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RATE OF SURVIVAL OF BROOK TROUT FROM EGG TO FINGERLING STAGE IN TWO MICHIGAN TROUT STREAMS

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The purpose of this study was to determine the percentage survival of brook trout (<u>Salvelinus</u> <u>fontinalis</u>) from the egg stage (at approximately mid-winter) to the fingerling stage of the following early fall. Two investigational methods were utilized: (1) Wild mature male and female brook trout of known sizes were confined in screened diversions of Hunt Creek and allowed to spawn; the young-of-the-year survivors were collected and enumerated during the following late summer or fall, and their numbers were compared with the estimated numbers of eggs deposited. Similar procedures were used by Smith (1947) in a study at Convict Creek, California. (2) In the second method, successive fall population estimates, by mark-and-recapture with an electric shocker, gave the numbers of mature fish present during a fall spawning season and the numbers of fingerlings which survived to the following fall. Potential egg production by the spawners was computed from the records of number and size of adult females present and from counts of ovarian eggs per female as related to size.

Experiments in Screened Diversions of Hunt Creek

The screened diversions (II and III), where controlled spawning experiments were conducted, lie in the mid-portion of Section C of Hunt Creek (Figure 1) which, on the basis of the numbers of young and adults observed annually, is considered good brook trout habitat. These diversions, constructed in 1940,

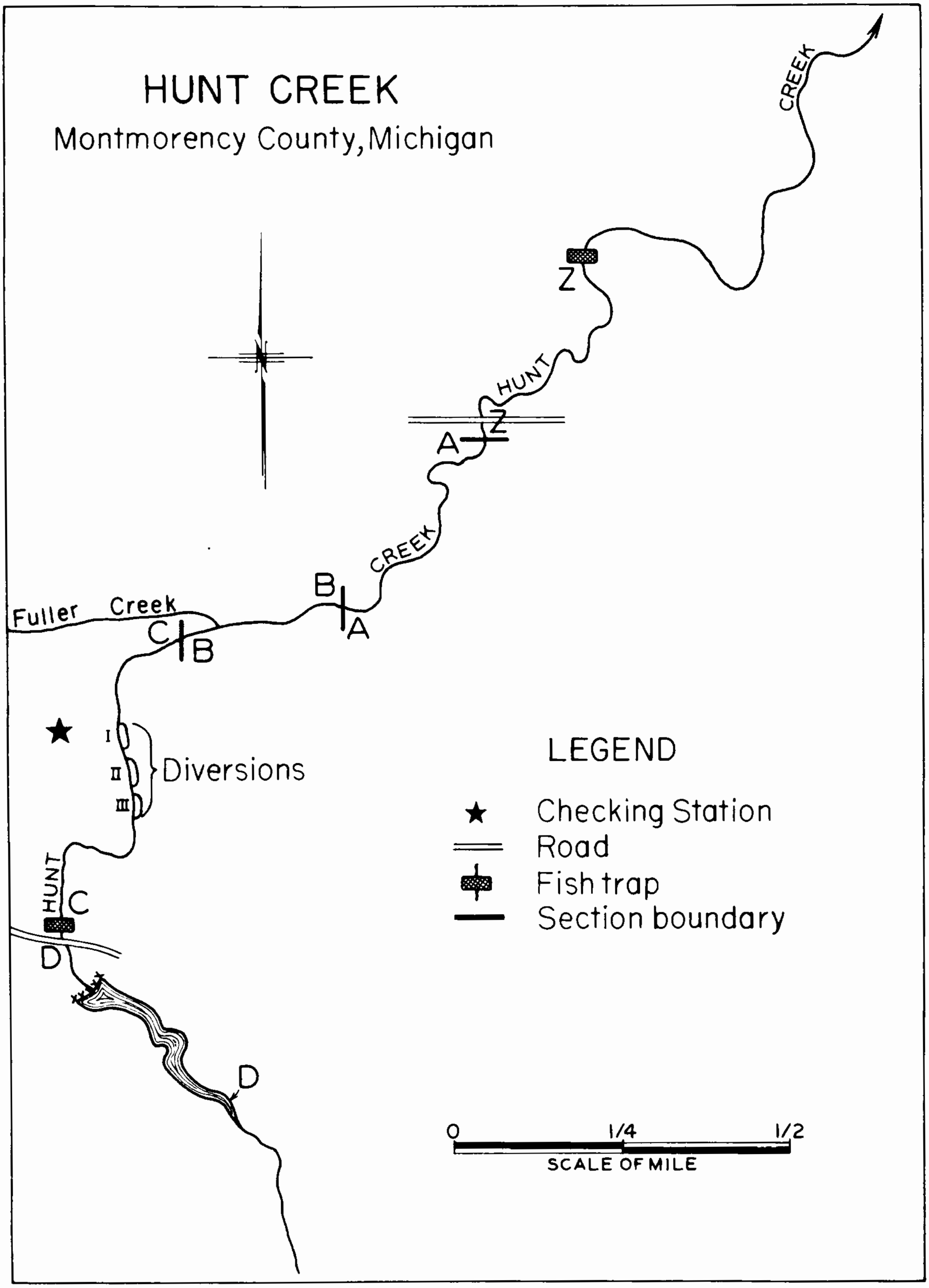

Figure 1.--The Hunt Creek Trout Research Area, Montmorency County, Michigan, showing the diversions and stream sections of particular interest in this study.

are equipped with concrete bulkheads which accommodate stop-logs and vertical screens. Diversion II is 193 feet long, 9 to 14 feet wide and has an area of 0.05 acre; Diversion III is 284 feet long, 8 to 14 feet wide, and has an area of 0.07 acre.

The ecological characteristics of the main channel of Hunt Creek were described by Shetter and Leonard (1943). In 1943, when the present study was begun, Diversions II and III were well established, natural in appearance, and apparently similar in physical characteristics to the natural channel. Both diversions have adequate bottom materials (gravel) for brook trout spawning. Surface ice forms only at the edges, or immediately upstream from the bulkheads during the colder portions of the winter. There are some habitat differences between diversions. Riffle areas predominate in Diversion III, and pool areas in Diversion II. Spring water seepage occurs along approximately 1/3 of the west bank of Diversion III; a somewhat smaller amount of ground water flows into II.

In addition to brook trout, the slimy sculpin (Cottus cognatus) was quite abundant in the diversions; the bluntnose minnow (Pimephales notatus), fathead minnow (Pimephales promelas) and northern redbelly dace (Chrosomus eos) were relatively rare.

The number of female brook trout spawners placed in the diversions amounted to one per 435 square feet or more of stream. Thus the results might be said to apply to a situation with a low density of eggs per square foot of stream, and few other fish present.

Collection of experimental fish and handling procedure

In the northern Lower Peninsula of Michigan, brook trout rarely spawn before mid-October; often the peak of spawning activity is not before the first week of November. For the experiments discussed here, adult females were put in the diversions several days or more before they were ready to spawn, i.e., before they were "ripe." In all years except 1943, experimental fish were collected between September 23 and October 3; in 1943 the experimental spawners were collected on October 29. In autumn it is easy to identify the sexes on the basis of secondary sexual characters.

The spawners were collected with seines in 1943, but in 1944 and subsequent years brood fish were collected with an alternating-current shocker (110/220 volts, 4.9 amps.) as described by Shetter (1947).

Each year before the experimental fish were put in the diversions, they were measured and weighed; in each year except 1943, all fish were jaw-tagged to permit individual identification.

Table 1 gives the average lengths and weights of males and females in the diversions, the mean coefficient of condition (C)[1] before spawning, the mean loss in weight resulting from spawning, the mean post-spawning C, the estimated number (with 95-percent confidence limits) of eggs deposited by the females, and the observed number of unspawned eggs retained by the females after spawning.

Some fish decreased slightly in length during spawning activities, besides losing weight. This loss of length resulted at least in part from physical erosion of the tail and nose membranes during redd building. Computation of condition factor (C) was in all instances based on the total length as measured before spawning.

In 1943, after the spawning season, removal of the spawners by gill-netting, trap-netting, and dip-netting was attempted, but 5 of the 15 trout used were not recovered. In 1944-1947 all of the spent females (and most males) were removed by electrofishing within the period December 1-12; by

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[1] $C = \frac{W\ 10^5}{L^3}$, where W = weight in pounds, and L = total length in inches.

Table 1.--Mean total length, weight and coefficient of condition (C) of brook trout spawners at time of introduction into Hunt Creek diversions, loss in weight and condition factor after spawning, and estimated egg production, for 1943-1947 spawning experiments

Spawning season, fall of:	Date spawners introduced	Date spawners removed	Source of females[1]
1943	Nov. 2	Feb. 11 ('44)	L
1944	Oct. 23	Dec. 7	5 S, 2 L
1945	Oct. 3	Dec. 7	S
1946	Sept. 5	Dec. 2	L
1946	Sept. 26	Dec. 2	L
1947	Sept. 23	Dec. 12	S

	Mean data on spawners					
	Number	Length (inches)	Weight (pound)	C	Loss in weight (pound)	C, after spawning
Males[2]						
1943	5	8.7	.24	35	.02	32
1944	10	8.5	.22	35	.03	30
1945	5	7.4	.15	35	.02	31
1946	8	9.4	.32	37	.05	31
1946	2	12.5	.83	44	.14	38
1947	9	7.6	.18	40	.03	33
Females						
1943	5	10.2	.37	33	.05	28
1944	7	8.5	.26	37	.05	29
1945	5	7.6	.17	38	.05	28
1946	5	9.8	.35	36	.09	28
1946	1	14.0	1.13	41	.22	33
1947	4	7.7	.19	41	.05	29

	Number of females	Estimated total eggs laid			Number of eggs retained by females
		Number	95 percent confidence limits		
1943	5	3,832	2,657	5,007	67
1944	7	3,732	2,706	4,774	1
1945	5	1,660	1,104	2,218	0
1946	5	3,304	2,051	4,461	1
1946	1	1,777	973	2,581	5
1947	4	1,373	879	1,867	0

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[1] L = East Fish Lake; S = Hunt Creek. In 1944, 5 females were from the stream, and 2 from the lake.

[2] Some of the male spawners which were introduced were not recovered, and such fish are not represented in the tabulation.

this time the eggs were in the eyed stage and presumably were quite resistant to injury which might result from the shocker crew wading in the stream. The females which were recovered were dissected to determine the numbers of mature eggs which they had retained. The surviving males were liberated outside the experimental diversions.

Collection of the surviving fingerlings

Usually 6-mesh-to-the-inch vertical screens were used to confine the brood fish in their respective diversions. Following the removal of the spent fish in December, 10-mesh-to-the-inch vertical screens were substituted for the coarser ones. (Tests indicated that it was not possible for newly hatched brook trout fry to pass through No. 10 mesh.) The stop-log slots were packed with oakum to fill the cracks. The screens were inspected daily and brushed to clean off water-born debris. Flood water was bypassed around the diversions whenever the water level rose. Water did not flow over the top of the blocking screens at any time during the study. There were two to five extraneous trout (see Table 2) in the diversions at the end of each experiment (except 1946); how they got there is unknown.

The fingerling survivors (Table 2) were collected during the summer or fall on dates as early as July 3 (1944) or as late as September 22 (1947). In collecting the fish, repeated runs were made with the A-C shocker, until no fish were captured on several successive runs. Then the water flow was blocked from the diversion, and the remaining spring water pools were treated with a dilute solution of a chlorinated bleach to capture any remaining survivors. The fish were counted, weighed, measured and removed from the diversions.

Method of estimating numbers of eggs deposited

The estimated number of eggs deposited by the females was determined from two regression equations developed from egg counts made on 56 female brook trout

Table 2.--Statistics on fingerling brook trout recovered from spawning experiments in Hunt Creek diversions

[For data on spawners and on eggs produced, see Table 1]

Spawning season, fall of:	Diversion	Collection of fingerlings			Predatory trout present		
						Length (inches)	
		Date[1]	Pounds	Number per female	Number	Min.	Max.
1943	II	July 8	0.8	35	2	6.8	9.3
1944	III	Aug. 26-27	2.1	30	5	4.4	5.7
1945	III	Sept. 11	5.4	105	2	5.0	6.2
1946	III	Sept. 15	2.4	45	4	6.1	8.9
1946	II	Sept. 16	1.7	156	0	...	...
1947	III	Sept. 22	1.8	26	5	6.2	9.6

	Fingerlings collected				Fingerling survival (percentage of eggs laid)		
		Length (inches)				95 percent confidence limits	
	Number	Mean	Min.	Max.	Survival		
1943	173	2.4[2]	1.6	3.1	4.5	3.5	6.5
1944	208	3.2	2.2	4.2	5.6	4.4	7.7
1945	527	3.1[3]	2.3	4.1	31.7	23.8	47.7
1946	224	3.1	2.1	4.3	6.8	5.0	10.9
1946	156	3.1	1.7	4.4	8.8	6.8	16.0
1947	104	3.6	2.1	4.7	7.6	5.6	11.8

[1] During calendar year following that of spawning season.

[2] Based on 146 measurements.

[3] Based on 521 measurements.

collected in the Hunt Creek drainage, mostly in 1939 and 1943. Fifty-two of the fish were taken during August, 3 in July, and 1 in October. All except the latter (trap-netted) specimen were obtained by angling. (Appendix A lists the pertinent data for each individual female brook trout.)

Vladykov (1956) demonstrated that egg counts made on brook trout females collected as early as August are likely to be misleading, yielding counts appreciably higher than the probable egg numbers deposited in the redds in October or early November. He showed that as the maturing ovarian eggs increased in diameter from 1 to 4 millimeters, the reduction in egg number was about 36 percent, as the result of atresia. The average diameters of 40 maturing eggs from each of 13 females collected from the Hunt Creek drainage in August 1943 ranged from 1.2 to 2.5 millimeters. On the basis of these diameters and data presented by Vladykov (1956), I estimated that my August counts of eggs in brook trout were 20 percent higher than the number which these fish would have laid during the following spawning season. Accordingly, in calculating the regression line for egg production of trout in the stream and pond habitats, individual counts were multiplied by a factor of 0.80.

Exploratory calculations by Dr. Don W. Hayne indicated that predictions of egg numbers based on fish weight were only slightly more accurate than predictions based on length. To permit direct comparison with other published data, and for convenience, my estimations of egg numbers are based on total length of the fish.

Among the 1939-1943 Hunt Creek collections of female brook trout for egg counts, most of the larger fish were taken from lake-pond habitats, and the smaller fish (those less than 9.3 inches long) were collected from stream habitats. The lake-pond fish were generally deeper bodied, and their growth pattern, particularly in East Fish Lake, was such that relatively few females matured at lengths less than 8 inches. For this reason separate regression lines were prepared for stream and for lake fish. The regression line of number of eggs and length for stream fish (20 brook trout, 6.3-9.2 inches in length) was

$$\underline{Y} \text{ equals } -245.91 + 76.02\underline{X}$$

where $\underline{Y}$ is the estimated number of eggs laid, and $\underline{X}$ is the length of the fish in inches. The regression line of eggs and length for pond-lake fish (36 brook trout, 7.6-16.4 inches in length) was

$$\underline{Y} \text{ equals } -1925.32 + 264.43\underline{X}$$

These two regression lines are shown in Figures 2 and 3. The 95-percent confidence limits were calculated by the method described by Snedecor (1957). Experimental fish from East Fish Lake were referred to the pond-lake regression line, and stream fish to the stream-fish regression line, for an estimate of the numbers of eggs produced. The estimates of egg production and their variances for individual female spawners were added to give the number (and its 95% confidence limit) of eggs deposited in each experiment.

Results in the diversions

Based on estimated numbers of eggs deposited (Table 1) and numbers of fingerlings recovered during the following summer or fall (Table 2), the percentage survival varied between 4.5 (1943) and 31.7 (1945). Except for 1945, all percentages were 8.8 or less. The below-average recovery of survivors from the spawning in 1943 may have resulted in part from the late date at which the experiment was started; some or all of the females may have deposited a portion of their eggs before confinement in the diversion.

Hobbs (1940) pointed out that superimposition of redds of brook trout resulted in loss of eggs deposited by early spawners in New Zealand streams. It is not believed that this was a factor in the Hunt Creek experiments, since the density of females never exceeded one per 435 square feet of stream, and an adequate amount of spawning gravel was available.

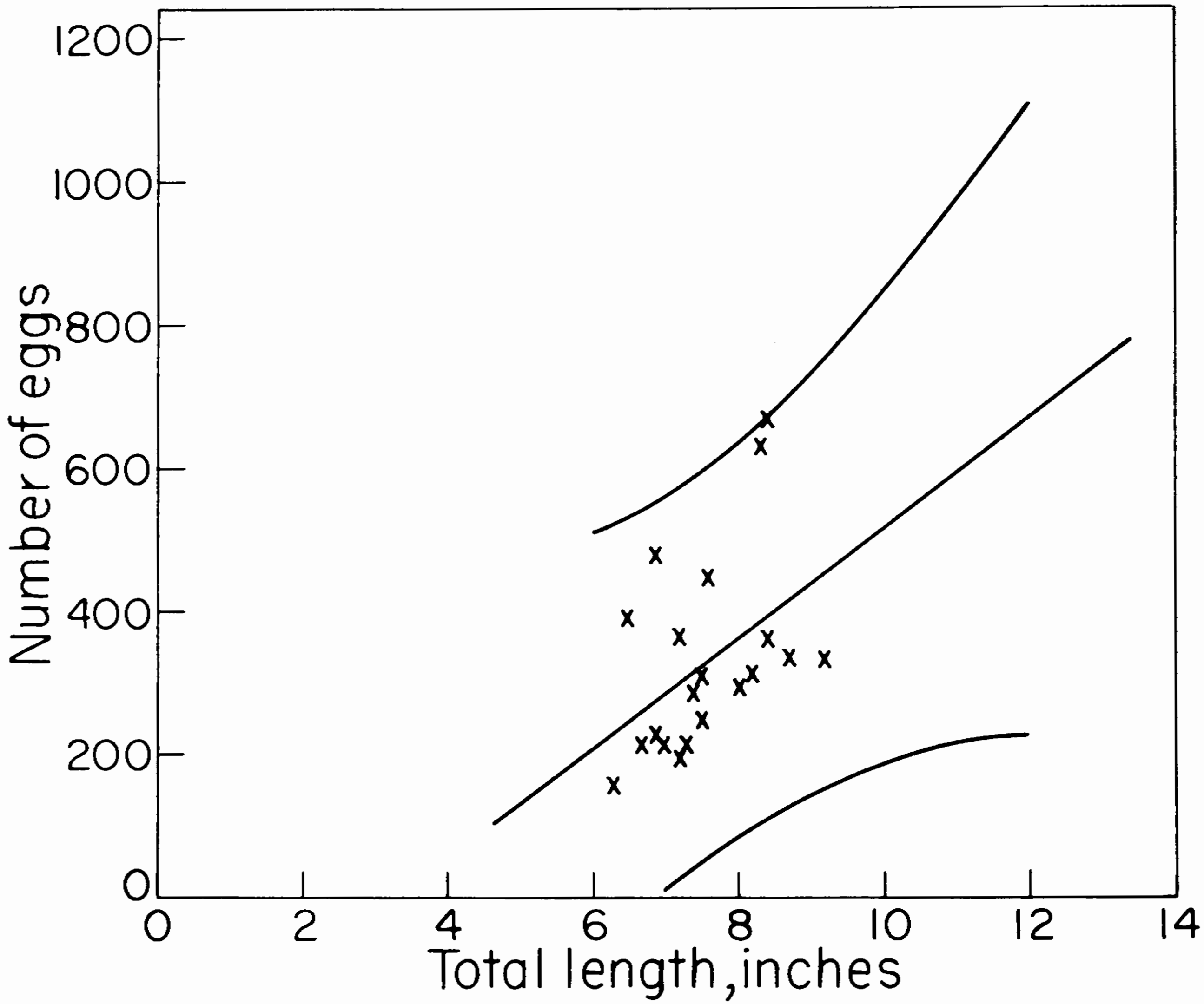

Figure 2.--Regression of number of eggs on total length, for 20 brook trout from streams of Hunt Creek drainage, with 95-percent confidence limits. See text for regression formula.

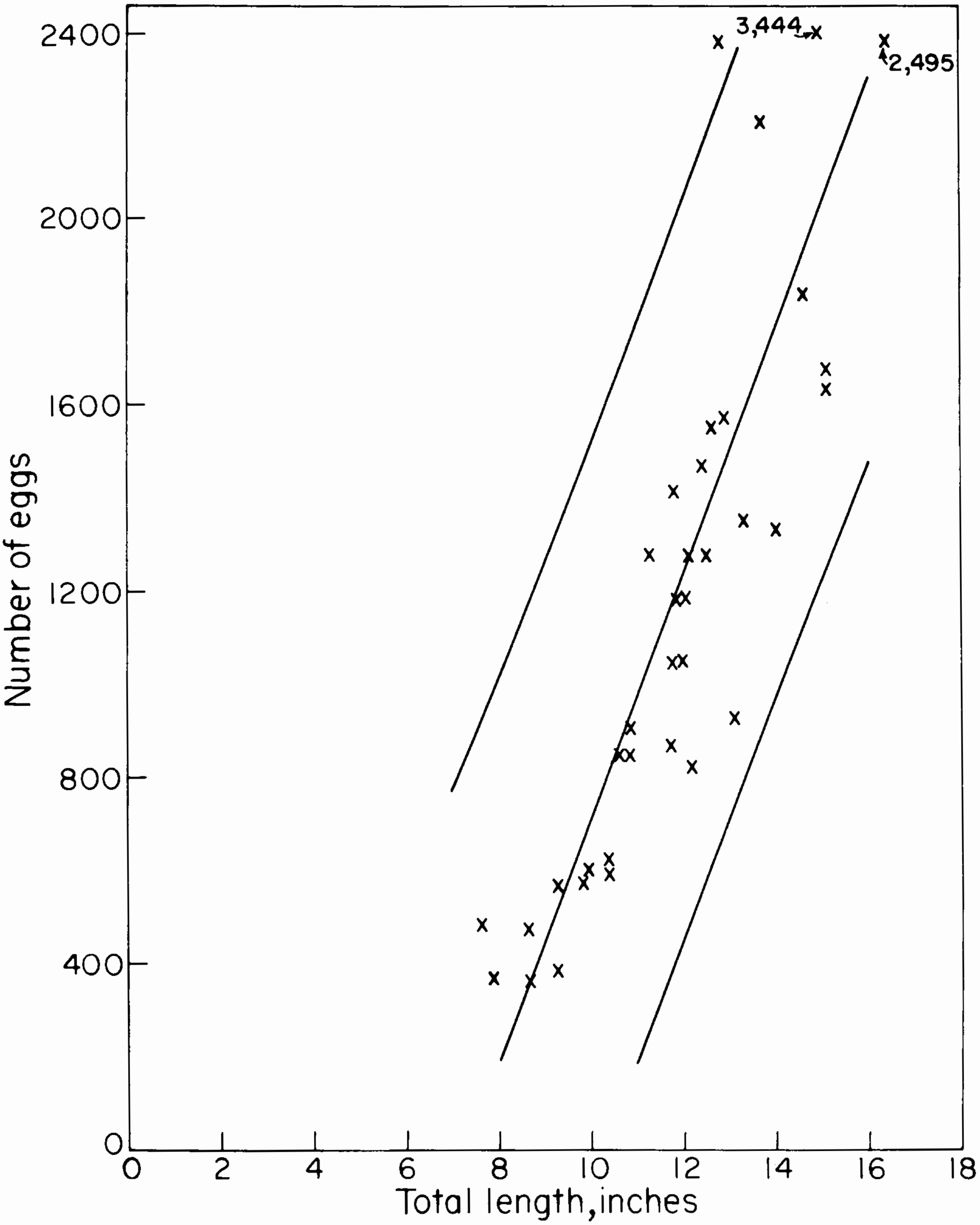

Figure 3.--Regression of number of eggs on total length, for 36 brook trout from lake or pond habitat of Hunt Creek drainage, with 95-percent confidence limits. See text for regression formula.

In five of the six diversion experiments there were 2 to 5 extraneous brook trout (4.4 to 9.3 inches long) present with the fry (Table 2). These fish may have consumed some of the fry or fingerlings, although studies at Hunt Creek (by J. W. Leonard[2] and by G. R. Alexander) fail to show that such predation occurs commonly. In the six diversion experiments there was no correlation between numbers of extraneous trout present (0 to 5) and percentage survival of the fry (4.5 to 31.7). Smith's (1947) data point to a similar conclusion, even though 18 to 264 potential competitor-predator brown or rainbow trout were present in his experimental sections.

Retention of eggs by female brook trout was not an important factor in this study. Of 27 females used in all the experiments only 6 retained eggs and the numbers were small (Table 1).

The estimates of fingerling survival obtained under controlled conditions at Hunt Creek and Convict Creek are plotted in Figure 4 along with their respective 95-percent confidence limits. Confidence limits for Smith's (1947) estimates were obtained in a manner similar to that used for the Hunt Creek data, using his information on standard error and numbers of experimental female brook trout in the various inch-groups.

The data obtained from the diversion experiments at Hunt Creek and Convict Creek were subjected to the White rank test (Edwards, 1954), both with and without the three high observed survival values. In neither test was there a statistically significant difference between the Hunt Creek and Convict Creek survival values.

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[2] Institute for Fisheries Research Report No. 659 (1941), unpublished.

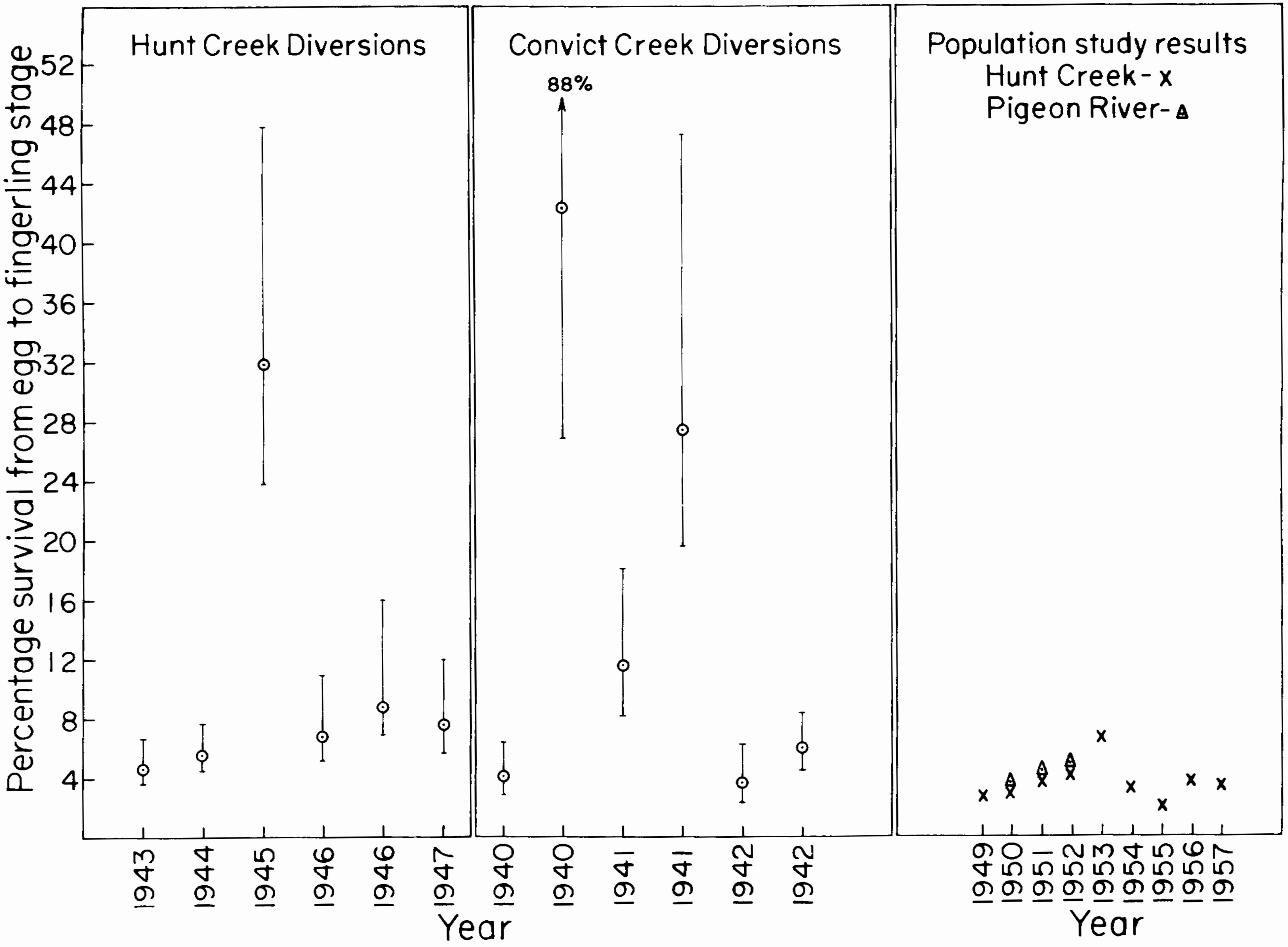

Figure 4.--Percentage survival of brook trout from egg to fingerling stage, determined by diversion studies at Hunt Creek and Convict Creek (with 95-percent confidence limits) and by population studies at Hunt Creek and Pigeon River.

Estimates of survival rate from egg deposition to the following fall as determined from population studies

The experimental sites, where estimates of brook trout survival from egg to the first fall were calculated from a combination of population study records and fecundity data, were the Pigeon River experimental sections described by Cooper (1952), and the experimental stream sections (not the diversions) of the Hunt Creek Trout Research Station. Records from the Pigeon River are for 4.8 miles (24.10 acres) of stream in 1950, and 2.5 miles (13.06 acres) of stream in 1951 and 1952.

At Hunt Creek, the population studies were conducted annually through 1.75 miles (3.91 acres) of stream. The four sections (see Figure 1) are: Section Z, with semi-open meadow bordered by scattered tamarack and low brush, and with varied current; Section A, in old beaver meadow with low tag alders bordering the stream, and with sluggish current; Section B, bordered by a dense swamp of cedar, spruce, balsam, and tamarack, and with rapid current; and Section C, of which the lower 1/3 flows through the same swamp as Section B, and the upper 2/3 is located in a narrow steep-sided valley with much shade from a mixed stand of tag alder, poplar, tamarack and pine. Barrier weirs and fish traps are located at the lower end of Section Z and at the upper end of Section C.

It is estimated that about 20 percent of the bottom area of the Hunt Creek experimental stream sections is suitable for brook trout spawning. A similar estimate is not available for the Pigeon River, but spawning grounds are extensive.

Species of fish most commonly encountered in the Pigeon River are brook trout, brown trout (Salmo trutta), rainbow trout (Salmo gairdneri), white sucker (Catostomus commersoni), common shiner (Notropis cornutus), creek chub (Semotilus atromaculatus), blacknose dace (Rhinichthys atratulus), longnose dace (Rhinichthys cataractae), central mudminnow (Umbra limi), and mottled sculpin (Cottus bairdi). Minnows are relatively scarce in the experimental waters of Hunt Creek, as compared with the Pigeon River. In the fall population studies at Hunt Creek, white suckers, creek chubs, bluntnose and fathead minnows, and northern redbelly dace are seen only infrequently; slimy sculpins, mottled sculpins and mudminnows are somewhat more numerous.

Subsequent to the termination of the Hunt Creek diversion experiments described here, and those reported by Smith (1947) from Convict Creek, California, considerable advancement has been made in electrofishing equipment and techniques, and their application to trout-stream population studies. When population data are combined with knowledge of potential egg deposition, it is possible to estimate the survival from the egg to the fingerling stage. E. L. Cooper (1953) reported such results for the Pigeon River, Michigan, for both brook and brown trout. His three estimates of brook trout survival in the Pigeon River have been combined with nine similar estimates based on Hunt Creek populations and brook trout fecundity. The population study data reported here were accumulated during the period 1949-1958, using the mark-and-recapture method in conjunction with alternating-current and direct-current electrofishing gear (Shetter, 1947). The age composition of the brook trout population each fall was determined following the method described by Ketchen (1950).

Estimates of numbers of spawners present, egg deposition, and survival to the fall stage for brook trout in the open waters of Pigeon River and Hunt Creek are given in Table 3. Only brook trout longer than 5.0 inches are considered as spawners, because egg contribution by females smaller than this size are presumed to be negligible in the two streams.

Cooper (1953) reported on the sex and maturity of 1,712 brook trout collected from 15 different Michigan localities; 55 percent of those over 1 year in age were females. He observed that, among the females, the percentages of mature individuals

Table 3.--Estimates of the numbers of mature female brook trout (larger than 5.0 inches), estimated egg production, and numbers of fingerlings surviving to the following fall, Hunt Creek and Pigeon River, Michigan

Spawning season, fall of:	Female spawners present	Estimated egg production	Fingerlings present, following fall	Percentage survival
Hunt Creek				
1949	810	141,424	3,850	2.7
1950	802	137,840	4,189	3.0
1951	813	134,092	4,950	3.7
1952	739	124,124	5,290	4.3
1953	586	92,420	6,212	6.7
1954	810	125,356	4,164	3.3
1955	1,074	181,296	4,915	2.7
1956	882	175,208	6,654	3.8
1957	794	146,512	5,030	3.4
Pigeon River[1]				
1950	529	150,720	5,491	3.6
1951	216	62,227	2,790	4.5
1952	236	75,251	3,250	4.3

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[1] From Cooper, 1953.

in different length groups were as follows: 5.0-5.9 inches, 62.5 percent; 6.0-6.9, 88.9; 7.0-7.9, 96.6; 8.0-8.9, 96.6; and 9.0 inches or over, 100 percent. His percentages were applied to the Hunt Creek population estimates to determine the numbers of mature females in each inch-group each year. Then the mid-point of each inch-group (e.g., 6.5 for 6.0-6.9) was arbitrarily used to compute (from Figure 2) the average and total egg production for females in this length class. The sum of the calculations for various inch-groups gave an estimate of the total egg deposition in the experimental waters of Hunt Creek each year.

The ratio of fall fingerlings to eggs deposited the previous fall gave an estimate of survival percentage. These estimates ranged from 2.7 to 6.7 for the nine years involved. Cooper's three estimates on egg-to-fall survival of brook trout in the Pigeon River in 1950, 1951, and 1952 were 3.6, 4.5, and 4.3 percent, respectively. His estimates were for stream areas which were under the same fishing regulations as those in force at Hunt Creek (a creel limit of 10 fish, and a minimum length of 7 inches).

The estimated numbers of spawning female brook trout varied from 17 to 22 per acre of stream in the Pigeon River and from 189 to 275 per acre in Hunt Creek. The number of young per acre surviving to the following fall varied from 214 to 248 in the Pigeon River and from 985 to 1,702 in Hunt Creek.

These density estimates can be compared with those which may be calculated for the Hunt Creek and Convict Creek Diversion tests, which were: Hunt Creek, 20 to 100 spawning females and 1,486 to 7,529 surviving fingerlings per acre; Convict Creek, 38 to 150 females and 838 to 32,550 fingerlings per acre.

The calculations of survival percentages for brook trout based on population estimates were mostly lower than the estimates from the diversion tests (Figure 4). Neither at the Pigeon River site nor at Hunt Creek was any attempt made to compensate for movement of fingerling brook trout out of, or into, the population study areas. Significant losses or gains among young-of-the-year fish by such movement would alter the estimated percentages of survival.

In other experiments at Hunt Creek, it has been observed that year-to-year survival of brook trout is noticeably higher in the screened diversions than in the natural channel. Possible contributing factors are: (1) the low fish population level in the diversions; and (2) a low population of bird and mammal predators, resulting from human activities in cleaning screens and inspecting the diversions.

The 24 survival estimates (from diversions at Hunt and Convict creeks, and from population estimates at Pigeon River and Hunt Creek) ranged from 2.7 to 43 percent (average, 8.6). Twenty of the 24 values ranged from 2.7 to 8.8 percent (average, 4.7). Based on these studies, a survival above 10 percent would be regarded as unusually high.

Records in the literature indicate that mortality among trout eggs in their redds is relatively low, as compared to mortality from egg to fall fingerling, which, in the present study, was found to be about 92 to 95 percent. Hobbs (1940) reported egg losses in New Zealand brown trout redds ranging from 3 to 29 percent (mostly less than 10 percent). Hazzard (1931) reported mortalities of brook trout eggs to vary from 1.5 to 73 percent (average, 20.2). Brasch (1949) investigated seven Wisconsin brook trout redds and reported an average mortality of 6.5 percent. These studies were limited to mortality of eggs while still in the redds.

In another series of observations Brasch (1949) placed fine-meshed screen cylinders over 16 brook trout redds in Wisconsin spring ponds; five of the redds were not disturbed until all fry had emerged. He collected the fry as they emerged, and at the conclusion of the emergence dug up the redds. His counts of dead eggs may have been low because of egg decomposition. Brasch arrived at a total mortality of 21.3 percent from the time of egg deposition to emergence as free-swimming fry. His observations agree well with those of

Hobbs for brown trout in that there appears to be little mortality in the redds once the sac-fry stage is reached.

From the low rate of mortality among trout eggs in redds, as reported in the literature, it is concluded that much of the egg-to-fingerling mortality occurs after the fry emerge from the redds. In Michigan, March is the time when most fry emerge from redds, and most of the egg-to-fingerling mortality (reported here) must occur between March and September.

Combining Brasch's findings with the present calculations as to numbers of brook trout surviving to the end of the first summer, the general picture would be something on this order:

Eggs deposited in the fall	1,000
Loss between deposition of eggs and emergence of fry	213
Loss between emergence and end of summer	740
Survival to the end of first summer (4.7%) . . .	47

Loss of weight by brood fish in experiments at Hunt Creek

Length and weight measurements of individually identified brook trout before and after spawning demonstrated that an appreciable portion of the pre-spawning weight of both sexes was lost during the spawning season. This loss can be expressed directly as a percentage of the pre-spawning weight, or shown as a loss in coefficient of condition (C).

The average percentage weight loss was calculated for each experiment for each sex separately, using only fish which were measured and weighed before and after spawning (Table 1). The average percentage loss among the six diversion experiments ranged from 8 to 17 percent for males and from 14 to 29 percent for females.

The percentage losses recorded for the 1943 experiment (Table 1) are very likely too low. The experimental fish may have regained some of their lost weight during the comparatively long period of confinement after spawning. If the 1943 experiment is excluded, the average weight loss for 34 males during confinement for spawning was 15 percent; for 22 females, 24 percent.

The 27 females and 39 males were arranged by inch-groups to determine if there was any relationship between length of fish and loss in condition resulting from spawning (Table 4, Figure 5). The males of all sizes were quite uniform in their losses in C; the females were less uniform, but there was no definite trend related to size.

The standard t test indicated that there was no significant difference in the average length of the males and females involved in the comparison, nor was there an average difference in the C values of the sexes before spawning (37.0 for both). The t test did demonstrate that the females had a post-spawning C (28.6) significantly lower than that found for the males (31.6), probably as a result of deposition of gonadal products which are obviously of greater bulk in females than in males.

Acknowledgments

Many former and present Hunt Creek staff members aided in collecting the data described here. Dr. Edwin L. Cooper made many of the egg counts; Lawrence H. Bush collected and recorded the survivors in the diversion experiments; and Gaylord Alexander provided tabulations of year-class estimates from the Hunt Creek population studies. Dr. D. W. Hayne reviewed the statistical procedures, and Drs. Gerald P. Cooper and Paul H. Eschmeyer read the manuscript and made suggestions.

Table 4.--Summary of the changes in coefficient of condition (C) resulting from spawning for 27 female and 39 male brook trout, Hunt Creek drainage, 1943-1947

[Total lengths are given in inches; Cp = Average C prior to spawning; Ca = Average C after spawning]

Length group (inches)	Females				Males			
	Number	Average total length	Cp	Ca	Number	Average total length	Cp	Ca
6.0- 6.9	2	6.7	37	30	4	6.8	40	35
7.0- 7.9	9	7.6	39	29	12	7.4	36	31
8.0- 8.9	6	8.2	39	29	10	8.5	37	32
9.0- 9.9	3	9.5	32	28	8	9.6	35	30
10.0-10.9	2	10.3	33	25	3	10.4	38	30
11.0-11.9	3	11.5	36	28	1	11.0	47	39
12.0-12.9	..	...	..	..	..	...	..	..
13.0-13.9	1	13.9	30	28	..	...	..	..
14.0-14.9	1	14.0	41	33	1	14.1	40	34
Total	27	8.97	37.0	28.6	39	8.57	37.0	31.6

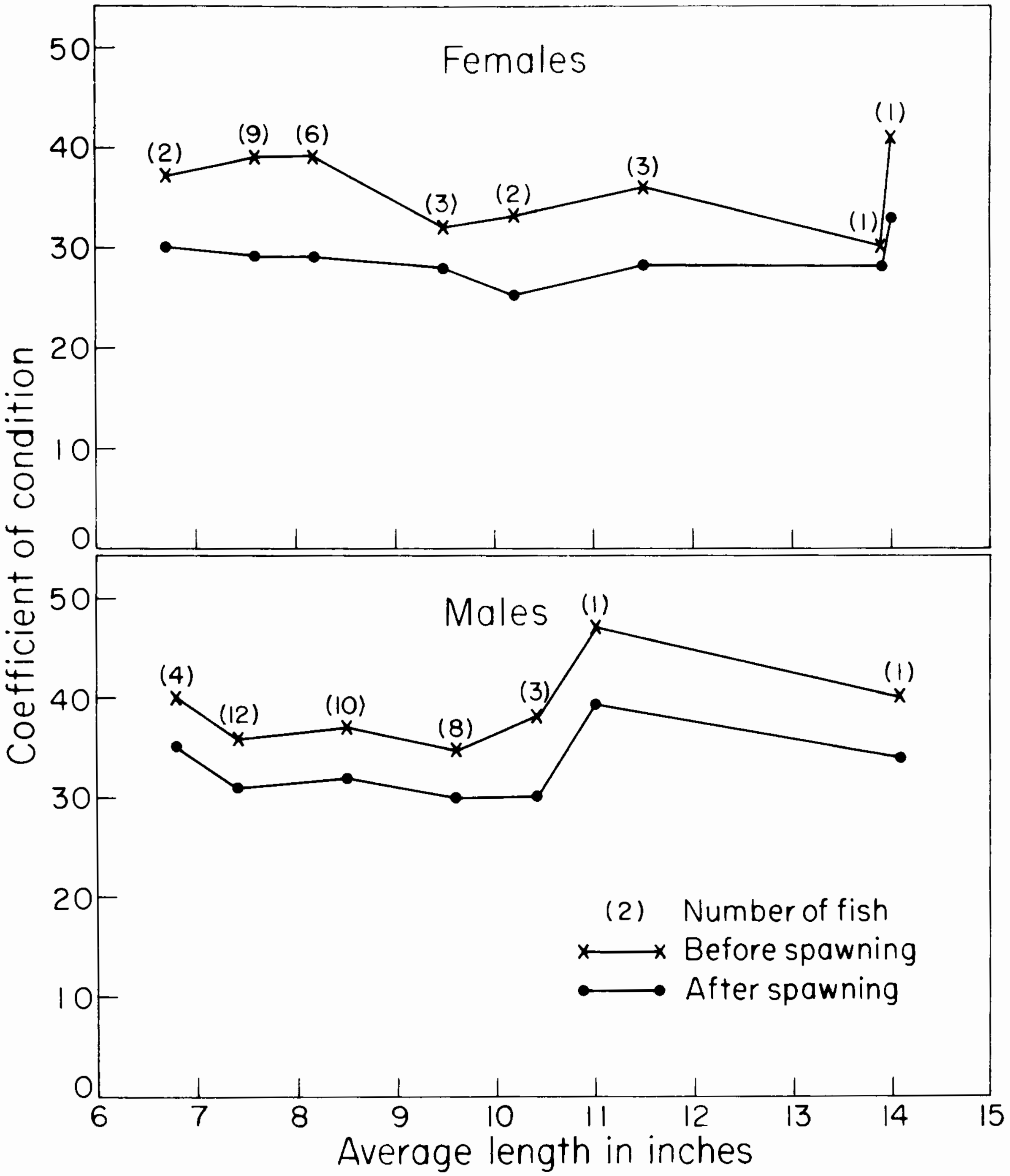

Figure 5.--Average coefficient of condition (C) in relation to length, of 27 female and 39 male brook trout before and after spawning, Hunt Creek drainage, 1943-1947. Data from Table 4.

Appendix Table A

Date, collection site, total length in inches (L), weight in grams (W), egg diameter, and total eggs found in 56 female brook trout from the Hunt Creek drainage, 1939-1947

Date collected	Locality in Hunt Creek drainage[1]	L	W	Average egg diameter (mm.)	Total eggs[2]	Date collected	Locality in Hunt Creek drainage[1]	L	W	Average egg diameter (mm.)	Total eggs[2]
8/30/39	Section A	6.3	40	....	189	8/12/39	Fuller Cr. BP	10.4	213	....	767
8/8/39	Section D	6.5	33	....	481	8/16/39	Fuller Cr. BP	10.4	227	....	772
8/8/39	Section D	6.7	47	....	255	8/10/39	Fuller Cr. BP	10.6	191	....	1,059
8/27/39	Section D	6.9	45	....	275	8/9/39	Fuller Cr. BP	10.7	191	....	1,055
8/18/43	Below A	6.9	54	1.74	598	8/12/39	Fuller Cr. BP	10.8	213	....	1,128
8/24/39	Section A	7.2	56	....	236	8/16/39	Fuller Cr. BP	11.3	256	....	1,596
8/8/43	Section B	7.0	49	1.77	260	8/29/39	Fuller Cr. BP	11.7	270	....	1,080
8/13/39	Below A	7.2	63	....	450	8/16/39	Fuller Cr. BP	11.8	256	....	1,307
8/27/39	Section D	7.3	54	....	268	8/9/39	Fuller Cr. BP	11.8	302	....	1,764
8/18/43	Below A	7.4	60	2.16	353	8/6/43	E. Fish Lake	11.8	302	2.19	1,471
8/18/39	Section D	7.5	60	....	316	8/3/39	Suttons Pond	11.9	232	....	1,321
8/18/39	Section D	7.5	68	....	379	8/7/39	Fuller Cr. BP	12.0	292	....	1,475
8/9/39	Fuller Cr. BP	7.6	70	....	600	8/10/39	Fuller Cr. BP	12.1	220	....	1,584
8/18/43	Below A	7.6	65	2.17	552	7/23/43	E. Fish Lake	12.2	320	1.50	1,028
8/11/43	E. Fish Lake	7.9	89	1.17	457	8/12/39	Fuller Cr. BP	12.4	334	....	1,831
7/9/39	Stream	8.0	80	....	368	8/10/39	Fuller Cr. BP	12.5	347	....	1,599
8/8/39	Section D	8.2	80	....	377	8/16/39	Fuller Cr. BP	12.6	355	....	1,934
8/8/43	Section A	8.3	81	1.54	778	8/7/43	E. Fish Lake	12.8	427	2.17	2,977
8/8/39	Section D	8.4	92	....	448	8/27/39	Fuller Cr. BP	12.9	355	....	1,954
8/18/43	Below A	8.4	95	2.50	826	8/10/43	E. Fish Lake	13.1	429	1.94	1,154
8/16/39	Fuller Cr. BP	8.6	114	....	591	8/16/39	Fuller Cr. BP	13.3	372	....	1,691
8/10/39	Fuller Cr. BP	8.7	99	....	446	8/6/43	E. Fish Lake	13.7	438	1.73	2,755
8/27/39	Section A	8.7	102	....	411	8/23/39	Fuller Cr. BP	14.0	504	....	1,659
8/24/39	Section A	9.2	110	....	402	8/12/39	Fuller Cr. BP	14.6	645	....	2,286
8/10/43	E. Fish Lake	9.3	149	1.74	701	10/13/47	E. Fish Lake	14.9	723	3.47	3,444
8/16/39	Fuller Cr. BP	9.3	138	....	475	8/27/39	Fuller Cr. BP	15.1	567	....	2,098
8/9/39	Fuller Cr. BP	9.8	156	....	716	8/25/39	Fuller Cr. BP	15.1	601	....	2,029
7/9/39	Lake	9.9	159	....	750	8/10/39	Fuller Cr. BP	16.4	850	....	3,119

[1] BP = beaver pond.

[2] All of these egg counts, except for the 14.9-inch fish taken from E. Fish Lake on October 13, were multiplied by the factor 0.80 to give the estimated number of eggs which would have been laid, for the regression lines of Figures 2 and 3.

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