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Title: POPULATION DYNAMICS OF COASTAL CUTTHROAT TROUT IN AN EXPERIMENTAL STREAM

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Gerald E. Davis

Population dynamics of coastal cutthroat trout were studied in a controlled-flow section of Berry Creek, Oregon, from August 1972 to August 1973. All trout except the underyearlings were tagged to allow movement, survival and weight change of individual trout to be monitored.

Fifty-eight percent of the tagged trout which were present in the study area for at least one month after the beginning of the study moved from one stream location to another. In general, the trend in movement was upstream during periods of low flow and downstream during periods of high flow.

Monthly mortality ranged from 1.0 to 17.5 percent of the population. High mortality during summer and fall was probably related to starvation and low stream flow. The annual expectation of death ranged from 0.57 for the 1972 year class to 1.00 for the 1967 year

class.

Growth rate and production values for the population were positive only from December 1972 through May 1973 and were negative during other months of the year. Total annual production for the population was 0.491 g/m^2. Annual production values were positive for the 1971 through 1973 year classes and negative for the 1967 through 1970 year classes. Annual production values were positive for those members of the 1969 and 1970 year classes which survived the entire year within the study area. Mean monthly trout biomasses ranged from 2.92 to 8.55 g/m^2 for the total study area and from 0.23 to 76.41 g/m^2 in specific stream locations. During most of the year positive values of production were recorded only for locations where the biomass was less than 4 g/m^2. During spring, high values of production were recorded for locations with trout biomasses as high as 14 g/m^2. Stream flow was probably a major factor affecting trout growth and production.

Population Dynamics of Coastal Cutthroat Trout in an Experimental Stream

by

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Associate Professor of Fisheries
in charge of major

Redacted for privacy

Acting Head of Department of Fisheries and Wildlife

Redacted for privacy

Dean of Graduate School

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Typed by Cheryl E. Curb for Thomas Earl Nickelson

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POPULATION DYNAMICS OF COASTAL CUTTHROAT TROUT IN AN EXPERIMENTAL STREAM

INTRODUCTION

The coastal cutthroat trout (Salmo clarki clarki Richardson) is an important member of many stream communities from northern California to southeastern Alaska (Clemens and Wilby, 1961). In these streams the cutthroat may be resident, migratory, or both (Dimick and Merryfield, 1945; Lowry, 1966; Cooper, 1970).

In Oregon, Lowry (1965, 1966) and Giger (1972) have studied the population dynamics of anadromous coastal cutthroat in several coastal streams. These studies relied heavily upon statistical methods for estimating population sizes and changes in the mean weight of individuals in each age group.

The approach taken in the study reported herein was to evaluate the dynamics of a coastal cutthroat trout population on the basis of measurements of movement, growth and survival of the individual trout that comprise the population. The view was taken that this approach would permit precise measurement of important population parameters and provide valuable insight into the role of the individual in determining the dynamics of the population. The study was undertaken between August 1972 and August 1973 as part of a continued program of research in the field of water pollution biology at Oregon

State University, with the objective of establishing a foundation for future studies of the effects of toxicants on stream communities.

Specific objectives of the study were: (1) to determine the annual expectation of death for each year-class; (2) to determine growth rates and estimate production for each year-class and for the total population; and (3) to study movement patterns and physical parameters which might affect survival and growth of the trout.

METHODS

Description of Study Area

The study was conducted in a 230 meter section of Berry Creek, a small woodland stream originating in the western foothills of the Willamette Valley, Oregon. The maximum flow in this section of stream was controlled by means of a dam and diversion channel. This facility and a detailed description of the stream are discussed at length by Warren et al. (1964).

The study area consisted of 12 riffles and 12 pools which were lettered alphabetically from "A" to "L" beginning with the uppermost riffle and pool. Measurements were made of each pool's surface area, maximum depth and area of undercut bank, and each riffle's surface area (Table 1).

Traps were located at the upstream and downstream ends of the study area to monitor immigration and emigration of the trout. However, the trap at the upstream end of the study area did not allow upstream movement of trout.

Stream flows during the study ranged from 0.6 to 34.8 liters per second (Figure 1). The entire stream flow of Berry Creek passed through the study area during summer and fall. During winter and spring, the maximum flow was controlled to keep the stream within the flow capacity of the traps.

Table 1. Physical parameters of the riffle and pool at each designated location measured at a stream flow of 2.8 liters per second.

Location	Riffle Surface Area (m^2)	Pool Surface Area (m^2)	Pool Undercut Area (m^2)	Pool Maximum Depth (m)	Undercut Area*10^2 / Pool Surface Area
A	12	32	1.55	0.53	4.85
B	10	24	1.09	0.46	4.55
C	23	5	0.07	0.23	1.40
D	9	34	2.43	0.46	7.15
E	10	12	1.48	0.20	12.32
F	17	31	1.17	0.46	3.77
G	11	21	0.23	0.30	1.10
H	5	22	0.10	0.30	0.45
I	2	21	1.50	0.61	7.15
J	23	26	0.25	0.36	0.96
K	12	13	0.20	0.28	1.54
L	3	3	0.05	0.28	1.67

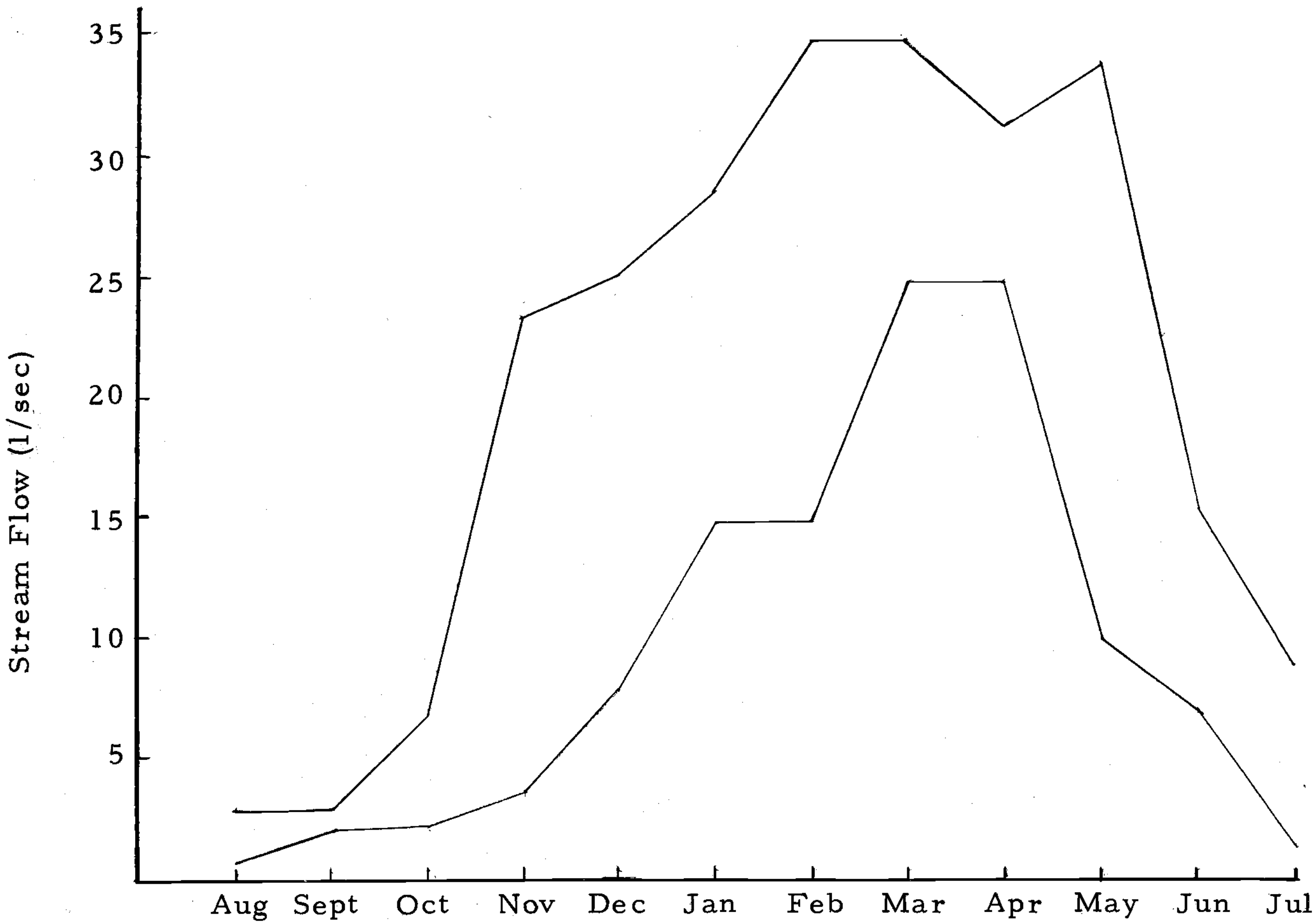

Figure 1. Monthly maximum and minimum stream flows in the experimental section of Berry Creek from August 1972 through July 1973.

Water temperature ranged from 0.6°C in December 1972 to 20.7°C in July 1973 (Figure 2). The stream was completely covered with ice for approximately one week in December.

The coastal cutthroat trout is the only salmonid present in Berry Creek. The reticulate sculpin (Cottus perplexus Gilbert and Evermann) and the brook lamprey (Lampetra richardsoni Vladykov and Follet) also inhabit the study area.

Recovery and Handling

The study area was seined during the first week of each month from August 1972 through August 1973. All trout were measured to the nearest millimeter forklength, and weighed to the nearest 0.01 gram. Those trout 80 mm or larger (age I+) were tagged with small, (2.4 mm by 4.8 mm), numbered, vinyl-pennant tags. The adipose fin of each tagged trout was removed to aid in later recognition of individuals which had lost their tag. The only trout left untagged at the beginning of the study were those of the 1972 year class (underyearlings). Their adipose fins were removed to make possible recognition of underyearlings which had not been previously captured. All trout were anesthetized with tricaine methanesulfonate (MS-222) before handling and were bathed in a dilute solution of malachite green after handling. All trout were released at the location of their capture. The location of capture of each tagged trout was recorded each month to study the movement of trout between the various stream locations.

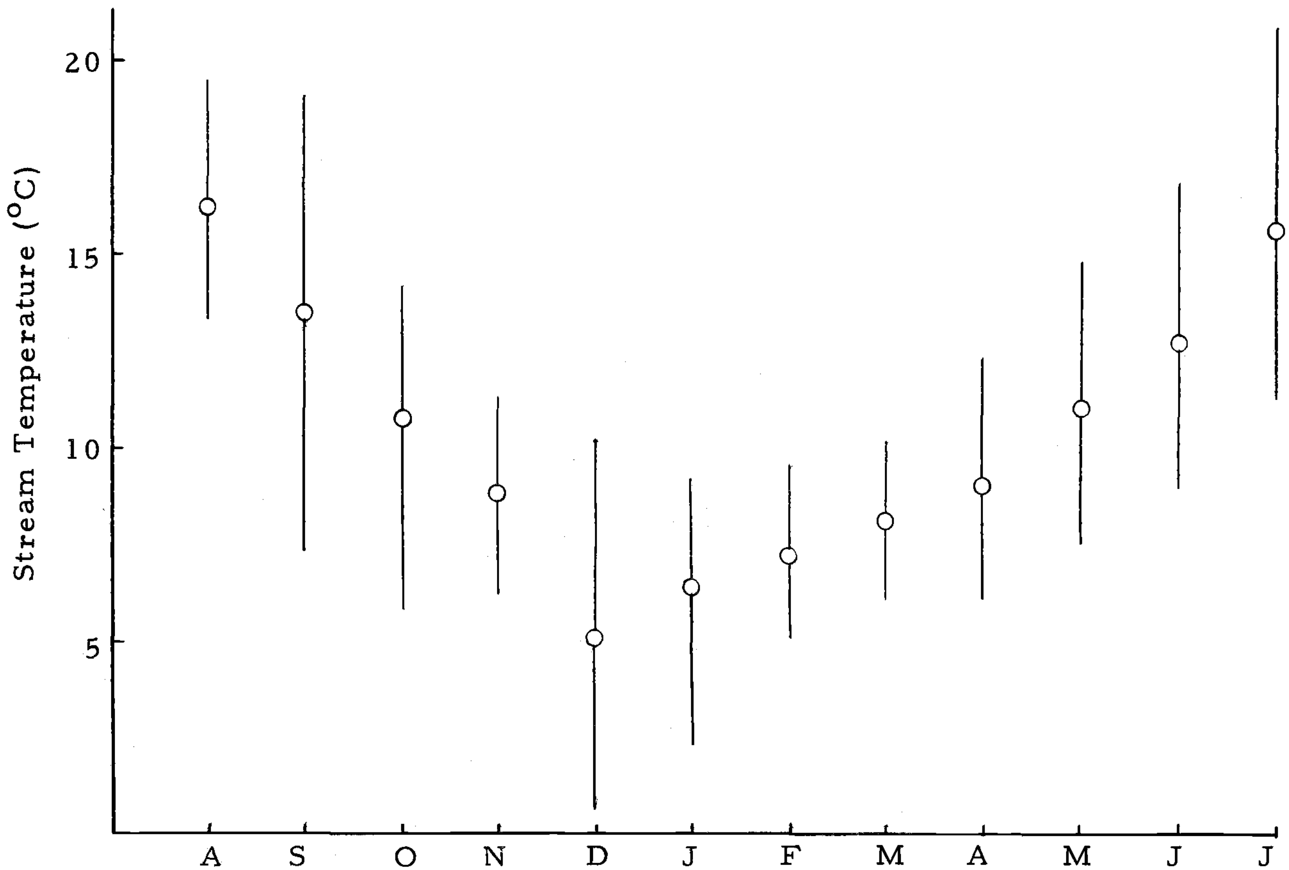

Figure 2. Monthly means and ranges of stream temperature in the experimental section of Berry Creek from August 1972 through July 1973.

Trout that moved into the traps were allowed to continue in the direction of their movement. Those that moved out of the study area were measured, weighed and identified if tagged. Trout that moved into the study area were measured, weighed and tagged (if 80 mm or larger).

The ages of most trout were determined from scale analysis. A length-frequency distribution was used to determine the age of those trout which died during August 1972 prior to scale collection in September 1972.

Survival

Monthly instantaneous mortality rates were calculated for each year class from a modification of an expression given by Ricker (1958):

$$\frac{N_1 - N_{im}}{N_0 - N_{em}} = e^{-i}$$

where:

i = instantaneous mortality rate

N_1 = number of fish at the end of the month

N_0 = number of fish at the beginning of the month

N_{im} = number of fish immigrating during the month

N_{em} = number of fish emigrating during the month

e = base of natural logarithms.

The monthly rates were then summed to give an annual instantaneous mortality rate for each year class. These were converted to annual expectations of death (a) using the equation of Ricker (1958):

$$a = 1 - e^{-i}$$

It was assumed that any tagged trout which was not recovered for the remainder of the study period died two weeks (one-half the sampling interval) after its last capture. Virtual population estimates (Ricker, 1958) were used to determine the number of underyearlings in the population each month.

Growth and Production

The relative growth rate of each tagged trout was calculated for each month from the equation:

$$GR = \frac{W_2 - W_1}{0.5(W_1 + W_2)t}$$

where:

GR = growth rate

W_1 = initial weight of the trout

W_2 = final weight of the trout

t = number of days in the month.

The weights of trout missing from one or more samples, but which were present in a subsequent sample and those which died during the interval between two samples were estimated by interpolation.

The average daily growth rate of the underyearling trout was calculated each month from the growth equation used for the tagged trout. This was done by substituting the mean initial weight and mean final weight of the underyearling trout for the actual initial and final weights (W_1 and W_2).

Production is defined as the tissue elaborated by a fish stock in a given unit of time, regardless of its fate (Ricker, 1958) and is expressed in grams per square meter of stream surface. Production by a given year class of tagged trout was computed by summing the actual or estimated weight changes of each trout in that year class (Warren et al., 1964). Production by the underyearlings was estimated graphically using the method described by Allen (1951). By this method, production is equal to the area under the curve which describes the relationship between the mean individual weight of a fish and the number of fish surviving on any sampling date. The daily growth rate for the total population during each month was calculated by dividing the monthly production of the population by its monthly mean biomass and the number of days in the month (Ricker, 1946).

Seasonal production values and seasonal mean trout biomasses were determined for each stream location. On the basis of similarities in stream temperature and flow, the seasons were defined as:

summer - June through September; fall - October and November; winter - December through February; and spring - March through May.

RESULTS

Population Structure

The trout population at both the beginning and end of the study consisted of six age groups (0+ through V+). The 1967 through 1973 year classes were present during the study.

Between August 1972 and August 1973 the percentage of the population in age-group I+ decreased from 47.2 to 31.0 (Table 2). Over the same period, age-group II+ increased from 15.8 to 25.0 percent of the population. This was attributed to an exceptionally strong 1971 year class. The percentage of the population in age-groups 0+, III+, and V+ remained about the same during the study, while that of age-group IV+ doubled.

Table 2. Numbers of trout and the percentages of the population in each age group in August 1972 and August 1973.

	August 1972		August 1973	
Age-Group	No. of Trout	% Pop.	No. of Trout	% Pop.
0+	53	21.6	30	25.9
I+	113	47.2	36	31.0
II+	38	15.8	29	25.0
III+	23	9.6	11	9.5
IV+	8	3.3	8	6.9
V+	6	2.5	2	1.7
Total	240	100.0	116	100.0

Scale analysis in September 1972 revealed that some of the trout of age-group IV+ and most of the trout of age-group V+ had spent one or two years, respectively, in a larger stream, probably the Luckiamute River or the Willamette River. This was indicated on their scales by a distinct increase in the distance between the circuli after the third annulus. These trout apparently migrated upstream to spawn during the spring of 1972 and remained within the study area thereafter. In the spring of 1973 only one upstream migrant entered the study area.

The 1973 year class consisted almost entirely of newly emerged fry which moved downstream into the study area. Recruitment of the 1973 year class within the study area was very poor. This was probably due to the limited amount of suitable spawning habitat within the study area. It appears that this resulted in the overlapping of spawning territories, and in at least one known case, the destruction of a completed redd.

Movement

Fifty-eight percent of the tagged trout which survived for one month or more after the beginning of the study moved from one stream location to another. Seventy-eight percent of the trout which were tagged in August 1972 and survived to August 1973 moved from one location to another.

There appeared to be no striking difference in the total amount of movement which took place each month except that few trout moved during September 1972 (Figure 3). However, there did appear to be trends in the direction of movement; downstream in October and from December through March; upstream from May through August. In general, this would correspond to downstream movement during periods of high flow and upstream movement during periods of low flow.

One hundred forty-three trout migrated into the study area and 69 trout migrated from the study area between August 1972 and August 1973 (Table 3). Most of the immigration took place in May and June. This was due to the downstream movement of newly emerged fry and to the influx of older trout, possibly those displaced by research activity taking place about 200 meters upstream from the study area.

Table 3. Numbers of immigrants and emigrants in each year class from August 1972 to August 1973.

Year-Class	Number of Immigrants	Number of Emigrants
1973	95	40
1972	18	6
1971	18	14
1970	4	5
1969	4	2
1968	2	1
1967	2	1
Total	143	69

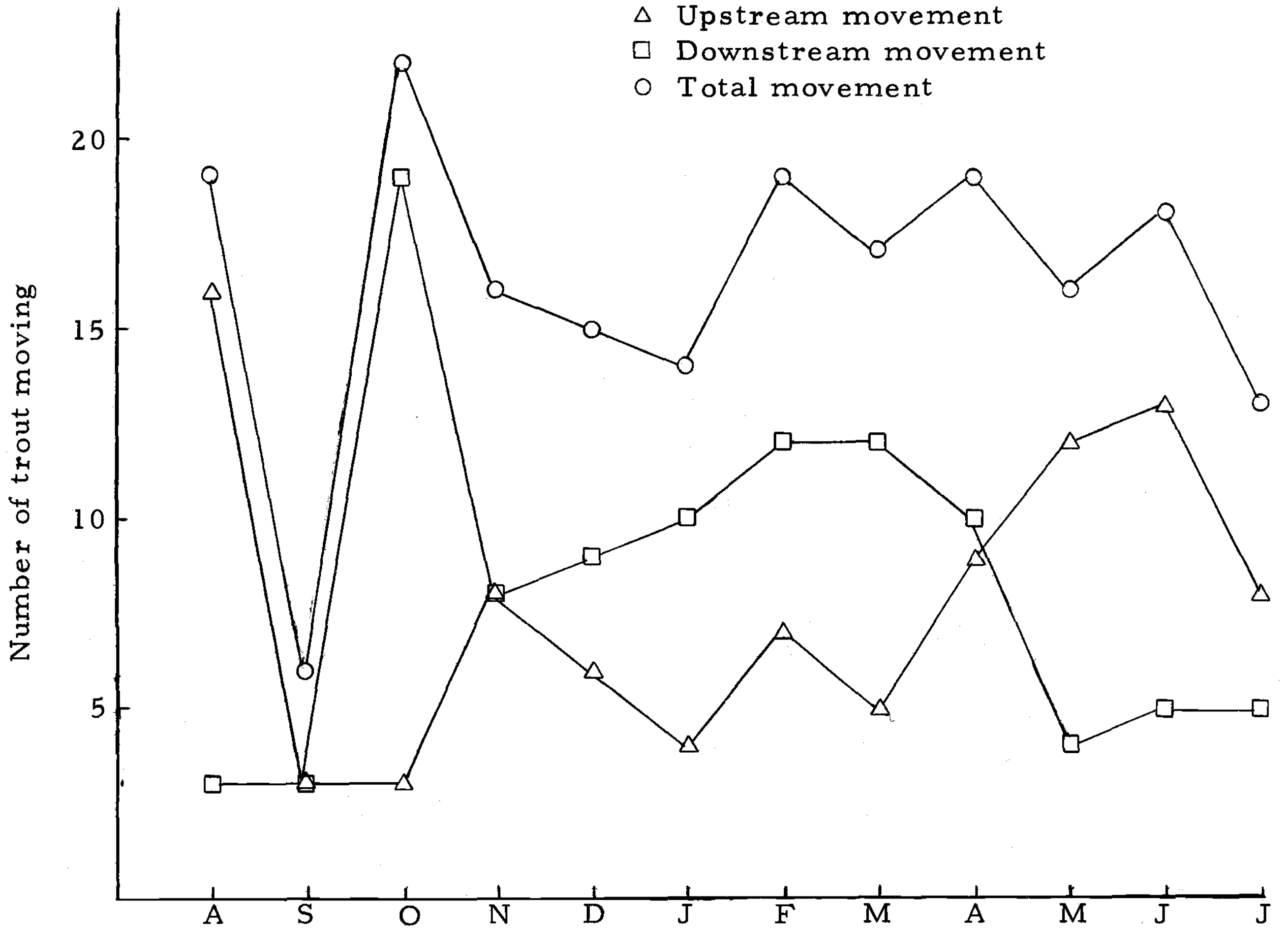

Figure 3. Monthly upstream, downstream and total movement of tagged cutthroat trout in the experimental section of Berry Creek from August 1972 through July 1973.

Survival

The numbers of trout in most year classes underwent a sharp decline during fall and winter (Figure 4). However, numbers remained constant during early spring and increased slightly during May and June because of immigration. Estimates of the numbers of trout in the 1972 and 1973 year classes each month represent only minimum values. Accurate estimation of the numbers of trout in each of these year classes could not be made because of their small size, which made capture and marking difficult.

The annual expectation of death ranged from 0.57 for the 1972 year class to 1.00 for the 1967 year class (Table 4). Monthly mortality ranged from 1.0 to 17.5 percent of the population (excluding the 1973 year class) (Table 4 and Figure 8). The high mortality in August (17.5%) may have resulted, in part, from the effects of handling the trout during very warm weather.

The most important cause of mortality was probably starvation, especially during late summer and fall. The rates of weight loss of yearling trout during the month preceding death were much greater than those of yearling trout which survived (Figure 5). Mortality of the yearlings after December probably was not importantly related to starvation because values of growth rate were generally positive. An unmeasured source of mortality was predation by great blue herons

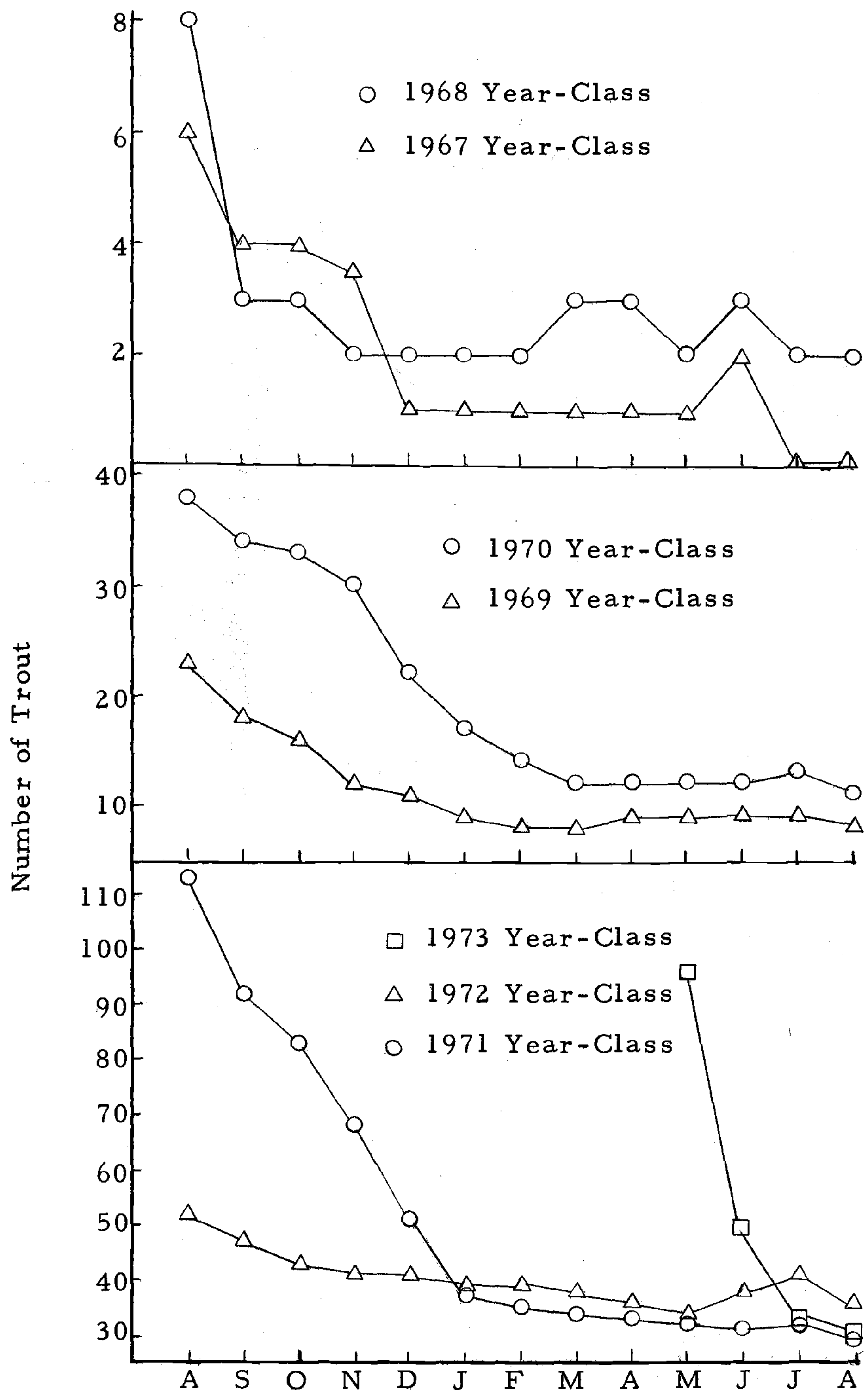

Figure 4. The number of trout in each year class each month from August 1972 to August 1973.

Table 4. Monthly instantaneous mortality rates and the annual expectations of death for the 1967 through 1972 year classes and the total monthly mortality rate for the population (excluding the 1973 year class) from August 1972 to August 1973.

	Year-Class						Total Monthly Mortality
Month	1967	1968	1969	1970	1971	1972	(%)
Aug	0.176	0.981	0.245	0.111	0.206	0.101	17.5
Sep	0.000	0.000	0.118	0.030	0.103	0.089	8.0
Oct	0.125	0.405	0.375	0.095	0.199	0.048	14.8
Nov	0.477	0.000	0.087	0.276	0.227	0.000	14.7
Dec	0.000	0.000	0.201	0.258	0.260	0.025	14.8
Jan	0.000	0.000	0.000	0.069	0.057	0.137	7.6
Feb	0.000	0.000	0.000	0.080	0.000	0.000	1.0
Mar	0.000	0.000	0.000	0.087	0.000	0.000	1.0
Apr	0.000	0.000	0.000	0.000	0.032	0.000	1.0
May	0.000	0.000	0.118	0.087	0.170	0.268	12.2
Jun	1.000	0.405	0.000	0.000	0.176	0.054	12.6
Jul	---	0.000	0.118	0.167	0.098	0.130	11.3
Annual Expectation of Death	1.00	0.83	0.72	0.72	0.78	0.57	

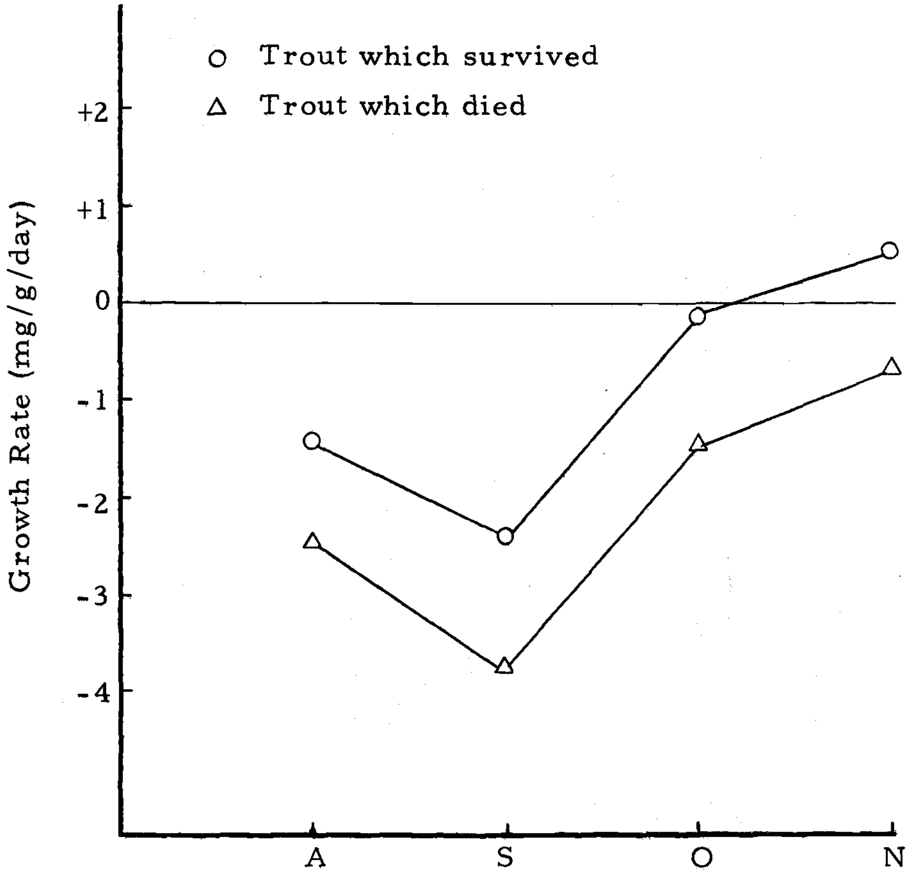

Figure 5. Mean growth rates for yearling trout which died during the subsequent month compared with those for trout which survived throughout the subsequent month, for August through November 1972.

(Ardea herodias) and belted kingfishers (Megacerle alycon).

A major factor influencing these sources of mortality was low stream flow. Mortality was considerably higher during months in which the monthly minimum stream flow was very low than during the months in which the monthly minimum stream flow was relatively high (Figure 6). The low stream flows forced most of the trout to congregate in the pools. This increased competition for food, and resulted in decreased growth. Low stream flows also made the trout more vulnerable to predation.

Growth and Production

Monthly production values for the 1972 and 1973 year classes were calculated from relationships between mean individual weight and numbers of survivors (Figure 7). The curve for the 1972 year class extends only to May 1973 because by that time all members of the year class had been tagged. From May onward, production for the 1972 year class was computed directly as was done with the older year classes. The production values derived from these curves (Table 5) represent underestimates of the actual production because of the questionable validity of the estimates of numbers of trout in the 1972 and 1973 year classes.

Monthly growth rate and production values for the population were positive from December through May, peaking in April (Figure 8).

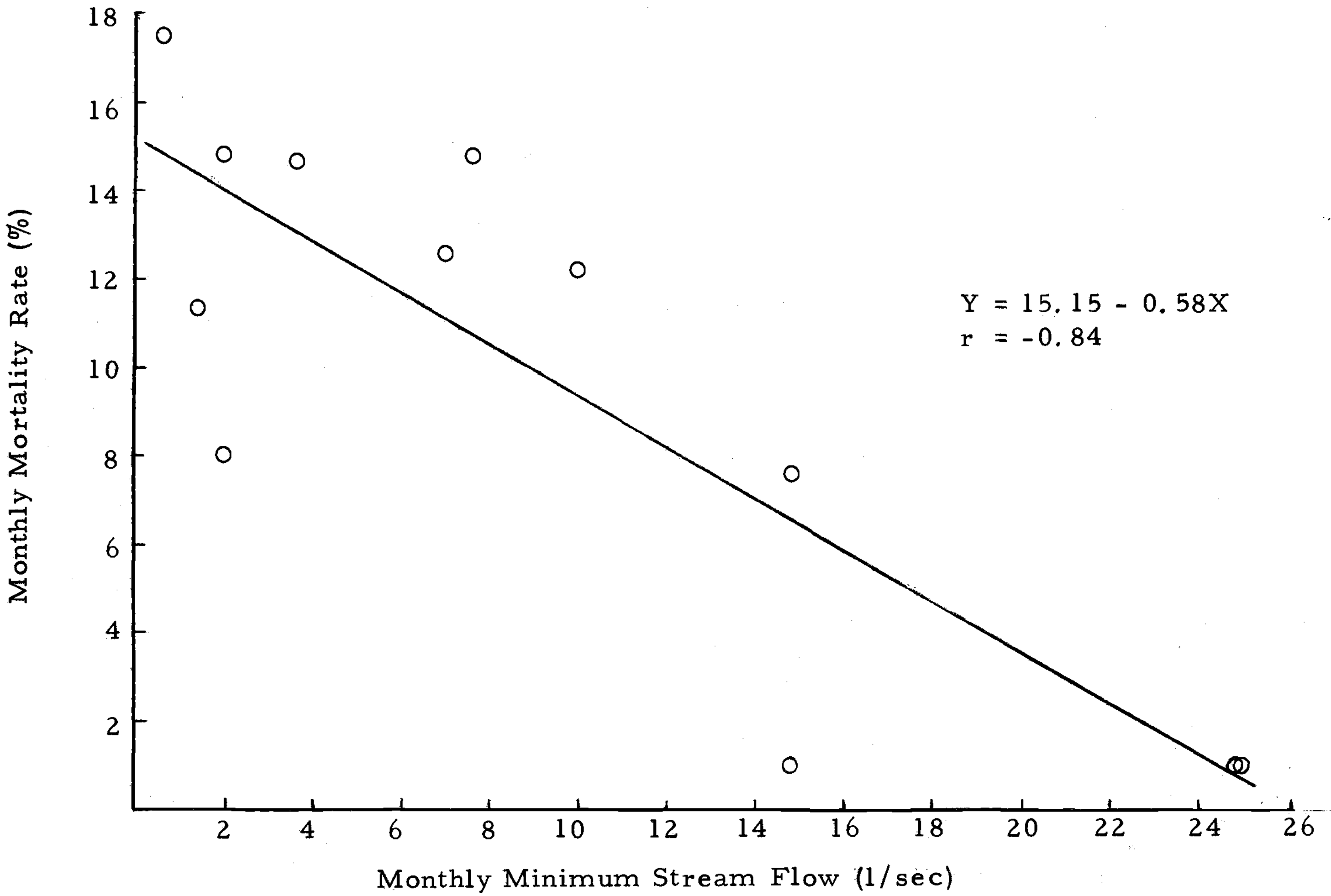

Figure 6. The relationship between monthly mortality rate and monthly minimum stream flow in the experimental section of Berry Creek from August 1972 through July 1973.

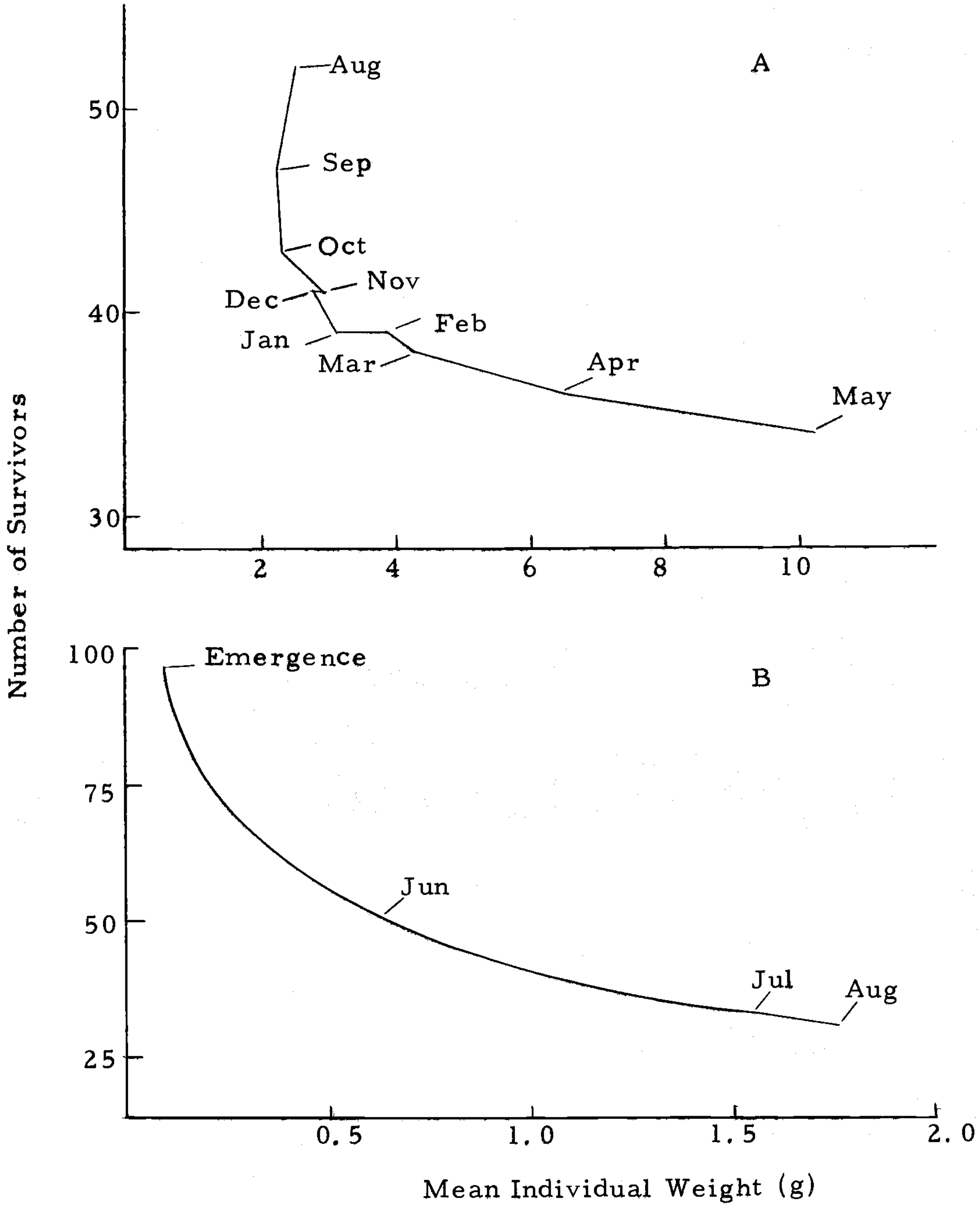

Figure 7. The relationship between mean individual weight and number of survivors in the 1972 year class from August 1972 to May 1973 (A), and the 1973 year class from emergence (late April-early May) to August 1973 (B).

Table 5. Values of monthly and total production (P) and mean growth rate ($\overline{GR}$) are given for each year class of cutthroat trout for the period August 1972 - August 1973. Values of monthly and total production, growth rate and mean biomass ($\overline{B}$) for the total population are also given. Units of production and biomass are g/m^2; those of growth rate are mg/g/day.

	1967		1968		1969		1970		1971		1972		1973		Total Population		
Month	P	$\overline{GR}$	P	$\overline{GR}$	P	$\overline{GR}$	P	$\overline{GR}$	P	$\overline{GR}$	P	$\overline{GR}$	P	$\overline{GR}$	P	$\overline{GR}$	$\overline{B}$
Aug	-0.098	-2.21	-0.070	-2.15	-0.031	-0.60	-0.084	-1.29	-0.196	-1.57	-0.027	-2.53			-0.508	-1.72	8.55
Sep	-0.065	-2.56	-0.033	-3.08	-0.078	-2.28	-0.136	-3.18	-0.146	-2.66	+0.004	+0.47			-0.455	-2.74	6.65
Oct	-0.059	-2.19	-0.021	-1.29	-0.029	-0.89	-0.052	-0.98	-0.037	-0.42	+0.059	+5.81			-0.138	-0.71	5.50
Nov	-0.011	-1.13	-0.003	-0.34	-0.007	-0.68	-0.011	-0.28	+0.003	+0.25	-0.004	-0.51			-0.033	-0.29	4.17
Dec	+0.009	+1.47	-0.010	-1.28	-0.011	-0.41	-0.012	-0.41	+0.016	+0.67	+0.034	+3.67			+0.026	+0.27	3.33
Jan	-0.011	-1.59	-0.013	-1.87	-0.013	-0.67	+0.026	+1.11	+0.049	+1.74	+0.083	+6.67			+0.120	+1.17	3.02
Feb	-0.011	-2.12	-0.031	-3.20	-0.013	-0.75	+0.036	+1.81	+0.095	+3.46	+0.039	+3.41			+0.115	+1.46	2.92
Mar	-0.080	-8.54	-0.014	-1.34	+0.016	+0.69	+0.057	+3.33	+0.161	+5.69	+0.207	+14.81			+0.348	+4.02	3.24
Apr	-0.010	-0.80	-0.008	-0.87	+0.113	+3.63	+0.138	+6.67	+0.250	+6.59	+0.345	+12.87			+0.829	+5.92	4.00
May	-0.003	-0.20	-0.008	-1.16	+0.038	+1.27	+0.088	+3.11	+0.131	+2.72	+0.037	+2.57	+0.095	+35.55	+0.378	+2.27	5.20
Jun	-0.002	-0.20	-0.024	-1.31	-0.029	-0.97	-0.045	-1.48	-0.008	-0.62	-0.033	-0.76	+0.095	+25.97	-0.046	-0.25	5.58
Jul	---	---	-0.018	-1.82	-0.030	-0.93	-0.012	-0.64	-0.041	-1.00	-0.060	-1.91	+0.016	+ 4.49	-0.145	-1.09	4.95
Totals	-0.342		-0.252		-0.073		-0.009		+0.277		+0.684		+0.206		+0.491		

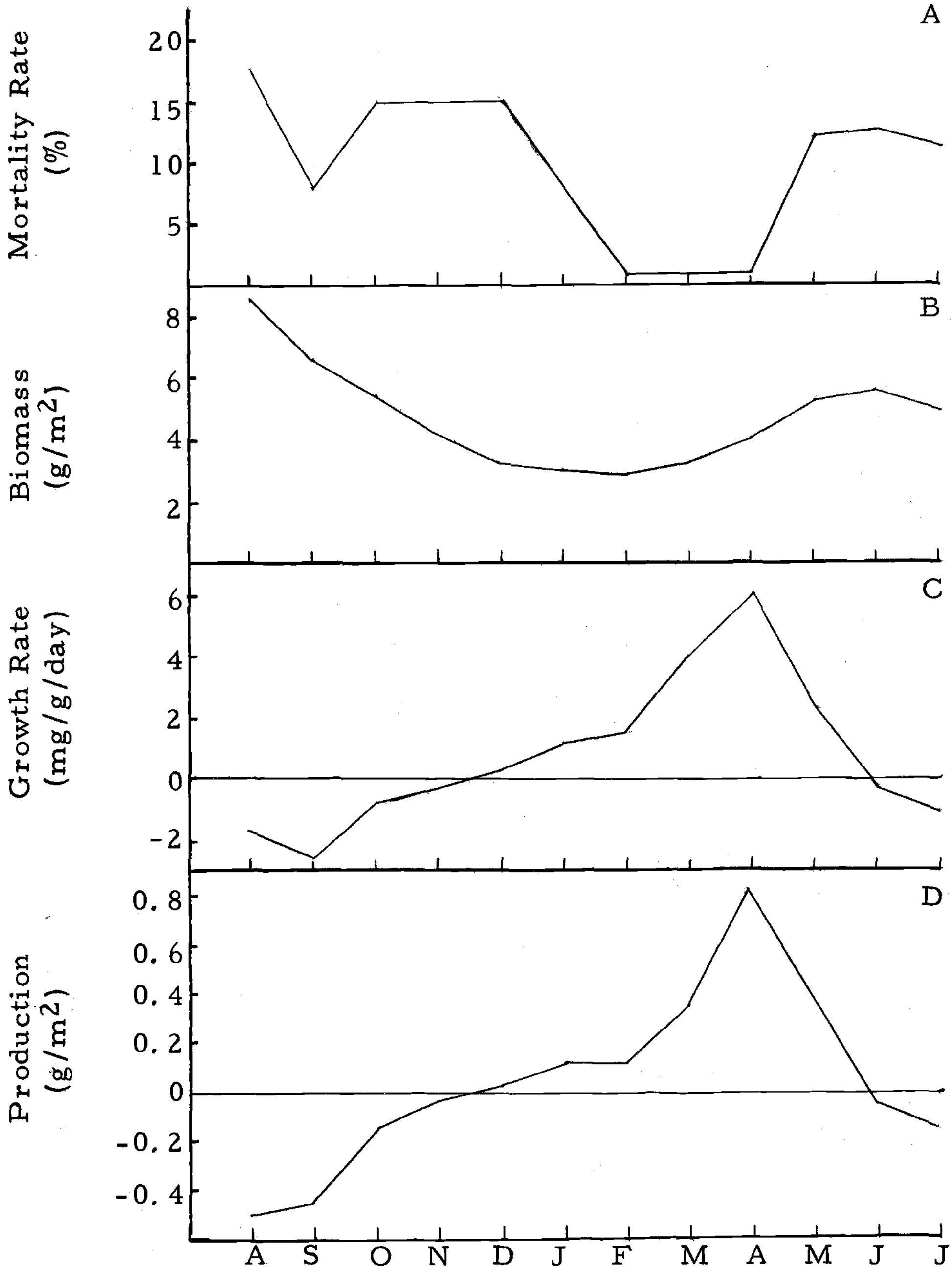

Figure 8. Monthly mortality (A), mean biomass (B), growth rate (C), and production (D) of cutthroat trout in the experimental section of Berry Creek from August 1972 through July 1973.

During the remaining months, the population's growth rate and production values were negative. This resulted in an annual production of 0.491 g/m^2 (Table 5). The annual production of the population resulted entirely from production by the 1971, 1972 and 1973 year classes. Negative values of annual production were recorded for the 1967 through 1970 year classes (Table 5 and Figure 9). These results suggest that little growth occurs once the trout reach two years of age. However, positive values of annual production were recorded for individual trout of the 1969 and 1970 year classes which survived the entire year within the study area (Figure 10). For the 1968 through 1971 year classes, total production was less than the production of the survivors in each respective year class (Figure 10). This resulted from the loss of weight during late summer and fall by a large number of trout which died or subsequently emigrated.

Negative growth and high mortality caused a steady decrease in the mean monthly trout biomass from a high of 8.55 g/m^2 in August 1972 to a low of 2.92 g/m^2 in February 1973 (Figure 8). High values of growth during spring together with low mortality subsequently increased the biomass to a 1973 high of 5.58 g/m^2 in June. Mean monthly trout biomasses in specific locations ranged from 0.23 g/m^2 in location H for October to 76.41 in location I in August 1972. Location I maintained an unusually high biomass of trout throughout the period of the study, the lowest being 8.70 g/m^2 in March 1973. In

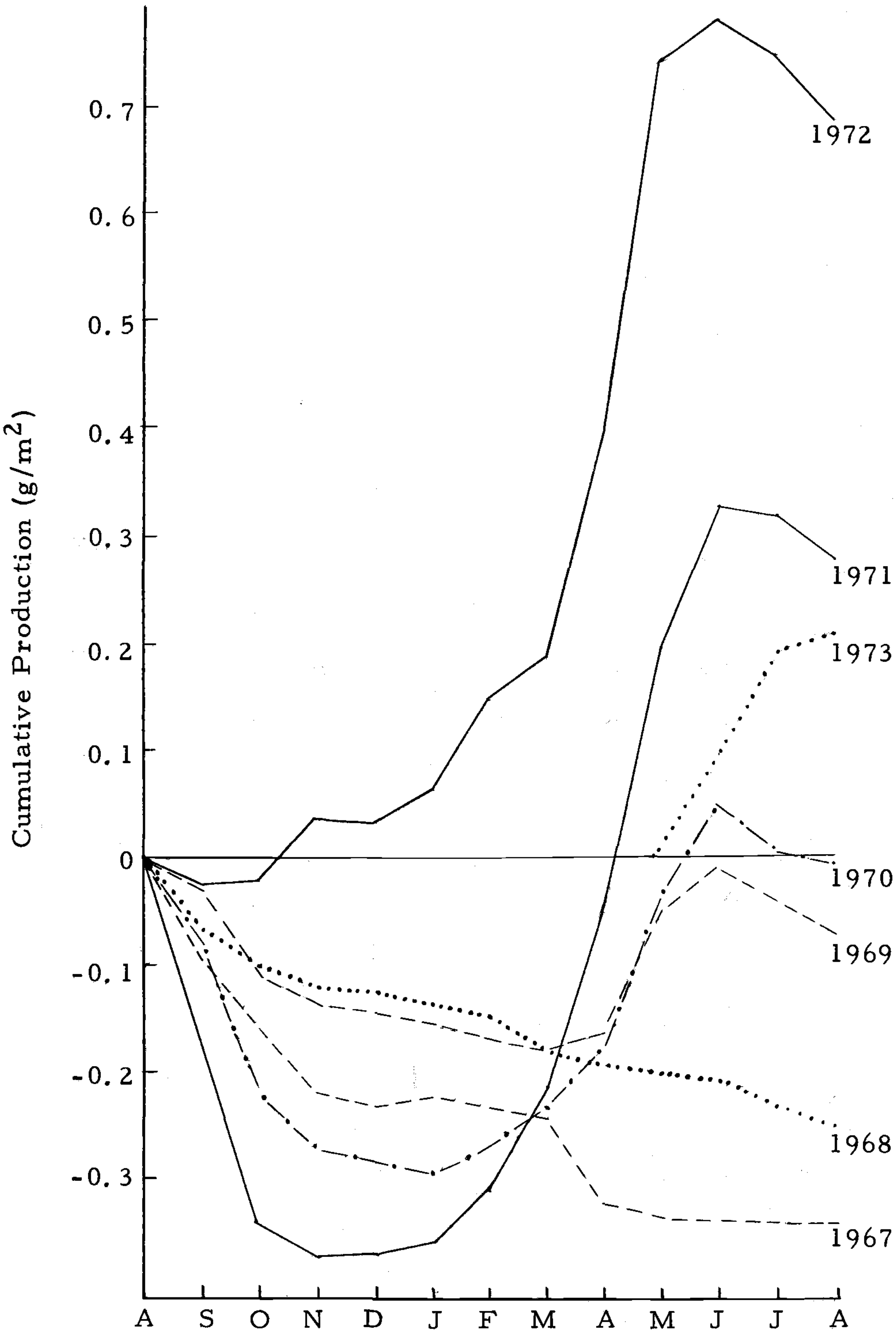

Figure 9. Cumulative production values for cutthroat trout in each year class for the period August 1972 - August 1973.

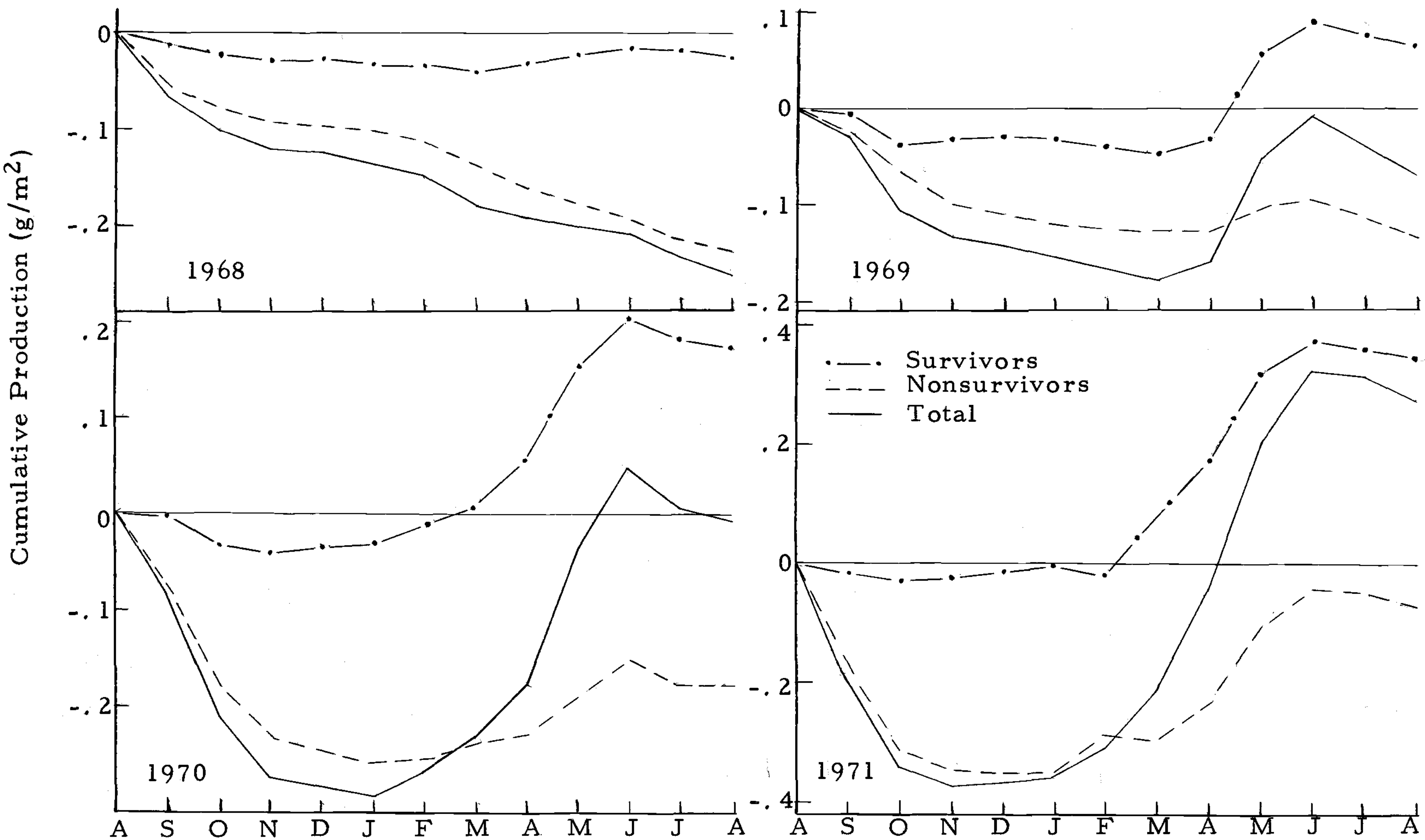

Figure 10. Cumulative production values for trout which survived the entire year in the study area compared with those for trout which immigrated, emigrated or died during the year (nonsurvivors), and with those for the total year class. Values are given for the 1968, 1969, 1970 and 1971 year classes.

most of the other stream locations, the trout biomass was less than 6 g/m^2 throughout the year.

The trout biomass in a given location has a considerable effect on the well-being of the individuals in that location. During most of the year, positive production occurred only in locations where the biomass was less than 4 g/m^2. However, during a short period of time in the spring, high values of production were recorded for locations with trout biomasses as high as 14 g/m^2 (Figure 11). A hump-shaped curve was fitted to the values relating biomass and production for the spring. Laboratory stream studies of trout and sculpins (Davis and Warren, 1965; Brocksen et al., 1968) have shown that biomass-production curves of this form are typical for fish in food limited systems.

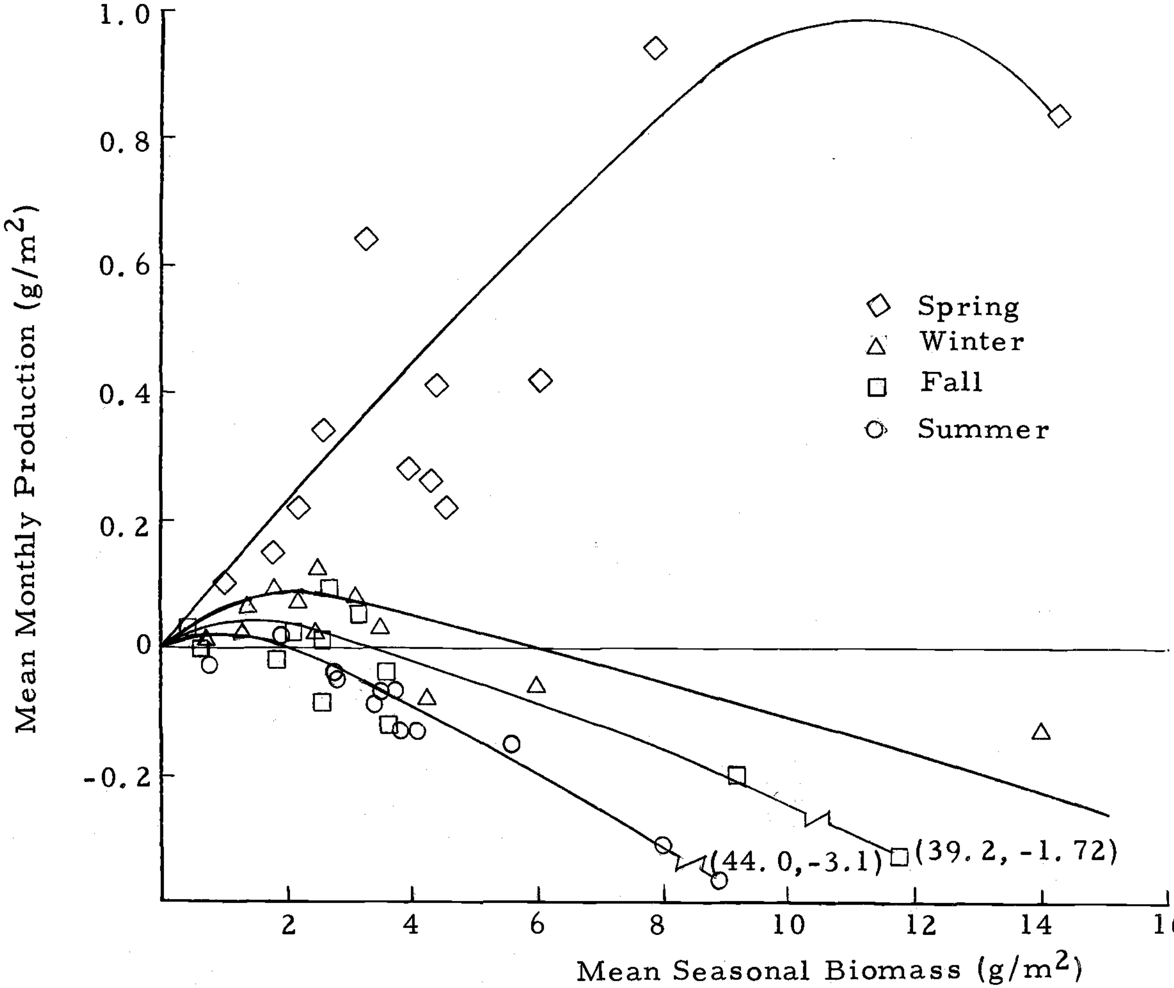

Figure 11. Seasonal relationships between mean biomass and the mean monthly production of trout in different stream locations. Lines fitted by inspection.

DISCUSSION

Dynamics of a stream-dwelling population of coastal cutthroat trout were determined by tagging each trout one year-of-age and older. Underyearling trout were too small to tag, thus the validity of the mortality and production values recorded for the 1972 and 1973 year classes is questionable.

Monthly mortality ranged from 1.0 to 17.5 percent of the population. High mortality during summer and fall was probably related to starvation and low stream flow.

Growth rate and production values were negative during summer and fall and were positive during winter and spring. Growth and production peaked during spring. Trout biomasses in specific stream locations ranged from 0.23 to 76.41 g/m^2. However, throughout most of the year, positive production values were recorded only for locations where the biomass was less than 4 g/m^2. High production values were recorded during spring for locations with trout biomasses as high as 14 g/m^2.

The degree to which a stream-dwelling trout population is able to utilize its available food resource would determine the rates of growth and production of the population at any given level of food abundance. Optimum food resource utilization by a population would occur if the available food were distributed proportionately among all members of the population. Optimum utilization of a food resource by a trout population probably never occurs in nature. Rather, there are always some members of the population which grow at the expense of others.

The amount of intraspecific competition for food is probably the key factor determining how efficiently a trout population distributes its food resource among all its members. Spatial isolation appears to be important in reducing competition and the amount of energy wasted on aggressive interactions among competitors (Kalleberg, 1958; Magnuson, 1962). Trout in riffles generally establish territories which minimize competition through isolation, while trout in pools, where isolation is usually minimal, generally form social hierarchies. Chapman (1966) suggests that:

> In stream populations when drift is the major food source, it would be to the advantage of the fish to keep as much of their population upstream as the available food at a given point will support. In this way the population as a whole will make maximal use of drift.

Stream flows in the experimental section of Berry Creek were probably high enough during winter and spring to allow all but the largest trout in the population to establish territories on the riffles. While no trout were actually observed in territories on riffles, trout were often seen to flee from riffles into pools. The degree to which the food resource was distributed among all the individuals in the population was probably highest during winter and spring because living space and isolation were the greatest. The improved growth of the trout during spring compared to that during winter was probably due to increased abundance of food during spring rather than increased utilization of the available food.

Stream flows during summer and fall were very low and most of the trout were forced off the riffles and into the pools. This resulted in high trout density in the pools and only certain individuals were able to consume much food. Increased aggressive activity among the trout may have resulted in the loss of energy which might otherwise have been used for growth. Under these conditions, the population was unable to efficiently utilize the food which was available and as a result, most of the trout starved. Starvation was not as severe during fall as it was during summer. Lower stream temperatures during fall probably lowered the metabolic rate of the trout, thus allowing more of the energy of the food consumed to be used for growth than was possible during summer. An increase in the food resource may also have been involved.

Certain individuals were able to grow to maintain their body weight during periods of low stream flow. Among these were the underyearling trout which were small enough during summer and fall to live on the riffles where they established territories and grew well. Also, there were individuals in the population which were apparently superior in some way to their peers (e.g., more aggressive or more efficient in capturing and handling food). These trout were able to maintain their body weight even in locations characterized by high biomass. In portions of the stream where the biomass was less than 2 or 3 g/m^2, competition for food was not as great as it was at higher biomasses and many of the trout were able to consume enough food to grow.

At any given food density, the growth rate and production of a trout stock is dependent upon the stock size. Growth rate can be expected to decrease as biomass increases. In this regard, Warren and Doudoroff (1971) state that:

> ...production will increase from a low level at some low biomass to a maximum at some intermediate biomass, and then with further increase in biomass, production will decline toward zero...

The "intermediate" biomass which results in maximum production could be considered to be the optimum biomass. If the biomass of a population is less than the optimum for a given food density, the amount of production of which the population is capable is limited by that biomass. Conversely, if the biomass of the population is greater than the optimum for a given food resource, the amount of production of which the population is capable is limited by the food density.

During spring, cutthroat trout production in Berry Creek is probably limited by the trout biomass, while during the remainder of the year, trout production is probably limited by the food resource. Trout biomasses in most locations during the spring of 1972 were considerably less than the probable optimum (Figure 11). During stream enrichment studies in Berry Creek (Warren et al., 1964; McIntyre, MS 1967), trout biomasses, especially in the enriched sections, were probably well below optimum (Figure 12). Summer, fall and winter mean seasonal biomasses in most locations during the present study were greater than the probable optimum biomass for the respective season (Figure 11).

There is a large seasonal variation in the capacity of Berry Creek to produce coastal cutthroat trout, probably due mainly to changes in the abundance of food organisms. However, it is likely that the variation that occurs in the stream flow throughout the year has an additional effect on trout production. This is probably typical of the small streams which drain the western slope of the Willamette Valley.

The life history of the cutthroat trout which inhabit these streams is complex. Because of the inability of the streams to maintain a substantial amount of trout biomass throughout much of the year, some of the trout migrate downstream to larger rivers. Owing to the limited success of the older age groups, the number of trout which remain in the small streams after their third year of life appears to be small. Since some of the migratory trout return to the small

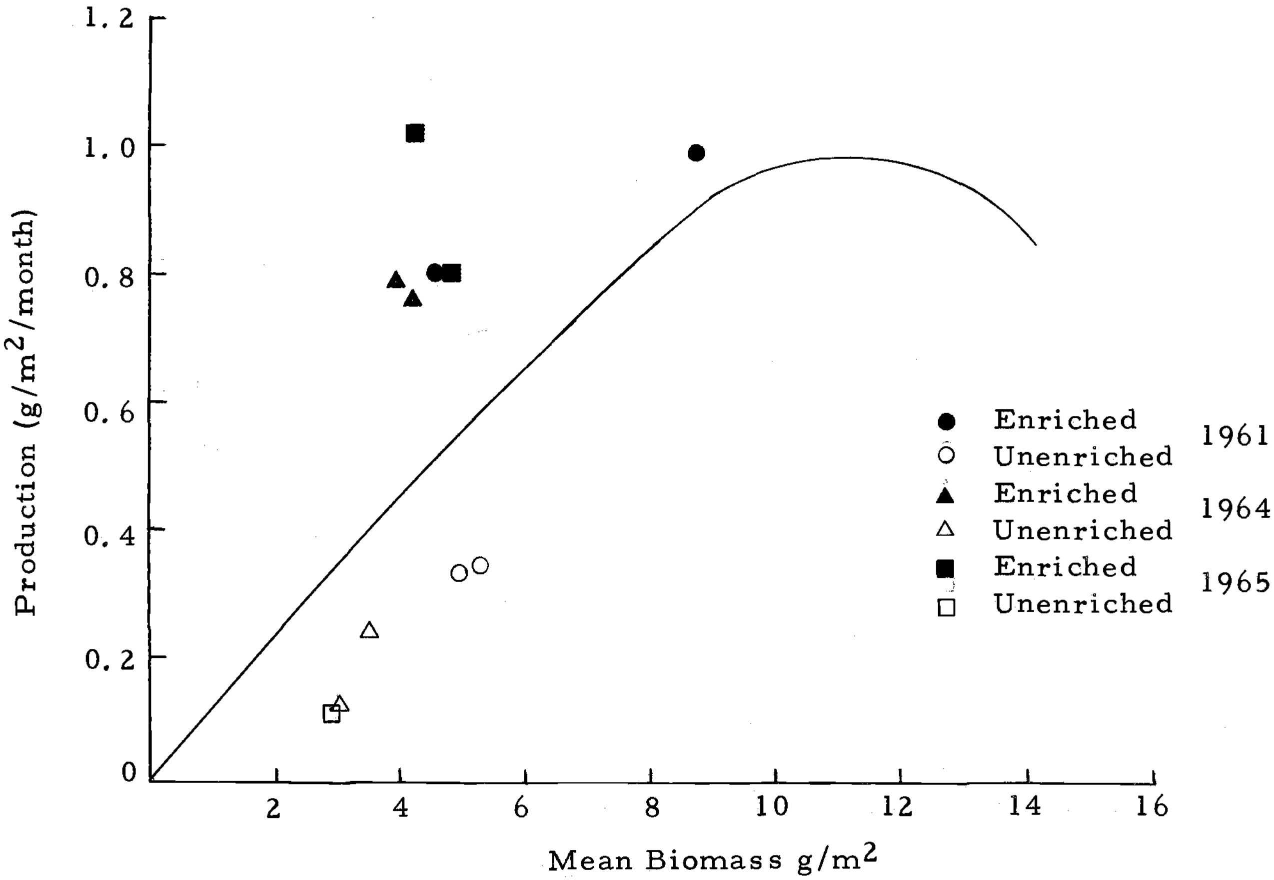

Figure 12. The cutthroat trout biomass-production relationship for the spring of 1973 compared with values of cutthroat trout biomass and production during the same period of previous studies conducted in Berry Creek involving stream enrichment [1961 data after Warren et al., (1964); 1964 and 1965 data after McIntyre (MS 1967)]. Based on means of monthly values.

streams to spawn, both migratory and nonmigratory trout contribute to the gene pool of the stream population. Thus, it is likely that a major role of these small streams is to serve as nurseries for the larger rivers.

It appears likely that there could be an important interaction between the trout of the small streams and those of the large rivers. Changes in the survival and growth of the cutthroat trout in one part of the stream ecosystem could have a subsequent effect on the trout population in the other part. More knowledge of the roles of the migratory and nonmigratory trout is needed to evaluate the effects of environmental changes in either the small streams or the large rivers.

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