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RATE OF GROWTH OF THE SMALL-MOUTHED BLACK BASS (*MICROPTERUS DOLOMIEU*) IN SOME ONTARIO WATERS

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Abstract

Scale reading is applied to determine the rate of growth of small-mouthed black bass from Georgian Bay, Lake Nipissing, Perch Lake, and Phantom Lake. The growth rate is similar in Perch Lake and Phantom Lake, the two smallest bodies of water. Growth in Lake Nipissing appears to be more rapid and in Georgian Bay less rapid than in Perch Lake. As a result the minimum length limit of ten inches is, on the average, attained by bass in their fourth summer in Lake Nipissing, in their fifth summer in Perch Lake, and in their sixth summer in Georgian Bay. A differential rate of growth of the sexes is indicated. The weight of bass in Perch Lake increases as the power 3.1(7) of the length. Georgian Bay specimens are found to have the highest, Lake Nipissing specimens an intermediate, and Perch Lake specimens the lowest value of K, the coefficient of condition. The 1928 year class is shown to be dominant in Perch Lake in 1930 and 1931.

Introduction

The apparent depletion of the small-mouthed black bass (*Micropterus dolomieu* Lacépède) in some waters of Ontario indicates the advisability of additional conservational measures. Such measures can be taken most successfully when the life-history of the species concerned is fully understood. With this in mind, a general study of the life-history was undertaken during the summers of the years 1928 to 1931. The present paper deals with the rate of growth—a phase of the life-history which is intimately bound up with successful restrictive legislation.

I wish to thank Professor W. J. K. Harkness of the Department of Biology, University of Toronto, for his help and supervision of this investigation. I also wish to thank Mr. F. Fry and other members of the Ontario Fisheries Research Laboratory who collected material for me from Perch Lake in 1931. I am indebted to Dr. J. L. Hart of the Pacific Biological Station for advice and criticism.

MATERIAL AND METHODS

The material for this present paper was obtained for the most part from the same specimens as that for the study of the food of the bass. Specimens were obtained from Georgian Bay in 1928, from Lake Nipissing and Phantom Lake in 1929, and from Perch Lake in 1930 and 1931. The location and a brief description of each of these bodies of water is contained in a previous paper on the food of the bass.

The tables and growth curves are based on an examination of the scales of 176 bass from Perch Lake, twenty-one from Phantom Lake, twenty-seven from Lake Nipissing, and twenty-six from Georgian Bay. Specimens were captured by means of hook and line, using earthworms as bait in all localities. In addition, a few bass were taken in gill nets in Georgian Bay and Perch Lake and in trap nets in Lake Nipissing.

Scales were taken from an area at the tip of the pectoral fin and were cleaned and placed in small envelopes. They were later mounted in glycerine jelly and were read with the aid of a Promar projection apparatus.

Both the standard length and total length of the fish were measured. The standard length is the distance from the tip of the lower jaw to the end of the vertebral column measured in centimetres. The total length is the distance from the tip of the lower jaw to the fork of the tail measured in inches. Weights were recorded in ounces, using a balance for fish from Lake Nipissing, Phantom Lake, and Perch Lake. Georgian Bay fish were weighed by means of a spring scales reading to the nearest eighth pound; these weights were later converted into ounces. All average weights are given in both ounces and grams.

ESTIMATION OF AGE BY THE SCALE METHOD

A bass scale may be divided into an *anterior field*, a large transparent area covered in life by adjacent scales; and a *posterior field*, the small exposed portion of the scale which bears the outer pigmented epithelium. *Circuli* or growth

rings are arranged concentrically about the *nucleus* or focus of the scale, the point of initial growth which occurs medially between the two fields. The *radii* are a series of grooves radiating from the nucleus to the scalloped *anterior margin* of the scale. An *annulus* or year mark is a discontinuity of the circuli caused by the retardation of growth in the winter time.

As in the case of other fishes, the age of a small-mouthed black bass may be estimated by counting the number of annuli appearing on the scales (Plate I). Age estimations from bass scales have already been made by Van Oosten (Reighard 1929) and by Hile (1931), for a few specimens.

An annulus may be recognized in several ways. In the anterior field it may consist of a distinct line of demarcation caused by the first complete circulus of rapid growth in spring enclosing incomplete circuli, presumably formed at a time of slower growth. As a consequence, the incomplete circuli meet the first complete circulus at an angle, producing what has been called "cutting over" (Hile 1931) (Plate ID). An annulus is also indicated by a crowding or approximation of the circuli with slow growth in winter. The crowding of the circuli becomes more apparent in annuli formed later in life. The first complete circulus formed at the beginning of the period of rapid growth is usually continued in the posterior field as an even, continuous line whereas subsequent complete circuli are wavy, irregular, or broken lines in this field.

The occurrence of "false annuli" caused by food shortage or other factors, during the normal summer's growth, made some age estimations difficult. These were usually recognized by their position. Partially regenerated scales with blank centres were frequently encountered. Great difficulty in age estimation was caused by the crowding of the annuli towards the margin of the scales of old fish. In fish older than ten years the estimation is at best only an approximation.

Readings were made at two separate intervals on scales from each body of water without reference to the lengths of the fish. The readings agreed in the majority of cases. Where discrepancies occurred, the scales were considered a third time and a probable age given to the fish.

Roman numerals are used throughout the report to indicate the age of the fish. A fish two months old is considered to be in its first year and is designated by the Roman numeral I; similarly a fish six years three months old is designated by the Roman numeral VII. In the tables the number of specimens on which each average is based is given in brackets.

RESULTS

Rate of Growth in Length

The results of the age estimations of bass from the four bodies of water are summarized in tables 1 to 4. The rate of growth is shown graphically in figure 1 for Perch Lake, Lake Nipissing, and Georgian Bay bass. In the figure, continuous lines have been drawn through points that are considered to have a reasonable degree of accuracy while broken lines have been drawn through points that represent averages that are based on a small number of specimens or on age approximations from scales of old fish. The number of specimens from Perch Lake is sufficient to make the results reliable over several age groups and thus to enable the rate of growth of bass in this lake to be used as a standard for comparison with the rates in the other bodies of water. The growth rates of bass in Phantom Lake, Lake Nipissing, and Georgian Bay are based on a smaller number of specimens and are consequently less reliable. The results given below are considered to be only as valid as is warranted by the number of specimens involved.

The curve showing the rate of growth in length of bass of Perch Lake is similar in form to growth curves obtained for other species of fish. Growth in length is rapid in early life and gradually becomes slower as the fish grows older. Compared to such other fish as trout, growth is relatively slow. Bass may be taken by anglers in Ontario when they reach a total length of ten inches. It may be seen that bass of Perch Lake attained this length about the middle of their fifth summer.

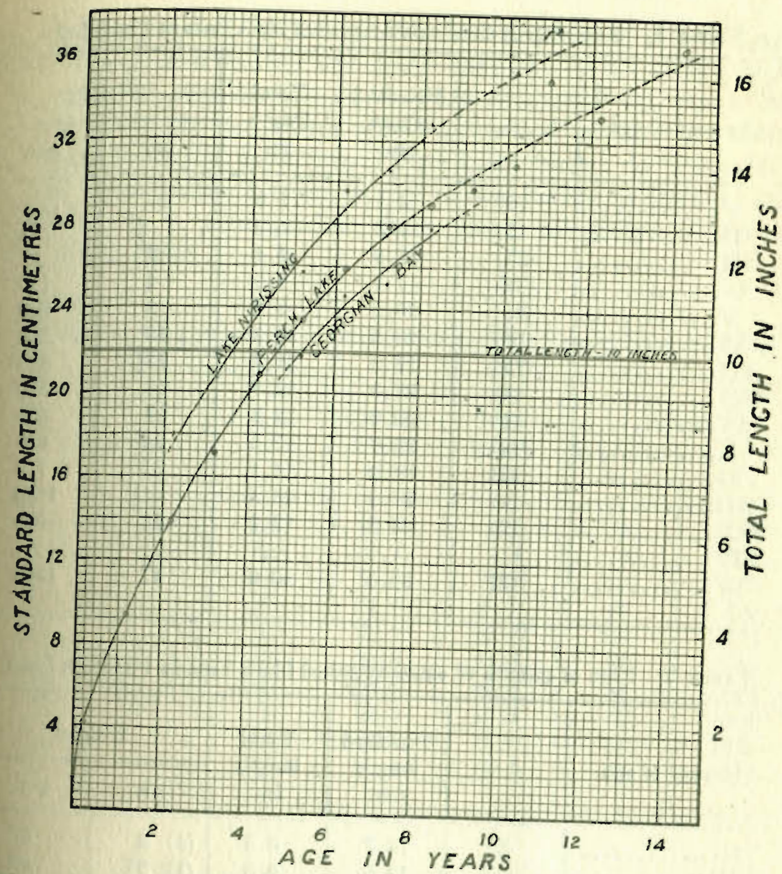

FIGURE 1. Graph showing the rates of growth of the small-mouthed black bass from Perch Lake, Lake Nipissing, and Georgian Bay

The results of age estimations for bass of Phantom Lake are given in table 2 but are not shown in figure 1 as the rate of growth is very similar to that of bass from Perch Lake. Although Perch Lake is about one-quarter the size of Phantom Lake, the two bodies of water are very similar and it might be expected that growth conditions in them would also be similar. The results for Phantom Lake serve as a check on those of Perch Lake and indicate the reliability of the estimations.

TABLE 1. Rate of growth of small-mouthed black bass in Perch Lake

In year of age		Standard length cm.	Total length in.	Weight	
				oz.	gm.
I............	(2)	4.1	1.9	..	....
II............	(2)	9.3	4.3	½	11
III............	(29)	13.9	6.4	2	57
IV............	(72)	17.1	7.9	4	110
V............	(21)	20.8	9.5	8	220
VI............	(20)	23.3	10.7	10	280
VII............	(12)	25.9	11.7	13½	380
VIII............	(5)	27.9	12.7	18	510
IX............	(4)	28.9	13.3	21	600
X............	(2)	29.7	13.6	23	650
XI............	(2)	30.9	14.1	25	710
XII............	(1)	34.9	16.4	44½	1260
XIII............	(2)	33.2	15.1	33	930
XIV............		....	....	..	....
XV............	(2)	36.5	16.6	47	1330

TABLE 2. Rate of growth of small-mouthed black bass in Phantom Lake

In year of age		Standard length cm.	Total length in.	Weight	
				oz.	gm.
III............	(2)	13.7	6.3	(1) 2	57
IV............	(1)	14.9	6.8	(1) 3½	99
V............		....	....	..	....
VI............	(2)	22.8	10.6	(2) 10	280
VII............	(2)	24.8	11.4	..	....
VIII............	(4)	25.5	11.8	(3) 14	400
IX............	(5)	28.4	13.0	(2) 15	425
X............	(4)	29.2	13.5	(4) 20	570
XI............		....	....	..	....
XII?............	(1)	33.0	15.0	..	....

The rate of growth of bass in Lake Nipissing appears to be much more rapid throughout life than that of bass in Perch Lake. A large number of the specimens were taken

in August and early September while those of Perch Lake were taken in late July and early August. This might cause an apparent acceleration of the rate of growth but when this is taken into account, there is still a marked increase in growth of Lake Nipissing bass over Perch Lake bass. In Lake Nipissing, bass attain a total length of ten inches in their fourth summer or a year earlier than those of either Perch or Phantom Lake.

TABLE 3. Rate of growth of small-mouthed black bass in Lake Nipissing

In year of age		Standard length cm.	Total length in.	Weight	
				oz.	gm.
III............	(3)	18.0	8.1	6	170
IV............	(4)	20.7	9.4	8	230
V............	(5)	23.9	10.9	13	370
VI............	(1)	25.7	11.7	17	480
VII............	(2)	29.6	13.4	25	710
VIII............	(2)	30.7	14.0	28	790
IX............	(4)	32.8	14.8	34	960
X............	(3)	33.2	15.5	40½	1150
XI............	(2)	35.4	16.2	43½	1230
XII............	(1)	37.3?	16.3	56	1580

TABLE 4. Rate of growth of small-mouthed black bass in Georgian Bay

In year of age		Standard length cm.	Total length in.	Weight	
				oz.	gm.
VI............	(3)	21.7	9.9	13	370
VII............	(9)	24.6	11.4	15	425
VIII............	(10)	25.2	11.5	15	425
IX............	(3)	27.8	12.8	22	620
[illegible]............		....	....	..	....
XII?............	(1)	34.4	15.2	52	1470

In marked contrast to bass in Lake Nipissing, those of Georgian Bay appear to have a much slower rate of growth than those of Perch Lake. In thirty-seven specimens which were examined from Georgian Bay there was but one greater than twenty-nine centimetres in length. It would seem that bass in this latter body of water do not attain a total length of ten inches until their sixth summer.

The cause of the differences in rate of growth of bass in Perch Lake, Lake Nipissing, and Georgian Bay, is doubtful. Temperature may be a factor. Moore (1922) reports that in Lake George, New York, four bass fingerlings taken in September ranged from 1.9 to 2.1 inches, while under pond conditions seven bass fingerlings, also taken in September, averaged 3.2 inches measured to the base of the caudal fin. The difference was inferred to be caused by later spawning and consequent retardation of the period of active feeding in the larger cold body of water. The waters of Georgian Bay are probably colder on the average than the waters of Lake Nipissing, a large, shallow lake. Conditions in Georgian Bay may have a similar effect on the rate of growth to those in Lake George. On this basis it would be expected that growth in Perch Lake would be more rapid than in Lake Nipissing, as this small body of water warms more rapidly in the spring and has a higher average summer temperature than Lake Nipissing. It has been shown above, however, that the reverse is true; the specimens from Lake Nipissing grew more rapidly than those from Perch Lake. Overcrowding is a possible factor in depressing the rate of growth of bass in Perch Lake.

Different food conditions in the various bodies of water are another possible explanation of the observed differences. Although no comparative studies were made of the available food material, the conclusion was reached in a previous paper that there seemed to be no apparent scarcity in any of the bodies of water except in Perch Lake. In this lake there was a scarcity of crayfish but a superabundance of small perch. It might be repeated here that ninety-seven per cent. of the stomachs of fish taken in Lake Nipissing contained food as compared to seventy per cent. for Georgian Bay and sixty

per cent. for Perch Lake. This might indicate that food conditions are better or that competition for food between bass and other species is less keen in Lake Nipissing and might be a contributory cause of the accelerated rate of growth in Lake Nipissing over that of the other two bodies of water.

Differential Rate of Growth of the Sexes

In order to compare the rates of growth of male and female bass, the average lengths for each were determined in the younger age groups of bass from Perch Lake where there was a sufficient number of specimens to give representative averages. The results, given in table 5, show that, on the average, female bass of Perch Lake grew at a slightly slower rate than male bass. In the older year groups this difference was not detected, possibly because of the small number of specimens and the more extensive individual variation in older fish. Whether the differential rate of growth observed for the Perch Lake specimens is general or not can be decided only by considering a larger number of specimens of both sexes in other bodies of water.

TABLE 5. Rate of growth of male and female small-mouthed black bass of Perch Lake

In year of age	Standard length of males	Standard length of females	All
III	(10) 14.6	(6) 13.7	(29) 13.9
IV	(37) 17.3	(32) 16.9	(72) 17.1
V	(14) 21.2	(6) 20.1	(21) 20.8
VI	(14) 23.6	(6) 22.5	(20) 23.3

Rate of Growth in Weight and the Coefficient of Condition

The average weight of the specimens in each age group in the four bodies of water is included in tables 1 to 4. As has been found for other species, growth in weight is different to growth in length in that fish increase slowly in weight when they are young and more rapidly as they grow older (table 1). In Perch Lake, bass by the middle of their fifth summer attained a weight of from eight to nine ounces at a total length of ten inches. Weight data on the few specimens from the other bodies of water show that at a total length of ten inches, bass from Lake Nipissing averaged about ten ounces while those from Georgian Bay averaged about thirteen ounces in weight.

Following the method used by Hart (1931) and others the relationship between length and weight for bass from Perch Lake was obtained by plotting average lengths against average weights on double logarithmic paper and deriving the natural slope of the resultant straight line drawn through the points. It was found that the weight increased by the power 3.1 (7) of the length and, following Hart, might be expressed in the following equation—

$$W = aL^{3.1(7)} + b$$

where W is the weight, L the length, and a and b constants depending on the units used. As W and L approach zero at the same time, $b=0$. Hile (1931) derives the following equation for determining the condition factor or coefficient of condition, a convenient means of comparing the relationship between length and weight of fish in various bodies of water—

$$K = \frac{100\ W}{L^3}$$

where K is the coefficient of condition, W the weight in grams, and L the length in centimetres. This equation is only approximate and might be better expressed—

$$K = \frac{100\ W}{L^x}$$

In the case of Perch Lake bass the power x would have a value 3.1(7). If the power $x=3$ is used, the value of K tends to increase with the length of the fish whereas it should remain constant. Using the approximate formula, Hile found the value of K for ten specimens of small-mouthed black bass

from Wawasee Lake, Indiana, to be 2.04. A comparison of the ages and lengths of these fish with those of Perch Lake showed that Wawasee Lake bass grew more rapidly in length. Over the same length range, the approximate formula gave an average value of K of 2.5(0) for bass of Perch Lake. This shows that, although Perch Lake bass grew in length at a slower rate than Wawasee Lake bass, they attained a greater weight for a given length.

Using the corrected value of x as determined for Perch Lake, the average value of K is equal to 1.3(7) for Perch Lake bass, 1.3(8) for Phantom Lake bass, 1.5(8) for Lake Nipissing bass, and 1.6(7) for Georgian Bay bass (table 6). To be strictly accurate, the value of x should be determined separately for each of the latter three bodies of water but sufficient

TABLE 6. Average value of K (the coefficient of condition) for small-mouthed black bass

Locality		K
Perch Lake	(174)	1.3(7)
Phantom Lake	(12)	1.3(8)
Lake Nipissing	(24)	1.5(8)
Georgian Bay	(26)	1.6(7)

numbers of specimens from each were not available for this to be done. The results obtained for Perch Lake bass and Phantom Lake bass are again similar. Although Georgian Bay specimens had the slowest rate of growth in length, they had a higher coefficient of condition than those of either of the other two bodies of water. While Lake Nipissing bass had a faster rate of growth in length than Perch Lake bass they had also a higher coefficient of condition, thus indicating that conditions in Lake Nipissing are more suitable than Perch Lake for both growth in length and growth in weight. If bodies of water of similar sizes only are considered—Wawasee Lake and Perch Lake; Lake Nipissing and Georgian Bay—it

TABLE 7. Percentages of small-mouthed black bass in the younger year groups of samples from Perch Lake in 1930 and 1931

In year of age	1930	1931
I	(2) 3.6	....
II	....	(2) 2.0
III	(26) 47.2	(3) 2.9
IV	(10) 18.2	(62) 60.2
V	(4) 7.3	(17) 16.5
VI	(9) 16.4	(11) 10.7
VII	(4) 7.3	(8) 7.7

SUMMARY

Scale reading is applied to determine the rate of growth of small-mouthed black bass from four Ontario lakes. The results for Phantom Lake, Lake Nipissing, and Georgian Bay are based on a small number of specimens and are consequently less reliable than those of Perch Lake.

The rate of growth of bass in Perch Lake is similar to that found for other species, *i.e.*, growth in length is rapid in early life and becomes slower as the fish grows older.

The rate of growth of bass in Perch Lake and Phantom Lake, two similar bodies of water, is similar.

From the small number of specimens considered it would appear that the rate of growth in length of bass in Lake Nipissing is more rapid and in Georgian Bay less rapid than in Perch Lake.

A length of ten inches was attained by specimens from Perch Lake and Phantom Lake in their fifth summer, from Lake Nipissing in their fourth summer, and from Georgian Bay in their sixth summer.

The cause of the observed differences in the rate of growth of the specimens is complex and probably a combination of factors such as temperature, food, and, in the case of Perch Lake, possibly overcrowding.

Female bass of Perch Lake appeared to increase in length at a slightly slower rate than male bass.

The weight of Perch Lake bass increases as the power 3.1(7) of the length.

A coefficient of condition K may be calculated for bass from Perch Lake from the equation $K = \frac{100\ W}{L^{3.1(7)}}$ where W is the weight and L the length. Georgian Bay specimens had the highest, Lake Nipissing specimens an intermediate, and Perch Lake and Phantom Lake specimens the lowest value of K. At a length of ten inches, Georgian Bay specimens averaged about thirteen ounces, Lake Nipissing specimens about ten ounces, and Perch Lake specimens from eight to nine ounces in weight.

A comparison of the value of K and rates of growth of bass in bodies of water of similar size indicates that slower growth induces a higher coefficient of condition. This result is in agreement with the tentative suggestion of Clark (1928).

Little information is available as to the age at which bass mature and spawn successfully.

A comparison of the year classes present in 1930 and 1931 in Perch Lake indicates that the 1928 year class was much more abundant than the 1929 year class.

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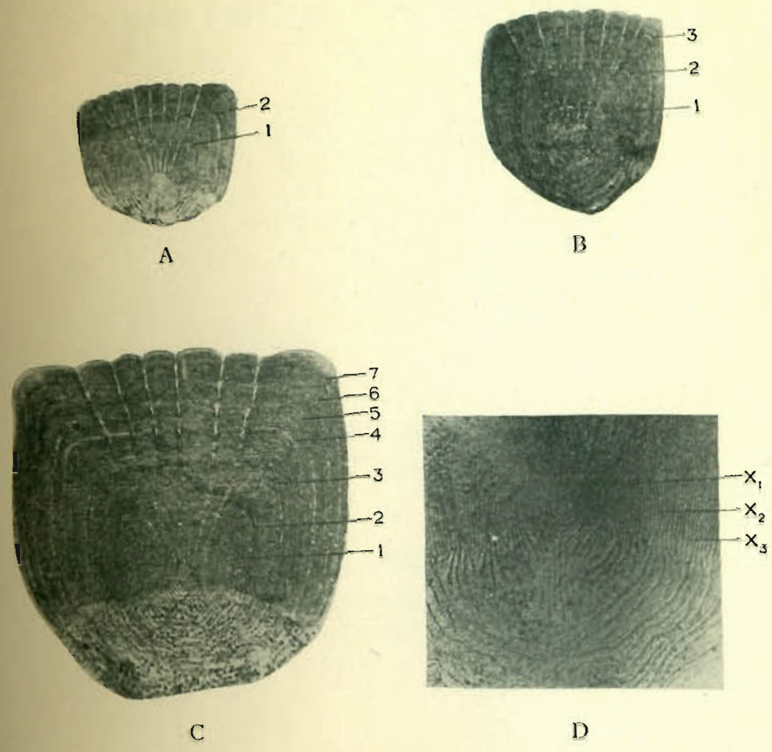

PLATE 1. A—Scale of small-mouthed black bass taken on August 8, 1930, from Perch Lake. Standard length—13.1 cm. Total length—6.0 in. Age—III.

B—Scale of small-mouthed black bass taken on July 21, 1930, from Perch Lake. Standard length—16.8 cm. Total length—7.8 in. Age—IV.

C—Scale of small-mouthed black bass taken on July 19, 1928, from Georgian Bay. Standard length—23.1 cm. Total length—10.7 in. Age—VIII.

D—The centre of a scale of a small-mouthed black bass at greater magnification to illustrate "crossing over" (x_1, x_2, x_3) at annulus.