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PERIODICITY OF GROWTH AND CHANGE OF CONDITION OF BROOK TROUT (SALVELINUS FONTINALIS) IN THREE MICHIGAN TROUT STREAMS

By

Edwin L. Cooper

Abstract

The periodicity of growth and change in condition of the brook trout was studied by extensive collections made in sections of three Michigan streams. These streams were the North Branch of the Au Sable River in Crawford County, Hunt Creek in Montmorency County and the Pigeon River in Otsego County.

The effect of direct-current electro-fishing in attracting fish to the positive electrode from hiding places in heavy cover made possible the collection of adequate numbers of fish for statistical comparison. Previous attempts to obtain enough fish, particularly in winter from these streams using seines or with alternating current shockers, were very ineffective. The growth rate and condition of the brook trout were compared by a series of 15 collections taken during one year from each stream.

In all three streams, the growth rate increased rapidly during the last week in April or first week in May. It remained rapid during May and June, slowed up considerably during July, August, September and October and practically ceased during November, Denember, January, February and March.

The North Branch of the Au Sable River exhibited the fastest growth rate, followed by the Pigeon River and Hunt Creek in that order. There was a large variation in growth rate in individual fish with a few trout of even the slowest growing population (Hunt Creek) becoming 7 inches long by July of their second summer.

The condition of the brook trout was uniformly low in all three streams during late March and early April, 1951. It rose rapidly during late April and May, reached a peak usually about the first week in June, and declined thereafter to the winter low condition. There was a decided drop in condition during October and November probably associated with spawning. The condition of the brook trout in the North Branch of the Au Sable River rose to a much higher peak in June than did those in both Hunt Creek and the Pigeon River. Also, this high level of condition was maintained by the fish in the North Branch of the Au Sable River over a much longer period during the summer.

Cursory investigation of the bottom fauna suggested that a scanty food supply is a contributing factor to slow growth of the Hunt Creek population.

In all three streams, water temperatures warmed abruptly during the last week in April and the first week in May, coincident with the disappearance of the accumulation of winter snow. Daily temperatures over 60 degrees F. were the rule during the months of May through September. During December, January, February and March, minimum water temperatures were seldom above 36 degrees F. Water temperatures fail to explain the differences in growth noted between Hunt Creek and the North Branch of the Au Sable River, for temperature conditions in Hunt Creek remain within the optimum range throughout the summer and fall while those in the North Branch of the Au Sable River frequently go over 70 degrees F.

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Introduction

One of the lesser known aspects of the life history of the brook trout concerns the periddicity of growth and the concurrent changes in condition from one season to another. Previous attempts to obtain sufficient data for a comprehensive study of these phenomena were largely futile due to the inability to "find" the brook trout during cold weather and the lack of interest in working under adverse climatic conditions. Recent advances in techniques of collecting trout during the winter months using direct-current electro-fishing have made such a study of trout on a year-round basis more efficient. The present discussion is based on a series of collections of brook trout from portions of three Michigan streams taken from March 27, 1951, to March 11, 1952, approximately at monthly intervals, with about 100 trout per collection. These streams are Hunt Creek in Montmorency County, the Pigeon River in Otsego County, and the North Branch of the Au Sable River in Crawford County. In each stream, a portion was selected which was known to contain a fair to large population of naturally spawned brook trout. Other factors considered in their selection were the lack of ice cover during severe winter weather and easy access by road during period of heavy snow. The sections designated for sampling were each approximately 500 yards long.

Methods

The fish were collected with a direct-current shocker, anesthetized, measured, weighed, scale sampled and returned to the stream. Many individual fish were recaptured and sampled during subsequent visits as evidenced by the marks left by scale sampling. The population density appeared not to fluctuate a great deal during the year although usually more effort was necessary during the winter to obtain a sample of about 100 trout. The portions of the stream frequented by trout changed radically with the change in seasons. During the spring, summer and fall, the trout were found in pools, riffles or near cover in the main part of the stream. During winter, these portions of the stream were completely deserted and the fish could be found only in places out of the current, under banks, in piles of stones and rocks, or amid heavy concentrations of brush and debris. The effect of direct-current electro-fishing in drawing fish to the positive electrode from hiding places in this heavy cover was the dominant factor responsible for numerically adequate collections of fish in winter. Previous attempts to collect fish from these streams during winter with seines or with alternating-current shockers were very ineffective.

The comparisons of growth rate between streams on different dates of collection have been based on the average length of all the fish in a sample of a particular year class. Periodic samples were taken in all three streams on the same date or at time intervals of not more than 3 days, so that average sizes would be directly comparable. Age determinations were made from samples of scales. Collecting was limited to direct-current electro-fishing since it has been shown that angling selects the faster-growing individuals of each age group and angling samples are thus not directly comparable to samples taken by other methods (Cooper, In press). Comparisons have been limited to the 1950 and 1951 year classes; fish that were in their first and second years of life.

These limitations were necessary to ensure the adequacy of sampling, and also to eliminate a systematic bias due to sampling a population that was being selectively cropped by fishermen. In comparing samples of the 1948 year class of brook trout in the Pigeon River taken by angling, Cooper (op. cit.) demonstrated a gradual decrease in calculated growth to the first annulus of about 25 percent from the individuals appearing in the catch in July, 1949, to the fish caught a year later. This latter source of error was not entirely eliminated, for a 7-inch minimum size limit on Hunt Creek and on a small portion of the Pigeon River enabled fishermen to remove some of the individuals of the 1950 year class that were more than 7 inches long. On the North Branch of the Au Sable River, a 10-inch minimum size limit prevented the exploitation of the 1951 and 1950 year classes almost entirely during the period of the study. On most of the section of the Pigeon River, a 9-inch minimum size limit gave protection to the 1951 and 1950 year classes.

Growth rate

In all three streams the growth rate increased rapidly during the last week in April or first week in May. It remained rapid during May and June, slowed up considerably during July, August, September and October and practically ceased during November, December, January, February and March (Figure 1 and Table 1). The North Branch of the Au Sable River exhibited the fastest growth rate for both year classes, followed by the Pigeon River and Hunt Creek, in that order. Because of the lack of growth during the period November through March, the last five collections in each stream may logically be combined to give a more adequate estimate of the differences in length attained by the two year classes in the three streams. Thus the average sizes of the 1951 and 1950 year classes of brook trout for the North Branch of the Au Sable River at the end of the 1951 growing season were 4.15 inches and 7.87 inches respectively. For the Pigeon River these values were

Figure 1. Curves for mean coefficient of condition (K) and mean total length in inches, with range given as vertical lines, for wild brook trout in monthly collections from three streams in Michigan (Data, in part, from Table 1).

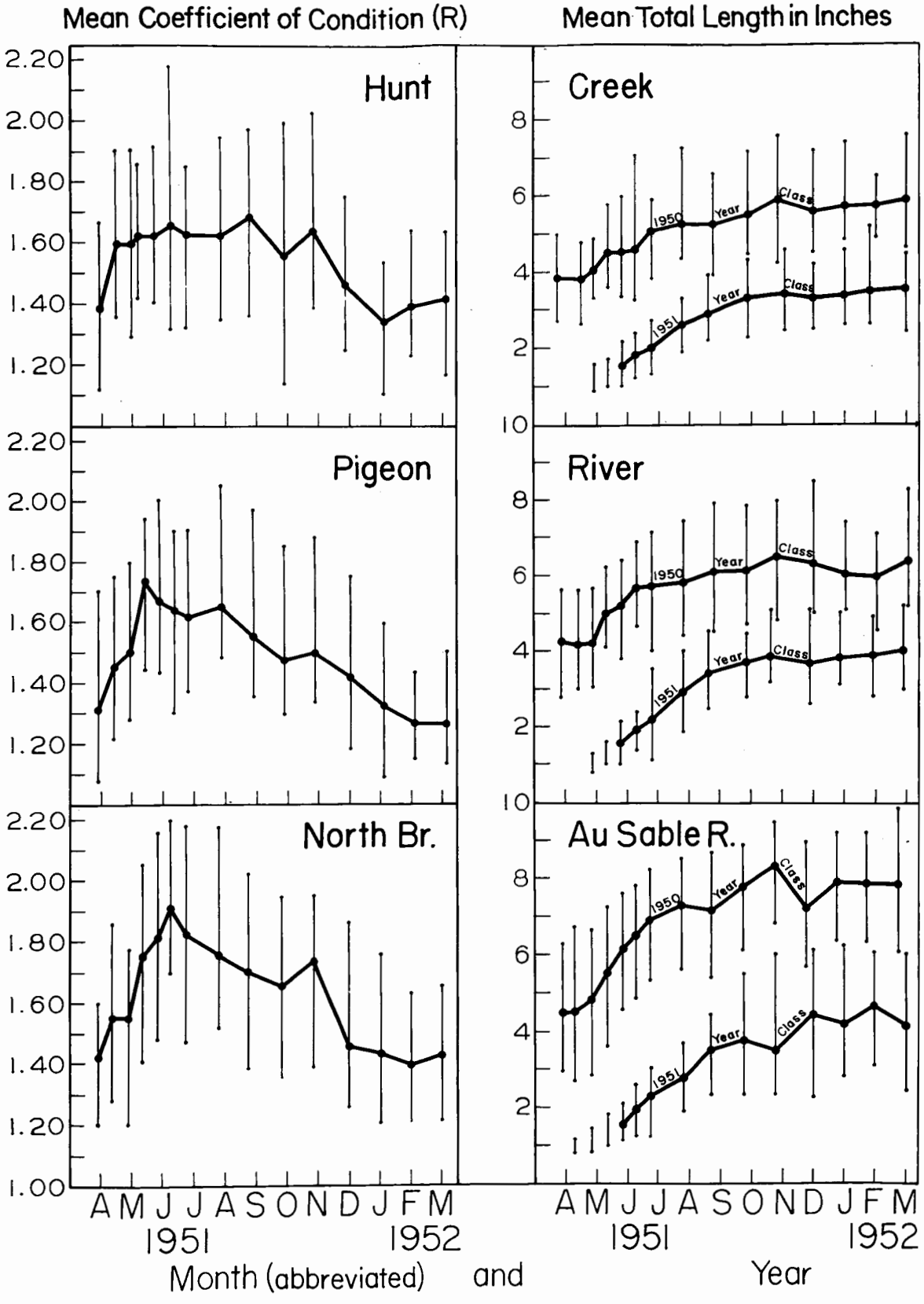
Mean Coefficient of Condition (R)
Mean Total Length in Inches
Hunt
Creek
Pigeon
River
North Br.
Au Sable R.
1950 Year Class
1951 Year Class
2.20
2.00
1.80
1.60
1.40
1.20
1.00
8
6
4
2
10
A M J J A S O N D J F M
1951
1952
Month (abbreviated) and Year

Table 1. Periodicity of growth and change in condition of wild brook trout from Hunt Creek, Pigeon River and North Branch of the Au Sable River from March 27, 1951, to March 11, 1952

Locality and date	1951 year class			1950 year class			Condition factor - K		
	Mean length	Standard error of mean	Number of individuals	Mean length	Standard error of mean	Number of individuals	Mean condition	Standard error of mean	Number of individuals
Hunt Creek									
March 28, 1951	...	...	0	3.85	0.10	32	1.38	0.020	35
April 13, 1951	....	...	0	3.83	0.07	52	1.61	0.015	62
April 26, 1951	...	...	15	4.03	0.10	25	1.61	0.018	68
May 10, 1951	...	...	12	4.47	0.11	25	1.63	0.023	22
May 24, 1951	1.56	0.05	33	4.55	0.09	33	1.63	0.020	31
June 7, 1951	1.81	0.05	42	4.59	0.13	35	1.66	0.026	43
June 21, 1951	2.00	0.05	63	5.06	0.09	29	1.63	0.019	46
July 26, 1951	2.61	0.05	49	5.26	0.09	39	1.63	0.022	40
August 23, 1951	2.87	0.05	61	5.26	0.11	30	1.68	0.025	37
September 26, 1951	3.30	0.08	68	5.48	0.10	37	1.56	0.027	43
October 25, 1951	3.40	0.08	41	5.89	0.14	36	1.64	0.021	45
November 29, 1951	3.30	0.06	51	5.60	0.11	30	1.47	0.021	32
January 2, 1952	3.35	0.08	44	5.72	0.09	36	1.34	0.015	45
February 1, 1952	3.44	0.08	53	5.76	0.08	30	1.39	0.013	46
March 4, 1952	3.54	0.08	49	5.91	0.11	37	*1.41	0.012	59
October 25, 1951 to March 4, 1952, inclusive	3.41	0.034	238	5.78	0.048	169	...	...	...
Pigeon River									
March 27, 1951	...	...	0	4.22	0.09	51	1.31	0.026	28
April 12, 1951	...	...	0	4.19	0.08	71	1.45	0.020	37
April 27, 1951	...	...	24	4.24	0.08	66	1.50	0.024	29
May 11, 1951	...	...	12	5.05	0.09	42	1.74	0.016	37
May 25, 1951	1.57	0.05	28	5.21	0.11	38	1.67	0.019	46
June 8, 1951	1.94	0.04	34	5.76	0.10	37	1.64	0.019	46
June 22, 1951	2.18	0.07	45	5.71	0.11	40	1.62	0.016	45
July 27, 1951	2.93	0.08	44	5.81	0.13	33	1.65	0.020	36
August 25, 1951	3.48	0.06	56	6.08	0.11	41	1.55	0.018	48
September 27, 1951	3.67	0.06	53	6.13	0.09	48	1.47	0.015	53
October 26, 1951	3.84	0.06	60	6.47	0.15	29	1.50	0.022	36
November 30, 1951	3.74	0.08	51	6.33	0.12	41	1.42	0.020	44
January 3, 1952	3.84	0.07	53	6.08	0.07	42	1.32	0.015	46
February 4, 1952	3.88	0.07	54	5.97	0.11	25	1.27	0.015	27
March 5, 1952	4.01	0.06	68	6.39	0.12	38	1.27	0.012	48
October 26, 1951 to March 5, 1952, inclusive	3.87	0.030	286	6.26	0.053	175	...	...	...
North Branch of the Au Sable									
March 29, 1951	...	...	0	4.52	0.09	70	1.42	0.019	27
April 11, 1951	...	...	71	4.51	0.07	138	1.55	0.019	40
April 26, 1951	...	...	50	4.81	0.08	107	1.55	0.016	53
May 10, 1951	...	...	20	5.53	0.14	38	1.75	0.021	46
May 24, 1951	1.54	0.06	25	6.19	0.14	29	1.81	0.022	45
June 7, 1951	1.97	0.07	35	6.49	0.12	42	1.91	0.016	58
June 21, 1951	2.30	0.08	43	6.87	0.11	42	1.82	0.019	56
July 26, 1951	2.77	0.07	45	7.28	0.13	29	1.76	0.017	49
August 23, 1951	3.50	0.07	43	7.19	0.12	38	1.71	0.018	46
September 26, 1951	3.75	0.09	50	7.77	0.11	29	1.65	0.020	43
October 25, 1951	3.48	0.11	76	8.36	0.11	36	1.73	0.019	47
November 29, 1951	4.42	0.11	69	7.21	0.14	33	1.46	0.024	44
January 2, 1952	4.22	0.10	69	7.94	0.13	34	1.43	0.018	50
February 1, 1952	4.64	0.10	57	7.86	0.11	41	1.38	0.014	50
March 4, 1952	4.15	0.11	66	7.92	0.15	45	1.42	0.014	53
October 25, 1951 to March 4, 1952, inclusive	4.15	0.053	337	7.87	0.063	189	...	...	...

* Collection date March 11, 1952.

3.87 inches and 6.26 inches; and for Hunt Creek, 3.41 inches and 5.78 inches (Table 1). The differences between the means for the three streams are all highly significant with values of "t" ranging from 4.6 to 26.4. There was considerable variation in growth rate of individual fish inall the samples, and the range in size, especially of the 1951 year class, increased throughout the season. For example, 71 of the 1951 year class from the North Branch of the Au Sable River on April 11, 1951, ranged in total length from 0.8 inch to 1.1 inches. On January 2, 1952, 69 individuals of the same year class ranged from 2.8 inches to 6.2 inches in length. In Hunt Creek, where the average growth rate is considered quite slow, 53 fish of the 1951 year class ranged in length from 2.6 inches to 5.2 inches on February 1, 1952, and 39 fish of the 1950 year class were from 4.4 inches to 7.3 inches on July 26, 1951. This rather large amount of variation in growth rate is important to note because it appears that the fast-growing individuals of each year class furnish the bulk of the anglers's catch in streams exhibiting a slower than average rate of growth. Average growth rates therefore do not portray adequately the contribution to the angler by individual year classes, without further information as to the amount of variation within samples. In Hunt Creek, the growth rate of the trout indicates that the average fish does not reach legal size until its fourth summer, yet much of the catch is composed of fish in their third summer and some during their second summer. In the North Branch of the Au Sable where growth is rapid, under a 7-inch minimum size limit, about half of the brook trout would be legal targets for fishermen by July 1 of their second summer.

Change in Condition

The coefficient of condition (R) has been used to determine changes in relative weight throughout the year (Cooper and Benson, 1951). Fish under 5.0 inches total length have not been used in these comparisons because the

balances used were not accurate enough under field conditions to record minor differences in weight. Also, the unit of measurement of weight used (one gram) represents too large a proportion of the total weight of small fish to detect minor changes in condition. The coefficient of condition was computed for each fish in a sample and their average condition obtained from these computations.

The condition of the brook trout was uniformly low in all three streams during late March and early April, 1951. It rose rapidly during late April and May, reached a peak usually about the first week in June, and declined thereafter to the winter low condition. There was a decided drop in condition during October and November, probably associated with spawning. The condition of the brook trout in the North Branch of the Au Sable River rose to a much higher peak in June than did those in both Hunt Creek and the Pigeon River. Also, this high level of condition was maintained by the North Branch of the Au Sable fish over a much longer period during the summer (Figure 1).

These average changes in condition from the winter low to early summer high represent tremendous differences in relative weight. In Hunt Creek, where the least amount of differences occurred, the fish gained an average of 22 per cent of their winter weight during a period of two months in the spring, disregarding the additional weight accompanying the growth in length. For the Pigeon River and the North Branch of the Au Sable River these values were 33 per cent and 35 per cent respectively.

An apparent correlation between high condition factor and growth is suggested by the data from these three streams. Growth rate increases rapidly in the spring conincident with an increase in condition and is maintained at a rapid rate only so long as the condition factor remains high. When the condition decreases in late summer, fall and winter, growth also decreases.

Bottom fauna

The distribution and abundance of the invertebrate fauna were studied by a series of 9, square-foot bottom samples from each of the three streams (Tables 2, 3, 4). This collecting was done in mid-February, just in advance of the trout growing season in 1952, using the sampler described by Surber (1937). The abundance of different bottom types (gravel, sand, and silt) in each stream section was estimated visually and samples were taken from these different bottom types in proportion to their abundance. Many samples were taken in sand, and mixtures of sand, in Hunt Creek because of the predominance of these bottom types in this stream. The series of samples from the North Branch of the Au Sable River averaged 2.87 cc. per square foot of bottom; the values for the Pigeon River and Hunt Creek were 2.26 cc. and 1.06 cc. respectively. Values of "t" (with eight degrees of freedom) for the differences of the means of these series of bottom samples are as follows:

North Branch of the Au Sable River and Hunt Creek - 2.99 (98% level)
Pigeon River and Hunt Creek - 2.55 (96% level)
North Branch of the Au Sable River and Pigeon River - 0.88 (60% level)

Leonard (1939) has discussed in some detail the adequacy of this technique of bottom sampling and makes note of its many limitations in the determination of the food supply of fishes. The present study was not intended to furnish detailed data but rather to indicate a possible avenue of investigation of the causes of the large differences in growth of the trout noted in these stream sections. The difference in abundance of bottom fauna noted in these stream sections is sufficient to indicate that the food supply is a contributing factor in the slow growth of the Hunt Creek population of brook trout. However, more detailed analysis of bottom fauna production on an area basis and better knowledge of the forage-ratios of particular groups of organisms present is needed for a proper evaluation of this environmental factor.

Table 2. Bottom fauna of North Branch of the Au Sable River, Crawford County. Collections taken with square-foot stream bottom sampler on February 14, 1952

Bottom type	Ephemeroptera		Plecoptera		Trichoptera		Diptera		Others		Total	
	Number	Volume	Number	Volume	Number	Volume	Number	Volume	Number	Volume	Number	Volume
Rubble	441	2.250	9	0.100	165	0.850	48	0.150	25	0.300	688	3.650
Coarse gravel	301	1.700	20	0.175	14	0.200	68	0.600	41	0.400	444	3.075
Coarse gravel	186	0.800	9	0.100	82	0.950	27	0.125	8	Trace	312	1.975
Coarse gravel	38	0.600	11	0.100	44	0.400	22	0.100	1	Trace	116	1.200
Gravel and sand	43	0.600	5	0.050	11	0.900	228	0.900	24	0.650	311	3.100
Gravel and sand	536	1.850	12	0.100	136	0.850	48	0.275	36	0.175	768	3.250
Sand and silt	273	1.000	0	...	19	0.200	42	0.300	5	Trace	339	1.500
Silt	141	0.400	0	...	4	Trace	94	0.300	47	1.000	286	1.700
Silt	99	4.500	0	...	5	0.400	166	0.550	54	0.900	324	6.350
Total (9 square feet)	2,058	13.700	66	0.625	480	4.750	743	3.300	241	3.425	3,588	25.800
Average square foot											399	2.87

Table 3. Bottom fauna of Pigeon River, Otsego County. Collections taken with square-foot stream bottom sampler during the period February 6 to 11, 1952

Bottom type	Ephemeroptera		Plecoptera		Trichoptera		Diptera		Others		Total	
	Number	Volume	Number	Volume	Number	Volume	Number	Volume	Number	Volume	Number	Volume
Coarse gravel	79	0.700	2	0.100	414	1.200	114	0.350	47	0.100	656	2.450
Coarse gravel	115	1.200	9	0.150	132	0.900	20	0.100	12	0.900	288	3.250
Coarse gravel	68	0.500	2	0.025	367	1.300	76	0.075	55	0.225	568	2.125
Coarse gravel	140	1.050	7	Trace	371	2.500	117	0.225	44	0.500	679	4.275
Fine gravel	18	0.125	5	0.075	79	0.400	14	0.250	13	Trace	129	0.850
Fine gravel	68	0.550	10	0.075	289	1.550	28	0.075	35	0.225	430	2.475
Fine gravel	64	0.600	16	0.150	92	0.400	10	0.075	12	0.075	194	1.300
Sand and silt	4	0.025	7	Trace	4	0.075	49	0.550	5	0.150	69	0.800
Silt	8	1.250	1	Trace	0	...	472	1.000	87	0.600	568	2.850
Total (9 square feet)	564	6.000	59	0.575	1,748	8.325	900	2.700	310	2.775	3,581	20.375
Average											398	2.26

Table 4. Bottom fauna of Hunt Creek, Montmorency County. Collections taken with square-foot stream bottom sampler on February 14, 1952

Bottom type	Ephemeroptera		Plecoptera		Trichoptera		Diptera		Others		Total	
	Number	Volume	Number	Volume	Number	Volume	Number	Volume	Number	Volume	Number	Volume
Coarse gravel	140	1.100	4	Trace	146	0.800	21	0.200	7	Trace	318	2.100
Coarse gravel	135	0.600	8	Trace	145	0.850	23	0.650	3	Trace	314	2.100
Fine Gravel	62	0.400	1	Trace	51	0.150	17	0.200	9	Trace	140	0.750
Sand	0	...	1	Trace	0	...	35	0.600	56	0.600	92	1.200
Sand	49	0.200	0	...	3	Trace	110	0.300	11	0.050	173	0.550
Sand	3	Trace	0	...	0	...	81	0.125	1	Trace	85	0.125
Sand and silt	7	0.650	0	...	0	...	69	0.125	56	0.300	132	1.075
Silt	11	0.200	0	...	0	...	33	0.100	33	0.400	77	0.700
Silt	3	Trace	1	Trace	0	...	63	0.250	80	0.700	147	0.950
Total (9 square feet)	410	3.150	15	Trace	345	1.800	452	2.550	256	2.050	1,478	9.550
Average square foot											164	1.06

Stream temperatures

Some information on water temperatures is available from the three stream sections studied. On the Pigeon River, a thermograph located about two miles downstream from the sampling area has been in continuous operation. Water temperatures at the site of fish sampling have been within one or two degrees of agreement with thermograph readings.

A thermograph has also been in operation on Fuller Creek, a tributary of Hunt Creek and comparable water temperatures for the sampling area in Hunt Creek have been obtained by adjusting these thermograph records on a basis of numerous coincident temperatures at both stream sites.

For the North Branch of the Au Sable River, temperatures were taken 2 to 4 days of each week during the trout season with a pocket thermometer. The time of observation here varied between 1:30 p.m. and 2:30 p.m. and attempts were made to record near-maximum water temperatures for the day. Temperature data from the North Branch of the Au Sable River are not considered as representative of true conditions as are those of Hunt Creek and the Pigeon River.

The mean maximum water temperature for each week has been computed from the daily records available (Table 5). In all three streams, water temperatures warmed abruptly during the last week in April and the first week in May, coincident with the disappearance of the accumulation of winter snow. Although the summer of 1951 was somewhat cooler than average, many daily maximum water temperatures over 70 degrees F. were recorded, especially in the North Branch of the Au Sable and the Pigeon Rivers. Daily temperatures over 60 degrees F. were the rule during the months of May through September. During December, January, February and March, maximum water temperatures were seldom above 36 degrees F.

Table 5. Mean weekly maximum water temperatures for the North Branch of the Au Sable River at Twin Bridges, 2 miles north of Lovells, Pigeon River, 13 miles east of Vanderbilt, and Hunt Creek, 10 miles east of Lewiston

Weekly period	Mean weekly maximum water temperature		
	N. Br. Au Sable River	Pigeon River	Hunt Creek
March 3 - 9, 1951	...	36	39
March 10 - 16	...	37	38
March 17 - 23	...	36	37
March 24 - 30	...	36	38
March 31 - April 6	...	39	41
April 7 - 13	...	42	45
April 14 - 20	...	40	41
April 21 - 27	...	43	46
April 28 - May 4	59	57	60
May 5 - 11	51	56	55
May 12 - 18	61	60	60
May 19 - 25	64	63	63
May 26 - June 1	67	61	63
June 2 - 8	68	61	62
June 9 - 15	65	64	62
June 16 - 22	70	66	65
June 23 - 29	66	66	64
June 30 - July 6	66	65	64
July 7 - 13	63	66	66
July 14 - 20	70	69	65
July 21 - 27	69	70	67
July 28 - August 3	70	71	68
August 4 - 10	63	66	63
August 11 - 17	65	64	63
August 18 - 24	65	64	63
August 25 - 31	65	66	65
September 1 - 7	61	62	61
September 8 - 14	60	62	61
September 15 - 21	...	59	60
September 22 - 28	...	54	54
September 29 - October 5	...	54	56
October 6 - 12	...	50	52
October 13 - 19	...	53	54
October 20 - 26	...	48	51
October 27 - November 2	...	47	44
November 3 - 9	...	37	35
November 10 - 16	...	40	39
November 17 - 23	...	36	36
November 24 - 30	...	36	36
December 1 - 7	...	41	41
December 8 - 14	...	37	36
December 15 - 21	...	34	32
December 22 - 28	...	34	32
December 29 - January 4, 1952	...	35	34
January 5 - 11	...	35	34
January 12 - 18	...	36	36
January 19 - 25	...	34	32
January 26 - February 1	...	34	32
February 2 - 8	...	36	34
February 9 - 15	...	35	33
February 16 - 22	...	35	32
February 23 - 29	...	37	34
March 1 - 7	...	36	33
March 8 - 14, 1952	...	37	37

Discussion

The data presented earlier concerning the rapid growth in the spring and the high condition factor of the brook trout at this time suggest a relationship between the two. This relationship was also found to hold for brown trout studied under controlled laboratory conditions, according to Brown (1946a), page 142: "Growth in length, which involves regional differentiation, occurs at a rate directly proportional to the condition factor and thus to the amount of reserve food."

Hansen (1951) also observed that in white crappies high condition accompanied rapid growth and that increases in K values occurred only during the annual growing period.

Stroud (1949), reporting on the growth of game and pan fish in Tennessee, stated that values of K were found to vary from one reservoir to another in about the same manner as growth rates of each species varied, averaging highest for fastest growing populations and lowest for slowest growing populations. However, in the same study he states that "K" is low immediately following spawning, although it may be even lower in late summer after periods of extremely rapid growth, and that Norris fish fatten up during fall and winter without increasing in length.

In a review of some environmental relations of the speckled trout, Fry (1951) lists temperature as one of the most decisive factors in determining the success of the brook trout in streams. Much interest has centered around optimum temperature conditions for growth and some experimental work has been reported. Brown (1946b), reporting on the growth of brown trout, found that the specific growth rates of trout living at different constant temperatures and of those living in water of changing temperature were high between 7 and 9 degrees C. (45 and 48 degrees F.) and between 16 and 19 degrees C. (61 and 66 degrees F.), and

were low above, between and below these temperatures. Baldwin (1951) measured the growth rate of a series of 4 brook trout allowed to take minnows at will in a confined space. Optimum growth under these circumstances took place at approximately 14 degrees C. (57 degrees F.). Davis (1946) also states from fish culture experience that the optimum for growth for trout appears to lie between 55 and 60 degrees F.

These temperature data on optima for growth agree with field observations in the present study. A change in maximum temperatures from 40 to 50 degrees F. during April to 50 to 65 degrees F. during May and June is accompanied by a tremendous increase in condition and growth. This was noted in all three streams studied. However, water temperatures fail to explain the differences in growth noted between Hunt Creek and the North Branch of the Au Sable River, for temperature conditions in Hunt Creek remain within the optimum range throughout the summer and fall while those in the North Branch of the Au Sable River frequently go over 70 degrees F. The much higher level of condition reached by the trout in the North Branch of the Au Sable River compared with Hunt Creek during the month of May, when temperature conditions were very similar, also suggests that the abundance of natural food in the North Branch of the Au Sable River is an important factor in the difference in growth of the trout populations in these streams.

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