LACK OF CONSISTENCY OF AGE AND GROWTH ANALYSES IN OKLAHOMA

GREGORY W. WIGTIL, Oklahoma Department of Wildlife Conservation, Norman, OK 73069

Abstract: Age and growth data pertaining to particular year-classes of largemouth bass (*Micropterus salmoides*), white crappie (*Pomoxis annularis*), bluegill sunfish (*Lepomis macrochirus*), white bass (*Morone chrysops*), gizzard shad (*Dorosoma cepedianum*), blue catfish (*Ictalurus furcatus*), and channel catfish (*I. punctatus*) from particular Oklahoma impoundments were tested for consistency of back-calculations at particular annulus formations among sampling years. A compilation of the results showed that there were significant differences ($\alpha = 0.10$), among what should have represented the same populations of scaly fish 69, 76, and 46% of the time for backcalculations at annulus I, annulus II, and annulus III, respectively. Significant differences among catfish data occurred 59 and 38% of the time at annulus I and annulus II, respectively.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 35:579-584

The Oklahoma Department of Wildlife Conservation has been routinely using age and growth analysis as part of its annual Standardized Sampling Procedures (SSP) since 1977. Most of the scales and spines involved in the analyses have been read at the Oklahoma Fishery Research Laboratory (OFRL) in Norman, although some, including those collected during 1980, were read by regional management personnel. Before the regional personnel began reading scales and spines, there was concern among regional biologists that newly introduced fish species stocked as young-of-the-year were sometimes determined by scale or spine analysis to be older than possible. Also, in July 1979, 36 scales were randomly selected from 1978 SSP samples and were independently read by 5 experienced scale readers at the OFRL (Mense, OFRL, personal communication). These personnel knew nothing about the scales, except that they were from largemouth bass. One of the scale readers had previously read the scales in 1978. The readers could only reach a 61% agreement as to the ages of the fish. Even the individual who had read the scales twice, had only a 62% agreement in age between his 1st and 2nd readings. In terms of size differences among the different presumed age groups, the individual who had read the scales twice showed very consistent results. In general, however, growth variation as determined by the scale readers was great.

A review of the literature showed that among the many papers pertaining to age and growth, there were few concerning the validity of the technique, and most of those publications concerned fish from waters north of Oklahoma, where growing seasons are considerable shorter. Some of these authors were of the opinion that scale and/or fin-ray analysis by experienced readers with good equipment was generally a good technique (Alvord 1953, Cable 1956, Judy 1961, Regier 1962, Johnson 1971), although Alvord (1953) had problems aging trout over 2 years old, the Regier (1962) had uncertainties concerning back-calculated lengths of 4 of 24 populations of bluegill from New York. Others had more serious reservations. Sych

(1971) found frequent underaging of Swedish coregonids, while Mills and Beamish (1980) considered scale aging to be unacceptable for lightly or unexploited Canadian populations of lake whitefish.

Scale analysis of fish from warmer waters has also been tested. Annuli were deemed to be poor indicators of age in *Hilsa,* a clupeid from India (Sundara Raj 1951). In Alabama, 76% of known-age bluegill (1 age I, 201 age II, 62 age III) and 80% of known-age largemouth bass (13 age 0, 238 age I, 21 age II) were correctly aged by an experienced scale reader (Prather 1966). While the ages of the fish were unknown at the time of reading, the ranges of possible ages were known. In 1981, only 90% of 115 scale samples taken from known age I largemouth bass which were mixed with a large group of unknown age largemouth bass scales from 2 Oklahoma impoundments were aged correctly by an experienced scale reader at the OFRL (Boxrucker, OFRL, personal communication).

These situations prompted the present study in which one of the underlying assumptions of age and growth analysis was tested. The assumption is that fish from the same impoundment, species, and year-class should represent 1 population, regardless of sampling year.

METHODS

For each year-class of a particular species from a particular impoundment which met the conditions listed below, a Kruskal-Wallis test (Marascuilo and McSweeney 1977) was used to determine whether backcalculated lengths at particular annulus formations varied significantly ($\alpha = 0.10$) among sampling years. These data had previously been collected from 1977 through 1980 as part of the SSP program. Several different scale/spine readers, who had been taught to use the same scale and spine reading techniques, were employed throughout these years. Only data pertaining to largemouth bass, white crappie, bluegill sunfish, white bass, gizzard shad, blue catfish, and channel catfish were used. Scales from individual fish were taken either from the side of the fish near the tip of the pectoral fin (ctenoid scales) or from an area between the dorsal fin and the lateral line (cycloid scales). Generally, pectoral spines were used for catfish spine analysis, although dorsal spines were also used. Scales and spines were collected during both the spring and the fall of the sampling years. Also, if there were fewer than 10 backcalculated lengths attributed to a given impoundment, species, year-class, sampling year, and annulus formation, those data were eliminated from further study. All tests were run on the IBM 370/158 owned by the University of Oklahoma at Norman.

RESULTS

Because of the relatively small numbers of tests involving white crappie, bluegill, white bass, gizzard shad, blue catfish, and channel catfish, the results of those tests were lumped together as either "Other scaly fish" or "Total catfish" (Table 1). The results of the largemouth bass tests are presented separately. There were totals of 101, 68, and 26 year-classes of different species of scaly fish which were tested for consistency of backcalculated lengths among sampling years at annulus I, annulus II, and annulus III, respectively. The proportions of significant tests for scaly fish ranged from 33% for backcalculated lengths at annulus III of scaly fish other than largemouth bass to 81% for backcalculated lengths at annulus II of scaly fish other than largemouth bass. For catfish, of 17 tests concerning backcalculated lengths at annulus I, 10 tests (59%) demonstrated significant differences among the sampling years. Three of 8 tests (38%) concerning backcalculated lengths at annulus II showed significant differences.

Table 1. Results of Kruskal-Wallis tests of backcalculated lengths at various annulus formations among sampling years.

Type of fish	Backcalculated lengths at annulus I		Backcalculated lengths at annulus II		Backcalculated lengths at annulus III	
	No. of tests	No. of significant tests	No. of tests	No. of significant tests	No. of tests	No. of significant tests
Largemouth bass	55	35 (64%)	37	27 (73%)	17	9 (53%)
Other scaly fish	46	35 (76%)	31	25 (81%)	9	3 (33%)
Total scaly fish	101	70 (69%)	68	52 (76%)	26	12 (46%)
Total catfish	17	10 (59%)	8	3 (38%)		

Table 2 gives information similar to that of Table 1, except the results are divided according to the estimated ages of the oldest fish involved in each test. Also, the results of all tests involving scaly fish are grouped together. The percentage of significant tests ranged from 25% for tests of backcalculated lengths at annulus II for catfish with a maximum estimated age of 4 to 100% for 5 of 6 categories of tests of fish whose maximum estimated age was 6.

Table 2. Significant tests of backcalculated lengths at various annulus formations among sampling years, arranged by the estimated ages of the oldest fish involved in each test.

Type of fish	Annulus formation	Significant tests by estimated age of the oldest fish involved in each test				
		II	III	IV	V	VI
Scaly	I	50% (22)[a]	75% (36)	72% (29)	67% (9)	100% (5)
	II		81% (26)	68% (28)	78% (9)	100% (5)
	III			53% (15)	50% (6)	50% (4)
Catfish	I		60% (5)	57% (7)	50% (4)	100% (1)
	II			25% (4)	33% (3)	100% (1)

[a] Number of significnt tests.

DISCUSSION

In general, neither scale nor spine analysis was very consistent among sampling years. Of all the tests involving scaly fish, 69, 76, and 46% indicated that the backcalculated lengths at annulus I, annulus II, and annulus III, respectively, varied significantly among what should have been samples of the same populations sampled during different years. While an argument may be made that spine analysis was more consistent in Oklahoma than scale analysis, the results of the Kruskal-Wallis tests show that consistency was still poor. These differences were not due to Lee's phenomenon, "the observation that fish captured at older ages are increasingly those for which computed growth in earlier years was slow" (Ricker 1978). The significant Kruskal-Wallis tests showed that in only 44, 48, and 42% of the tests concerning annulus I, II, and III, respectively, did the collections from early years of a particular year-class of scaly fish show larger backcalculated lengths than fish collected in later years. Similarly, in only 2 each of the tests of catfish year-classes at annulus I and II (20 and 67% respectively)did fish of early collections show larger backcalculated lengths than fish from later collections. Furthermore, while some believe that age and growth analysis works better for young fish than for older fish (Alvord 1953, Johnson 1971), Table 2 shows that scale and spine analysis in Oklahoma was inconsistent regardless of the presumed age of the fish.

In addition to the poor consistency of scale and spine analysis among sampling years, there are cases of apparent differences among years which have turned out to be statistically nonsignificant. For example, when sampled in 1979, the presumed 1975 year-class of largemouth bass from Fort Supply Reservoir, Oklahoma, had a mean backcalculated length at annulus I of 99 mm (n = 11), while what was considered to be the same year-class sampled in 1980 had a mean backcalculated length at annulus I of 120 mm (n = 11). These 2 sets of data were not statisticallly different at $\alpha = 0.10$. This is also likely to happen when comparing backcalculations at given annulus formations among different year-classes, not just among sampling years of the same year-class. Since biologists often use mean backcalculated lengths without the benefit of statistical analysis, it would be possible to find an apparent, though statistically unreal, difference among year-classes. This situation could lead to inappropriate management decisions.

Judging from the results of the Kruskal-Wallis tests, neither scale nor spine analysis appears to be suited to routine fisheries work in climatic areas similar to Oklahoma. While these tests did not measure the accuracy of the techniques, they did show that past SSP scale and spine analyses have been inconsistent from 1 year to the next. Many of these inconsistencies may be explained by the fact that physical characteristics often vary widely among individuals of the same population. Some members of a population form true annuli during a given year, while others do not (Surber 1937, Regier 1959, Frost and Kipling 1961, Muncy 1965). Likewise, some members of a population may form false annuli during a given year, while others do not (Cross 1951, Berry 1957, Magnuson and Smith 1963, Muncy 1965). Physical characteristics also have been reported to vary among individual scales from the same fish. Both Blair (1942) and Al-Rawi (1971) found false annuli to be present on some but not all scales of individual fish. Therefore, it is probable that many of the inconsistencies among scale and spine data in Oklahoma were due to biological variations, prior knowledge of which could not have been provided to the scale reader.

LITERATURE CITED

Al-Rawi, T. R. 1971. Investigating the validity of the scale method in determining the growth of two species of fish in Oklahoma and its relation to temperature and water level. *From* K. D. Carlander, ed. 1977. Handbook of freshwater fishery biology, volume two. Iowa State Univ. Press, Ames. 431pp. Original not seen.

Alvord, W. 1953. Validity of age determinations from scales of brown trout, rainbow trout, and brook trout. Trans. Am. Fish. Soc. 83:91-103.

Berry, F. H. 1957. Age and growth of the gizzard shad in Lake Newman, Florida. Proc. Ann. Conf. S.E. Assoc. Game and Fish Comm. 11:318-32.

Blair, A. A. 1942. Regeneration of scales of Atlantic salmon. *In* K. D. Carlander, ed. 1969. Handbook of freshwater fishery biology, volume one. Iowa State Univ. Press., Ames. 752pp. Original not seen.

Cable, L. E. 1956. Validity of age determination from scales, and growth of marked Lake Michigan lake trout. USDI Fish and Wildl. Serv., Fish. Bull. 107. 59pp.

Cross, F. B. 1951. Early limnological and fish population conditions of Canton Reservoir, Oklahoma, with special reference to carp, channel catfish, largemouth bass, green sunfish and bluegill, and fishery management. *In* K. D. Carlander, ed. 1969. Handbook of freshwater fishery biology, volume one. Iowa State Univ. Press, Ames. 752pp. Original not seen.

Frost, W. E., and C. Kipling. 1961. Some observations on the growth of pike, *Esox lucius,* in Windermere, *in* K. D. Carlander, ed. 1969. Handbook of freshwater fishery biology, volume one. Iowa State Univ. Press, Ames. 752pp. Original not seen.

Johnson, L. D. 1971. Growth of known-age muskellunge in Wisconsin and validation of age and growth determination methods. Wisc. Dept. Nat. Resour., Tech. Bull. 49. 24pp.

Judy, M. H. 1961. Validity of age determination from scales of marked American shad. USDI Fish and Wildl. Serv., Fish. Bull. 185, Vol. 61. 9pp.

Magnuson, J. J., and L. L. Smith, Jr. 1963. Some phases of the life history of the trout-perch. Ecology 44:83-95.

Marascuilo, L. A., and M. McSweeney. 1977. Nonparametric and distribution-free methods for the social sciences. Brooks/Cole Publ. Co., Monterey, Calif. 556pp.

Mills, K. H., and R. J. Beamish. 1980. Comparison of fin-ray and scale age determinations for lake whitefish (*Coregonus clupeaformis*) and their implications for estimates of growth and annual survival. Can. J. Fish. and Aquat. Sci. 37:534-544.

Muncy, R. J. 1965. Aging and growth of largemouth bass, bluegill and redear sunfish from Louisianna ponds of known stocking history. Proc. Ann. Conf. S.E. Assoc. Game and Fish Comm. 19:343-349.

Regier, H. A. 1959. An evaluation of the scale method for age and growth determination of bluegills in New York farm ponds, M.S. thesis. Cornell Univ., Ithica, N.Y. 140pp.

___________. 1962. Validation of the scale method for estimating age and growth of bluegills. Trans. Am. Fish. Soc. 91:362-374.

Ricker, W. E. 1978. The historical development. Pages 1-26 *in* J. A. Gulland, ed. Fish population dynamics. John Wiley and Sons, New York.

Prather, E. E. 1966. A note on the accuracy of the scale method in determining the ages of largemouth bass and bluegill from Alabama waters. Proc. Ann. Conf. S.E. Assoc. Game and Fish Comm. 20:483-486.

Sundara Raj, B. 1951. Are scales an index to the age and growth of Hilsa? Proc. Nat. Inst. Sci. India 27:1-6.

Surber, E. W. 1937. Rainbow trout and bottom fauna production in one mile of stream. *In* K. D. Carlander. 1969. Handbook of freshwater fishery biology, volume one. Iowa State Univ. Press, Ames. 752pp. Original not seen.
Sych, R. 1971. Some considerations on the theory of age determination of fish from their scales - finding proofs of reliability. European Inland Fish. Advisory Comm., Tech. Paper 13. 68pp.