Manual of Fisheries Survey Methods II: with periodic updates

Chapter 9: Age and Growth Methods and State Averages

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Chapter 9: Age and Growth Methods and State Averages

James C. Schneider, Percy W. Laarman, and Howard Gowing

Scales of fishes are remarkable structures. Much information can be obtained about the growth history and longevity of individual fish by close examination of their scales or other bony structures. On the population level, also, age and growth is an excellent index to well being.

Scales are bony structures that grow shingle-like from pockets within the skin. Scales are covered with a very thin, outer layer of skin called the epidermis. Among Michigan fishes there are basically two kinds of scales: the ctenoid scale found on spiny-rayed fishes such as bass, sunfish, perch, and walleye; and the cycloid scale found on soft-rayed fishes such as trout, suckers, and northern pike (Figure 9.1). The ctenoid scale has small, sharp projections (ctenii) which give a rough texture to spiny-rayed fish. The cycloid scale lacks ctenii; thus soft-rayed fish tend to be smooth textured.

Scales start to form when a fish is about an inch long. The number of scales covering the body remains constant throughout life, and in general, scale growth is proportional to fish growth. As the scale grows, circuli (ridges) form on the edge. Circuli form a concentric pattern over the course of a year that is related to environmental and growth conditions. During the colder months, when fish eat little and growth ceases, the circuli are crowded together and may be incomplete. In the spring, when feeding and growth resume, new circuli form that are spaced further apart. Also, the first new circuli in the spring cut across the incomplete circuli (Figure 9.1). Annuli (true year marks) are characterized by crowded ridges and consistent "cutting across" at both sides of the scale.

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Unusual events may cause false annuli to form on scales. Examples are extreme water temperatures, injury, or any other stress that causes growth to stop for a period of time during the normal growing season. False annuli may be very similar in appearance to true annuli, but often "cut across" on only one side of the scale or are not evident on all scales from a particular fish.

Old fish are often under-aged from scales. As a fish becomes older, growth rate slows down and annuli become closer together. The result is that it is difficult (sometimes impossible) to recognize the most recent annuli on very old fish scales.

Typical and atypical scale patterns, and aging difficulties, are illustrated in a report by Schneider (2000). That report contains examples of known-age scales of walleye, yellow perch, and northern pike

Some fish (such as bullheads and catfish) have no scales, and other species (such as bowfin) have no recognizable pattern on their scales. For those fish, a cross-section of a spine or a vertebra should be examined for age rings similar to rings on trees. Ear bones (otoliths), spines, and vertebrae are also more reliable than scales for aging walleye, perch, bass, sucker, pike, salmon, and burbot. In addition, cleithra have been recommended for aging musky and northern pike, and opercula bones for aging yellow perch.

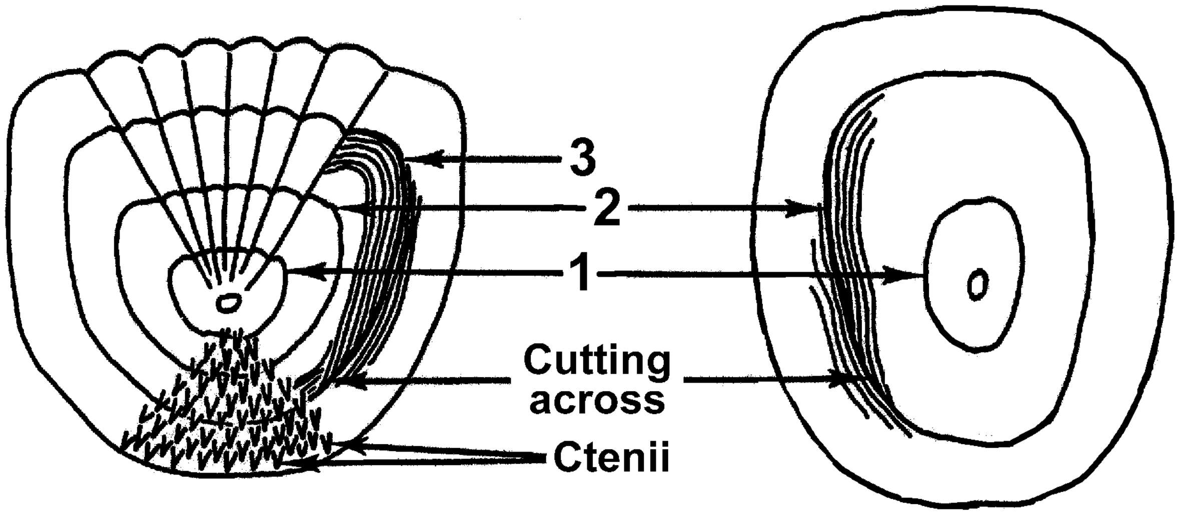

Figure 9.1–Ctenoid scale of bluegill (left) and cycloid scale of sucker (right). Annuli are indicated by numerals.

9.1 Procedures

9.1.1 Recording data on scale envelopes

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Record accurate and complete information on the scale envelope. Give the following information:

Species–Give common name of fish.

Locality–Give the name of the lake or stream from which fish was taken.

County–The name of the county in which lake or stream is located.

T. R. Sec–Give the Township, Range, and Section in which body of water is located. This is especially needed when two lakes with the same name occur in the same county.

Date–Date when fish was collected.

Length–Total length is defined as a straight-line measurement (not over the curve of the body) from the tip of the snout (with mouth closed) to the end of the caudal fin with the lobes squeezed together (Figure 9.2).

Weight–Total weight, accurately measured under good conditions.

Sex–Determine and record the sex when possible.

State of organs–This refers to sex organs. Record here whether the fish is immature or mature; and if mature, whether ripe or spent.

Gear–Record the method used in capturing the fish, such as gill net, trap net, seine, or angling.

Collector–Name of person who caught the fish.

9.1.2 Taking the scale sample

Age determination is easier if care is used when taking the scale sample. Scale samples should be taken from a definite area on the fish. The recommended location on spiny-rayed fishes is just below the lateral line and below the middle of the spiny dorsal fin (Figure 9.2). For most soft-rayed fishes the area between the lateral line and the dorsal fin is preferred; for trout the best spot is directly below the lateral line beneath the posterior end of the dorsal fin (Figure 9.3).

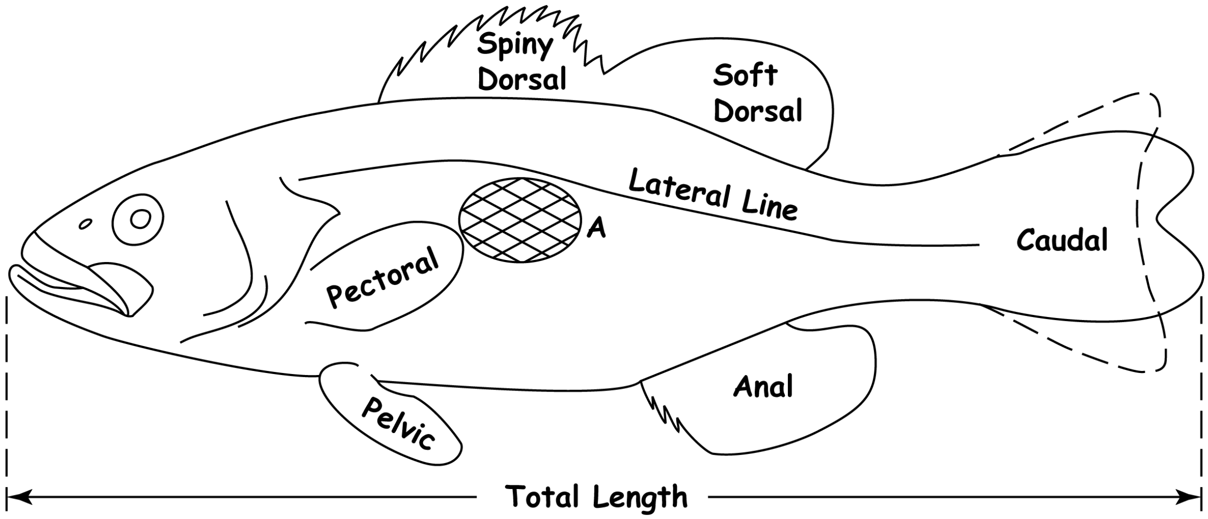

Figure 9.2–Area for taking scale samples from a spiny-rayed fish.

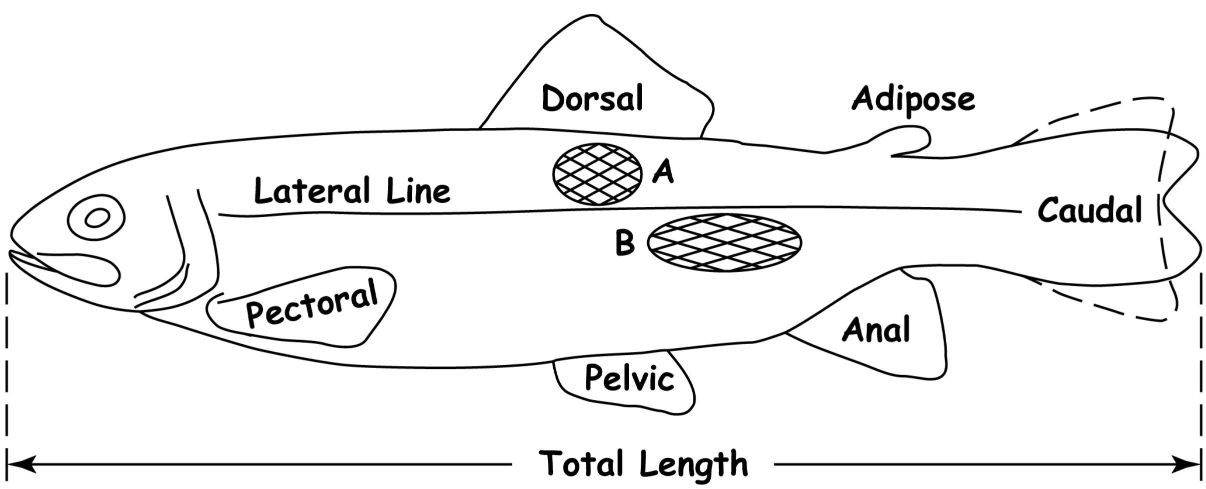

Figure 9.3–Areas for taking scale samples from most soft-rayed fish (A) or trout (B).

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About 10-20 scales should be taken from a fish. First, scrape mucous from the spot where scales are to be removed. This cleans the scales and makes processing easier. Then, remove scales with a knife blade and insert them into the envelope. Wipe the knife blade clean between samples to prevent cross contamination.

9.1.3 Making age determinations

To prepare scales for age determination, place four to six scales on a slide of clear plastic (vinyl or cellulose acetate, 0.5 mm thick) with sculptured side (side with ridges) down. Then, sandwich the slide with the scales between two more pieces of plastic and run through a roller press, using enough pressure to make a distinct impression of the scales on the plastic slide. Store the plastic slide with the scale impressions in the scale envelope from which the scales were taken. Only complete and normal scales can be used for age determinations. Abnormal or regenerated scales are often found on fish. When a fish loses a scale, it grows a replacement lacking circuli and annuli in the center. Consequently, the early part of the growth history is lost.

To make age determinations (i.e., to "read" the scale), the plastic impression is viewed through a microprojector or microfiche reader that magnifies the impression up to 90 times, as needed. A binocular microscope provides suitable magnification for counting year marks, but if the scales are to be measured, as is done in "back calculation", a microprojector is needed.

The age of a fish is determined by counting completed annuli (year marks) on the scale. Age is recorded on the scale envelope in Arabic numerals (use of roman numerals has been discontinued).

All fish are considered to have a birthday on January 1. Therefore, fish collected between January 1 and the time of annulus formation in spring or early summer are recorded as 1 year older than the number of visible annuli on the scale. The presence of this unseen (or virtual) annulus is recorded by adding 1 year to the number of visible annuli, and adding an asterisk to the numeral. To illustrate: a fish at the end of its second growing season, say in October, is designated as 1; the same fish the following February, prior to new growth, would be 2*; and 6 months later, after new scale growth, it is recorded as 2.

For anadromous salmonids, such as steelhead, there is a more complex system of counting annuli. First, the number of annuli during stream residence is counted, then the number of annuli during Great Lakes residency (usually obvious by faster growth pattern). The two numbers are separated by a decimal. Thus “1.2” indicates 1 year in the stream and 2 years in the Great Lakes. Scale characteristics may be used for identifying steelhead of wild and hatchery origin as well as aging (Seelbach and Whelan 1988).

9.1.4 Back calculation

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The back-calculation technique is useful for determining more precisely a fish's growth during each year of life prior to the sampling date. The results might reveal, for example, that a fish which is of average size for its age now, grew fast in certain earlier years and slow in other years. The technique is especially useful if no growth samples were taken prior to a management activity or if only a few fish were sampled afterwards.

There are problems to be considered, however. Back-calculated lengths at age 1 and age 2 are imprecise if small fish were not sampled adequately. Generally, it is not wise to extrapolate the fish length vs. scale radius relationship beyond the sizes actually sampled. Another problem is "Lee's phenomenon". This is the tendency for the computed lengths of the older fish in their early years of life to be systematically lower than those of younger fish at the same age. That is, it *appears* that the slower-growing fish live the longest. This error can be minimized by sampling a wide range of fish sizes.

The procedure for back calculation is as follows:

1. Obtain scale samples from the same area of each fish. Ideally, use key scales (identical area) because they have the same shape.
2. While projecting the scale and counting annuli, measure with a ruler the radius of the scale and the distance to each annulus. Select a standard axis for measuring along (such as the axis from the focus to the middle of the anterior field) and use the same magnification for all samples in the collection.
3. Compute the relationship between fish length (L) and scale radius (S). This linear equation will usually give a satisfactory fit:

$$L = a + bS$$

4. Compute the length at each annulus (L_n) from the distance from the focus to that annulus (S_n). The following equation is appropriate to use with the equation just given:

$$L_n = \frac{S_n}{S}(L - a) + a$$

The process may be automated by projecting the scale image onto a digitizing pad or video monitor linked to a computer and "marking" each annulus with an electronic mouse or stylus. Available software will then perform all the computations.

The intercept (a), also called the correction factor, is a very important parameter that is difficult to estimate. It may be thought of as the length at which scales begin to form, but in a practical vein it just helps make the data fit mathematically. The intercept should be determined for each species and each population. Normal values of (a) are approximately 1 inch for centrarchids and percids; unrealistically high values often result from samples containing only large fish. Back calculation with a high correction factor causes inflated estimates of the lengths of age-1 and age-2 fish. When samples are inadequate, or empirical estimates of (a) are unrealistic, the following standard intercepts are recommended (Carlander 1982): 10 mm (0.4 in) for green sunfish; 20 mm (0.8 in) for bluegill, largemouth bass, and warmouth; 25 mm (1.0 in) for pumpkinseed and rock bass; 30 mm (1.2 in) for yellow perch; 35 mm (1.4 in) for smallmouth bass, black crappie, and white crappie; and 55 mm (2.2 in) for walleye.

9.2 Michigan average growth summaries

Statewide average growth rates for many species of fish in Michigan have been determined from many years of collecting data in Michigan (Tables 9.1-9.3). More than 122,000 fish, representing 25 species, were used to calculate average length at age. The basic statistical unit used in determining the averages for each species was the mean length for each age group in each collection from each body of water; each mean was given equal weight in determining the final growth rate averages.

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Sufficient data were available to compute average lengths attained at various months of the growing season for eight species of warmwater fish (Laarman 1963a). These data were plotted on graph paper and a smoothed stair-step curve was fit by eye which reflected the known seasonal growth pattern (virtually all growth in length occurs between mid-May and mid-September). Similar curves were developed for walleye (Schneider 1978), tiger musky, and redear sunfish (data provided by Gary Towns). Comparable curves were developed for stream-dwelling brook, rainbow, and brown trout by graphing annual averages, smoothing them with straight lines, and then superimposing the seasonal growth pattern (determined by Cooper in 1953 for age-0 and age-I brook trout in three streams). In 1996, averages were developed for lake-dwelling trout and lake herring by plotting seasonal lengths at age and fitting linear regressions because no seasonal growth pattern was evident. [Trout growth does retard in mid-winter; however, considerable growth occurs in late fall and early spring, when warmwater fish are inactive.] In 1999, the statewide average lengths for age-1 bluegill and pumpkinseed were reduced based on better information obtained from well-studied lakes. Also in 1999, a tentative annual average for channel catfish was developed based on spine samples from four populations (there are relatively few channel catfish populations in Michigan). For the most important species, Tables 9.1 and 9.2 contain the estimated average lengths at four-time periods during each age. For other species, refer to Table 9.3 for annual averages.

For simplicity, the lengths in Tables 9.1-9.3 will be taken as representative of waters throughout the state. Actually, there are regional differences in time of annulus formation, length of growing season, and growth rates (Beckman 1943; Laarman 1963b). Surprisingly, the average growth of bluegill and largemouth bass is better in the Upper Peninsula than in the southern Lower Peninsula. This indicates growth is more dependent on population density and relative food availability than on length of growing season. An additional problem with any average figure is that the time of annulus formation is not fixed but varies from year to year, depending upon spring weather. Even with these limitations, the lengths in Tables 9.1-9.3 are very useful and are to serve as standards for comparing the growth of fish populations in Michigan.

9.3 Growth index

A growth index has been devised for expressing the degree to which the growth of a species in a given body of water differs from the statewide average. The index is calculated as follows:

1. Use only those age groups represented by five or more fish.
2. For each age group, determine the deviation (difference) between the observed average length and the statewide seasonal average length.
3. Add the deviations and divide the sum by the number of age groups.

A growth index of 0.0 means that the sampled population is growing at exactly the state average rate for the species in question. An index of +1.0 inch means that the sampled population is growing 1.0 inch faster than average. In the following illustration, the bluegills sampled at Example Lake in June were growing, overall, 0.2 inch below the statewide average. The age group deviations ranged from +0.8 to -0.7; the growth index was -0.2 inches.

	Average length of each age group (Number of fish in parentheses)					
Species	**1**	**2**	**3**	**4**	**5**	**6**
Bluegill, Example Lake	3.2 (15)	4.5 (3)	5.2 (6)	5.5 (17)	6.4 (15)	7.0 (5)
State average	2.4	4.2	5.3	6.2	6.9	7.4
Deviation	+0.8	–	-0.1	-0.7	-0.5	-0.4

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$$\textit{Growth index} = \frac{0.8 - 0.1 - 0.7 - 0.5 - 0.4}{5} = \frac{-0.9}{5} = -0.2 \textit{ inch}$$

As a rule of thumb, satisfactory growth indices are in the range of +0.5 to -0.5 inch for panfish, and +1.0 to -1.0 inch for game fish. Thus, bluegills in Example Lake were growing rather slowly (-0.2 inch), but satisfactorily. Panfish populations with growth rates less than -1.0 inch are generally stunted and dominated by small-size fish.

Table 9.1.–State average total length (inches) by age and month for important Michigan fishes.

Age	Month	Bluegill	Pumpkin-seed	Redear sunfish	Rock bass	Black crappie	Yellow perch	Lake herring
0	Jan-May							
	Jun-Jul							
	Aug-Sep							
	Oct-Dec	1.8	1.8	1.9	2.4	4.2	3.3	7.6
1	Jan-May	1.8	1.8	1.9	2.4	4.2	3.3	7.9
	Jun-Jul	2.4	2.4	2.8	3.0	4.8	4.0	8.2
	Aug-Sep	3.3	3.3	3.6	3.5	5.6	5.0	8.4
	Oct-Dec	3.8	3.8	4.4	3.9	6.0	5.2	8.7
2	Jan-May	3.8	3.8	4.4	3.9	6.0	5.2	8.9
	Jun-Jul	4.2	4.2	5.0	4.3	6.5	5.7	9.2
	Aug-Sep	4.7	4.6	5.6	4.8	7.2	6.3	9.5
	Oct-Dec	5.0	4.9	6.2	5.1	7.5	6.5	9.7
3	Jan-May	5.0	4.9	6.2	5.1	7.5	6.5	10.0
	Jun-Jul	5.3	5.2	6.9	5.4	7.9	6.8	10.3
	Aug-Sep	5.8	5.4	7.4	5.9	8.4	7.2	10.5
	Oct-Dec	5.9	5.6	7.6	6.1	8.6	7.5	10.8
4	Jan-May	5.9	5.6	7.6	6.1	8.6	7.5	11.0
	Jun-Jul	6.2	5.8	8.0	6.4	8.9	7.8	11.3
	Aug-Sep	6.6	6.0	8.3	6.7	9.2	8.2	11.6
	Oct-Dec	6.7	6.2	8.7	6.9	9.4	8.5	11.8
5	Jan-May	6.7	6.2	8.7	6.9	9.4	8.5	12.1
	Jun-Jul	6.9	6.3	9.0	7.2	9.7	8.7	12.4
	Aug-Sep	7.1	6.5	9.1	7.6	10.0	9.2	12.6
	Oct-Dec	7.3	6.6	9.6	7.8	10.2	9.4	12.9
6	Jan-May	7.3	6.6	9.6	7.8	10.2	9.4	13.1
	Jun-Jul	7.4	6.8	9.8	8.1	10.4	9.7	13.4
	Aug-Sep	7.6	7.0	10.1	8.4	10.7	10.1	13.7
	Oct-Dec	7.8	7.1	10.3	8.6	10.8	10.3	13.9
7	Jan-May	7.8	7.1	10.3	8.6	10.8	10.3	14.2
	Jun-Jul	8.0	7.2	10.5	8.8	11.1	10.5	14.4
	Aug-Sep	8.1	7.4	10.7	9.2	11.3	10.9	14.7
	Oct-Dec	8.2	7.5	10.8	9.3	11.4	11.1	15.0
8	Jan-May	8.2	7.5	10.8	9.3	11.4	11.1	15.2
	Jun-Jul	8.4			9.4	11.6	11.3	15.5
	Aug-Sep	8.5			9.6	11.8	11.5	15.8
	Oct-Dec	8.6			9.8	11.9	11.6	16.0
9	Jan-May	8.6			9.8	11.9	11.6	16.3
	Jun-Jul	8.7					11.7	
	Aug-Sep	8.8					11.9	
	Oct-Dec	8.9					12.1	
10	Jan-May	8.9					12.1	

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Table 9.1.–Continued:

Age	Month	Largemouth bass	Smallmouth bass	Walleye	Northern pike	Tiger musky
0	Jan-May					
	Jun-Jul					
	Aug-Sep					
	Oct-Dec	4.2	3.8	7.1	11.7	12.5
1	Jan-May	4.2	3.8	7.1	11.7	12.5
	Jun-Jul	5.4	5.5	8.2	14.5	14.7
	Aug-Sep	6.9	7.0	9.8	16.6	19.5
	Oct-Dec	7.1	7.5	10.4	17.7	22.0
2	Jan-May	7.1	7.5	10.4	17.7	22.0
	Jun-Jul	8.7	8.8	11.4	19.0	23.3
	Aug-Sep	9.3	10.1	13.3	20.1	25.5
	Oct-Dec	9.4	10.8	13.9	20.8	27.0
3	Jan-May	9.4	10.8	13.9	20.8	27.0
	Jun-Jul	10.6	11.1	14.4	21.8	28.0
	Aug-Sep	11.2	12.0	15.2	22.8	29.7
	Oct-Dec	11.6	12.6	15.8	23.4	30.7
4	Jan-May	11.6	12.6	15.8	23.4	30.7
	Jun-Jul	12.0	13.0	16.2	24.2	31.5
	Aug-Sep	12.7	14.0	17.2	25.0	33.0
	Oct-Dec	13.2	14.4	17.6	25.5	33.7
5	Jan-May	13.2	14.4	17.6	25.5	33.7
	Jun-Jul	13.7	14.7	18.0	26.1	34.2
	Aug-Sep	14.4	15.2	18.6	26.9	35.2
	Oct-Dec	14.7	15.3	19.2	27.3	35.8
6	Jan-May	14.7	15.3	19.2	27.3	
	Jun-Jul	15.0	15.5	19.6	27.8	
	Aug-Sep	16.0	16.0	20.3	28.8	
	Oct-Dec	16.3	16.3	20.6	29.3	
7	Jan-May	16.3	16.3	20.6	29.3	
	Jun-Jul	16.7	16.6	20.8	30.0	
	Aug-Sep	17.1	17.1	21.3	30.7	
	Oct-Dec	17.4	17.3	21.6	31.2	
8	Jan-May	17.4	17.3	21.6	31.2	
	Jun-Jul	17.6	17.4	21.7		
	Aug-Sep	18.0	17.8	22.1		
	Oct-Dec	18.3	18.1	22.4		
9	Jan-May	18.3	18.1	22.4		
	Jun-Jul	18.6	18.3	22.6		
	Aug-Sep	19.1	18.7	22.9		
	Oct-Dec	19.3	18.9	23.1		
10	Jan-May	19.3	18.9	23.1		

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Table 9.1.–Continued: State average total length (inches) by age and month for trout in lakes and streams.

		Trout in lakes[a]					Wild trout in streams		
Age	Month	Brook	Brown	Rainbow	Lake	Splake	Brown	Brook	Rainbow
0	Jan-May						1.0	1.0	1.0
	Jun-Jul						2.5	2.3	2.0
	Aug-Sep						3.2	2.9	2.7
	Oct-Dec						4.0	3.6	3.4
1	Jan-May	6.8	8.4	8.2	5.8	9.7	4.1	3.8	3.7
	Jun-Jul	7.5	9.3	9.0	6.8	10.3	5.8	5.3	5.2
	Aug-Sep	8.1	10.1	9.7	7.9	10.9	6.2	5.7	5.7
	Oct-Dec	8.8	11.0	10.5	8.9	11.5	6.9	6.4	6.5
2	Jan-May	9.4	11.9	11.2	9.9	12.1	7.2	6.6	6.7
	Jun-Jul	10.0	12.7	12.0	10.9	12.6	8.8	8.1	8.0
	Aug-Sep	10.7	13.6	12.8	11.9	13.2	9.2	8.5	8.7
	Oct-Dec	11.3	14.4	13.5	12.8	13.8	9.9	9.2	9.5
3	Jan-May	12.0	15.3	14.3	13.7	14.4	10.2	9.4	9.8
	Jun-Jul	12.6	16.1	15.0	14.6	15.0	11.8	10.9	11.0
	Aug-Sep	13.3	17.0	15.8	15.4	15.6	12.2	11.3	11.7
	Oct-Dec	13.9	17.8	16.5	16.3	16.1	12.9	12.0	12.4
4	Jan-May	14.6	18.7	17.3	17.1	16.7	13.2	12.2	12.7
	Jun-Jul	15.2	19.5	18.0	17.9	17.3	14.8	13.7	14.0
	Aug-Sep	15.9	20.4	18.8	18.7	17.9	15.2	14.1	14.7
	Oct-Dec	16.5	21.2	19.5	19.4	18.4	15.9	14.8	15.4
5	Jan-May	17.2	22.1	20.3	20.1	19.0	16.2	15.0	
	Jun-Jul	17.8	23.0	21.0	20.8	19.6	17.8	16.5	
	Aug-Sep	18.4	23.8	21.8	21.5	20.2	18.2	16.9	
	Oct-Dec	19.1	24.6	22.6	22.2	20.8	18.9	17.6	
6	Jan-May	19.7	25.5	23.4	22.8	21.4	19.2		
	Jun-Jul		26.4		23.4	21.9	20.8		
	Aug-Sep		27.2		24.0	22.5	21.2		
	Oct-Dec		28.1		24.6	23.1	21.9		
7	Jan-May		28.9		25.1	23.7	22.2		
	Jun-Jul				25.6	24.3	23.8		
	Aug-Sep				26.2	24.8	24.2		
	Oct-Dec				26.6	25.4	24.9		
8	Jan-May				27.1	26.0	25.2		
	Jun-Jul				27.5	26.6	26.8		
	Aug-Sep				27.9	27.2	27.2		
	Oct-Dec				28.3	27.8	27.9		
9	Jan-May				28.7	28.3			
	Jun-Jul				29.0				
	Aug-Sep				29.3				
	Oct-Dec				29.6				
10	Jan-May				29.9				

[a] There is much variation in lake data due to length at stocking and strain, as well as growing conditions. For example, data for brook trout includes the old "domestic" and the newer Assinica and Temiscamie strains.

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Table 9.2.–State average total length (millimeters) by age and month for important Michigan fishes.

Age	Month	Blue-gill	Yellow perch	Pump-kin-seed	Redear sunfish	Rock bass	Black crappie	Wall-eye	Small-mouth bass	Large-mouth bass	Northern pike	Tiger musky	Lake herring
0	Jan-May												
	Jun-Jul												
	Aug-Sep												
	Oct-Dec	61	84	61	48	61	107	180	97	107	297	318	194
1	Jan-May	61	84	61	48	61	107	180	97	107	297	318	201
	Jun-Jul	76	102	71	71	76	122	208	140	137	368	373	208
	Aug-Sep	89	127	88	91	89	142	250	178	175	422	495	214
	Oct-Dec	97	133	97	112	99	152	264	191	180	450	559	221
2	Jan-May	97	133	97	112	99	152	264	191	180	450	559	228
	Jun-Jul	107	145	105	127	109	165	292	224	221	483	592	234
	Aug-Sep	119	160	116	142	122	183	338	257	236	511	648	241
	Oct-Dec	127	165	124	157	130	191	353	274	239	528	686	247
3	Jan-May	127	165	124	157	130	191	353	274	239	528	686	254
	Jun-Jul	135	165	131	175	137	201	366	282	269	554	711	261
	Aug-Sep	147	183	137	188	150	213	386	305	284	579	754	267
	Oct-Dec	150	191	142	193	155	218	401	320	295	594	780	274
4	Jan-May	150	191	142	193	155	218	401	320	295	594	780	280
	Jun-Jul	157	198	147	203	163	226	411	330	305	615	800	287
	Aug-Sep	166	208	152	211	170	234	437	356	323	635	838	294
	Oct-Dec	170	216	157	221	175	240	447	366	335	648	856	300
5	Jan-May	170	216	157	221	175	240	447	366	335	648	856	307
	Jun-Jul	175	221	160	229	183	246	457	373	348	663	869	314
	Aug-Sep	180	234	165	231	193	254	472	386	366	683	894	321
	Oct-Dec	185	240	170	244	198	259	488	389	373	693	909	327
6	Jan-May	185	240	170	244	198	259	488	389	373	693		334
	Jun-Jul	189	246	173	249	206	265	498	394	381	706		340
	Aug-Sep	193	257	178	256	213	272	516	406	406	732		347
	Oct-Dec	198	262	180	262	217	276	523	414	414	744		354
7	Jan-May	198	262	180	262	217	276	523	414	414	744		360
	Jun-Jul	203	267	183	267	224	282	528	422	424	762		367
	Aug-Sep	206	277	188	272	232	287	541	434	434	780		374
	Oct-Dec	208	282	191	274	236	290	549	439	441	792		380
8	Jan-May	208	282	191	274	236	290	549	439	441	792		387
	Jun-Jul	212	287			240	295	551	442	446			394
	Aug-Sep	216	292			244	300	561	452	457			400
	Oct-Dec	218	295			250	302	569	460	466			406
9	Jan-May	218	295			250	302	569	460	466			414
	Jun-Jul	221	297					574	465	472			
	Aug-Sep	224	302					582	475	485			
	Oct-Dec	226	307					586	480	491			
10	Jan-May	226	307					586	480	491			

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Table 9.2.–Continued: State average total length (millimeters) by age and month for trout in lakes and streams.

		Trout in lakes[a]					Wild trout in streams		
Age	Month	Brook	Brown	Rainbow	Lake	Splake	Brown	Brook	Rainbow
0	Jan-May						24	24	24
	Jun-Jul						64	58	51
	Aug-Sep						81	74	69
	Oct-Dec						103	91	86
1	Jan-May	173	215	209	148	246	105	96	94
	Jun-Jul	189	236	228	174	262	148	136	132
	Aug-Sep	206	258	247	201	277	157	145	145
	Oct-Dec	222	279	266	227	292	175	162	165
2	Jan-May	239	301	285	252	306	182	168	170
	Jun-Jul	255	323	305	277	321	224	207	203
	Aug-Sep	272	344	324	301	336	234	216	221
	Oct-Dec	288	366	343	325	351	252	233	241
3	Jan-May	304	388	362	348	366	258	239	249
	Jun-Jul	321	409	382	370	380	300	278	279
	Aug-Sep	337	431	401	392	395	310	287	297
	Oct-Dec	354	453	420	414	410	329	304	315
4	Jan-May	370	474	439	434	424	335	310	323
	Jun-Jul	387	496	458	454	439	377	349	356
	Aug-Sep	403	518	477	474	454	386	358	373
	Oct-Dec	419	539	496	493	469	405	375	391
5	Jan-May	436	561	516	511	484	411	381	
	Jun-Jul	452	583	535	529	498	453	420	
	Aug-Sep	467	605	554	547	513	463	429	
	Oct-Dec	485	626	573	563	528	481	446	
6	Jan-May	500	648	594	579	543	487		
	Jun-Jul		671		595	557	529		
	Aug-Sep		691		610	572	539		
	Oct-Dec		714		624	587	557		
7	Jan-May		735		638	602	563		
	Jun-Jul				652	616	605		
	Aug-Sep				664	631	615		
	Oct-Dec				676	646	633		
8	Jan-May				688	661	640		
	Jun-Jul				699	675	681		
	Aug-Sep				709	690	691		
	Oct-Dec				719	705	710		
9	Jan-May				728	720			
	Jun-Jul				737				
	Aug-Sep				745				
	Oct-Dec				753				
10	Jan-May				759				

[a] There is large variation in lake data due to length at stocking and strain, as well as growing conditions. For example, data for brook trout includes the old "domestic" and Assinica and Temiscamie strains.

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Table 9.3.–Average annual total length (inches and mm), at age, for Michigan fishes lacking established seasonal averages.[a]

Species	Age group										
	0	1	2	3	4	5	6	7	8	9	10
Muskellunge	6.8	15.7	19.9	25.4	31.9	34.7	36.8	39.2	41.7	45.3	48.7
	173	399	505	645	810	881	935	996	1,059	1,151	1,237
Channel catfish		6.5	11.2	13.6	15.8	17.7	19.3	20.6	22.0	23.2	23.8
		165	284	345	401	450	490	523	559	589	605
Grass pickerel	3.1	7.8	9.5	9.6	10.2	10.4	10.9				
	79	198	241	244	259	264	277				
Warmouth		3.1	4.4	5.2	5.5	6.2	6.7	6.9	6.6	7.5	
		79	112	132	140	157	170	175	168	191	
Green sunfish		3.0	3.9	4.7	5.1	5.7	5.7				
		76	99	119	130	145	145				
Longear sunfish	1.5	2.5	3.2	3.8	4.0	4.3					
	38	64	81	97	102	109					
Rainbow smelt		5.3	6.9	7.7	8.1	8.8	9.6				
		135	175	196	206	224					
White sucker	3.5	8.6	12.0	14.3	16.3	16.9	18.1	18.1			
	89	218	305	363	414	429	460	460			

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[a] Averages apply to the middle of the growing season, except for age-0 fish which were usually collected in the fall and channel catfish which were mostly collected in the spring. The channel catfish data represent a smoothed average based on only four populations and is a tentative statewide average. Fish become 1 year older on January 1. All data are from inland lakes and reservoirs.

9.4 References

Beckman, W. C. 1943. Annulus formation on the scales of certain Michigan game fishes. Michigan Academy of Science 28:281-312.

Carlander, K. D. 1982. Standard intercepts for calculating lengths from scale measurements for some centrarchid and percid fishes. Transactions of American Fisheries Society 111:332-336.

Cooper, E. L. 1953. Periodicity of growth and change of condition of brook trout (Salvelinus fontinalis) in three Michigan trout streams. Copeia 2:107-114.

Laarman, P. W. 1963a. Average growth rates of fishes in Michigan. Michigan Department of Natural Resources, Fisheries Research Report 1675, Ann Arbor.

Laarman, P. W. 1963b. Relationships of some environmental factors to growth of three species of fishes in Michigan. Master of Science thesis, School of Natural Resources, University of Michigan, Ann Arbor.

Schneider, J. C. 1978. Selection of minimum size limits for walleye fishing in Michigan. American. Fisheries Society Special Publication 11:398-407.

Schneider, J. C. 2000 (In press). Aging scales of walleye, yellow perch, and northern pike. Michigan Department of Natural Resources, Fisheries Technical Report 2000-?, Ann Arbor.

Seelbach, P. W. and G. E. Whelan. 1988. Identification and contribution of wild and hatchery steelhead stocks in Lake Michigan tributaries. Michigan Department of Natural Resources, Fisheries Research Report 1950, Ann Arbor.

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