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POPULATION CHARACTERISTICS AND SUMMER-TO-AUTUMN SURVIVAL OF JUVENILE RAINBOW TROUT AND COHO SALMON IN TWO LAKE SUPERIOR TRIBUTARIES, 1969-1972 [1]

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ABSTRACT

Population estimates of age-0 and age-I rainbow trout and age-0 coho salmon were made during June-November in the Little Garlic River (1969-70) and in Chinks Creek (1971-72). Estimates were made and growth data were obtained, usually monthly, on a 305-m section of each stream.

Numbers of age-0 rainbow trout ranged from 607 to 6,327 fish and density was on the order of 1-4 trout per square meter during August to November. Biomass in the two streams was about 1-3 g/m^2, and production was 0.72-1.29 g/m^2 for Chinks Creek and 1.54-2.31 g/m^2 for the Little Garlic River. Age-0 rainbow trout in the two streams grew to 62 mm (TL) by November. Numbers of age-0 rainbow trout declined rapidly during August-November. August, September and October populations were 44, 60 and 80%, respectively, of that present in November. These values can be used for comparative purposes, to estimate the numbers ultimately present in November.

Age-I rainbow trout numbers ranged from a very few to 724 (0.43/m^2) during June-November. The Little Garlic had by far the largest population. Biomass was 1-3 g/m^2 in the Little Garlic River whereas it was much less in Chinks Creek. Production in the Little Garlic was 2.0 g/m^2. By November, Little Garlic trout averaged 127 mm long and Chinks Creek averaged 138 mm. Rainbow trout numbers declined during June-August, probably due to downstream migration, but did not change in September, October or November.

The numbers of age-0 coho salmon ranged from a very few to 1,590 during July-November. Density and biomass were much higher in Chinks Creek (0.22-1.23 fish per square meter and 1.09-2.51 g/m^2) than in the Little Garlic River (maximum of 0.09 fish per square meter and 0.39 g/m^2). Maximum production (1.89 g/m^2) occurred in Chinks Creek in 1972. By November coho averaged 77 mm long. Numbers declined rapidly and average survival of the three cohorts to November was 49, 56, 67 and 83%, respectively, for salmon present at the beginning of July, August, September and October. These values can be used to estimate the numbers ultimately present in November.

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[1] Contribution from Dingell-Johnson Projects F-31-R and F-35-R, Michigan.

Introduction

Adult rainbow trout (Salmo gairdneri) and coho salmon (Oncorhynchus kisutch) reproduce in many of the tributaries of Lake Superior. The young remain in the stream for a year or two, migrate into the lake where they grow rapidly and then return to streams to spawn. These two salmonids provide a sports fishery of high quality both in the lake and in spawning streams. Population characteristics and survival of juvenile rainbow trout and coho salmon in Lake Superior nursery streams are not well known. While Hassinger, Hale and Woods (1974) have reported on certain parameters of juvenile rainbow trout in Minnesota tributaries of Lake Superior, there has been little study of the coho salmon, which was introduced in 1966.

The purpose of this report is twofold. One is to describe little known parameters of age-0 and age-I rainbow trout and age-0 coho salmon such as numbers and survival, density, biomass, production and growth in two Lake Superior tributaries. The other is to use my data on survival to provide other investigators with a means of equating population estimates made at different times in different streams so that they can be compared. To equate populations, they must be adjusted to a common point in time. In this report I adjust populations to that in November, which seems a logical choice because it is the end of the growing season.

The streams selected for study were the Little Garlic River and Chinks Creek, located on the south shore of central Lake Superior. The streams have relatively steep gradients and extensive spawning areas for salmonids. Both streams have had excellent rainbow trout spawning runs for many years. Rainbow trout spawn in April and May in Lake Superior tributaries and the young emerge in June and July (Hassinger et al., 1974). Adult coho salmon first spawned in these streams in 1967 and have spawned there every year, with the exception of Chinks Creek in 1969. In Lake Superior tributaries, coho salmon spawn in October-November and their young emerge in May (Peck, 1970).

On each stream a 305-m section was selected for study, with two criteria: easy access, and an abundance of age-0 rainbow trout where one could obtain good population estimates. In the study section of the Little Garlic River, age-0 rainbow trout and mottled sculpins (Cottus bairdi) were abundant; age-I rainbow trout, age-0 coho salmon and longnose dace (Rhinichthys cataractae) were common; and age-II rainbow trout, age-I coho salmon, brook trout (Salvelinus fontinalis) and burbot (Lota lota) were sparse. In Chinks Creek, age-0 rainbow trout, age-0 coho salmon and slimy sculpins (C. cognatus) were abundant; age-I rainbow trout, blacknose dace (R. atratulus), longnose dace, brook trout and mottled sculpins were common; and age-I coho salmon were sparse. The study sections contained abundant spawning substrate for salmonids. Maximum water temperature was 21 C in the Little Garlic River, and 18 C in Chinks Creek. Other physical characteristics of the study sections are described in Table 1. On the Little Garlic River, the study section was 2 km upstream from Lake Superior; on Chinks Creek it was the lower 305 m above its confluence with the Huron River which in turn is some 9 km from where the latter empties into Lake Superior.

Table 1.--Physical parameters of 305-m study sections in two Lake Superior tributaries, June-November 1969-1972

Stream	Average width (m)	Average depth (cm)	Area (m^2)	Volume of flow (m^3/sec)	Conductivity (μmho/cm^3)	Bottom type[a] (percentage)				
						B	G	S	SS	D
Little Garlic	5.6	18	1696	0.15	144	59	35	4	0	2
Chinks	4.2	15	1291	0.19	140	25	53	2	15	5

[a] B = boulders, G = gravel, S = sand, SS = silty-sand, D = debris.

Procedures

Numbers of age-0 and age-I rainbow trout and age-0 coho salmon were determined by population estimates, usually monthly during June-November, on the Little Garlic River in 1969-70 and on Chinks Creek in 1971-72. Estimates were made during the following periods each year: 1-12 June, 6-9 July, 3-6 August, 1-9 September, 3-8 October and 1-13 November. The mark-and-recapture method was used; the fish were caught with a dc shocker, marked and released on one day, and recaptured the next. Population estimates and their variances were calculated from formulae given by Bailey (1951):

$$\text{Population} = N_1 (N_2 + 1)/(N_{12} + 1)$$

and

$$\text{Variance} = \frac{(\text{Population estimate})^2 (N_2 - N_{12})}{(N_2 + 1)(N_{12} + 2)}$$

Where: N_1 = total number of fish caught, marked and released on the first day

N_2 = total number of fish caught on second day

N_{12} = number of marked fish caught on second day

Within age groups, estimates were made for the smallest size group that met the requirement for computation of standard error, $N_2 pq > 9$.

Population estimates were not made in the Little Garlic River in October 1969, and the October estimate in 1972 on Chinks Creek was aberrant (probably because the mark-and-recapture runs were made on the same day). These October populations were estimated from instantaneous mortality rates that were derived from the respective September and November estimates.

The ages of juvenile salmonids were determined easily by scale examination and by the virtually discrete length frequencies of the various age groups. Average total length (TL) was obtained by measuring all salmonids taken on the first day of the estimate.

Length-weight relationships were derived from length and corresponding weight measurements of five rainbow trout and five coho salmon in each 5-mm size group at each monthly population estimate. Additional size data were taken when population estimates were not made.

Biomass of each size group, for which a population estimate was made, was obtained by multiplying the estimate by the average weight of fish in the group. These products were summed to obtain the total biomass of each age group and then divided by the area of the study section to obtain biomass in terms of grams per square meter.

Production was determined graphically, as done by Allen (1951) and Chapman (1965).

Survival and population trends were assessed by comparing the monthly estimates of numbers in each age group. These assessments may have been biased by migration of fish in or out of the study area. I did not measure migration in my study streams, but investigations by others suggested that it was of small magnitude during the period of my study, except for age-I rainbow trout. Downstream migration of age-0 rainbow trout during August-October was of little consequence, as judged from studies of Bjornn (1971), Hartman (1959), Sumner (1953), and Alexander and MacCrimmon (1974). On the other hand, Shapovalov and Taft (1954) found some downstream migration during August-October although most was in June and July. Little upstream migration of rainbow trout fry was found by Alexander and MacCrimmon (1974) or by Shapovalov and Taft (1954). Downstream migration of age-I rainbow trout was heavy in spring and early summer, but was negligible after the middle of July (Alexander and MacCrimmon, 1974; Hassinger et al., 1974; Stauffer, 1972; and Shapovalov and Taft, 1954). The absence of upstream migration of age-I rainbow trout during the period of my study was established by Alexander and MacCrimmon (1974), Stauffer (unpublished records), and Shapovalov and Taft (1954). Age-0 coho salmon were generally nonmigratory during July-October (Chapman, 1962; Sumner, 1953; and Shapovalov and Taft, 1954).

Results

Age-0 rainbow trout

The numbers of age-0 rainbow trout in the study sections were considerable, and the quite variable density ranged from less than one-half to almost four fish per square meter (Table 2). In the Little Garlic River, the 1969 densities were about twice the corresponding densities of 1970. In Chinks Creek, the August 1972 density was about twice the August 1971 density, but by November, both densities were nearly the same and similar to that in the Little Garlic in 1970. There were appreciable decreases in numbers (density) during August-October. On the average, for the four cohorts, survival to November was 44, 60 and 80% for trout present at the beginning of August, September and October, respectively (Fig. 1).

Biomass in the Little Garlic River was quite constant within years; it was on the order of 3 g/m^2 in 1969 and 2 g/m^2 in 1970 (Table 2). In Chinks Creek the biomass, which was about 1-2 g/m^2, increased from August to September; it then remained constant in 1971, but decreased in 1972. Production ranged from 0.72 to 2.31 g/m^2 from 1 August to 1 November for the four cohorts of age-0 rainbow trout (Table 2) and most of it occurred in August.

Age-0 fish, from emergence (June) to August, doubled their length and increased their weight by a factor of 10 (Table 3 and Fig. 2). By November they had reached lengths of 57-69 mm and weights of 2-3 g. There was not much difference in growth rate between streams. Within streams, growth rate was significantly different between years and was negatively associated with population density. The length-weight relationships of the four groups of rainbow trout (age-0 plus age-I for each year of collection) were virtually identical; hence, only the regression for 1970 is shown in Figure 2.

Table 2.--Age-0 rainbow trout number (± 2 SE), density (number per square meter), biomass (grams per square meter), and production (grams per square meter) in a 305-m section of each of two Lake Superior tributaries, 1969-1972

Parameter and month	Little Garlic River 1969	Little Garlic River 1970	Chinks Creek 1971	Chinks Creek 1972
Number				
August	6,327	2,845	1,049	1,745
September	3,758	1,913	913	1,374
October	2,878[a]	1,533	756	813[a]
November	2,352	1,166	646	607
± 2 SE Number				
August	672	320	139	295
September	285	146	93	199
October	...	160	98	...
November	444	158	130	120
Density				
August	3.73	1.68	0.81	1.35
September	2.22	1.13	0.71	1.06
October	1.70	0.90	0.59	0.63
November	1.39	0.69	0.50	0.47
Biomass				
August	3.42	1.73	0.94	1.18
September	2.75	1.62	1.62	1.43
October	....	1.83	1.78	0.80
November	2.76	1.72	1.55	0.78
Production				
August	0.88	0.55	0.81	0.48
September	....[b]	0.60	0.43	0.08
October	....[b]	0.39	0.05	0.16
Total	2.31	1.54	1.29	0.72

[a] Instantaneous mortality rate between September and November used to derive October population.

[b] Production totaled 1.43 g/m^2 for September plus October.

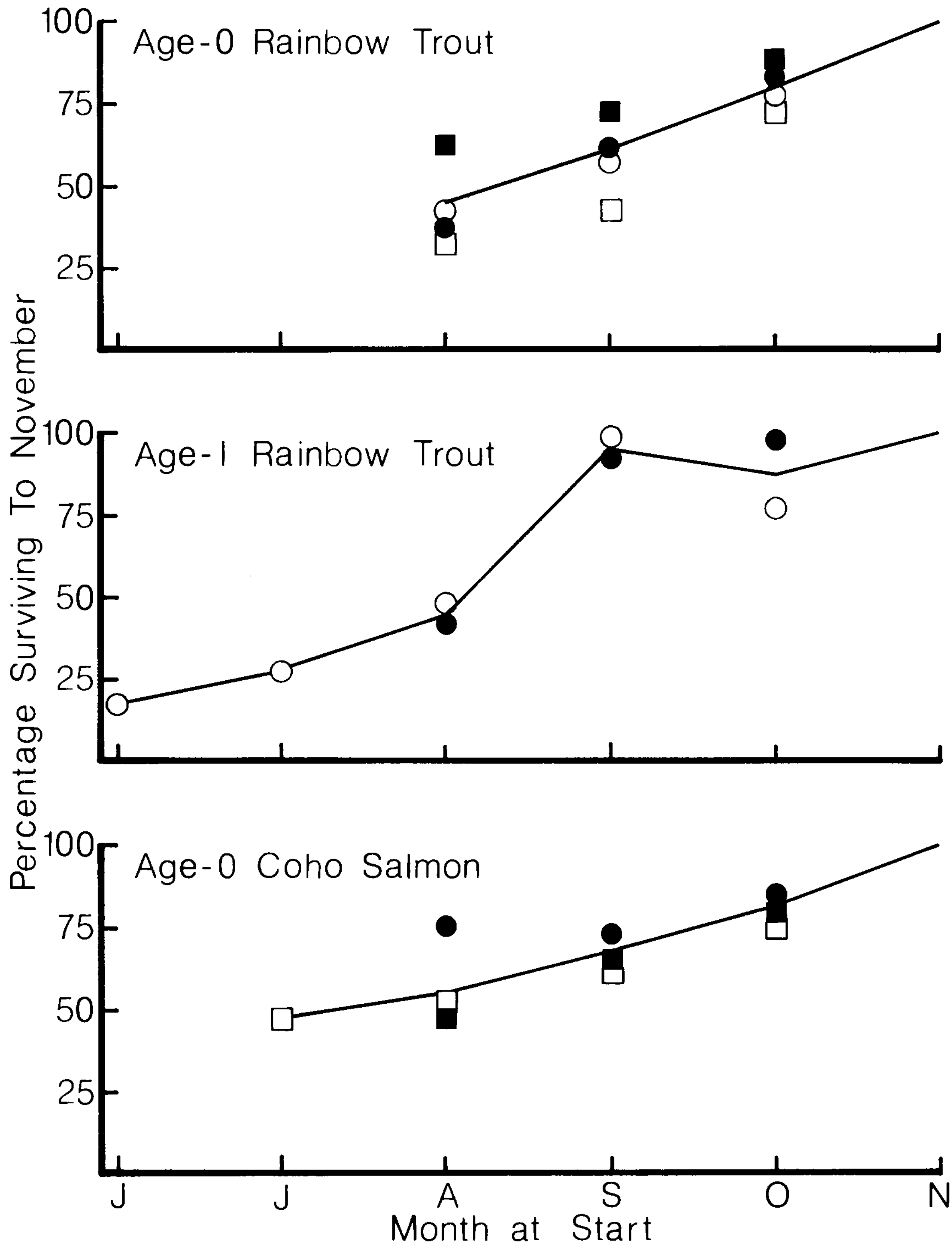

Figure 1.--Average percentage of age-0 and age-I rainbow trout and age-0 coho salmon present during June to October that survived to November, in two Lake Superior tributaries. The position of the symbols indicates percentage survival to November from each monthly estimate. Solid circles = Little Garlic, 1969; open circles = Little Garlic, 1970; solid squares = Chinks Creek, 1971; and open squares = Chinks Creek, 1972.

Table 3.--Average length (mm) of age-0 and age-I rainbow trout and age-0 coho salmon in two Lake Superior tributaries, June-November, 1969-1972

(95% confidence limits are in parentheses)

Fish group and stream	Date of measurement					
	1-10 June	6-9 July	3-6 Aug	31 Aug-9 Sep	3-8 Oct	1-13 Nov
Age-0 rainbow trout [a]						
Little Garlic 1969	...	...	45 (0.4)	51 (0.4)	...	57 (0.7)
Little Garlic 1970	23	35 (1.3)	48 (0.5)	53 (0.5)	60 (0.7)	64 (0.9)
Chinks 1971	...	31 (0.9)	49 (0.9)	64 (0.8)	67 (0.9)	69 (1.2)
Chinks 1972	...	31 (0.9)	46 (0.8)	53 (0.9)	56 (1.4)	57 (1.3)
Age-I rainbow trout [b]						
Little Garlic 1969	...	...	117 (2.6)	125 (4.1)	...	129 (5.3)
Little Garlic 1970	86 (2.0)	99 (1.7)	109 (2.5)	112 (3.6)	120 (3.2)	125 (4.1)
Chinks 1971	91 (5.4)	115 (8.5)	124 (5.9)	126 (10.8)	133 (8.3)	139 (12.0)
Chinks 1972	91 (4.0)	109 (5.6)	121 (9.9)	130 (10.9)	...	137 (14.3)
Age-0 coho salmon [c]						
Little Garlic 1969	...	...	71 (2.0)	78 (1.6)	...	80 (2.5)
Chinks 1971	32 (0.9)	47 (1.3)	65 (1.0)	78 (1.2)	81 (1.3)	83 (1.7)
Chinks 1972	31 (0.3)	47 (0.6)	58 (0.7)	65 (1.0)	65 (1.4)	67 (1.3)

[a] Sample size was 4 (sac fry) in June, 25 to 62 in July, and in excess of 200 in the remaining months.

[b] Sample size was 44 to 166 for the Little Garlic, and 7 to 31 for Chinks Creek.

[c] Sample size was 40 to 69 for the Little Garlic, and 50 to 543 for Chinks Creek.

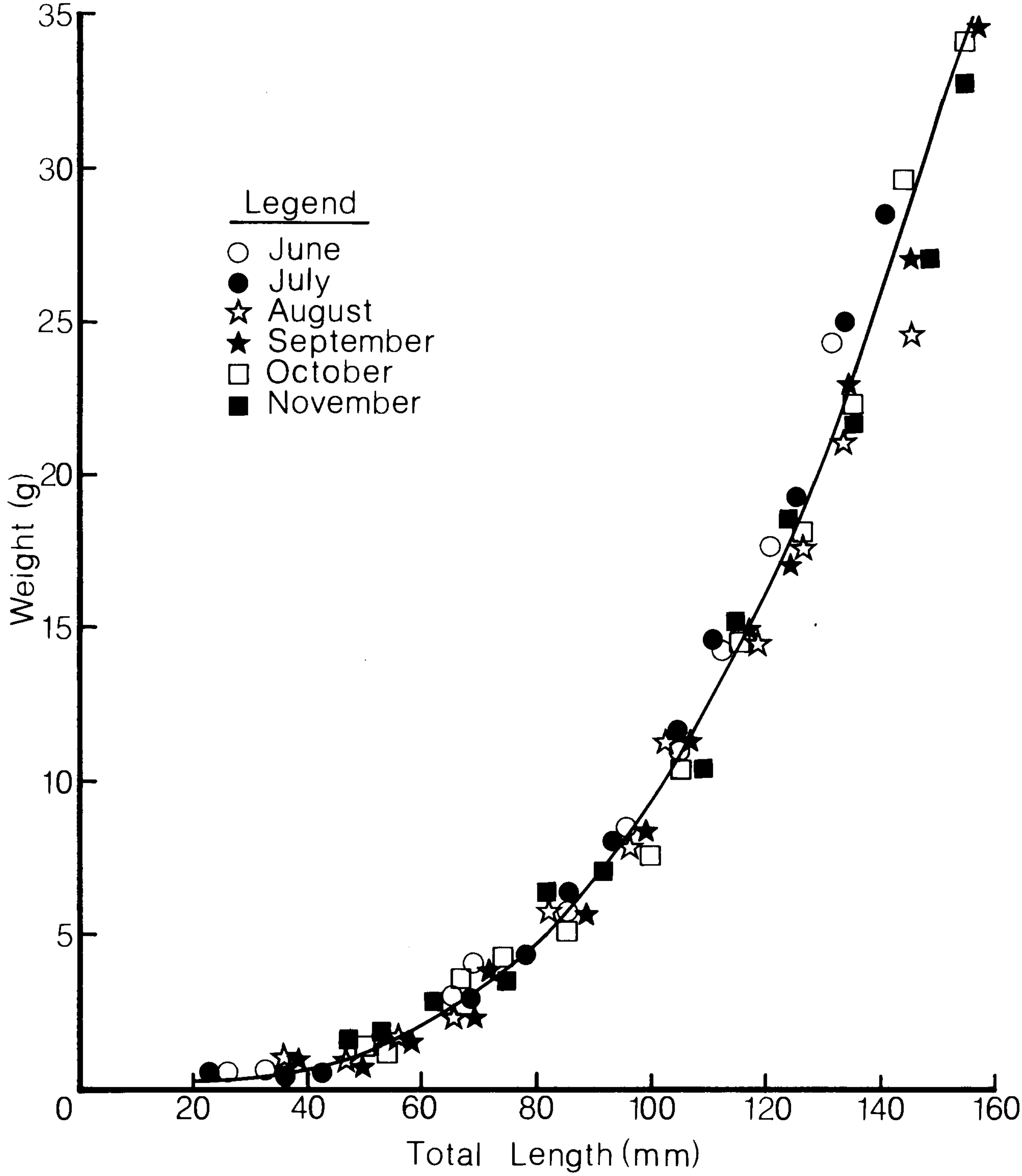

Figure 2.--The length-weight relationship (log W = -5.12091 + 3.04627 log L) of age-0 and age-I rainbow trout, Little Garlic River, 1970. The symbols represent empirical data collected during different months.

Age-I rainbow trout

The number of these fish was considerably less than that of age-0 trout, and ranged from only a few to 724 trout or $0.43/m^2$ (Table 4). Number and density, while quite similar within streams, were much greater in the Little Garlic River than in Chinks Creek. All four cohorts declined rapidly in numbers from June through August. In the Little Garlic River, average survival to November of the two cohorts was 18, 27, 45, 100 and 83% respectively, for trout present at the beginning of June, July, August, September and October (Fig. 1). In Chinks Creek, only a few age-I trout remained by October.

Biomass in the Little Garlic was 1-3 g/m^2 and was greatest in June (Table 4). Production (Table 4) from June through October was about 2.0 g/m^2 in the Little Garlic River. Most production occurred in June and July.

Growth of age-I rainbow trout is shown in Table 3, and the length-weight relationship in Figure 2. The growth reported here is judged to be minimal because of out-migration of the faster-growing individuals (Shapovalov and Taft, 1954; Stauffer, 1972). In early June, trout were 86 to 91 mm long; by early November they had reached lengths of 125 to 139 mm. During the same period, weight increased from 6-8 g to 19-25 g. Chinks Creek trout were somewhat larger than Little Garlic fish, perhaps because of their lesser abundance. In the Little Garlic River, trout in 1969 were bigger than in 1970, but here the difference did not appear to be related to density. There was no apparent difference in length-weight relationship between streams or among months.

Age-0 coho salmon

Coho salmon in the Little Garlic River in 1970 were so sparse that data could not be collected. The number of coho salmon in the other three cohorts was impressive in view of its recent introduction (1966) into Lake Superior (Table 5). Salmon were more abundant in Chinks Creek (288-1,590) than in the Little Garlic River (0-148). Density reached a high of $1.23/m^2$ during July in Chinks Creek. At the high densities encountered

Table 4.--Age-I rainbow trout number (± 2 SE), density (number per square meter), biomass (grams per square meter), and production (grams per square meter) in a 305-m section of each of two Lake Superior tributaries, 1969-1972

Parameters and month	Little Garlic River 1969	Little Garlic River 1970	Chinks Creek[a] 1971	Chinks Creek[a] 1972
Number				
June	...	724 ± 206	38	53
July	...	464 ± 112	..	18
August	241 ± 57	263 ± 45	27	15
September	112 ± 17	114 ± 22	15	19
October	107[b]	161 ± 41	19	4
November	108[c]	127 ± 35	18	11
Density				
June	...	0.43		
July	...	0.27		
August	0.14	0.16		
September	0.07	0.07		
October	0.06	0.09		
November	0.06	0.07		
Biomass				
June	...	2.96		
July	...	2.65		
August	2.19	1.81		
September	1.27	0.92		
October	...	1.60		
November	1.36	1.42		
Production				
June	...	0.95		
July	...	0.42		
August	0.37	0.21		
September	...[d]	0.24		
October	...[d]	0.17		
Total	0.51	1.99		

[a] These numbers are the sum of the fish caught on the marking run and unmarked fish caught on the recapture run.

[b] Instantaneous mortality rate between September and November used to derive the October population.

[c] This estimate was less reliable than the other estimates because $N_2pq < 9$, thus a different formula was required which gave asymmetrical limits of 76 and 200, respectively.

[d] Production totaled 0.14 g/m^2 for September plus October.

Table 5.--Age-0 coho salmon number (± 2 SE), density (number per square meter), biomass (grams per square meter), and production (grams per square meter) in a 305-m section of each of two Lake Superior tributaries, 1969-1972

Parameter and month	Little Garlic River 1969	Chinks Creek 1971	Chinks Creek 1972
Number			
July	...	...	1,590 ± 306
August	139 ± 59	646 ± 119	1,440 ± 188
September	148 ± 38	444 ± 86	1,275 ± 226
October	122[a]	352 ± 105	955[a]
November	104 ± 32	288 ± 82	771 ± 159
Density			
July	....	....	1.23
August	0.08	0.50	1.12
September	0.09	0.34	0.99
October	0.07	0.27	0.74
November	0.06	0.22	0.60
Biomass			
July	....	....	1.13
August	0.26	1.30	2.00
September	0.39	1.48	2.51
October	....	1.31	1.85
November	0.29	1.09	1.55
Production			
July	....	....	1.07
August	0.10	0.72	0.76
September	....[b]	0.15	....[c]
October	....[b]	0.02	0.06
Total	0.12	0.89	1.89

[a] Instantaneous mortality rate between September and November used to derive October population.

[b] Production totaled 0.02 g/m^2 for September plus October.

[c] Negative production.

in Chinks Creek, number of salmon declined during the period from July to November, but it remained fairly constant in the Little Garlic where density was low. Average survival of the three cohorts to November was 49, 56, 67 and 83% for salmon present at the beginning of July, August, September and October, respectively (Fig. 1).

Biomass of coho salmon was highest (2.51 g/m^2) during September 1972 in Chinks Creek, and production during July-October of 1972 reached a high (1.89 g/m^2) in Chinks Creek (Table 5).

Age-0 coho salmon in early June were 31-32 mm long; by November they had grown to a length of 67 to 83 mm and a weight of 3-5 g (Table 3 and Fig. 3). Growth in length was most rapid during June-August (7-18 mm per month), but it slowed during September-October (0-3 mm per month). Among cohorts, growth was similar during June and July, but thereafter, growth of the 1972 cohort lagged behind, probably because of its relatively high density. The length-weight relationship of age-0 salmon is shown in Figure 3. This relationship did not differ appreciably between months, but fish from the 1972 year class were slightly less robust than salmon of the 1971 year class.

Discussion

Age-0 rainbow trout

In the two Lake Superior tributaries, density was about 1-4 trout per square meter. In comparison, Alexander and MacCrimmon (1974) found a density of 1-2 trout per square meter in Bothwell's Creek, a tributary of Lake Huron. Biomass in my streams (1-3 g/m^2) was fairly constant, but in Bothwell's Creek it increased from 2 to 4 g/m^2 during the period from August to November.

Production of age-0 rainbow trout from August to November was 0.72-1.29 g/m^2 for Chinks Creek and 1.54-2.31 g/m^2 for the Little Garlic River. The larger production in the Little Garlic River likely was associated with the somewhat higher water temperature there. Production in the two Lake Superior tributaries was considerably less

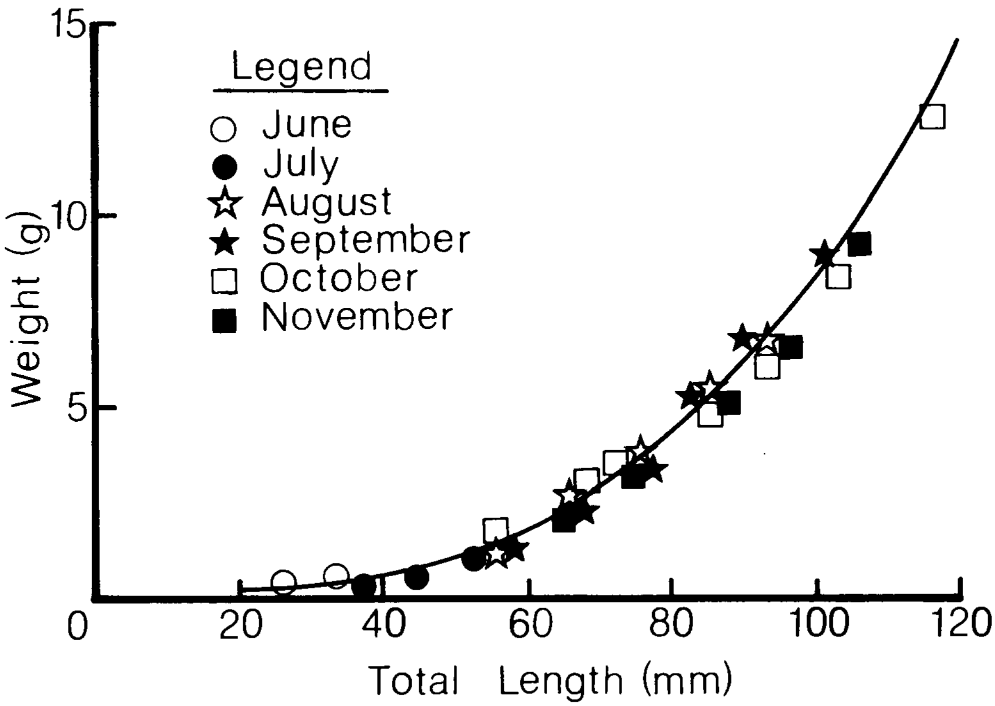

Figure 3.--The length-weight relationship (log W = -4.87517 + 2.90379 log L) of age-0 coho salmon, Chinks Creek, 1971. The symbols represent empirical data collected during different months.

than that found for a similar period by Alexander and MacCrimmon (1974) for Bothwell's Creek (3.95 g/m^2) and by Goodnight and Bjornn (1971) for Big Springs Creek (4.93 g/m^2). Differences in production of age-0 rainbow trout between the Lake Superior tributaries and Big Springs Creek may be related, in part, to differences in water hardness. Big Springs Creek had a water hardness of 164 ppm (Goodnight and Bjornn, 1971) as compared to 26-82 ppm (Zimmerman, 1968) for the Little Garlic River. No measurements were made in Chinks Creek, but judging from Zimmerman's measurements on neighboring streams, it was similar in hardness to the Little Garlic River.

Growth of age-0 rainbow trout in Lake Superior tributaries during August to November was slower than in tributaries of the other Great Lakes. By November, Little Garlic and Chinks Creek trout averaged 62 mm long, and in late summer, age-0 trout in a Minnesota tributary averaged 51 mm long (Hassinger et al., 1974). In two Lake Michigan tributaries, average lengths in or near November were 74 mm (Stauffer, 1972) and 86 mm (Avery, 1974). For a Lake Huron tributary, an average length of 70 mm was reported by Alexander and MacCrimmon (1974). The mechanisms causing slower growth in Lake Superior tributaries are likely lower basic productivity, lower water temperatures, a somewhat shorter growing season, and perhaps a higher density.

My data enabled calculation of an adjustment factor for use in equating population estimates of age-0 rainbow trout, made at different times on different streams, to numbers theoretically present in November so that such estimates can be compared. Adjustment factors for the population estimates of each month were equal to the average survival of the four cohorts to November (Fig. 1). For example, to adjust population estimates on 1 August, 1 September and 1 October to 1 November populations, it is merely necessary to multiply the respective estimates by 0.44, 0.60 and 0.80. Since these factors are based on only four cohorts from two streams, skepticism is warranted as to their validity when applied to populations in other streams. Fortunately, there are two studies similar to mine which provide data on which my adjustment factors can be tested.

Alexander and MacCrimmon (1974) made monthly estimates from August to November on a Lake Huron tributary. I used the appropriate adjustment factor and their August, September and October estimates to derive a November population, and then compared these estimates of the November population with that actually found. My calculations of the November population from August, September and October estimates were 82, 90 and 90%, respectively of that actually found.

Goodnight and Bjornn (1971) estimated density of an age-0 rainbow trout population on 11 August and 15 October. I applied the mean (0.52) of my August and September adjustment factors to their 11 August estimate to compute a population figure for November. My estimate was 86% of their November estimate (adjusted from 15 October). I conclude that my correction factors for population estimates made during August-October can be used to approximate November populations.

Age-I rainbow trout

Density of age-I rainbow trout ranged from near zero to $0.43/m^2$. Consistently, density in June was higher than in later months, probably because migration to Lake Superior was not completed by June. In Bothwell's Creek (Alexander and MacCrimmon, 1974), June-August density (0.21-0.45 g/m^2) was similar to that in the Little Garlic River, but in September-November this creek had twice the density found in the Little Garlic River. The density in Chinks Creek was much lower than in either the Little Garlic River or Bothwell's Creek. Biomass of age-I trout during June-November in the Little Garlic River was 1-3 g/m^2. Biomass in Bothwell's Creek (Alexander and MacCrimmon, 1974) during the same period was greater (3-5 g/m^2).

Production of age-I trout was 2.0 g/m^2 in the Little Garlic which compared well with that for a similar period found by Alexander and MacCrimmon (1974) in Bothwell's Creek (2.1 g/m^2) and by Goodnight and Bjornn (1971) in Big Springs Creek (2.0 g/m^2).

Growth of age-I rainbow trout in the Little Garlic River and Chinks Creek was similar to that reported for other streams. By

November, Little Garlic fish averaged 127 mm long and Chinks Creek averaged 138 mm. Trout growth was somewhat slower (to 112 and 124 mm, respectively) in a Minnesota tributary (Hassinger et al., 1974) and in Bothwell's Creek (Alexander and MacCrimmon, 1974) but it was faster in two Lake Michigan tributaries where they reached lengths of 163 mm (Stauffer, 1972) and 168 mm (Avery, 1974).

All four cohorts declined in number from June to August, probably due to migration, but did not decline during the period from September through October. These trends in population suggest that September to November estimates may be compared with each other, but that June-August estimates cannot be compared with each other or with later estimates. The similarity of numbers that I found in September-November is supported by the data of Alexander and MacCrimmon (1974) whose September and October estimates (49 and 45) were similar to the November estimate (40).

My data are inadequate to predict November populations from estimates made in June-August, since only the two cohorts from the Little Garlic could be used to obtain a correction factor. This inadequacy was confirmed by application of correction factors derived for the two cohorts to the data of Alexander and MacCrimmon (1974). I used the appropriate correction factor and their June, July and August estimates to get estimates of the populations ultimately present in November. The estimated populations in November were 50, 48 and 60% of that actually found. I suspect that the time of migration varies with climatic and other factors to an extent that precludes adjustment of late spring and early summer estimates to November populations.

Age-0 coho salmon

During July-November, density and biomass were much higher in Chinks Creek (0.22-1.23 fish per square meter and 1.09-2.51 g/m^2) than in the Little Garlic River (0.00-0.09 fish per square meter and 0.00-0.39 g/m^2). The difference may be related to abundance of spawners. Adult salmon were common in the Huron River (Chinks Creek is a tributary) in 1970-71, but rare in the Little Garlic River in 1969; no information was available for 1968. Production during July-October ranged from zero to 1.89 g/m^2. Chapman (1965) estimated density, biomass and production of age-0 coho for three streams in Oregon during August to November; his estimates of density (1-1 1/2 fish per square meter), of biomass (2-3 g/m^2), and of production (1 1/2 g/m^2) fell within the range found for Lake Superior streams. So, although just recently introduced, coho salmon in Lake Superior show characteristics of long established populations.

Growth among the three cohorts studied was similar in June and July; thereafter, the 1972 cohort lagged behind, probably because of its higher density. On the average, fish in the three cohorts were 65 mm long by August and 77 mm by November. This represented somewhat slower growth than that recorded from a Lake Michigan tributary (74 mm, August; 97 mm, November) by Avery (1974) but faster than that found by Chapman (1965) and Hartman (1965) for Oregon and British Columbia streams (about 58 mm, August; 68 mm, November).

The decline in numbers of the three cohorts from July to November was substantial enough to demonstrate a need for a method of equating population estimates made at different times to a common point in time, in this case, November. Correction factors derived from my data indicate that November populations can be approximated by multiplying July, August, September and October estimates by 0.49, 0.56, 0.67, and 0.83, respectively. To test the validity of these correction factors, I applied them to the monthly population estimates made by Chapman (1965) and Avery (1974). Applying my correction factors to Chapman's estimates for August, September and October, gave estimates of the November population which are (range of three populations) 77-85, 71-83 and 89-98% of his November population figure. Applying my correction factors to estimates by Avery (1974) of populations in August and September gave estimates for the November population which are 182 and 99% of his figure for the November population. I conclude that my correction factors and July-October estimates can be used, with caution, to approximate November populations.

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