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RELATIONSHIP OF YOUNG-OF-THE-YEAR TROUT TO MATURE TROUT AND GROUND WATER[1]

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Abstract

Estimates of the numbers of young-of-the-year and mature (age-groups I and older for the brook trout, and 9 inches and longer for the brown trout) brook and brown trout present in Sections B, C and D of the Pigeon River were made each September, 1949-60. Correlation coefficients (r) were calculated for the numbers of young-of-the-year trout, and ground water levels in October as measured in feet below land surface datum at an observation well within the Pigeon River drainage. Calculation of the difference between the average minimum discharge (in cubic feet per second) at two stream flow gaging stations on the Pigeon River, indicated the well measurements were reflected in the flow data. For the 9 years of available data, 1949-57, there was a highly significant linear correlation between numbers of young-of-the-year brook trout and ground water levels;

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[1] Contribution from Dingell-Johnson Project F-27-R, Michigan.

for the brown trout no correlation was evident. During years of high ground water level, large numbers of young-of-the-year brook trout were present. Correlation coefficients calculated for the number of mature trout estimated to be present each September and the number of young-of-the-year trout present the following September, for 12 years of data, 1949-60 were non-significant for both brook trout and the brown trout. Analyses of variance of regressions of young-of-the-year trout on ground water levels and mature trout for the years 1949-57 agreed essentially with the correlation coefficients.

Introduction

Benson (1953a) found a direct relationship between amount of ground water present, size of trout populations, and number of redds at four study areas on the Pigeon River, Michigan. The first study area, located near the headwaters of the stream, had the largest population of trout, the greatest number of redds, and the most ground water. Number of trout, number of redds, and amount of ground water decreased progressively at each study area downstream. In his thesis, Benson (1953b) noted an increase in the number of young-of-the-year brook trout (Salvelinus fontinalis) in the fall of 1951 over that of 1950, in 4.8 miles of experimental water of the Pigeon River, with an increase in amount of ground water, but a decrease in the number of young-of-the-year brown trout (Salmo trutta). In these two years, there was no apparent relationship between the number of young-of-the-year trout and the size of the spawning populations. Since 1951, the data necessary to determine if there is a consistent relationship between the number of young-of-the-year trout and amount of ground water, and if there is any correlation between the number of young trout and the spawning population have been gathered. In this paper no attempt has been made to analyze the relationship between standing crop and/or catch and ground water; few counts of redds have been made since Benson's work.

The Pigeon River Trout Research Station of the Institute for Fisheries Research is located 13 miles east of Vanderbilt, Michigan, in Otsego County. Since 1949, 4.8 to 6 miles of the Pigeon River have been controlled by the Department of Conservation. The 6 miles of stream is divided into five experimental sections, A through E, each about the same length (Section E was added in 1953). Cooper (1952) and Benson (1953a) provided descriptions of the area and the watershed. A daily permit system has insured a nearly complete census of the angling, and each fall, immediately after the close of the fishing season (second Sunday in September), an estimate of the standing crop of trout remaining has been made by electrofishing.

The trout population data presented here were taken from Sections B, C, and D. Data from Sections A and E were not used because Section A was physically modified (stream improvement experiment) twice since 1949, and Section E was not added to the experimental water until 1953. Section B is 1.19 miles long and has an area of 5.9 acres; Section C, 1.13 miles long, 5.4 acres; and Section D, 1.18 miles long, 5.6 acres. The fishing regulations in Section B have remained unchanged since 1949; 5 trout per day, minimum length of 7 inches, any lure, e.g., worms, minnows, artificial flies, etc. However, in Sections C and D the regulations have been changed frequently (Table 1). At the present time, the regulations are: 5 trout per day; minimum length, 9 inches; lure restricted to artificial fly.

Table 1.--Fishing regulations in Sections B, C and D, Pigeon River, 1949-60

Years	Stream sections: B — Creel limit (trout per day)	B — Minimum legal length (inches)	C, D[1] — Creel limit (trout per day)	C, D[1] — Minimum legal length (inches)
1949-50	5	7	15	7
1951-54	5	7	2	9
1955-60	5	7	5	9

[1] Lure was restricted to artificial flies only in Sections C and D in 1958-60.

Methods

The mark-and-recapture (Petersen) method was used to calculate the number of trout present each fall in each experimental section of the river (Ricker, 1958). Two trips were made through each section using a direct-current electric shocker[2] to take samples of trout (one trip to mark trout and the second to recapture, with an interval of a week between trips). The number of fish in each 1-inch group of each species for each section was calculated. In 1953, and 1956 through 1960, about 15 scale samples were taken from each 1-inch size group of each species in each section in order to delimit age groups. Age-group 0 (young-of-the-year) and age-group I (yearlings) overlap in the 4- and 5-inch size groups. Average percentages of overlap of 0 and I age groups from the years in which scale samples were taken were used to delimit age groups in the years in which no scale samples were taken. In general, about 82 percent of the 4-inch brook trout are young-of-the-year and about 98 percent of the 5-inch brook trout are yearlings; all of the 4-inch brown trout are young-of-the-year and about 83 percent of the 5-inch brown trout are yearlings. The age groups could be separated on the basis of size alone with little change in the number in each age group as determined from the scale samples (all 4-inch and smaller trout could be considered young-of-the-year).

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[2] In 1949 and 1950, an alternating-current shocker was used instead of the direct-current shocker.

In the Pigeon River, brook trout mature at about 5 inches (age-group I) and brown trout at about 9 inches. The estimated number of brook and brown trout in age-group 0 and the number of mature trout (brook trout, age-group I and older; brown trout, 9 inches or longer) for the years 1949-60, are given in Tables 2 and 3.

Ninety-five percent confidence limits for young-of-the-year and mature brook and brown trout populations in Sections B, C, and D of the Pigeon River in September, 1956, were calculated following McFadden, 1961 (Table 4). The size of the trout population in 1956 was small in comparison with other years and the sampling errors were high. The confidence limits in 1956 are given as an example of about the maximum errors to expect.

In Michigan, the United States Geological Survey in cooperation with the Michigan Department of Conservation and the Water Resources Commission of Michigan measures ground water levels and collects other hydrologic data throughout the state. Ground water level measurements are taken from a network of observation wells and streamflow records are gathered from a series of gaging stations (Giroux, 1957; Ash, 1961). In 1951-52, Benson (1953a) measured the amount of ground water entering each of his study areas but no further measurements of this kind were made. My measurements of ground water were taken from the United States Geological Survey hydrologic records.[3]

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[3] Mr. Paul R. Giroux, United States Geological Survey, Lansing, Michigan, provided the data. Mr. Giroux's report on ground water conditions in Michigan in 1956 (Giroux, 1957) gives other available sources of these data.

Table 2.--Number of young-of-the-year (0 age group) and mature (I and older age groups) brook trout estimated to be present each September in Sections B, C and D, Pigeon River, 1949-60

Year	Section B		Section C		Section D	
	0 age group	I and older age groups	0 age group	I and older age groups	0 age group	I and older age groups
1949	496	410	1,618	618	1,263	985
1950	889	320	2,584	950	1,419	1,331
1951	1,653	281	2,929	621	3,936	1,686
1952	2,559	233	3,681	779	4,356	980
1953	2,202	587	2,604	1,335	2,599	1,351
1954	2,651	696	2,964	1,021	3,285	1,298
1955	796	343	1,659	593	1,616	860
1956	694	210	1,521	340	2,444	471
1957	860	107	2,137	443	1,838	600
1958	1,242	210	2,096	787	2,640	1,263
1959	1,318	520	2,509	988	2,292	1,054
1960	1,469	362	2,365	852	2,031	829

Table 3.--Number of young-of-the-year (0 age group) and mature (9 inches or longer) brown trout estimated to be present each September in Sections B, C and D, Pigeon River, 1949-60

Year	Section B		Section C		Section D	
	0 age group	9 inches or longer	0 age group	9 inches or longer	0 age group	9 inches or longer
1949	834	67	389	41	86	52
1950	758	43	251	32	154	46
1951	410	42	232	76	137	96
1952	965	74	871	72	769	61
1953	343	68	595	103	72	87
1954	438	111	576	176	306	123
1955	635	82	882	77	175	48
1956	381	28	330	37	79	41
1957	915	26	470	30	82	57
1958	1,308	19	1,487	42	1,558	32
1959	767	22	423	22	58	28
1960	350	47	372	60	183	67

Table 4.--Ninety-five percent confidence limits in percentage (±) of number of young-of-the-year (0 age group) and mature (I and older age groups or 9 inches or longer) brook and brown trout estimated to be present in Sections B, C and D, Pigeon River, September, 1956

	Section B		Section C		Section D	
	Number of fish	Confidence limits in percentage (±)	Number of fish	Confidence limits in percentage (±)	Number of fish	Confidence limits in percentage (±)
Brook trout						
0 age group	694	28.2	1,521	13.5	2,444	24.9
I and older age groups	210	42.9	340	24.1	471	25.1
Brown trout						
0 age group	381	40.9	330	44.8	79	116.5
9 inches or longer	28	35.7	37	32.8	41	58.5

Observation well 33 N., 1 W., 3-1 is located about 7 miles north of the experimental sections but within the watershed of the Pigeon River. This well, the only one in the Pigeon River drainage, is in the SW 1/4 SW 1/4 Sec. 3, T. 33 N., R. 1 W., Cheboygan County. It is 15 feet deep, 2 inches in diameter, and the chief aquifer is "glacial drift deposits of Pleistocene age." Measurements were taken in 1935-44 and 1948-57. Unfortunately, the number of measurements made each year was irregular. In some years, as many as twenty-four measurements were made while in other years only one measurement was made. The single measurement was usually made in October which would likely be the lowest level for the year. Ground water levels normally rise during spring thaws and decline to a low during the fall. Water levels in feet below land-surface datum for well 33 N., 1 W., 3-1, in October, 1949-57 (except 1954 when the measurement was made in September) are listed in Table 5 and plotted in Figure 1.

Evidence that the water level measurements from the well are indicative of changes in stream flow was provided from records from two United States Geological Survey gaging stations on the Pigeon River. The Vanderbilt gaging station is located at about the middle of Section B in the experimental water of the Pigeon River. The Afton station is located 15 miles downstream. Ash (1961) gives a detailed description of each station. The minimum flow for each month was calculated by taking the average of the minimum daily discharges.[4]

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[4] Flow records were obtained from Mr. Dale Pettengill, United States Geological Survey, Grayling, Michigan, but they are also available in the Geological Survey water-supply papers entitled, "Surface Water Supply of the United States."

Table 5.--Water levels in feet below land-surface datum for well 33 N., 1 W., 3-1, Cheboygan County, October 1949-57, and difference in average minimum discharge (cubic feet per second) between Vanderbilt and Afton gaging stations, Pigeon River, for the water years, 1951-57

Year	Well 33 N., 1 W., 3-1 Cheboygan County	Minimum discharge difference
1949	7.44	...
1950	7.22	...
1951	5.24	40.4
1952	4.85	47.7
1953	5.48	36.9
1954	5.48	33.3
1955	6.22	37.3
1956	7.63	30.2
1957	6.33	33.9

Figure 1.--Ground water levels as measured in feet below land-surface datum for well 33 N., 1 W., 3-1, Cheboygan County, 1949-57, and minimum discharge difference in cubic feet per second between Vanderbilt and Afton gaging stations on Pigeon River, 1951-57.

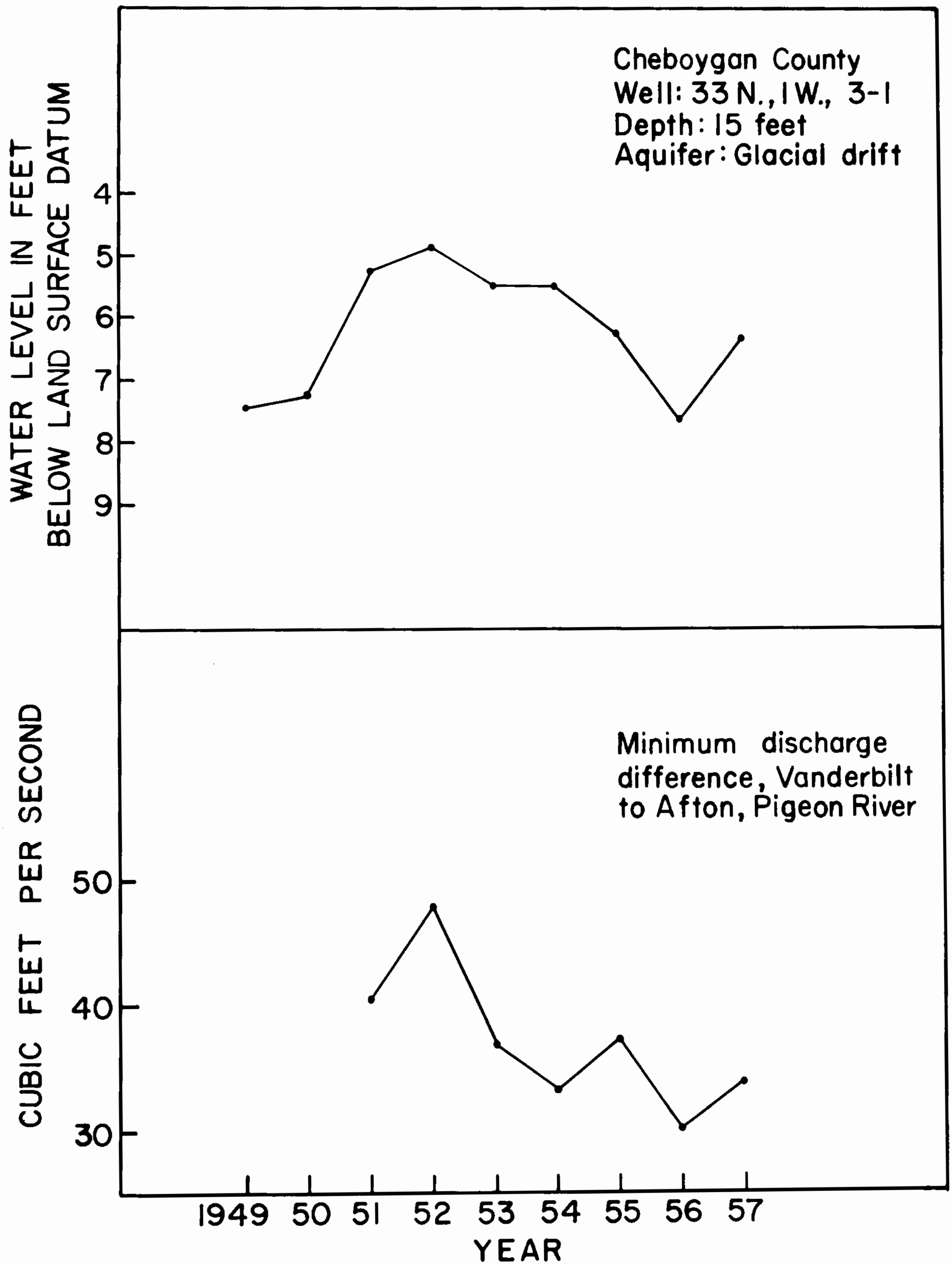
Cheboygan County
Well: 33 N., I W., 3-I
Depth: 15 feet
Aquifer: Glacial drift
WATER LEVEL IN FEET
BELOW LAND SURFACE DATUM
4
5
6
7
8
9
Minimum discharge
difference, Vanderbilt
to Afton, Pigeon River
CUBIC FEET PER SECOND
50
40
30
1949
50
51
52
53
54
55
56
57
YEAR

Figure 1

Monthly averages were used to calculate the average minimum flow for each water year, October through September. Minimum daily discharge was used to minimize the influence of runoff. The Vanderbilt Station was established in September, 1950. For each water year 1951-57, the difference between the average minimum discharge at Vanderbilt and Afton, in cubic feet per second, is given in Table 5 and plotted in Figure 1. Although flow records for the years 1949-50 are lacking, the records for the later years do show that well measurements were reflected in the flow data.

Giroux and Thompson (1960, Figure 9) show the similarities between water levels in two key wells in the northern half of the lower peninsula of Michigan, levels of Lakes Michigan and Huron, and the state-wide cumulative departure of precipitation from the long-term mean, 1943-58. They state, "The similarity in fluctuations in levels of those lakes and the Crawford County well provide evidence that water levels in the drift aquifers of the area and the lake levels each respond primarily to the same general climatic conditions, especially cumulative precipitation." Undoubtedly, streams in northern Michigan are affected in the same way.

Weather observations are made at the Pigeon River Trout Research Station for the U. S. Weather Bureau.[5] The cumulative departure of precipitation in inches from long-term mean for the experimental area of the Pigeon River follows the same pattern as

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[5] Precipitation summaries are published in "Annual Summaries, Climatological Data, Michigan" by U. S. Department of Commerce, Weather Bureau.

the cumulative precipitation graph shown by Giroux and Thompson (1960), and the water level measurements from the well in the Pigeon River drainage (Table 6, Figures 1 and 2).

Relationship of young-of-the-year trout to mature trout and ground water

The numbers of young-of-the-year brook and brown trout estimated to be present each September, 1949-60 in Section B, and Sections C and D combined, are plotted in Figures 3 and 4, respectively. A comparison between the numbers of brook trout (Figure 3) and the ground water levels (Figure 1) shows a linear correlation. Little correlation is apparent between numbers of brown trout (Figure 4) and ground water levels (Figure 1). Brown trout numbers were large in 1952 and 1958. Correlation coefficients (r) were calculated for young-of-the-year trout and ground water levels as measured in feet below land-surface datum (Table 7). Because a high ground water level is recorded as a short distance below land surface datum, a linear correlation between numbers of trout and high ground water levels is negative. For the 9 years of data, 1949-57, there was a highly significant correlation between the number of brook trout and ground water levels. For the brown trout, there was no correlation with ground water levels for those in Section B, and for those in Sections C and D, the r of -0.603 was not significant at the 0.05 probability level.

Table 6.--Total precipitation, departure from long-term mean and cumulative departure from long-term mean for Pigeon River area, 1948-60

Year	Total precipitation (inches)	Departure from long-term mean (inches)	Cumulative departure (inches)
1948	25.90	2.83	2.83
1949	22.85	-2.91	-0.08
1950	31.65	1.16	+1.08
1951	35.70	7.07	+8.15
1952	26.39	-2.24	+5.91
1953	27.16	-1.47	+4.44
1954	32.16	3.53	+7.97
1955	24.08	-4.55	+3.42
1956	26.90	-2.23	+1.19
1957	28.31	-0.82	+0.37
1958	25.16	-3.97	-3.60
1959	32.78	3.65	+0.05
1960	31.17	2.04	+2.09

Figure 2.--Cumulative departure of precipitation in inches from long-term mean for the experimental area of the Pigeon River, 1948-60.

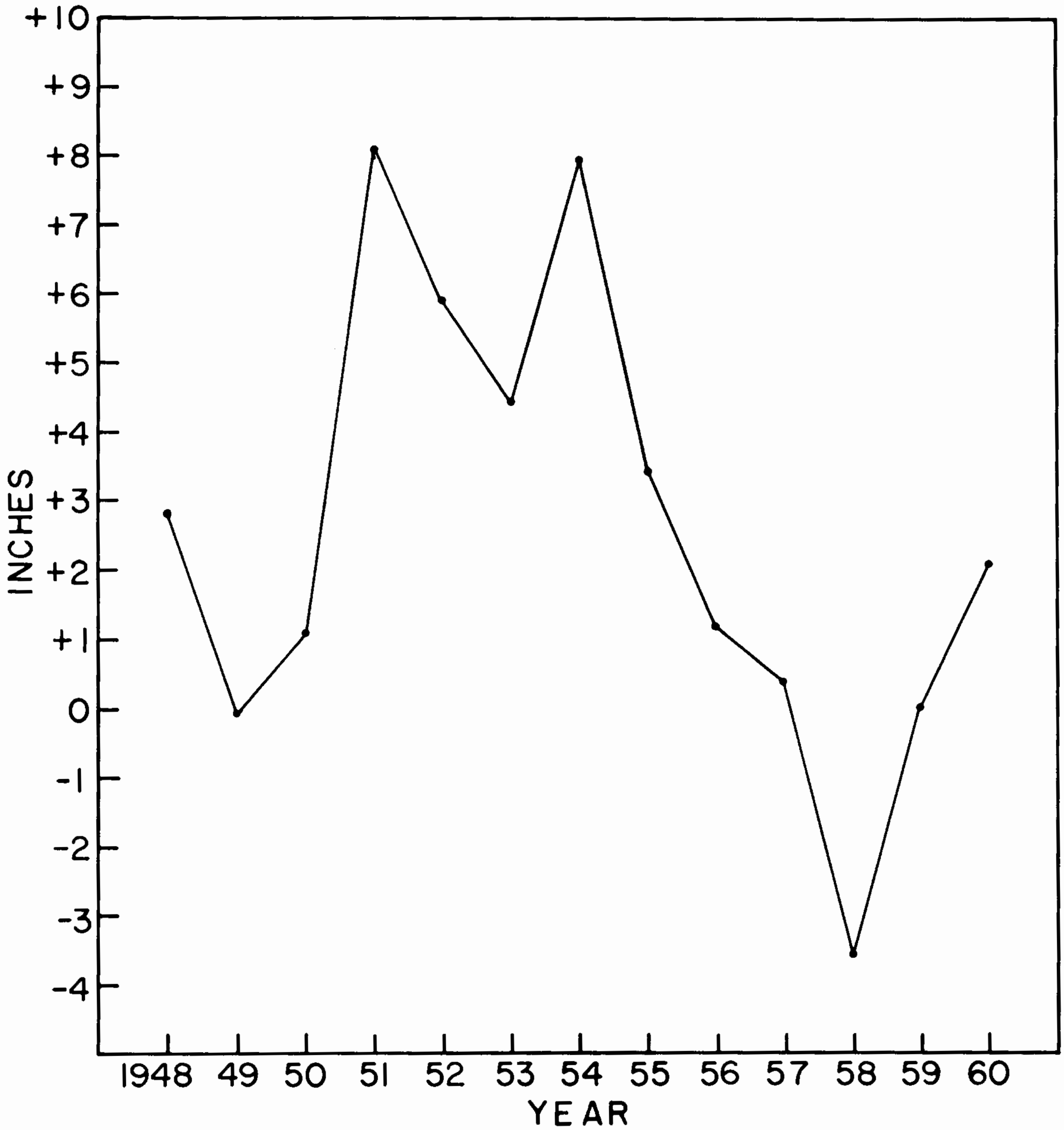
+10
+9
+8
+7
+6
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
INCHES
1948
49
50
51
52
53
54
55
56
57
58
59
60
YEAR

Figure 2

Figure 3.--Number of fingerling brook trout estimated to be present each September in Sections B, C and D, Pigeon River, 1949-60.

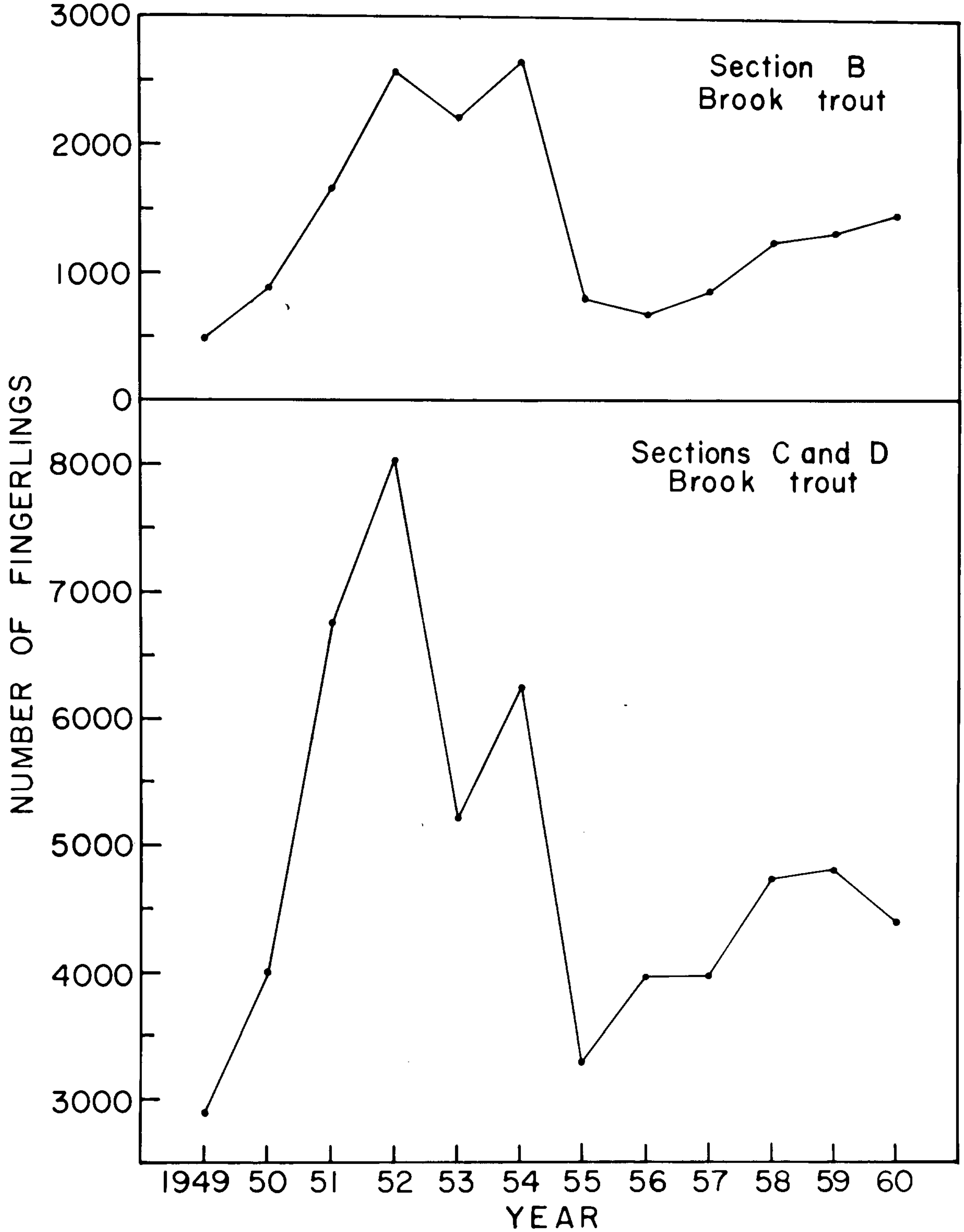
Section B
Brook trout
Sections C and D
Brook trout
NUMBER OF FINGERLINGS
3000
2000
1000
0
8000
7000
6000
5000
4000
3000
1949
50
51
52
53
54
55
56
57
58
59
60
YEAR

Figure 3

Figure 4. --Number of fingerling brown trout estimated to be present each September in Sections B, C and D, Pigeon River, 1949-60.

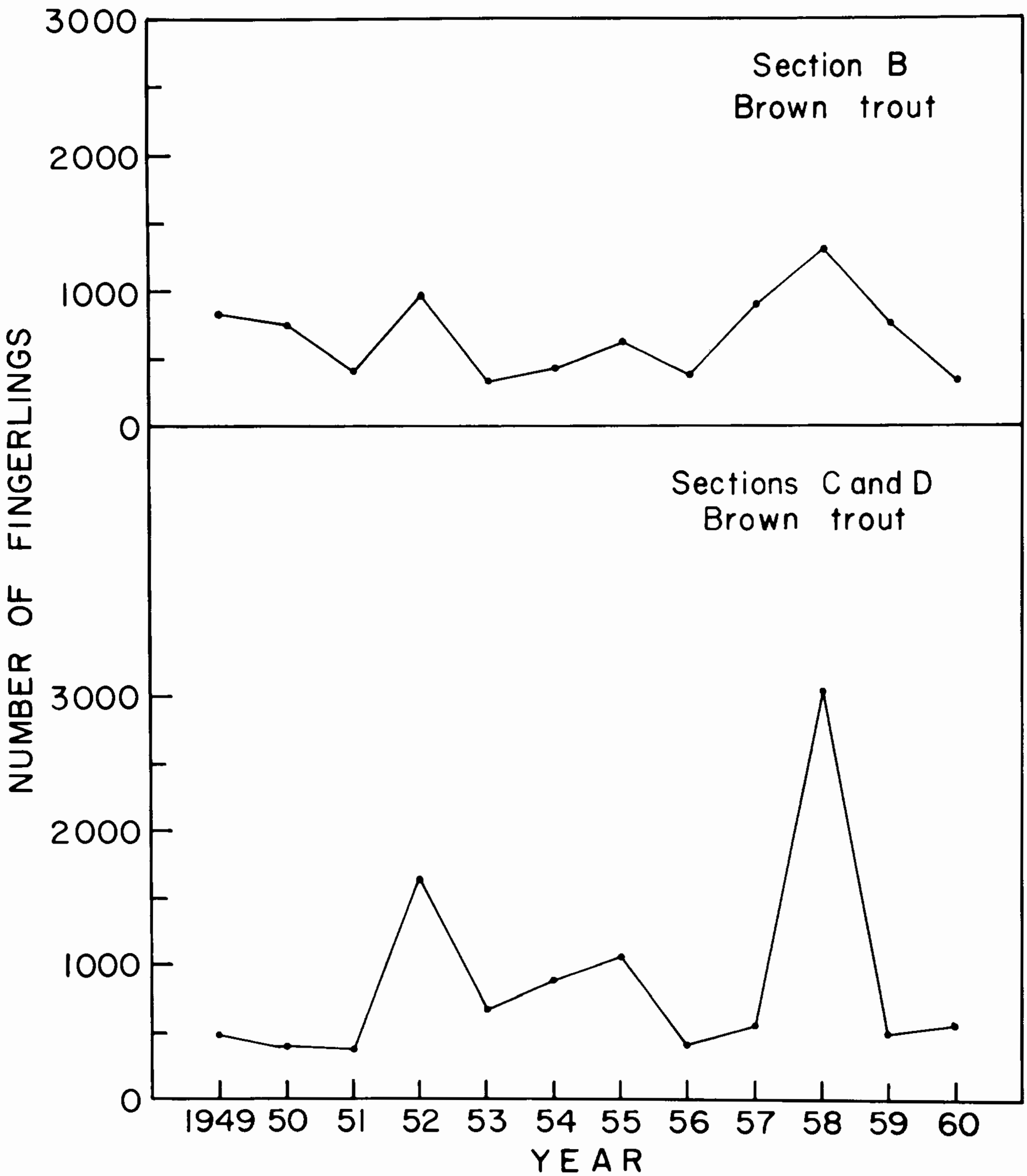
Section B
Brown trout
Sections C and D
Brown trout
NUMBER OF FINGERLINGS
3000
2000
1000
0
3000
2000
1000
0
1949 50 51 52 53 54 55 56 57 58 59 60
YEAR

Figure 4

Table 7.--Correlation coefficients (r) for number of young-of-the-year trout and ground water levels in the Pigeon River, 1949-57

Species	Stream sections	
	B	C, D
Brook trout	-0.859[1,2]	-0.844[1,2]
Brown trout	+0.086	-0.603[1,3]

[1] Correlation coefficients are negative because water levels were measured from land surface down.

[2] $P < 0.005$

[3] $P = 0.09$

Correlation coefficients were calculated for the number of mature trout estimated to be present each September in Section B and C, D combined, and the number of young-of-the-year trout present the following September (Table 8). For the 12 years of data, 1949-60, neither the brook nor the brown trout had a significant correlation (less than 0.05 probability).

Analyses of variance of regressions of young-of-the-year trout (Y) on ground water levels (X_1) and mature trout (X_2) in Sections B and C, D of the Pigeon River are summarized in Table 9. The data used in these calculations were the ground water levels for October (which are indices of the amount of ground water present in the stream the preceding year), the number of young-of-the-year trout present in September of the same year as the ground water measurements, and the number of mature trout from the previous September, 1949-56. F values are given for the regression of young-of-the-year trout, Y, on ground water levels, X_1, after the effect of mature trout, X_2, has been discounted and for the regression of Y on X_2 after the effect of X_1 has been discounted. Of these F values, only the regression of young-of-the-year brook trout on ground water levels for Section B was significant at the 0.05 probability level. In Sections C, D the F value for regression of young-of-the-year brook trout on ground water levels was slightly less than the 0.10 probability level. Although this F value is below the 0.05 probability level, there is little indication from the regression of young-of-the-year trout on mature trout, after discounting the effects of ground water levels,

Table 8.--Correlation coefficients (r) for number of mature trout and number of young-of-the-year trout present the following September, Pigeon River, 1949-1960

Species	Stream sections	
	B	C, D
Brook trout	+0.010	+0.509[1]
Brown trout	-0.396	+0.140

[1] P = 0.11

Table 9.--Summary of analyses of variance of regressions of young-of-the-year trout (Y) on ground water levels (X_1) and mature trout (X_2), Sections B and C, D, Pigeon River, 1949-57

Species and section	Source of variation	Degrees of freedom	Mean square	F value
Brook trout				
Section B	X_2 after X_1	1	1.00	0.00
	X_1 after X_2	1	33,149.87	10.84[1]
	Error	5	3,058.90	...
Section C, D	X_2 after X_1	1	8.25	0.06
	X_1 after X_2	1	668.15	4.91[2]
	Error	5	136.02	...
Brown trout				
Section B	X_2 after X_1	1	878.58	1.26
	X_1 after X_2	1	48.75	0.07
	Error	5	694.33	...
Section C, D	X_2 after X_1	1	3,830.17	3.82
	X_1 after X_2	1	3,103.43	3.10
	Error	5	1,002.34	...

[1] $P < 0.025$

[2] $P < 0.100$

that numbers of mature trout influence the numbers of young-of-the-year trout produced in Sections C and D. I would judge that, within the limits of population density observed here, amount of ground water has much more influence than number of potential spawners on number of young-of-the-year brook trout produced in Sections C and D even though the F value is below the 0.05 level. In Section B, as in Sections C, D, the F value indicated no significant relationship between young-of-the-year and mature brook trout. None of the F values for the brown trout were significant.

No evidence was obtained to indicate that either ground water levels or number of mature trout influence the number of young-of-the-year brown trout present in the Pigeon River each September. For the brook trout, there is little indication that the number of potential spawners influences the number of young-of-the-year trout present in the fall but much indication that in years of higher ground water level larger numbers of young-of-the-year brook trout are present in the Pigeon River.

Discussion

High survival of salmonid eggs to an advanced stage in the redds is usual (see McFadden, 1961, for a comparison of reproductive success among various species of salmonids). In years of high ground water levels, the number of eggs surviving is probably higher but I doubt whether this increase leads to a larger number of fingerlings in the fall. McFadden (1961) found that the survival of brook trout fingerlings was density dependent, as did LeCren (1962) for the brown trout. Among brook trout and brown trout, most of this compensatory mortality occurs during the first three months after emergence from the redd (Latta, 1962; Allen, 1951). Probably, the higher ground water levels increase the carrying capacity of the stream and thereby improve survival during these critical early months of life. Kalleberg (1958) and LeCren (1962) have indicated that brown trout fry establish territories as soon as they start to feed. I have also observed brook trout fry (caught soon after emergence) establish territories in aquariums. While skin-diving in the Miramichi River, Keenleyside (1962) observed young brook trout maintaining territories in shallow rapids, but also some schooling in pools and quiet backwaters. It seems reasonable to assume that the higher ground water levels in the Pigeon River, actually a larger basic flow of water, result in a greater food supply and increased survival of trout fry.

Why the young-of-the-year brown trout did not show an increase in survival, as did the brook trout in the Pigeon River, is not known. The more numerous brook trout may depress numbers of brown trout but there is no apparent relationship between the species in the data presented here.

During the years 1949-60, fishing regulations in Section B remained constant, whereas in Sections C and D several changes in regulations occurred (Table 1). The creel limit in Sections C and D has changed from 15 fish to 2 fish to 5 fish per day while the size limit changed from 7 to 9 inches. Reduction in creel limit apparently has little influence on the catch (or the population) (Cooper, 1953a; Hunt, Brynildson and McFadden, 1962). In 1958, fishing in Sections C and D was restricted to artificial flies only. Shetter and Alexander (1962) found that a flies-only regulation with a minimum size limit of 7 inches did not increase the population of sublegal brook trout in Hunt Creek. It is doubtful that the same regulation has increased the population of sublegal brook trout in the Pigeon River.

The ratios of the number of young-of-the-year and mature brook and brown trout in Section B, to number in Sections C and D, were calculated for the years 1949-60 (Table 10). In addition, the mean ratios for the years before and after a minimum legal size limit of 9 inches was imposed on Sections C and D were calculated. The 9-inch size limit began in 1951, and accordingly, the "before" years for the mature trout were 1949-50, and the "after" years, 1951-60. But for the young-of-the-year trout, any effect of a higher size limit would not appear until the next year, thus the "before" years were 1949-51, the "after" years, 1952-60. The mean ratios for the brook trout indicate no increase in either the number of mature trout or young-of-the-year trout with the increase in size limit from 7 inches to 9 inches (*t* tests substantiated no significance). Unfortunately the number of "before" years is small for statistical reliability.

Table 10.--Ratio of number of young-of-the-year and mature brook and brown trout in Section B to number in Sections C and D, Pigeon River, 1949-60, and mean ratios before and after a minimum legal size limit of 9 inches was imposed on Sections C and D

Year	Brook trout Ratio B:C+D	Brook trout Mean ratio	Brown trout Ratio B:C+D	Brown trout Mean ratio
Young-of-the-year trout				
1949[1]	0.172	...	1.756	...
1950	0.222	0.212	1.872	1.580
1951[2]	0.241	...	1.111	...
1952	0.318	...	0.588	...
1953	0.423	...	0.514	...
1954	0.424	...	0.497	...
1955[2]	0.243	...	0.601	...
1956	0.175	0.297	0.932	0.827
1957	0.216	...	1.658	...
1958[2]	0.262	...	0.430	...
1959	0.275	...	1.595	...
1960	0.334	...	0.631	...
Mature trout				
1949[1]	0.256	...	0.720	...
1950	0.140	0.198	0.551	0.636
1951[2]	0.122	...	0.244	...
1952	0.132	...	0.556	...
1953	0.219	...	0.358	...
1954	0.300	...	0.371	...
1955[2]	0.236	0.194	0.656	0.391
1956	0.259	...	0.359	...
1957	0.103	...	0.299	...
1958[2]	0.102	...	0.257	...
1959	0.255	...	0.440	...
1960	0.215	...	0.370	...

[1] In Section B, creel limit 5 trout per day, minimum legal length 7 inches, 1949-60; in Sections C and D, creel limit 15 trout per day, minimum legal length 7 inches, 1949-50.

[2] In Sections C and D, creel limit 2 trout per day, minimum legal length 9 inches, 1951-54; creel limit 5 trout per day, minimum legal length 9 inches, 1955-60; lure was restricted to artificial flies only, 1958-60.

For the brown trout, the mean ratios indicated an increase in both the number of young-of-the-year and mature trout with the increase in the size limit (t tests significant at the 0.05 level), but, as was shown above, there was no correlation between numbers of young-of-the-year and ground water levels, or between young-of-the-year and number of mature trout.

Further analysis may reveal the relationships between populations of brook and brown trout and regulations, fishing pressure, catch, or ground water levels. However, it does not appear that the data used in the analysis of the relationship of young-of-the-year trout to mature trout and ground water was influenced by the changes in fishing regulations in Sections C and D.

Shetter, Whalls and Corbett (1954) attributed an increase in numbers of young-of-the-year brook trout in North Branch of the Au Sable River from 1948 to 1953, to an increase in the adult population resulting from a higher size limit (9 and 10 inches) and a "flies-only" regulation. The data presented here indicate no relationship between numbers of mature brook trout and numbers of young-of-the-year present the succeeding fall; likewise, McFadden (1961) found no linear correlation between numbers of young trout and density of mature brook trout in Lawrence Creek. The years 1948-53, when young-of-the-year brook trout were increasing in the North Branch, were also years when ground water levels were increasing in northern Michigan (Giroux and Thompson, 1960). Unfortunately, numbers of young-of-the-year brook trout present in the North Branch were not recorded in all years so that a comparison with ground water levels could be made. No control data were available until 1953. Shetter, et al., state, "We do not know with certainty if the population level of the normal section has increased or decreased since application of restrictions, as the only measure available for the pre-restricted period is the 1948 fall sample taken when the Twin Bridge area was under normal fishing regulations." In view of the above observations, the increase in numbers of young-of-the-year brook trout attributed to regulations could well have been due to an upward trend in ground water levels.

Hunt, Brynildson and McFadden (1962) indicated an increase in young-of-the-year (9 months old) after the adoption of a 9-inch size limit in Lawrence Creek in 1958. The question arises as to whether the carrying capacity (perhaps as measured by ground water levels) for young-of-the-year brook trout had not increased in Lawrence Creek in 1959. No control data were presented.

McFadden (1961) used data published by Cooper (1953b) from the experimental sections of the Pigeon River as "an example of a population where cropping of mature fish will result in a direct reduction in recruitment." The data (number of 9-month-old fingerling brook trout and size of parental egg complement) are for the years 1949-52, the years in which the ground water levels were increasing and there was increased survival of young-of-the-year brook trout. The additional data presented here do not substantiate McFadden's conclusion.

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