North American Journal of Fisheries Management 6:122–125, 1986

A Comparison of the Otolith and Scale Methods for Aging White Crappies in Oklahoma[1]

JEFF BOXRUCKER

Oklahoma Department of Wildlife Conservation
Oklahoma Fishery Research Laboratory
1416 Planck Street, Norman, Oklahoma 73069, USA

Abstract.—Scales and otoliths (sagittae) were taken from a sample of 137 white crappies (*Pomoxis annularis*) collected by fyke netting from Ft. Supply Reservoir, Oklahoma, in November 1982. Scales and otoliths from each fish were aged independently by three experienced scale readers, none of whom had prior experience aging otoliths. The average percent error and coefficient of variation of the scale method was approximately seven times greater than for the otolith method, indicating a greater degree of precision for the otolith method. No differences were observed in back-calculated lengths derived from measurements obtained from the right versus left otolith. No significant differences in back-calculated lengths up to age 3 for a given year class sampled in successive years were observed for white crappies aged by the otolith method. These results indicate that age and growth data generated from the otolith method would be sufficiently consistent for biologists to recognize yearly trends in growth variations. Known-age white crappies, needed to verify the accuracy of the otolith technique, were unavailable. However, scales and otoliths were taken from 31 white crappies collected from the James River arm of Table Rock Lake, Missouri, in spring 1984. The scale method for aging white crappies in Missouri is considered to be accurate by the Missouri Department of Conservation. The ages of these fish, as determined by scales read in Missouri and otoliths aged in Oklahoma, were in agreement for 30 of the 31 fish sampled. The use of the otolith method for aging white crappies in Oklahoma is recommended over the scale method. Once field personnel become efficient in extracting otoliths, processing time in the field is only slightly greater than when taking scale samples. No elaborate preparation procedures are required because ages can be obtained from whole otoliths.

The scale method is believed to be inadequate for accurately aging and measuring growth rates of sport fishes in Oklahoma (Wigtil 1984). Therefore, the development of an alternative aging procedure was needed and it was decided to try the otolith method on white crappies (*Pomoxis annularis*).

Otoliths are commonly used to age marine fish and generally are considered to be more accurate than scales (Williams and Bedford 1974). Erickson (1983) found that age estimates based on otoliths were more accurate than those based on scales for older walleye (*Stizostedion vitreum*). Schramm and Doerzbacher (1985) indicated that unsectioned otoliths (sagittae) from black crappies (*Pomoxis nigromaculatus*) in Florida satisfied the necessary criteria for validating aging structures. The objective of this study was to compare the precision and address the accuracy of age and growth data derived from scale and otolith methods of age determination for white crappies.

[1] Contribution 202 of the Oklahoma Fishery Research Laboratory, a cooperative unit of the Oklahoma Department of Wildlife Conservation and the University of Oklahoma.

Methods

White crappies were collected from Ft. Supply Reservoir, Woodward County, northwest Oklahoma. The reservoir was impounded in 1942 and is operated by the U.S. Army Corps of Engineers. It is a shallow, windswept, turbid reservoir with a surface area of 752 hectares and a shoreline development ratio of 4.4. The white crappie population exhibits above-average growth and is dominated by large individuals. Proportional Stock Density values ranged from 69 to 100% during 1977–1981 (Stahl 1981).

Fyke netting in November 1982 yielded 137 white crappies. Scale samples and otoliths (sagittae) were taken and total length and weight measurements were made on all fish collected. Scale samples were heat-pressed on acetate and read utilizing an Eberbach projector. Otoliths were viewed wet under 10× magnification with transmitted light. Distances from the kernel to each opaque band (annulus) were measured with an ocular micrometer. The otolith radius was measured from the center of the kernel to the anterior of the otolith.

All scales and otoliths were aged independently by three laboratory personnel who were experi-

TABLE 1.—Measures of precision among three readers who aged white crappies by both scale and otolith methods. Values given are means for all readers and all fish.

Aging method	Number of fish	Average percent error	Coefficient of variation	Index of precision
Scale	137	0.4264	58.5502	33.8040
Otolith	137	0.0625	8.1739	4.7192

enced in scale aging but who had no prior experience in aging otoliths. The precisions of the ages estimated by the scale and otolith methods were compared by means of the average percent error (*APE*) as described by Beamish and Fournier (1981):

$$APE = \frac{1}{R}\sum_{i=1}^{R}\frac{|X_{ij} - X_j|}{X_j} \times 100;$$

X_{ij} = the ith age determination of the jth fish;
X_j = average age calculated for the jth fish; and
R = number of times each is aged.

An alternate index suggested by Chang (1982), which employs a coefficient of variation (V) to test the reproducibility of age determinations among readers, was used for comparison with the *APE*. The coefficient of variation is derived by replacing that absolute average deviation from the arithmetic mean in the above equation with the standard deviation. The percent error contributed by each observation to the average age class, may be estimated by an index of precision (D), or V divided by $\sqrt{R}$ (Sokal and Rohlf 1969).

TABLE 3.—Differences[a] in back-calculated length at each annulus formation derived from right and left otoliths of white crappies. Probabilities are based on dependent t-tests.

Reader	Age	N	Mean difference (mm)	SE	P
1	1	33	2.94	1.74	0.1007
	2	33	0.96	1.37	0.4895
	3	17	−0.98	0.67	0.1637
	4	3	−3.93	3.93	0.4226
2	1	38	−0.22	3.15	0.9440
	2	37	2.74	2.15	0.2098
	3	20	0.78	1.25	0.5422
	4	2	−1.12	1.12	0.5000
3	1	38	1.42	1.58	0.3762
	2	37	−0.54	0.83	0.5225
	3	17	0.39	0.97	0.6931
	4	2	−0.32	0.32	0.5000

[a] Difference = length calculated from right otolith minus length calculated from left otolith.

Differences in lengths back-calculated from measurements of right and left otoliths from each of these readers also were determined with Student's t-tests. Back-calculated lengths were computed for a subsample of 38 fish from unsectioned otoliths by the Dahl–Lea direct proportion method (Lagler 1956).

An underlying assumption of age and growth

TABLE 2.—Ages of a subsample of white crappies collected from Ft. Supply Reservoir, Oklahoma, as determined by three independent readers (R-1 to R-3) using both the scale and otolith method on each fish.

Fish number	Scale method						Otolith method					
	Assigned age			Average % error	Coefficient of variation	Index of precision	Assigned age			Average % error	Coefficient of variation	Index of precision
	R-1	R-2	R-3				R-1	R-2	R-3			
17	2	4	1	47.62	65.47	37.80	3	3	3	0.0	0.0	0.0
22	2	6	3	42.24	56.77	32.78	3	3	3	0.0	0.0	0.0
23	2	4	1	47.62	65.47	37.80	1	2	2	26.67	34.64	20.00
24	2	4	2	33.33	43.30	25.00	3	3	3	0.0	0.0	0.0
27	2	4	2	33.33	43.30	25.00	3	2	2	19.05	24.74	14.29
37	2	0	2	66.67	86.60	50.00	2	2	2	0.0	0.0	0.0
40	1	2	0	66.67	100.00	57.74	1	1	1	0.0	0.0	0.0
55	2	4	1	47.62	65.47	37.80	2	2	2	0.0	0.0	0.0
62	2	4	1	47.62	65.47	37.80	3	3	3	0.0	0.0	0.0
65	2	3	1	33.33	50.00	28.87	2	2	1	26.67	34.64	20.00
67	4	3	1	41.67	57.28	33.07	1	2	1	33.33	43.30	25.00
68	3	4	2	22.22	33.33	19.25	3	3	3	0.0	0.0	0.0
88	2	3	1	33.33	50.00	28.87	1	1	1	0.0	0.0	0.0
99	2	3	1	33.33	50.00	28.87	2	2	2	0.0	0.0	0.0
105	2	3	2	19.05	24.74	14.29	3	3	3	0.0	0.0	0.0
126	2	5	2	44.44	57.74	33.33	3	3	3	0.0	0.0	0.0
127	2	3	1	33.33	28.87	50.00	1	1	1	0.0	0.0	0.0
129	3	4	3	13.33	17.32	10.00	4	4	4	0.0	0.0	0.0
130	2	4	2	33.33	43.30	25.00	3	3	3	0.0	0.0	0.0
134	2	3	0	66.67	91.65	52.92	1	2	2	26.67	34.64	20.00

TABLE 4.—Mean lengths back-calculated from otoliths, for white crappies of year classes 1979–1981 in Ft. Supply Lake, Oklahoma, sampled in successive years, and the associated Student's *t* statistic.

		1979			1980			1981		
Annulus	Year sampled	Number of fish	Mean length (mm)	*t*	Number of fish	Mean length (mm)	*t*	Number of fish	Mean length (mm)	*t*
I	1982	44	116.9		50	133.7		41	138.9	
	1983	36	119.8	0.44	25	129.2	0.35	9	129.6	0.21
II	1982	44	179.9		50	194.7				
	1983	36	175.8	0.26	25	203.5	0.13			
III	1982	44	223.4							
	1983	36	222.7	0.88						

analyses is that fish from the same impoundment, species, and year class represent one population regardless of sampling year. This assumption was tested with a Student's *t*-test to determine whether or not back-calculated lengths at particular annulus formations varied significantly ($P \leq 0.10$) between sampling years. Otoliths were collected from white crappies from Ft. Supply in November 1982 and 1983. Back-calculated length measurements were made by the same reader for both samples.

Known-age white crappies, needed to verify the accuracy of the otolith method, were unavailable in Oklahoma. Because the scale method was shown to be unreliable for aging sport fish in Oklahoma (Wigtil 1984), the accuracy of the otolith method for aging white crappies could not be compared to an established aging technique. Missouri Department of Conservation personnel studying crappie populations feel that the scale method for aging crappies in Missouri is valid (Mike Colvin, personal communication). Scales and otoliths were removed from 31 fish collected from the James River arm of Table Rock Reservoir, Missouri in spring 1984. Scales were aged by biologists in Missouri who were experienced in aging white crappie; otoliths from the same fish were aged by the author. Ages obtained by these two methods were compared for agreement.

Results

The greater precision achieved in aging white crappies by the otolith method was demonstrated by the lower values of average percent error and coefficient of variation (Table 1). The calculated values for *APE* and *V* increased approximately sevenfold when the scale method was used. A randomly selected subsample of fish aged from scales and otoliths by the three readers, plus the respective values for *APE*, *V*, and *D* are given in Table 2.

Although differences in the size of otoliths from the same fish were observed, there were no significant differences in back-calculated lengths estimated from the right and left otoliths (Table 3). This contradicts the work of Jonsson and Stenseth (1977) who found as much as a 14% error between the back-calculated lengths obtained from the two otoliths of the same fish.

No significant differences were found in the back-calculated lengths at annulus formation between sampling years by the otolith method (Table 4). In contrast, Wigtil (1984) found that lengths back-calculated from scale annuli varied significantly among years (69% at annulus I, 76% at annulus II, and 46% at annulus III) for fish from the same populations from Oklahoma reservoirs.

The ages determined by the otolith and scale methods of the white crappies sampled from Table Rock Reservoir were in agreement for 30 of 31 fish aged. This sample was taken from a fast-growing population which was dominated by age-2 fish. Comparisons of the ages determined by the otolith and scale methods need to be made over a wider range of ages and for slow-growing populations to add validity to the otolith method for aging white crappies.

Discussion

Techniques used in compiling data for the routine management of our fishery resources must be time- and cost-efficient and produce reliable data. Determinations of age and growth for white crappie using the otolith method are easily obtainable and precise. Once field personnel become proficient in extracting the otoliths, each fish can be measured and weighed and otoliths removed in approximately 1 min. Because whole otoliths can be aged, no elaborate preparations are needed, and samples can be processed quickly.

Beamish (1979) stated that sectioned otoliths were preferable to whole otoliths when aging older fish. Schramm and Doezbacher (1985) found the number of annuli to be identical in whole and sectioned otoliths of black crappies up to age 7. Sagittae of crappies are relatively flat and thin, which aids in distinguishing annuli in unsectioned otoliths. Furthermore, white crappies are relatively short lived (6–8 years), therefore otolith calcification is less of a problem in these fish than in longer-lived species. Although whole otoliths give reliable age estimates for white crappie, accurate age determinations of other species may require sectioning at least a subsample of the otoliths collected.

Age and growth analyses of samples collected during routine management surveys of Oklahoma's reservoirs were discontinued due to the inconsistency of the scale method (Wigtil 1984). As a result, valuable information on previous growth histories of the state's primary fishes were unavailable. The otolith method gives the reservoir manager a reliable means of determining the age structure and growth rates of white crappie populations—information that helps in the selection and evaluation of various management strategies.

The need to sacrifice the fish to extract the otoliths may be one drawback to this method. However, any significant impact on the population can be avoided by subsampling at given length intervals.

References

Beamish, R. J. 1979. Differences in the age of Pacific hake (*Merluccius productus*) using whole otoliths and sections of otoliths. Journal of the Fisheries Research Board of Canada 36:141–151.

Beamish, R. J., and D. A. Fournier. 1981. A method for comparing the precision of a set of age determinations. Canadian Journal of Fisheries and Aquatic Sciences 38:982–983.

Chang, W. Y. B. 1982. A statistical method for evaluating the reproducibility of age determination. Canadian Journal of Fisheries and Aquatic Sciences 39:1208–1210.

Erickson, C. M. 1983. Age determination of Manitoban walleyes using otoliths, dorsal spines, and scales. North American Journal of Fisheries Management 3:176–181.

Jonsson, B., and N. C. Stenseth. 1977. A method for estimating fish length from otolith size. Institute of Freshwater Research Drottningholm Report 56:81–86.

Lagler, K. 1956. Freshwater fishery biology. William C. Brown, Dubuque, Iowa.

Schramm, H. L., Jr., and J. F. Doerzbacher. 1985. Use of otoliths to age black crappie from Florida. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies, 36:95–105.

Sokal, R. R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman, San Francisco.

Stahl, J. 1981. Oklahoma fisheries management program. Oklahoma Department of Wildlife Conservation, Federal Aid in Fish Restoration Project F-38-R-4, Job 1, Norman.

Wigtil, G. W. 1984. The consistency of age and growth analyses in Oklahoma. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 35:579–584.

Williams, T., and B. C. Bedford. 1974. The use of otoliths for age determination. Pages 114–123 *in* T. B. Bagenal, editor. Aging of fish. Unwin Brothers, Old Woking, England.