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THE TIME OF ANNULUS FORMATION ON THE SCALES OF CERTAIN

MICHIGAN GAME FISHES

by

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ABSTRACT

The study was made to determine the time at which the annulus formed on the scales of the game fishes of Michigan. One of the main objectives was to provide the means for a more accurate age determination of the fish taken in spring and early summer.

Seven lakes and a pond were selected for the monthly collecting of samples. Additional data were obtained from several other lakes in connection with other investigations.

It was found that the date of annulus formation varies with latitude, becoming progressively later toward the north. In the southern one-third of the Lower Peninsula (Section 1), the year mark is formed by the middle of May. In the northern two-thirds of the Lower Peninsula (Section 2), this mark is laid down by the first part of June. In the Upper Peninsula (Section 3), it is completed by the first part of July.

Spawning has little effect on the time of annulus formation. There is a correlation with the age of the fish, for those over six years old form their annulus later than those under six years. The effect of temperature, apparent in the later time of forming in the northern part of the state, was studied more precisely by means of a thermograph record taken in one lake. The annulus formed during the week when the water temperature increased  $7.2^{\circ}$  over the preceding week.

### INTRODUCTION

When the continuation of the growth studies of Michigan game fishes was assigned the writer in September, 1938, it soon became apparent that one of the first problems to solve was the time of year at which the annulus or year mark forms on the scales. The precise and objective determination of the age of the fish collected in spring and early summer was obviously difficult and questionable, and at times quite impossible, because of the lack of exact information on the time of annulus formation. On many scales it was difficult to say whether the marginal area outside the last annulus represented the new season's growth or the entire last year's growth. If the year mark had already formed, the age as determined by the number of completed annuli would be correct, but if the mark had not been completed, the fish was one year older than indicated by the number of annuli. It was apparent that the solution of this problem would contribute in other ways to an understanding of fish growth.

The problem was undertaken for the Institute for Fisheries Research with approval of the writer's doctorate committee. Results are to be

presented in partial fulfillment of the requirements for the Ph.D. degree at the University of Michigan. The problem has been investigated under the joint direction of Dr. Carl L. Hubbs of the University, and Dr. A. S. Hazzard of the Institute. The writer is especially indebted to Dr. Ralph Hile, of the U. S. Fish and Wildlife Service, for his criticism and assistance in planning the investigation and in the interpretation of the data.

### MATERIALS

At the beginning of the investigation eight accessible waters (seven lakes and a pond) were selected for the monthly collecting of scale samples. The choice was made to insure a range of samples from south to north for several species.

Collections were made in the course of the study at the following places and dates:

#### Section 1

Clear Lake, Jackson County (area, 160 acres; maximum depth, 35 feet) -- April, June, July, 1939; May, June, 1940; game species, yellow perch (Perca flavescens), black crappie (Pomoxis nigro-maculatus), bluegill (Lepomis macrochirus), pumpkinseed sunfish (Lepomis gibbosus), rock bass (Ambloplites rupestris), largemouth black bass (Huro salmoides), green sunfish (Lepomis cyanellus).

Pasinski Pond, Livingston County (area,  $4\frac{1}{2}$  acres; maximum depth, 5 feet) -- September, 1938; April, May, June, July, September, 1939; and April, 1940; game species, bluegill.

Section 2

Budd Lake, Clare County (area, 150 acres; maximum depth, 34 feet) -- May, June, October, 1939; May, June, July, 1940; game species, yellow perch, black crappie, bluegill, pumpkinseed sunfish, rock bass, largemouth black bass, green sunfish, northern pike (Esox lucius).

Round Lake, Emmet County (area, 250 acres; maximum depth, 27 feet) -- May, June, October, 1939; May, June, 1940; game species, bluegill, pumpkinseed sunfish, rock bass, northern pike, smallmouth black bass (Micropterus d. dolomieu).

Section 3

North Manistique Lake, Luce County (area, 2,000 acres; maximum depth, 50 feet) -- June, July, September, October, 1939; May, June, July, 1940; game species, yellow perch, rock bass, walleyed pike (Stizostedion vitreum), cisco (Leucichthys artedi), smallmouth black bass.

Bass Lake, Marquette County (area, 400 acres; maximum depth, 30 feet) -- June, July, September, October, 1939; May, June, July, 1940; game species, yellow perch, bluegills, pumpkinseed sunfish, smallmouth black bass, walleyed pike.

Crooked Lake, Gogebic County (area, 450 acres; maximum depth, 65 feet) -- July, August, September, October, 1939; May, June, July, 1940; game species, yellow perch, bluegills, pumpkinseed sunfish, cisco, largemouth black bass, smallmouth black bass, black crappies.

Lake Fannie Hooe, Keweenaw County (area, 600 acres; maximum depth, 45 feet) -- July, August, September, October, 1939; May, June, July, 1940; game species, yellow perch, rock bass, smallmouth black bass.

Some data were taken in the following additional lakes during the investigation:

Standard Lake, (Section 2), Cheboygan, Charlevoix, and Otsego counties (area, 32 acres; maximum depth, 31 feet) -- May, June, October, 1939; May, 1940; game species, yellow perch, rock bass, smallmouth black bass.

Ford Lake (Section 2), Otsego County (area, 11.7 acres; maximum depth, 39 feet) -- May, 1939; May, 1940; game species, bluegill.

Deep Lake (Section 1), Oakland County (area, 15 acres; maximum depth, 61 feet) -- May, June, July, 1938; April, May, June, July, August, 1939; April, May, June, July, August, September, 1940; game species, bluegill, pumpkinseed sunfish, rock bass, green sunfish, largemouth black bass, yellow perch.

Several lakes in Menominee County (Section 3) -- June, 1940.

The collections were made with experimental gill nets ( 5 by 125 feet, with five mesh sizes grading from  $1\frac{1}{2}$  to four inches stretched measure), seines, and a river fyke net ( nine feet long, with five-foot wings). Rod and line fishing also aided in the taking of samples.

Standard and total lengths, weight, sex, state of maturity, and scale samples were taken in the field from all fish collected. In the laboratory the scales were cleaned and mounted in glycerin-jelly compound, and then studied on a scale projection machine.

Standard methods were followed in the study, and the annuli were recognized by the criteria usually employed. More than 5,000 scale samples were aged during the course of the study.

### Time of Annulus Formation

In Pasinski Pond, in 1939, the annulus formed on the scales of bluegills (the only game fish present) between April 23 and 29. None of the scales collected on April 23 had a marginal annulus, but the year mark was evident on all the scales taken on the 29th. It was unfortunate that this pond suffered a complete winter-kill during the winter of 1939-40, particularly since the fish were of known age, and many had been jaw tagged. Work has been resumed on this pond with a new stocking of bluegills.

Some of the scales obtained from Clear Lake on April 28, 1939, showed an annulus on the edge, and others had a trace of this mark. All those secured June 1, 1939, exhibited a completed annulus and a margin of new growth. The marginal annulus had formed on some of the scales taken May 7, 1940, whereas on others there was only a trace or no indication at all of the year mark. All scales collected on June 6 showed an annulus inside a margin of growth.

The annulus was just on the edge of the scales taken from Budd Lake, May 17-18, 1939, but there was no evidence of the mark in the sample taken on May 17, 1940. All scales taken on June 19, 1940, showed an annulus with a marginal growth.

Of the scales secured in Round Lake on May 26-28, 1939, the annulus was on the edge of some, but was lacking on others. The next collection, made on June 21-23, showed all fish to have an annulus followed by a growth band. In 1940 a collection on May 20 showed no annulus, but one taken on the 19th of June indicated that an annulus was present inside the scale margin on all fish.

On the 25th of June, 1939, in North Manistique Lake, the annulus was

on the edge of some scales and a few showed a slight marginal growth. In 1940, a collection made here on the 22nd of May gave no indication that an annulus had been laid down. On the 24th of June, when another sample was obtained, the annulus had been formed on all specimens, with a slight marginal growth on some.

In Bass Lake, when a collection was made on June 25, 1939, the annulus was obvious on all specimens. All scales taken on July 28-29 showed a band of marginal growth. In 1940, a sample was taken on the 24th of May, at which time no annulus was apparent. The next collection was made on the 25th of June, at which time the annulus was formed.

In Crooked Lake, collections were made on July 1-3, 1939. The annulus was to be seen on the edge of the scales, and a few showed a little marginal growth. In 1940, a collection made in May showed no annulus present. All scales collected June 26 had an annulus on the edge.

Of the samples secured from Lake Fannie Hooe on July 4-6, 1939, the annulus was on the edge of all except a few which showed a little marginal growth. No annulus was present on any of the scales collected in May, 1940. The next collection, taken on June 27-28, showed an annulus on the edge of all scales.

#### Additional Material

Additional material was obtained through samples taken from other lakes in the spring, while working on other problems. Samples were obtained (in Section 2) from Standard Lake during May and June, 1939, and May, 1940, and from Ford Lake in May, 1939, and May, 1940. Scale samples were kept from fish caught in June, 1940, during a survey of certain lakes in Mehominee County (Section 3). In all these samples the time of annulus formation agreed with the findings for the test lakes in the same region.

Data from Deep Lake, Oakland County

Data pertinent to the problem were collected in Deep Lake (Section 1) in connection with other investigations made during 1938 and 1939, but in 1940 a special effort was made to take scale samples at frequent intervals. A thermograph installed at the lake made it possible to secure adequate temperature data along with scale samples.

In 1938, the first collection was made on May 30, at which time the scales had an annulus with a band of marginal growth. In 1939, the first collection was on April 27, when none of the scales showed a completed annulus, though a few showed the beginning of one. The next collection was made on the 17th of May, at which time all scales in the sample showed an annulus and a narrow band of growth on the margin.

In 1940, collections were begun on April 30. Samples taken then and on May 2 and 8 showed no annulus on the margin. On May 10 a few of the scales showed a beginning of an annulus. On May 13 and 14 all the samples taken had an annulus on the margin. Collections of May 20-22 showed the annulus and a little marginal growth.

The statements made above hold for all species of fish present in each lake.

In summarizing the data for the several lakes in Michigan, it appears that there are distinct differences in the time of the year when the annulus forms. Since these differences appear to be correlated with the mean annual temperature, the lakes were placed into three groups according to the location of the average isotherms as indicated by the climatological data of the U. S. Weather Bureau (Map 1). In Section 1, roughly covering the southern one-third of the Lower Peninsula, the formation of the annulus is completed by the middle of May. In Section 2, the northern two-thirds of the Lower



Peninsula, the year mark is completed by the first part of June. In Section 3, the Upper Peninsula of Michigan, the annulus is completely formed by the first part of July.

#### Factors in the Time of Annulus Formation

**SPAWNING.-** Spawning appears to have little effect upon the time of annulus formation. For example, perch are early spawners, but do not form their annuli earlier than do the other species.

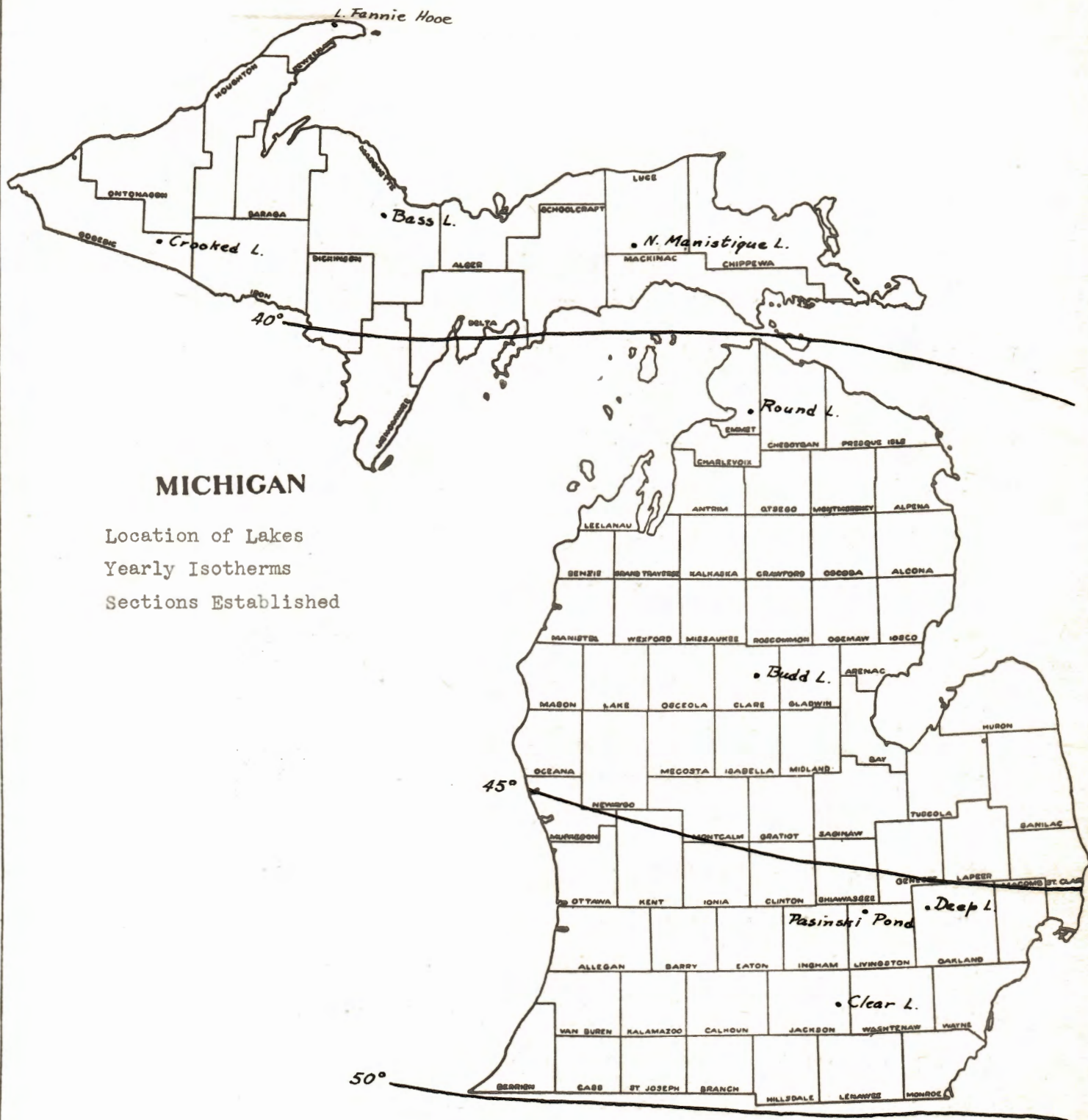
The question of whether spawning marks are developed on the scales of our fish is being checked with tagged fish in Deep Lake. Scale samples were taken as the fish were tagged before the annulus was formed and before they had spawned in 1940. Some of these fish will be recovered in 1941 before they spawn or an annulus is formed, to see whether any mark in addition to the regular annulus is formed.

**AGE.-** It is apparent that older fish form their annulus later than do the younger fish. The few available samples representing fish older than six years showed a delay in the formation of the year mark. Fish six years of age and younger form their annulus at about the same time, according to the samples studied.

**SIZE.-** I have not as yet been able to complete an analysis of the relation between size and the time of annulus formation. This will be done in the near future.

**TEMPERATURE.-** The effect of rising temperatures in the spring on the formation of the annulus is suggested by the observation already detailed that the time of formation is progressively retarded toward the

MAP 1



### MICHIGAN

Location of Lakes  
 Yearly Isotherms  
 Sections Established

cooler, northern parts of Michigan. This relation will be subjected to a more detailed analysis by comparing the scale data with the monthly mean isotherm of air temperatures for the state.

More precise correlations, using water temperature, are being made in Deep Lake, Oakland County. Here it was found that the annulus formed in 1940, between May 10 and May 15-14. A thermograph (operated from April 22 to September 23) demonstrated that the water temperature on a shaded section of the bottom, at a depth of 18 inches, varied as follows: The mean maximum temperature for the week ending May 4 was  $49.1^{\circ}$  F., and the minimum was  $42.5^{\circ}$  F.; mean maximum for the week ending May 11 was  $56.3^{\circ}$  F., the minimum was  $46.6^{\circ}$  F.; mean maximum for the week ending May 18 was  $58.8^{\circ}$  F., the minimum was  $52^{\circ}$  F.

Thus there was an increase of  $7.2^{\circ}$  F. in the weekly mean maximum temperature during the week just preceding the time when the year mark was laid down. These observations are to be repeated next year.

#### SUMMARY

1. Collections were made from numerous lakes scattered over the state, throughout the years 1939 and 1940.
2. The state was divided into three sections, based on mean annual temperatures. The time of annulus formation was progressively later, going from south to north, varying from the middle of May in the southern one-third of the Lower Peninsula to the first part of July in the Upper Peninsula.
3. Spawning appears to have little if any effect on the time of annulus formation.

4. The old fish (seven years and older) form their annuli later than the younger fish.

5. Temperature appears to affect the time of formation of the annulus.

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