# Use of Otoliths to Age Black Crappie from Florida[1]

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*Abstract:* The scale method and length-frequency analysis were not adequate for accurately aging and measuring growth rate of black crappie (*Pomoxis nigromaculatus*) collected in Florida. Black crappie otoliths (sagittae) showed clearly recognizable bands in whole view, suggesting possible use of otoliths to age black crappie. Otoliths satisfied necessary criteria for validating aging structures: growth was proportional to black crappie growth, annuli formed in the spring, and back-calculated lengths agreed with lengths for age-classes estimated from length-frequency analysis. We consider otoliths useful for accurately aging black crappie in Florida.

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Measures of growth rate, mortality rate, and age-size structure of fish populations are used by fisheries scientists to describe and compare populations and to develop and evaluate management plans. Determination of these statistics requires accurate age data for the fish.

Two commonly employed methods for aging centrarchid populations are annual marks on scales and analysis of length-frequency data. We encountered several problems attempting to age black crappie (*Pomoxis nigromaculatus*) collected from Florida waters by these 2 methds. Corroborating the findings of Huish (1954) and Ager et al. (1974), we observed poorly defined annual marks on scales from Florida black crappie. Length-frequencies have been used to delimit year-classes of black crappie in Lake Okeechobee, Florida (Ager et al. 1978, 1979, 1980; Schramm et al. 1982); however, variations in growth of black crappie within and between year-classes do not provide accurate age-size distributions and central tendencies necessary for precise measurements of growth rate and mortality rate.

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Otoliths are commonly used to age marine fish and, in most cases, are considered more suitable than scales (Williams and Bedford 1974). Various authors have successfully used otoliths to age fish from tropical and subtropical waters (e.g., Volpe 1959; McErlean 1963; Moe 1969; Bruger 1974; Warburton 1978; Fagade 1980; Coleman, pers. commun.).

Black crappie otoliths (specifically sagittae) had clearly visible bands present in patterns expected for annual marks. The purpose of our research was to validate the use of otoliths for age and growth determinations.

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## Methods

Otoliths and scale samples were removed from black crappie collected in Newnans Lake (Alachua County, Florida) during September 1981–July 1982, and in Lake Okeechobee (Galdes, Hendry, Highlands, Martin and Okeechobee Counties, Florida) during October 1981 and April and June 1982. Otolith measurements were available for black crappie collected from Lake Baldwin (Orange County, Florida) during January–July 1982 (M. J. Maceina and J. V. Shireman, unpubl. data).

Whole otoliths and longitudinal and transverse cross sections of otoliths were examined. The cross sections of otoliths were prepared by breaking the otolith at the kernel along the anterior-posterior axis (longitudinal section) or the dorso-ventral axis (transverse section) (Fig. 1). The otolith halves were mounted on a glass microslide with thermoplastic cement and ground to a 1–2 mm thickness with number 400 Carborundum wet-dry sandpaper. Whole otoliths and cross sections were submersed in water in a black-bottomed dish, illuminated with reflected light, and viewed with a dissecting microscope at 10–20× magnification.

Black crappie have relatively thin otoliths. Whole otoliths viewed at 10–20× magnification clearly showed alternating opaque (white) and hyaline (gray) bands. Beamish (1979) found Pacific hake (*Merluccius productus*) could be aged with whole otoliths, but accurate ages of individuals with thickened otoliths could only be determined by viewing cross sections. To determine whether it was necessary to examine cross sections of black crappie otoliths we compared cross sections and whole otoliths from black crap-

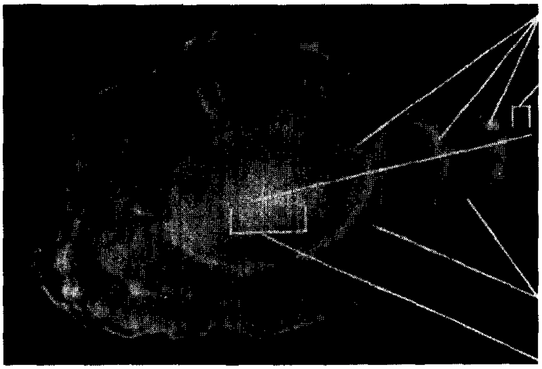


**Figure 1.** Right otolith of black crappie.

pie collected from Newnans Lake. Because older fish had thicker otoliths, and would therefore be more likely to have bands masked in whole view, we compared all otoliths from fish showing 4 or more opaque bands (5 with 7 bands, 2 with 6 bands, 1 with 5 bands, and 11 with 4 bands), plus a random subsample of otoliths showing 3 or fewer opaque bands (7 with 3 bands, 6 with 2 bands, and 1 with 1 band). The same number of opaque bands were visible in cross section and whole view for 32 fish; one cross section was not readable. Because the number of bands were identical in whole and sectioned otoliths, whole otoliths were used to expedite our analyses.

Otolith radius was measured from the center of the kernel to the anterior tip of the otolith (Fig. 1). Distance to each opaque band was measured along the radius from the center of the kernel to the distal margin of the opaque band. Marginal increment was measured along the radius from the distal margin of the outermost opaque band to the otolith margin. All distances were measured with an ocular micrometer at 10× magnification.

Based on Van Oosten's (1929) criteria for validating marks on scales to age fish, 4 conditions must be satisfied to use otoliths to age black crappie:

1. the otoliths must remain constant in number and identity throughout the life of the fish,
2. growth of the otoliths must be proportional to growth of the fish,
3. the annulus must be formed yearly and at the same approximate time each year, and
4. body lengths calculated from prior annuli must agree with empirical lengths of young age groups.

To determine if otolith growth was proportional to fish growth, we evaluated the relationship between otolith radius and fish total length.

To determine if the opaque bands formed yearly and during a brief period of time, we compared changes in marginal increment over time.

Quarterly length-frequency data were available from the Florida Game and Fresh Water Fish Commission for Lake Okeechobee black crappie. Each quarterly sample was collected with an otter trawl (12.2-m spread, 63-mm square mesh in wings and throat, 25-mm square mesh bag) and included approximately 500 black crappie. These length frequencies were used by Schramm et al. (1982) to delineate age-classes for estimation of growth rates. These analyses provided estimated total lengths for age classes of black crappie that we compared with total lengths back-calculated from otolith measurements from a subsample of Lake Okeechobee black crappie collected with the same trawl during October 1981. Total lengths were back-calculated by the Fraser-Lee method (Bagenal and Tesch 1978):

$$TL_n = \frac{OR_n}{OR} (TL\text{-}c) + c; \qquad (1)$$

where $TL_n$ = total length of the fish when annulus (opaque band) 'n' was formed,
$TL$ = total length of the fish when the otolith was obtained,
$OR_n$ = distance from the kernel to annulus (opaque band) 'n',
$OR$ = total otolith radius, and
$c$ = the intercept value from the regression equation

$$TL = c + b(OR). \qquad (2)$$

## Results

Otoliths were found in all black crappie sampled and showed easily recognizable opaque bands in whole view. A total of 789 otoliths were examined. The number of opaque bands ranged from 0 to 7. Our independent counts of opaque bands agreed for all otoliths.

The relationships between otolith radius (OR) and black crappie total length (TL) were evaluated for 184 black crappie from Lake Okeechobee and 142 black crappie from Newnans Lake. Otolith radius was linearly and significantly ($P < 0.001$) related to total length for fish from both lakes. The regression equation for Lake Okeechobee black crappie was

$$TL = -18.36 + 56.90\ (OR);\ R^2 = 0.94. \qquad (3)$$

The regression equation for Newnans Lake black crappie was

$$TL = -45.58 + 62.54\ (OR);\ R^2 = 0.97. \qquad (4)$$

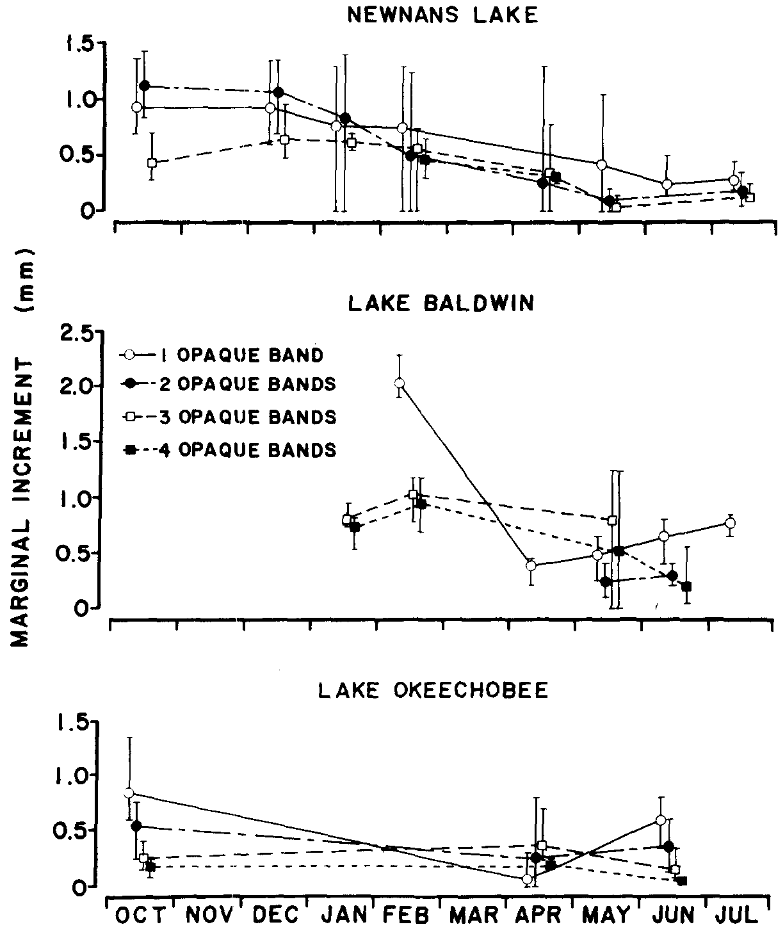


**Figure 2.** Temporal changes in otolith mean marginal increment for black crappie collected from Newnans Lake, Lake Baldwin, and Lake Okeechobee, Florida. Vertical lines represent range.

Otolith marginal increments were measured for 429, 228 and 275 black crappie from Newnans Lake, Lake Baldwin and Lake Okeechobee, respectively. Decreased mean marginal increment and otoliths with zero marginal increments (Fig. 2) indicated new opaque bands were formed on otoliths of these black crappie during spring. As evidenced by wide ranges of marginal increments in the spring, not all black crappie formed new opaque bands on their otoliths at the same time. In the April sample from Newnans Lake, 71%, 50% and 0% of the black crappie otoliths with 2, 3 and 4 opaque

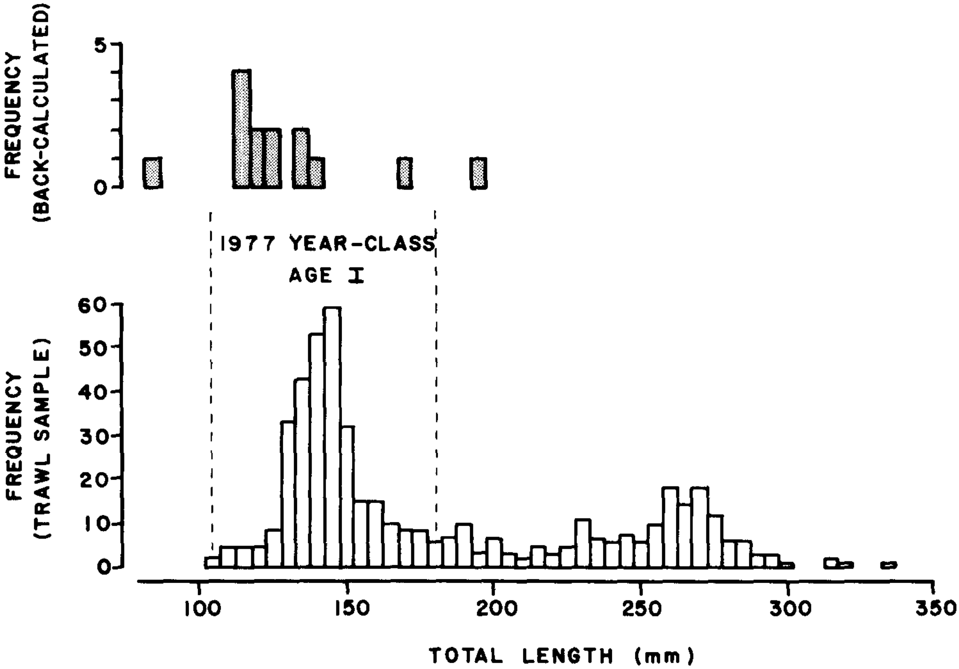


**Figure 3.** Length frequency of black crappie collected by trawl from Lake Okeechobee during April 1978 and back-calculated total lengths at first opaque band formation determined from black crappie with four opaque bands on their otoliths in October 1981.

bands, respectively, had recently formed new bands. Two black crappie with 1 band on the otoliths were collected; both fish had recently formed the opaque band. In the May sample from Newnans Lake, 61%, 100%, 100% and 0% of the black crappie otoliths with 1, 2, 3 and 4 opaque bands, respectively, had recently formed new bands. By June, all otoliths collected from Newnans Lake black crappie had recently formed a new opaque band.

In Lake Baldwin, all black crappie with 1 opaque band on the otolith had formed a new band by late April. Black crappie with 2 opaque bands on the otoliths were first collected during May; all had recently formed opaque bands. Of fish with 3 and 4 opaque bands, 25% and 56%, respectively, had formed a new opaque band by May. All fish with 4 bands on the otoliths had recently formed an opaque band on their otoliths by June.

In Lake Okeechobee, 100%, 59%, 67% and 0% of the black crappie with 1, 2, 3 and 4 opaque bands, respectively, collected in the April sample had recently formed bands. By June, all fish sampled had recently formed a new opaque band on the otoliths.

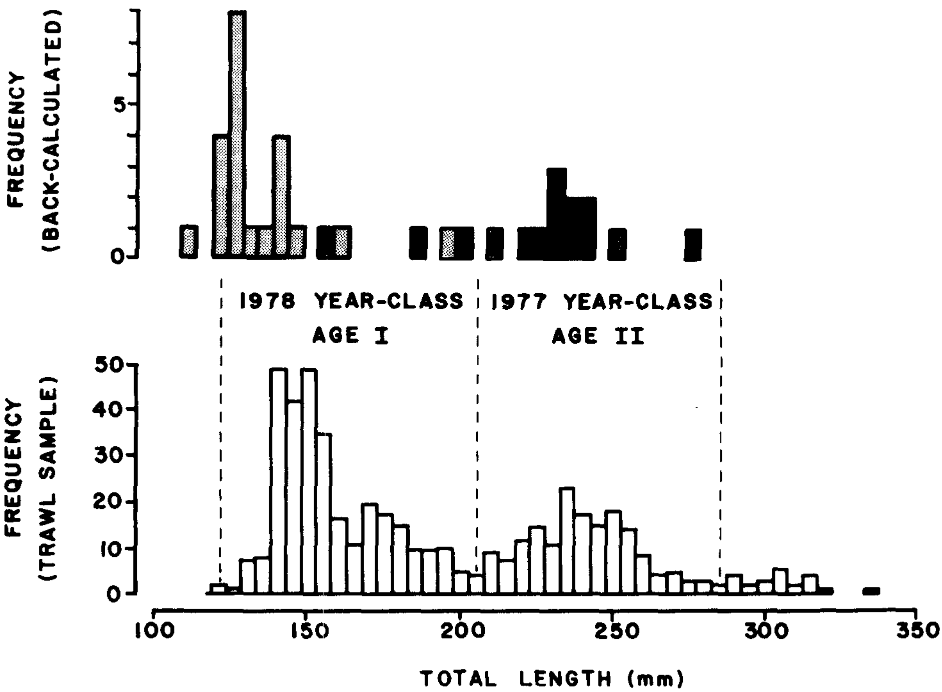


**Figure 4.** Length-frequency of black crappie collected by trawl from Lake Okeechobee during April 1979, back-calculated total lengths at the first opaque band formation determined from black crappie with three opaque bands on their otoliths in October 1981 (light stipple), and back-calculated total lengths at the second opaque band formation determined from black crappie with four opaque bands on their otoliths in October 1981 (dark stipple).

Total lengths at time of opaque band formation were back-calculated for black crappie collected in Lake Okeechobee during October 1981 and compared to length-frequency data for April, 1978–1981. From Equations 1 and 3 total lengths were back-calculated by:

$$TL_n = \frac{OR_n}{OR}(TL + 18.4) - 18.4. \qquad (5)$$

The total lengths back-calculated for the first and second opaque bands from fish sampled in October 1981 with 4 opaque bands on their otoliths (assumed to be 1977-year-class) corresponded well with the total lengths of 1977-year-class fish aged I (Fig. 3) and aged II (Fig. 4) by length-frequency analysis. The total lengths back-calculated for fish with 3 opaque bands on the otoliths (assumed to be 1978-year-class) corresponded exactly with the

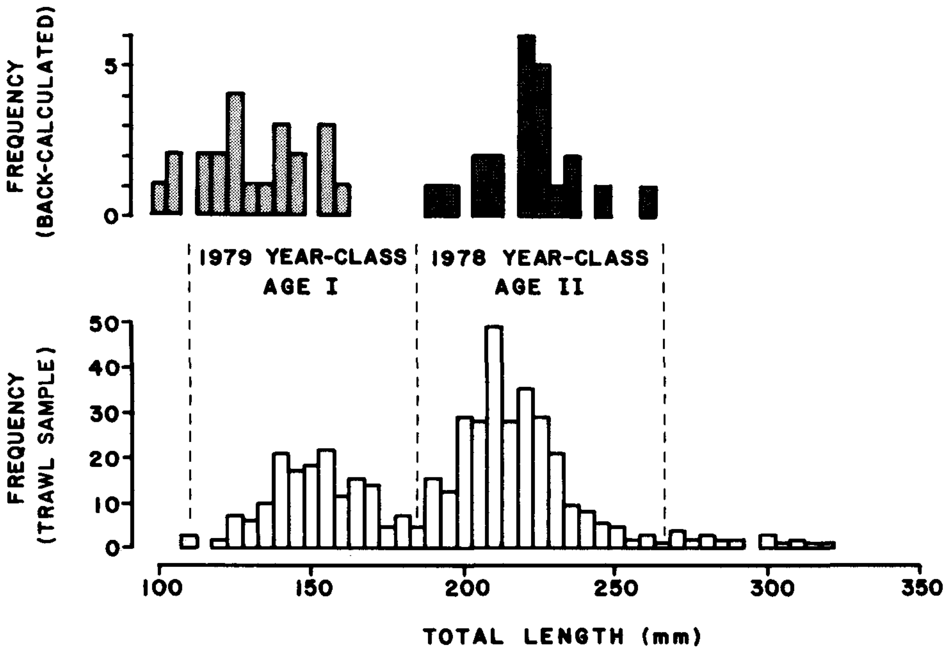


**Figure 5.** Length-frequency of black crappie collected by trawl from Lake Okeechobee during April 1980, back-calculated total lengths at the first opaque band formation determined from black crappie with two opaque bands on their otoliths in October 1981 (light stipple), and back-calculated total lengths at the second opaque band formation determined from black crappie with three opaque bands on their otoliths in October 1981 (dark stipple).

total length ranges of 1978-year-class fish aged I (Fig. 4) and aged II (Fig. 5) by length-frequency analysis. Total lengths back-calculated from the first opaque band for fish with 2 opaque bands on the otoliths in October 1981 (assumed to be 1979-year-class) closely approximated the range of the total lengths for 1979-year-class fish at age I (Fig. 5) and age II (Fig. 6) estimated by length-frequency analysis. The back-calculated total lengths for fish showing 1 opaque band on the otolith in October 1981 were no larger than the maximum total length of age-I 1980-year-class fish estimated by length-frequency analysis (Fig. 6). However, 52% of the back-calculated total lengths were below the minimum size collected by the standard trawl in the April 1981 sample.

We compared the number of opaque bands on otoliths to our best estimate of the age of the fish determined by interpretation of scales. Of 59 com-

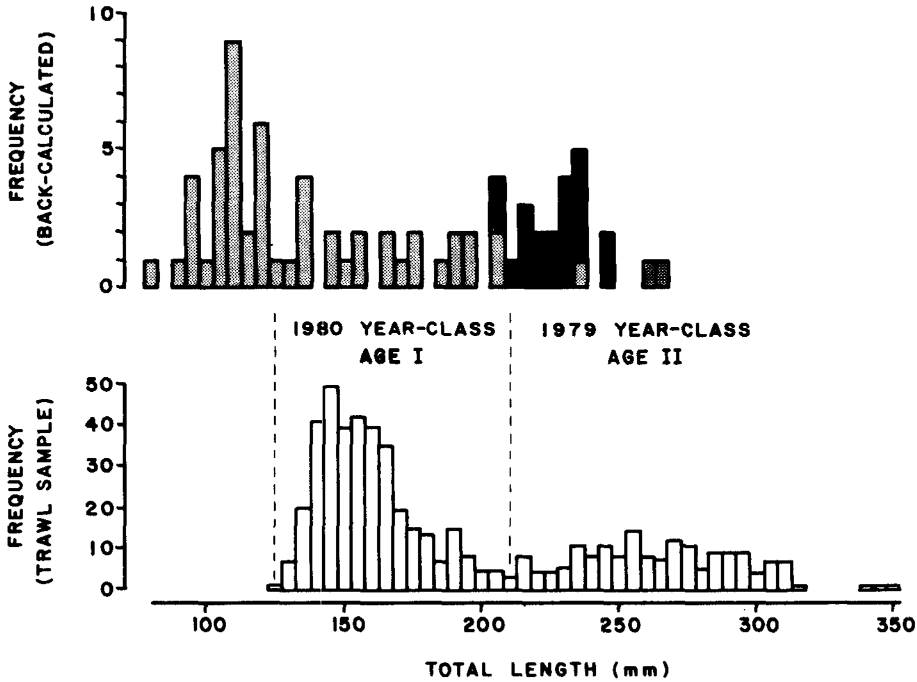


**Figure 6.** Length-frequency of black crappie collected by trawl from Lake Okeechobee during April 1981, back-calculated total lengths at the first opaque band formation determined from black crappie with one opaque band on their otoliths in October 1981 (light stipple), and back-calculated total lengths at the second opaque band formation determined from black crappie with two opaque bands on their otoliths in October 1981 (dark stipple).

parisons for Lake Okeechobee black crappie, the number of opaque bands was the same as the age assigned by reading scales for 35 fish. For 14 fish, the number of opaque bands was greater than the assigned age; 11 fish had fewer opaque bands than the assigned age. Of 34 comparisons for Newnans Lake, the number of opaque bands was the same as the age assigned by reading scales for 25 fish. The number of opaque bands was greater than the assigned age for 6 fish and less than the assigned age for 3 fish.

## Discussion

We consider otoliths to be valid structures for aging black crappie in Florida. The otoliths are present throughout the life of the black crappie. Otoliths from all black crappie sampled showed easily recognizable annual bands. Otolith radius was proportional to the total length of black crappie. The observed changes in marginal increments indicated the opaque bands on black crappie otoliths formed each spring; therefore, we consider them to be annuli. The data from all 3 lakes suggested younger black crappie formed annuli earlier in the spring than the older fish. All otoliths observed had a newly formed band by June.

Back-calculated total lengths of black crappie from Lake Okeechobee very closely overlapped the length ranges for age-I and age-II fish estimated by length-frequency analysis, with the exception of the 1980-year-class. The back-calculated total lengths predicted that a large portion of the 1980-year-class was too small to be collected by the trawl. This finding is supported by the analysis of length frequency data (Figs. 1–36 in Schramm et al. 1982) that indicated the 1980-year-class was abundant and slow-growing. The agreement between back-calculated lengths and length-frequency analysis reinforces our conclusion that otolith growth is proportional to growth of the fish in length and indicates the usefulness of otoliths for estimating growth rate of black crappie.

Ages assigned from otoliths agreed with those assigned from scales for 65% of the comparisons. We consider the ages determined from whole otoliths to be the accurate age of the black crappie. Furthermore, unlike scales, the otolith annuli are easily and clearly distinguishable. This facilitates quick and accurate age determinations and precise measurements necessary for back-calculations. Application of this technique to studies of other black crappie populations will allow further evaluation of the use of otoliths for aging black crappie.

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