the 27 redds checked during the 1957 spawning season.

This shows it is poor management to blast beaver dams while ova and alevins are still in the redds. When a dam is blasted, or washed out, silt is spread for long distances downstream and continues long after the runoff from the dam is over. The silt covers the redds, stops the flow of subsurface water, and results in the death of ova and alevins in the gravel.

Conclusions. In the study area the beaver is very detrimental to the migration and production of cutthroat trout. Along with non-game fish, it is probably one of the main factors holding down the lake population of cutthroat. The main harmful influences are blocking migrations and the flooding and siltation of gravel areas. All beaver and beaver dams should be removed.

Water temperatures. Some tributaries have high daytime water temperatures, which in conjunction with other factors, result in mortalities in the redd.

Drying of redds. In the years with low runoff, a large percentage of ova in redds are probably left to die by receding streams. During the course of this study water runoff was sufficient to prevent drying of redds. Man-made practices leave some stream bed sections dry. The upper Strawberry River is diverted through the mountain to empty into Daniels Creek (Figure 1). During the spawning season runoff is high enough so part of the flow continues down Strawberry River. Later, when the canal can carry all of the flow, water does not continue below the dam; as a result a long stretch dries up. This is not only fatal to ova and alevins in the redd but also to fish that have moved into the area.

Concussion. Eggs in the pre-eyed stage are more sensitive to concussion than during the eyed stage. Redd checks also showed that heaviest mortalities occur during the pre-eyed stage. Mortalities due to concussion are brought out in the discussion of the Trout Creek redds.

Disease. Saprolegnia was found only in redds in which the specimens were in the advanced stages of development; it was seldom found in very dirty redds. This disease can be considered an unimportant mortality factor.

Conclusions

Average mortality of ova and alevins in the 1957 redd checks was 37 percent, showing natural reproduction in the favorable spawning areas is an efficient process and should be utilized whenever possible.

From artificial spawning

Figure 6 briefly summarizes the mortality suffered during artificial spawn taking. This does not include mortality suffered from loss of eggs due to spawners dying in the traps or in the stream before they reach the trap. Nor does it account for spawners releasing eggs in the trap or those delayed and releasing eggs in the restricted area below the traps where the same portion of the redds are dug over and over by successive spawners. The number of ova retained may seem high. To get every egg would result in high mortality of females. Also many female spawners cannot be spawned because of injuries or blocked genital pores. The percent of ova developing into free swimming fry is slightly more than produced by natural reproduction.

DOWNSTREAM MIGRATION TO RESERVOIR

Trout that do not migrate to the lake but choose to remain in the stream are lost to the fishery. Only those remaining which mature and produce migrant fish are of any value.

During 1956, downstream traps were placed in three streams to determine if cutthroat fry plants were surviving and migrating to the reservoir. During 1957 downstream traps were placed in three streams to determine the results of natural reproduction. The downstream trap was placed in Streeper Creek to determine spawning efficiency from a known number of potential spawners. Data was used to compare natural reproduction with artificial propagation.

Table 6. Eggs retained by cutthroat trout spawners after being spawned artificially, 1957

Number of specimens	Length class in millimeters	Average total length in millimeters	Range of numbers of eggs retained	Total eggs retained	Average number of eggs per fish retained
3	370 - 389	381	9 - 381	476	159
1	390 - 409	394	-	24	24
2	410 - 429	419	3 - 390	393	197
3	430 - 449	436	447 - 1,442	2,531	844
1	450 - 469	457	-	289	289
2	470 - 489	483	545 - 1,849	2,394	1,197
1	490 - 519	496	-	395	395
Totals 13				6,502	
Average eggs retained per spawner					500

Methods

The stream flowed over a spillway through bars and into a screened trap (Appendix 3). Fish larger than 10 inches landed on the bars, flopped off, and continued downstream. Very few fish in the stream attain lengths of over 10 inches. The majority of migrant fish missed by the trap were returning lake spawners.

Downstream traps were operated as soon as fry started emerging from the gravel or were planted. Traps were checked once and sometimes twice a day to determine number of daily migrants.

Migration of stocked plus natural fry, 1956

Streeper Creek trap. The Streeper Creek downstream trap was originally installed to determine natural reproduction. Twenty one thousand cutthroat fry were mistakenly planted 100 yards above the trap therefore results were from both naturally and artificially propagated spawn. An estimated 100 female spawners entered Streeper Creek to spawn naturally.

From July 19 to October 13, an average of 61.4 fish, under 9 inches, migrated out per day. The fry run during this time amounted to 5,360 or almost 100 percent of the total migrants of the stream. There was a sudden jump in daily numbers of migrants immediately after the large plant. This soon dropped off and daily numbers did not start increasing until natural reproduction began producing migrants. Figure 3 shows the daily numbers migrating downstream during 1956. Forty-two fish, a year or older, also entered the trap.

Two areas in Streeper Creek were sampled in November with an electric shocker. It was estimated that there were approximately 1,850 cutthroat trout inhabiting the available spawning area at this time, and less than 50 percent were young-of-the-year. The results showed that the majority of fry either migrates out or perishes in the stream. Only a small fraction of the available one year or older fish migrates out of Streeper

Table 7. Numbers of migrant fish entering the Streeper Creek downstream trap, July 19 to October 13, 1956

Date	Cutthroat trout fry	Cutthroat trout 3 - 9 inches
July 19-31	2,614	14
August 1-31	2,646	15
September 1-30	68	10
October 1-13	32	3
Totals	5,360	42

Table 8. Numbers of migrant fish entering the Strawberry River downstream trap July 19 to September 5, 1956

Date	Cutthroat adult	Cutthroat fry	Shiner adult	Shiner fry	Dace adult	Dace fry	Perch	Mountain sucker	Chub
July 19-31	2	0	28	0	41	0	0	9	2
August 1-31	1	0	135	14	167	0	1	21	0
September 1-5	2	0	16	0	35	0	0	0	0
Totals	5	0	179	14	243	0	1	30	2

Creek.

Resident trout are predatory and undoubtedly have a great effect in lowering the success of spawning by reducing the number of fry. As mentioned before, carrying capacity is maintained at all times, so fry coming out of the redds find very little available space. Fry migrating to the reservoir find an environment filled completely with predators; namely yellow perch, Utah chub, and trout.

Migration of stocked fry

Mud Creek trap. The Mud Creek trap was operated from July 19 to October 13, 1956, to check fry plants. From the original plant of 25,416 cutthroat fry only 3 entered the reservoir during the 88 days the trap was in operation. Mud Creek put .91 trout per day under 10 inches into the reservoir (Table 9), with rainbow outnumbering the cutthroat. Some of the rainbow were marked trout which were planted in the reservoir and had migrated upstream. Forage fish made up the bulk of the migrants; the redside shiner being the most abundant.

Strawberry River trap. This trap was also used to determine the results of fry plants. In 1954, 1955, and 1956, 27,500, 125,300 and 244,700 cutthroat trout fry, respectively, were planted in the Strawberry River. Although 244,700 fry were planted in 1956, not one fry migrated downstream into the trap during the time of operation (Table 8). Only 5 trout, all older cutthroat, entered the trap. Trout migration amounted to only .057 per day.

Again forage fish made up almost 100 percent of the total number with dace the most abundant.

Conclusions. The results show that planting large numbers of fry in Mud Creek and Strawberry River is wasteful. Only Streeper Creek had a good run of migrant trout.

From shocking sample areas and results of downstream traps it was found the heaviest migration comes immediately after fry start emerging

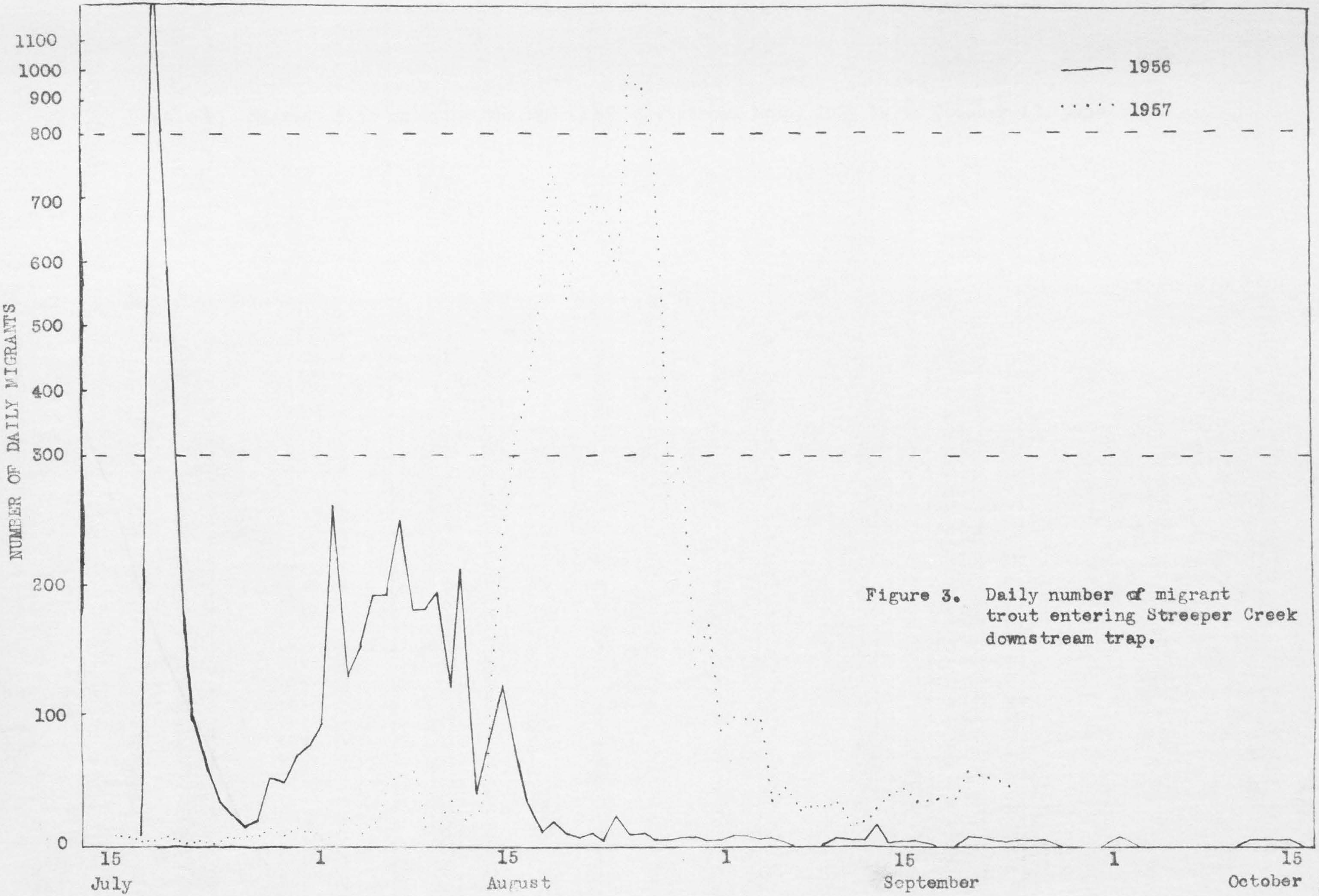

Figure 3. Daily number of migrant trout entering Streeper Creek downstream trap.

Table 9. Migrant fish entering the Mud Creek downstream trap, July 19 to October 13, 1956

Date	Cutthroat trout		Rainbow trout	Brook trout	Shiner		Dace		Sculpin		Mountain sucker	Chub
	adult	fry			adult	fry	adult	fry	adult	fry		
July 19-31	11	0	35	1	572	3	139	0	1	0	17	8
August 1-31	7	1	12	0	316	4	157	0	0	7	8	0
September 1-30*	6	2	2	0	32	0	55	0	1	0	4	0
October 1-13	4	0	0	0	35	85	40	22	1	1	9	0
Totals	28	3	49	1	955	92	391	22	3	8	38	8

*Traps not working September 5 through September 11, 1956.

but soon tapers off after they stop. By late fall there are very few fish left in the stream to migrate.

Migration of fry from natural reproduction

Streeper Creek trap. A trap was installed in Streeper Creek during the 1957 season to determine success of natural reproduction. The fry run during the 1957 season, resulting from the 123 female spawners released, averaged 191 migrants per day as compared to 64 migrants per day during the 1956 season when the stream was planted with fry. Each female spawner released in Streeper Creek resulted in 80 fry migrating from the stream with 98 days.

Welsh (1953), in his Arnica Creek study, had a total of 9,556 fry pass through the downstream trap during 1950. This was from an estimated total of 2,657,000 eggs carried into the stream. During 1951 an estimated 3,261,000 eggs were carried into the stream, but only 4,651 fry migrated out. Streeper Creek made a good showing with over 10,000 fry migrating through the downstream trap from 270,000 eggs carried in.

Trout Creek trap. An effort was made to operate a downstream trap, but because cattle kept large quantities of silt, debris, and vegetation moving down the stream it was impossible. The trap would plug up in less than an hour if cattle were in the stream. Two days during operation conditions were right so the trap did not flood. On these days 17 trout, a year or older, migrated into the trap; even on days when the trap flooded an average of 1.5 trout per day was found. Although Trout Creek was not planted prior to 1957 and was seined from mouth to source just prior to trap operation, it still had a good showing of year or older migrant trout.

Bryants Fork trap. A trap was installed in Bryants Fork Creek to determine the natural reproduction. Because of the early spawning the trap was put in too late to catch the peak of the fry run. During the time of operation (Table 11) 521 fry migrated through the trap averaging

Table 10. Weekly summary of numbers of migrant fish entering the Streeper Creek downstream trap, July 16, to September 23, 1957.

Date	Cutthroat trout fry	Cutthroat trout one year or older
7-16 to 7-22	0	26
7-23 to 7-29	18	21
7-30 to 8-5	49	20
8-6 to 8-12	233	6
8-13 to 8-19	2,316	19
8-20 to 8-26	5,064	12
8-27 to 9-2	1,748	17
9-3 to 9-9	359	11
9-10 to 9-16	201	7
9-17 to 9-23	303	17
Totals	10,291	156

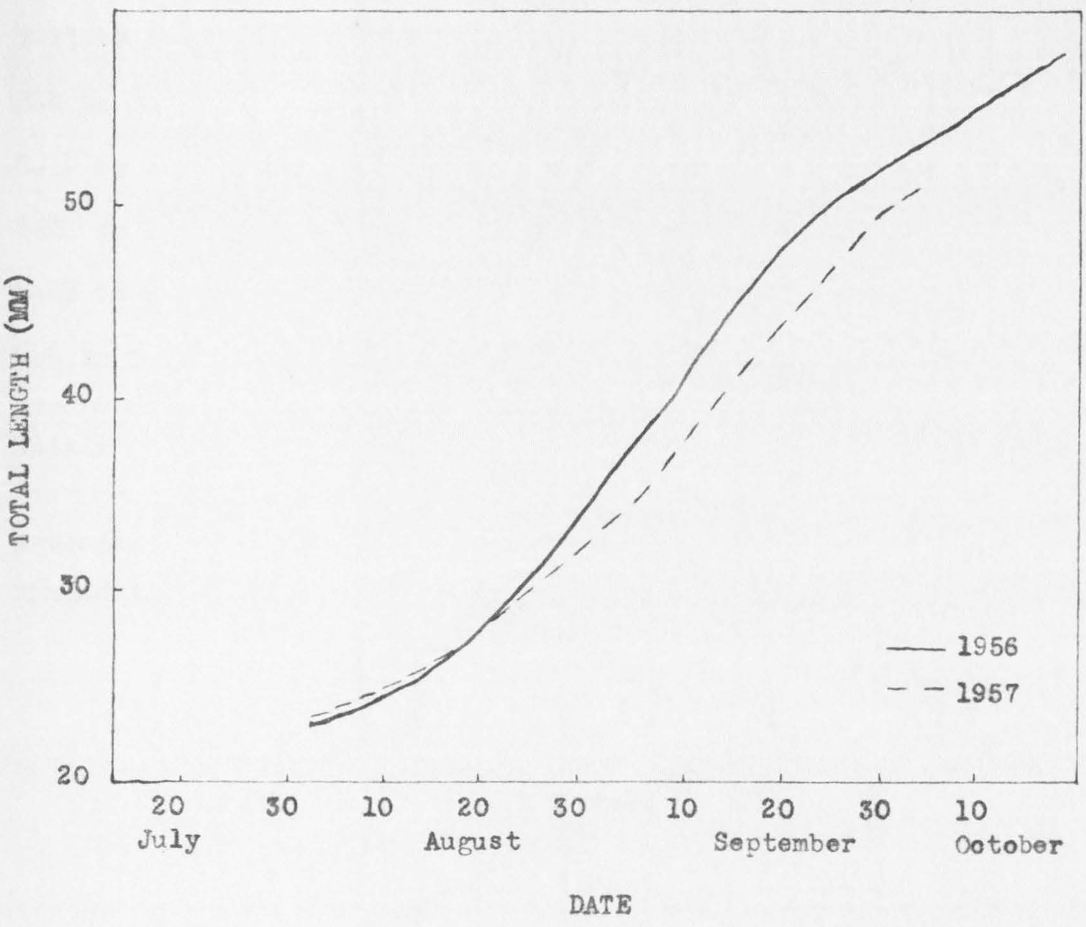

Figure 4. Average total lengths of the 1956 and 1957 alevins migrating through the Streeper downstream trap.

Table 11. Weekly summary of numbers of migrant fish entering the Bryants Fork Creek downstream trap, July 31 to September 6, 1957

Date	Cutthroat fry	Cutthroat adult	Rainbow	Shiner	Dace	Mountain sucker	Sculpin
7-13 to 8-6	175	13	5	71	12	1	4
8-7 to 8-13	124	3	0	25	4	8	1
8-14 to 8-20	103	8	1	15	5	6	0
8-21 to 8-27	87	5	0	2	5	15	0
8-28 to 9-3	14	8	1	0	3	3	0
9-4 to 9-6	18	2	0	0	8	14	0
Totals	521	39	7	113	37	47	5

Average fry migrating per day - 13.7

13.7 fry per day.

Conclusions

Spawning efficiency of cutthroat spawners in Streeper Creek is favorable, being higher than most studies. Natural reproduction has probably been the main factor in replenishing the population of cutthroat trout in the reservoir. Heaviest migration occurs during the time fry are emerging from the gravel and by late fall few are left in the stream.

Strawberry River and Mud Creek both have a poor showing of migrant fish but have always been planted the heaviest. Planting should be switched to Trout, Bryants Fork, Streeper, and Indian Creeks where trout do migrate in large numbers to the reservoir.

HOMING, MOVEMENTS, AND MORTALITY OF ARTIFICIAL AND NATURAL SPAWNED FISH

While Utah Fish and Game personnel were sorting the daily runs it became evident that the ratio of spent to green spawners increased as the season progressed. It was also evident that the mortality of each daily run increased. If spawners repeatedly re-entered the trap after being spawned artificially and released back into the reservoir, then the total number entering the trap would be much larger than the actual population of spawners running the stream. Also, if spawners re-entered the traps extra handling plus other hazards that a spawner suffers with each spawning run would result in high mortality.

Homing was studied to determine if Strawberry cutthroat trout have a strong homing instinct. This factor would be very important in establishing future runs. Movements were studied to determine initial time of spawning movements, length of stay in the tributaries, and desire to return to the reservoir. Mortality was studied to determine what value these spawners would contribute to the replenishment of their species in future years and also to determine the number entering the creel. The number entering the creel was derived from the creel census taken during the 1956 and 1957 fishing seasons.

Methods

During the 1956 and 1957 spawning runs 2,068 and 1,983 spawners, respectively, were marked by removing a combination of fins. A different combination was used at each trap. Spawners were marked immediately after artificial spawning. Marked spawners were then released into the reservoir at a distance of one to four miles from the traps. The small size of the tributaries was ideal for observations of marked spawners. During and after the marking program all tributaries were observed frequently, marked spawners were counted and dead marked spawners were removed. The marking project was undertaken to determine number of re-entries, the number taken in the fishery, and to study general homing, movement, and mortality.

Homing

Homing studies (compulsion of an individual to return to a specific locality) in the salmonidae family have been mainly restricted to anadromous species. Adfluvial species have receive less attention. Although the following data does not deal with the known return of mature fish to the parent stream it does shed some light on the homing instinct of an adfluvial species.

Indian Creek trap. During the 1956 spawning run 918 spawners were marked after artificial spawning, then released into the reservoir one to two miles away. Of this total 418 returns were observed, with most returns coming one to three days after release. Three hundred and forty-four ascended the fish ladder and returned to the same stream, of these

44 were found dead. Fourteen were found dead in the reservoir. Sixty were observed in tributaries other than Indian Creek where only one was dead. Eighty-three percent of the returns returned to the home stream and 14 percent migrated into other tributaries. This clearly shows the strong homing instinct since the locations of release into the reservoir gave spawners an equal opportunity to enter other tributaries.

<u>Clyde Creek trap</u>. During the 1956 spawning run 1,156 spawners were marked and released into the reservoir at a distance of from one to four miles. Seven hundred and twelve returns were observed in the tributaries, 644 were observed to return to the home stream, of these 141 were found dead. Forty-eight spawners were observed to return to streams other than the home tributary, of these 32 were found dead. One spawner marked at the Clyde Creek trap entered the Indian Creek trap. Only 7.5 percent were observed to enter tributaries other than the home stream. This again shows the strong homing instinct.

The percentage of spawners returning to the tributaries is high; part of this is due to the same fish returning to the trap more than once. Each time a marked spawner returned to the trap it was counted and again returned to the reservoir. It is possible that some may have made three or four appearances. By marking spawners it was found that a large percent would traverse the distance of the reservoir and re-enter the tributaries. On June 6, 1956, 24 hours after release, 79 of 850 marked spawners returned to the home stream.

<u>Mortality</u>

The return of only 31 marked spawners the second year to the Indian Creek trap indicates the high mortality suffered from the hazards that accompany spawning. Out of the 918 marked spawners 4 percent were caught during the 1956 fishing season, 2 percent returned the following year to spawn, and less than 1 percent was taken by fishermen during the 1957 fishing season. This leaves 93 percent unaccounted for, which is probably close to the actual mortality. High mortality also occurred in marked spawners from the Clyde Creek trap, as only a very low percentage returned to the trap in 1957, and only 10 percent of the 1,150 were caught by fishermen during the 1956 fishing season. This leaves almost 90 percent that are unaccounted for and probably represents the mortality.

During the 1957 season 123 male and 129 female spawners were collected from the Indian Creek Trap, fin clipped, and released in Streeper Creek. Thirty-three percent of the spawners were taken from the stream dead, with males and females dying at the same rate, showing the effect of spawning was as hard on the male as on the female. Approximately 40 percent were known to return downstream alive, the remaining 27 percent were not accounted for but probably can be included as mortality. The spawners migrating from the stream, many being diseased, would suffer further mortality after reaching the reservoir. Both natural and artificially spawned fish suffer high mortality.

Movements

Before spawning. In early May, usually during time of ice break up, spawners under the various effects of migratory stimuli start ascending streams to spawn. Not all spawners migrate to the spawning grounds at the same time and as a result the spawning season is spread out from early May to late July. The daily intensity of migration appeared to be associated with a rise in water temperature.

The majority of male cutthroat trout ripen before the females, therefore the sex ratio on the spawning grounds at the beginning of the spawning run is predominately male. Four males caught at the onset of the spawning run while the reservoir was still completely covered with ice (April 27, 1957) were all ripe.

After spawning. The female cutthroat, unlike salmon, does not defend her redd or continue to dig other redds after she has completed

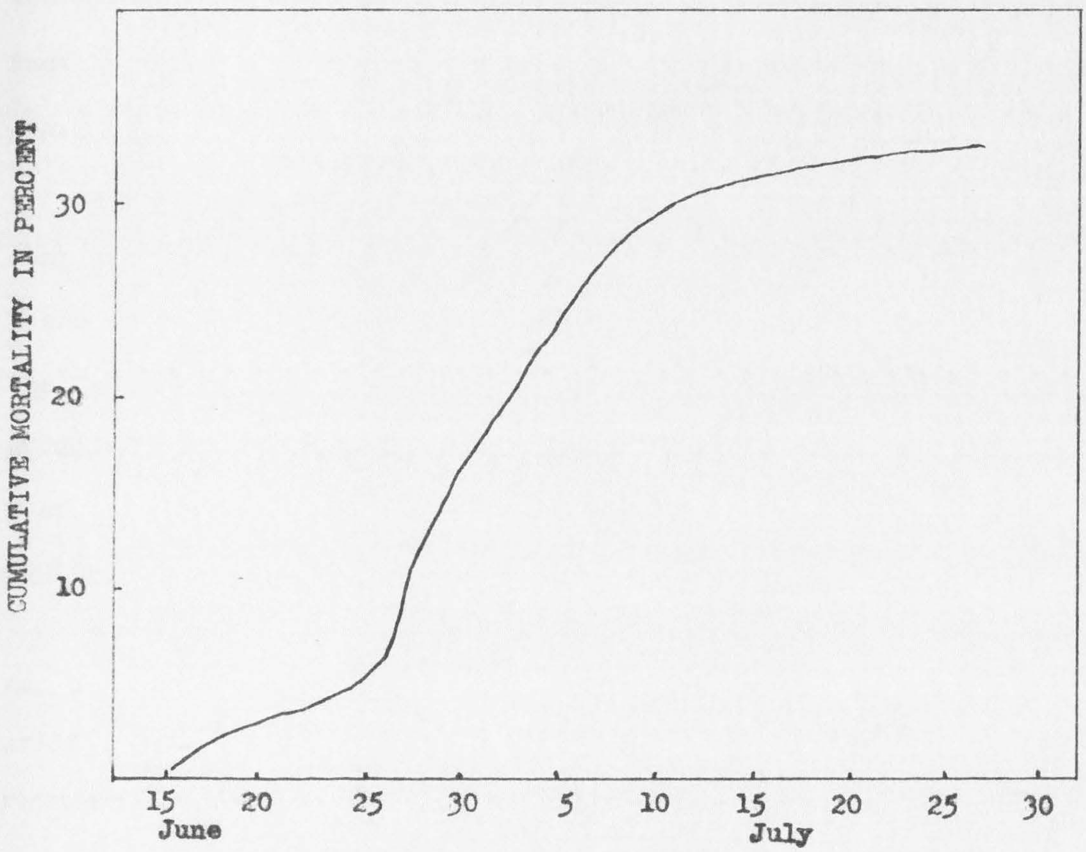

Figure 5. Observed mortality of 252 spawners released in Streeper Creek during the 1957 season.

spawning. However many females that were spawned artifically in the traps continued upstream and defended a territory on which to dig a redd. Males were also seen attending artificially spawned females. It is possible that all of the eggs were not taken leaving the female with a desire to deposit them. Even if all of the eggs were taken by artificial spawning it still may not quell the spawning urge as evidenced by the fact that a high percentage of released spent spawners returned to the spawning traps.

After spawning is completed most spawners soon lose the urge to stay on the spawning grounds. It is my opinion from observation that there is a definite stimulus that gives spawners the desire to return to the reservoir. However, all spawners do not have this stimulus as evidenced by the fact that marked spawners have been observed to winter over in the tributaries.

Conclusion

Strawberry Reservoir cutthroat trout have a strong homing instinct and a strong drive to complete the spawning act. Both natural and artificial spawning results in high mortality leaving few spawners to return the following year.

NATURAL VERSUS ARTIFICIAL PRODUCTION

The effectiveness of artificial versus natural reproduction is one of the most fundamental problems in fishery management. An overall conclusion would be hard to obtain as each area is different. In the same area different streams will vary from each other in natural reproduction potentialities. Even the same stream will vary from year to year depending on various factors.

There are those who contemplate the complete stoppage of natural

Female cutthroat spawner
2,090 eggs

Natural reproduction	Artificial propagation
female cutthroat 2,090	female cutthroat 2,090
Eggs retained 100	Eggs retained 500
Eggs deposited 95 percent	Eggs rejected 5 percent
Eggs fertilized 84 percent	Eggs fertilized 87 percent
Eggs lost through superimposition unknown	-
Eggs developing into free-swimming fry minus superimposition 1,007	Eggs developing into free swimming fry 1,012

Figure 6. Summary of natural versus artificial findings, 1957.

reproduction and stocking with only hatchery reared fish. This idea would be sound if an unlimited budget and facilities were offered just for rearing of fish. Because this would never happen, natural reproduction has its place and only with the combination of the two will the most be gained in the fishery.

It is possible that losses resulting from interference with natural spawning runs and artificial propagation of eggs obtained can be greater than would have occurred had the fish been left to spawn naturally. It has been shown that hatchery fry show greater mortality after planting than natural fry; Shuck (1943), White (1927) and others.

The main objective was to determine if loss resulting from interference of natural spawning was more or less than would happen if spawners were allowed to spawn naturally.

Conclusions

Figure 6 summarizes the results of the comparison. Artificial propagation produces slightly more fry with natural reproduction a close second. The expense of procuring fry artificially, plus the fact that natural fry are more capable of meeting their environment, makes it advantageous to utilize the natural reproduction potentialities.

Recommendations

The present cutthroat spawning run in some tributaries is larger than the favorable spawning grounds can care for. Spawners should be allowed to utilize the favorable spawning areas; excess spawners could be spawned artificially and the fry used where they are needed. These excess fry could be planted back in the tributaries after that portion of the stream was cleared of trash fish by the use of toxicants. The planting of fry in streams containing large populations of other fish is usually ineffective since competition and predation prevent any significant survival.

CONCLUSIONS

Natural reproduction in the favorable areas is an efficient process with 63 percent of the ova, minus superimposition, surviving to the fry stage. Once in the fry stage mortality is very high; it takes 92 percent by the end of their first summer. This high percent is probably why the planting of fry produces so few catchable fish. From the effects of natural reproduction spawners suffered such high mortality that they are lost to the future replenishment of their species and also to man. Non-game fish, beaver, and man are the most harmful influences to the cutthroat population in Strawberry Reservoir.

SUMMARY

1. Natural reproduction and artificial propagation were studied to determine the part each plays in the replenishment of the cutthroat trout.

2. Natural and artificial methods were evaluated and compared by determining efficiency of extrusion and fertilization of ova and by measuring the mortality through the ova and alevin stages.

3. In Streeper Creek 252 cutthroat trout were released to determine spawning efficiency.

4. Losses of ova and alevins in the gravel were determined by checking 154 cutthroat redds.

5. The effects of beaver and cattle on cutthroat trout are discussed.

6. Downstream traps were placed in the tributaries entering Strawberry Reservoir to determine results from planting fry and those produced naturally.

7. To study homing, mortality, and movements, 2,838 spawners were marked.

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APPENDIX 1

REDD CHECK TABLES

Table 12. Summary of mortality and survival in eggs and fry in the 1956 redd checks on the tributaries entering Strawberry Reservoir, Utah.

Date checked	Live Eggs	Live Sac fry	Live Fry	Dead eggs
		Bryants Fork Creek		
6-23	9	-	-	-
6-23	3	-	-	-
6-23	9	-	-	8
7-9	-	-	2	82
7-29	-	-	4	194
Totals	21	0	6	284
		Indian Creek		
6-23	52	-	-	5
6-23	60	-	-	-
6-23	36	-	-	-
6-23	40	-	-	2
6-23	5	-	-	1
6-23	7	-	-	1
6-23	8	-	-	-
7-3	25	-	-	-
7-3	419	10	-	165
7-15	96	39	-	238
7-29	-	56	42	218
8-14	-	-	-	253
Totals	748	105	42	883
		Mud Creek		
7-15	100	15	-	226
7-27	-	-	3	25
8-14	-	-	-	1,103
Totals	100	15	3	1,354
		Streeper Creek		
7-26	3	-	-	-
7-26	3	-	-	-
7-26	3	-	-	-
7-26	136	-	-	-
8-9	214	44	-	142
8-26	-	77	-	130
8-27	332	181	112	234
9-12	-	-	9	9
9-12	-	1	27	229
9-21	-	-	7	41
9-21	-	-	1	9
Totals	691	303	156	794

Table 12. continued.

Trout Creek

Date checked	Live			Dead
	Eggs	Sac	Fry	Eggs
7-16	64	0	0	0
Totals	64	0	0	0

Clyde Creek

7-22	28	28	1	776

Table 13. Summary of mortality and survival in eggs and fry in Streeper Creek redd checks sampled at 5-day intervals, 1957.

Date of deposition	Number of days from deposition when checked	Live				Dead			
		Pre-eyed eggs	Eyed eggs	Sac fry	Fry	Pre-eyed eggs	Eyed eggs	Sac fry	Fry
6-21	5	427	-	-	-	15	-	-	-
6-19	10	661	-	-	-	14	-	-	-
6-20	10	15	-	-	-	2	-	-	-
6-19	15	76	-	-	-	3	-	-	-
6-19	15	134	3	-	-	39	-	-	-
6-19	15	no specimens							
6-20	20	280	3	-	-	5	-	-	-
6-19	20	2	23	-	-	2	-	-	-
6-19	25	no specimens							
6-19	25	no specimens							
6-21	25	-	1	-	-	-	-	-	-
6-20	30	238*	60	-	-	108	-	-	-
6-20	35	1	-	45	-	-	-	-	-
6-20	35	-	-	-	-	4	-	-	-
6-20	40	24	1	191	-	148	9	-	-
6-19	45	-	-	7	-	3	2	-	-
6-20	50	-	-	-	-	-	-	-	3
6-20	50	no specimens							
6-19	50	-	-	-	1	-	-	-	-
6-19	50	-	-	-	58	18x	-	-	-
Totals		1,858	91	243	59	361	11	0	3

* Almost eyed

x Too far decomposed to tell stage of development

Table 14. Summary of mortality and survival in eggs and fry in Trout Creek redd checks sampled at 5-day intervals, 1957.

Date of deposition	Number of days from deposition when checked	Live				Dead			
		Pre-eyed eggs	Eyed eggs	Sac fry	Fry	Pre-eyed eggs	Eyed eggs	Sac fry	Fry
5-13	5	580	-	-	-	8	-	-	-
6-14	5	65	52	-	-	4	-	-	-
6-10	10	176	147	-	-	110	-	-	-
6-14	10	-	2	-	-	384	-	-	-
6-14	10				no specimens				
6-20	10	87	-	-	-	25	-	-	-
5-17	15	980	-	-	-	164	-	-	-
5-17	15	-	-	-	no specimens				
5-17	15				no specimens				
6-7	20	-	-	-	-	1	-	-	-
6-7	20	-	3	-	-	298	-	-	-
6-14	20	42	-	-	-	1	-	-	-
6-14	25	1	1	-	-	4	-	-	-
6-20	25				no specimens				
6-24	30	-	-	-	-	40	-	-	-
6-30	30	19	141	-	-	40	-	-	-
6-28	35				no specimens				
6-30	40	-	-	-	-	225	30	-	-
6-28	40	4	-	47	-	11	2	-	-
6-24	45	-	-	10	-	27	5	-	-
6-28	50	-	-	60	-	11	-	-	-
6-30	50	-	-	-	-	89	36	-	-
6-30	55				no specimens				
6-30	60	-	-	-	16	1	-	-	-
6-30	60	-	-		no specimens				
6-30	65	-	-	-	29	1	-	-	-
Totals		1,954	346	117	45	1,444	73	0	0

Table 15. Summary of mortality and survival in Trout Creek redd checks taken upstream above the influences of cattle, 1957.

Estimated days from deposition when checked	Live				Dead			
	Pre-eyed eggs	Eyed eggs	Sac fry	Fry	Pre-eyed eggs	Eyed eggs	Sac fry	Fry
15	90	-	-	-	7	-	-	-
20	42	-	-	-	1	-	-	-
30	1	9	2	-	8	-	-	-
30	19	141	-	-	40	-	-	-
35	1	-	-	8	-	-	1	-
40	4	-	47	-	11	2	-	-
45	-	-	10	-	27	5	-	-
50	-	-	60	-	11	-	-	-
60	-	-	-	16	1	-	-	-
65	-	-	-	29	1	-	-	-
Totals	157	150	127	45	107	7	1	0

Table 16. Summary of mortality and survival in eggs and fry in Indian Creek redd checks sampled at 5-day intervals, 1957.

Date of deposition	Number of days from deposition when checked	Live				Dead			
		Pre-eyed eggs	Eyed eggs	Sac fry	Fry	Pre-eyed eggs	Eyed eggs	Sac fry	Fry
6-21	5	61	-	-	-	5	-	-	-
6-19	10	31	-	-	-	1	-	-	-
6-19	10	no specimens							
6-19	15	282	-	-	-	3	-	-	-
6-19	20	-	-	no specimens					
6-29	20	no specimens							
6-30	20	-	1	-	-	1	-	-	-
6-19	25	-	1	-	-	-	-	-	-
6-19	25	77	129	-	-	8	-	-	-
6-20	30	-	no specimens						
6-20	30	no specimens							
6-20	30	-	94	-	-	10	5	-	-
6-19	40	-	-	-	-	5	-	-	-
6-19	40	-	-	1	2	15	7	-	-
6-20	45	-	-	-	-	5	-	-	-
Totals		451	225	1	2	53	12	0	0

Table 17. Summary of mortality and survival in eggs and fry in Bryants Fork Creek redd checks sampled at 5-day intervals, 1957.

Date of deposition	Number of days from deposition when checked	Live				Dead			
		Pre-eyed eggs	Eyed eggs	Sac fry	Fry	Pre-eyed eggs	Eyed eggs	Sac fry	Fry
6-28	5	6	-	-	-	12	-	-	-
6-30	5	31	-	-	-	7	-	-	-
5-19	10				no specimens				
7-4	10	339	-	-	-	11	-	-	-
6-28	15	215	3	-	-	48	-	-	-
5-19	20				no specimens				
6-28	20	305	-	-	-	46	-	-	-
6-17	25	7	59	-	-	10	2	-	-
6-28	30				no specimens				
6-29	30	-	11	1	-	27	11	-	-
5-19	35	224	17	-	-	28	-	-	-
5-15	40	-	5	-	-	2	-	-	-
5-18	45	2	2	7	-	27	52	-	-
5-18	45	1	1	8	-	20	38	-	-
6-28	50 a	-	-	-	-	8 b	-	-	-
6-28	50 a	-	-	-	10	53 b	-	-	-
6-28	50				no specimens				
6-15	50 a	-	-	-	3 c	48 b	-	-	-
Totals		1,130	98	16	13	347	103	0	0

a Fry had already left the redd

b Too far decomposed to determine stage of development

c One fry was well advanced but was deformed so it could not fight its way out of the redd.

Table 18. Summary of mortality and survival in eggs and fry in Mud Creek redd checks sampled at 5-day intervals, 1957.

Date of deposition	Number of days from deposition when checked	Live				Dead			
		Pre-eyed eggs	Eyed eggs	Sac fry	Fry	Pre-eyed eggs	Eyed eggs	Sac fry	Fry
6-18	5	235	-	-	-	5	-	-	-
6-20	5				no specimens				
6-18	10	1,149	-	-	-	102	-	-	-
6-20	10	162	-	-	-	20	-	-	-
6-19	15	18	84	-	-	9	-	-	-
6-19	15				no specimens				
6-23	20	5	63	4	-	10	-	-	-
5-26	25	7	117	-	-	5	-	-	-
5-26	25	10	7	-	-	6	-	-	-
6-20	30				no specimens				
6-20	30				no specimens				
6-23	30	-	1	-	-	1	-	-	-
6-23	30	97	-	-	8	3	-	-	-
6-24	30	-			no specimens				
5-26	35	-	-	-	-	1	-	-	-
5-26	35	-	-	2	-	108	11	-	-
6-15	35	67c	5	46	-	49	12	-	-
5-26	40	-	-		no specimens				
5-26	40	-	7d	-	-	-	-	-	-
6-24	40	-			no specimens				
6-24	40	-	-	4	71	71b	-	-	-
6-24	45	-	-	-	25	1	-	-	-
7-1	45	-	-	-	93	34	12	-	-
6-23	50	-	-		no specimens				
6-23	50	-	-	-	2	12b	-	-	-
6-23	55a	-	-	-	1	46b	16	-	-
6-23	55	-	-	-	44	169b	-	-	2
Totals		1,750	284	56	244	652	51	0	2

Fry averaged 24 mm.

a Fry had already left redd

b Too badly decomposed to tell the stage

c Almost eyed

d Ready to become sac fry

Table 19. Summary of mortality and survival in eggs and fry in Sage Creek redd checks sampled, 1957

Number	Live		Dead	
	Pre-eyed eggs	Eyed eggs	Pre-eyed eggs	Eyed eggs
1	1	-	19	-
2		no specimens		
3	-	-	1	-
4	-	-	1	-
5	-	-	35	-
6		no specimens		
7		no specimens		
8		no specimens		
9	-	-	1	-
10	252	-	7	-
11	3	-	3	-
12		no specimens		
13	2	-	1	-
14	1	-	1	-
15	12	-	33	-
Totals	271	0	102	0

Table 20. Summary of mortality and survival in eggs in Charlie Chaplin Creek redd checks sampled, 1957.

Number	Live		Dead	
	Pre-eyed eggs	Eyed eggs	Pre-eyed eggs	Eyed eggs
1		no specimens		
2		no specimens		
3	1	-	1	-
4	1	-	10	-
5	2	1	6	-
Totals	4	1	17	0

Table 21. Summary of 15 redds checked to determine fertility of eggs deposited naturally by the cutthroat trout in the tributaries entering Strawberry Reservoir, 1957.

Days from deposition when checked	Live					Dead				Estimated fertility in percent
	Pre-eyed fertile eggs	Pre-eyed infertile eggs	Eyed eggs	Sac fry	Fry	Pre-eyed eggs	Eyed eggs	Sac fry	Fry	
20	91	114								44.4
20		2	23							92.0
30	195	43	60							85.6
30			94			10	5			100.0
30		1	9	2		8				91.4
35	1			45		2				97.9
35		4		47		11	2			92.5
35		1		8		1		1		90.0
35		19	141			40				88.1
40		24	1	191			9			89.3
45	97				8				3	100.0
45		2	2	7		23	45			97.9
45		1	1	8		23	48			98.3
45				7		3	2			100.0
55					25	1				100.0
Totals	384	211	331	315	33	122	111	1	3	84.8

APPENDIX 2

LENGTH-FREQUENCIES FIGURES

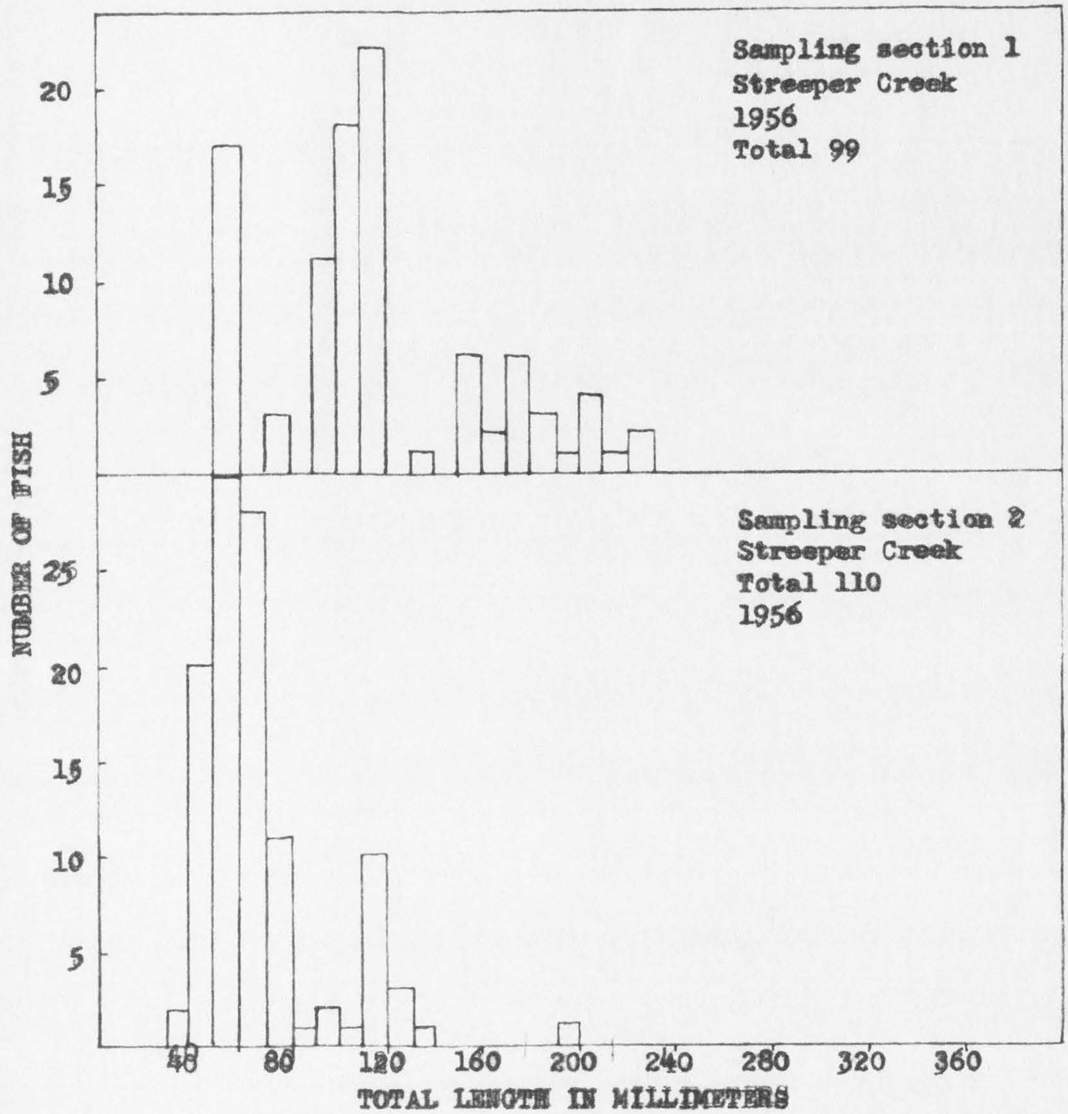

Figure 7. Length-frequencies of resident trout captured in Streeper Creek sample areas, November 1956.

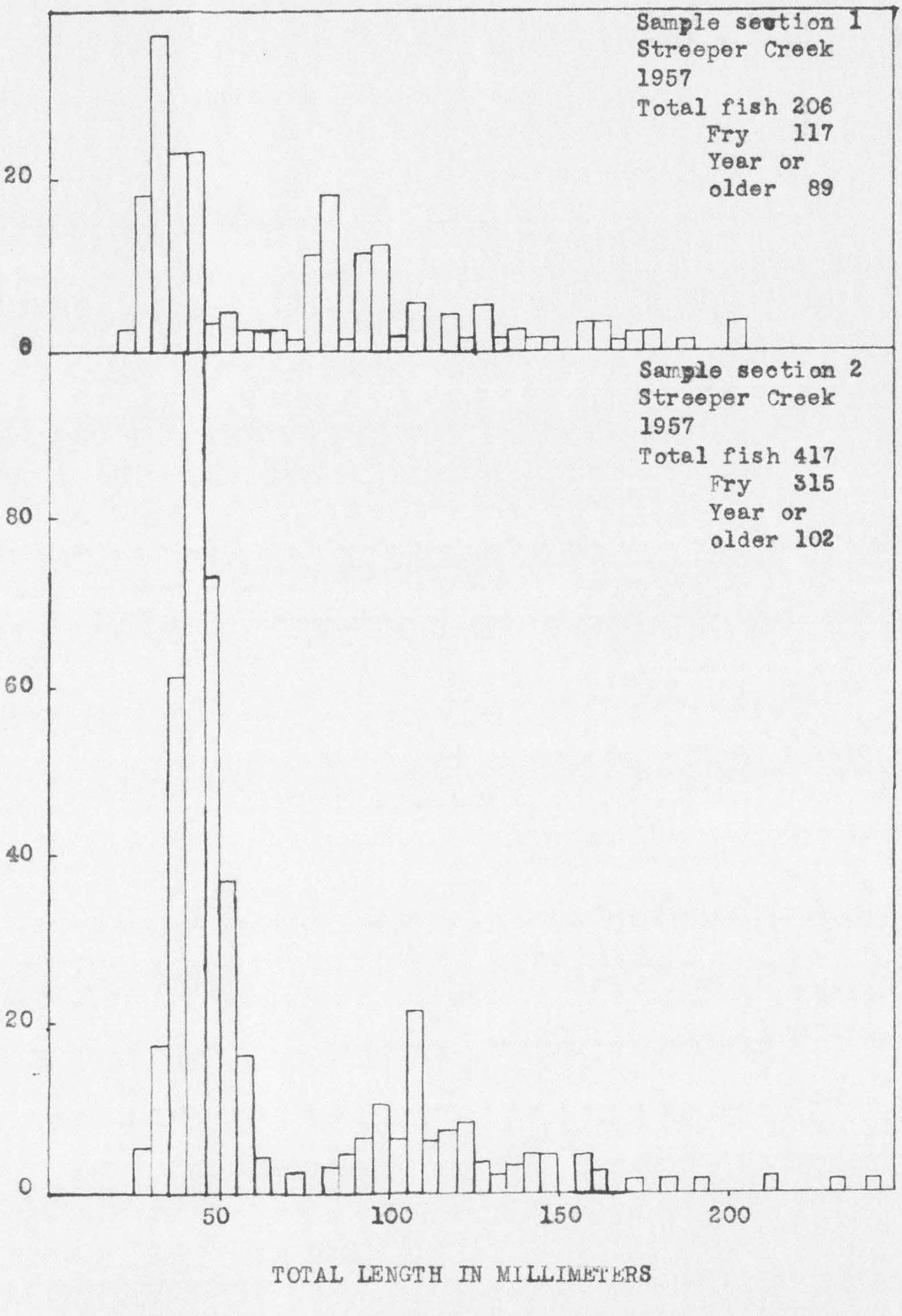

Figure 8. Length-frequencies of resident trout captured in Streeper Creek sample areas, September, 1957.

APPENDIX 3

PHOTOGRAPHS

Figure 9. Mud Creek downstream fish trap, 1956.

Figure 10. Female cutthroat trout from Indian Creek with blocked genital pores, September, 1956.

Figure 11. Male and female cutthroat trout spawning in Bryants Fork Creek, 1956.

APPENDIX 4

SPAWNING ACT

SPAWNING ACT

The female, upon reaching the spawning ground, selects a gravel site where there is an adequate current, then she defends this area against other females and males, driving both away. When a female is successful in defending an area she begins to dig, not always in the same location but in different places, finally settling to one place.

The female turns on her side while digging and at the same time striking her tail vigorously along the bottom she suddenly shoots forward. The body is curved with the tail and head being lower. The female seems at times to be digging with her entire body with even the head or operole moving gravel. The hydraulic force and suction developed by the tail sweeps the small gravel, sand, and detritus into the current where it is carried back into the tailspin. Briggs (1953), in describing the spawning act of silver salmon, concluded that "digging" was accomplished by the salmon suddenly lifting the tail upward resulting in a strong hydraulic suction lifting the substrate into the current. Chamberlain (1907) was under the impression that spawning fish moved the gravel by forcing the body and tail against it. In cutthroat spawning all three were used, i.e., hydraulic force, hydraulic suction, and actual body contact with hydraulic force and suction moving most of the substrate. Actual body contact is used as evidenced by the fact that parts of the body are worn away, especially the lower part of the caudal fin.

The digging of the female attracts the males towards which the female has now become more tolerant. Males station themselves downstream with the dominant male, which is usually the largest one, stationing himself just below the female so as to prevent other males from approaching her. The dominant male drives off all other males. In two instances I observed a male drive away a sandpiper when it walked along near the spawning pair. The male came almost completely out of the water to drive this shore bird away.

By now the female is defending the redd from other females and also defends to some extent against other males, sometimes driving the dominant one away. My observations indicate that the female defends the redd but the male defends a redd only when the female is over it. What he defends is a territory around the female. If the female drops below the redd to rest the male defends this territory around the female and does not necessarily defend the redd. When the female moves from redd to redd the territory around her is still defended.

The female with the redd pit deep enough for spawning digs more rapidly and settles down in it from time to time. Each time she settles the attending male will rush up alongside and then drift back into position below her. When spawning is near the male will sometimes stay close to the female.

Finally, the female settles down in the redd with pectoral and ventral fins well spread along the bottom. The male then darts to position against the female. For several seconds there is a viberation of the male against the female. It is during this time that the eggs and milt are released.

After a few seconds the male again drops back below the female who then covers the eggs. If more spawning is to take place she will usually move a short distance upstream and prepare a new egg site. The eggs are usually covered quickly enough by the female to prevent predation. Taft and Shapovalov (1945) believe that at least 97 percent of the eggs lodge in the pit and are buried. The percent of cutthroat eggs that lodge in the redd depends on the quality of the redd.