Bias from Age-grouping Black Crappie by Length-frequency as Compared to Otolith Aging

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Abstract: Eighteen hundred and thirty-four black crappie (*Pomoxis nigromaculatus*) were collected from the St. Johns River, Florida, in late winter and early spring, 1982 to 1985. Differences in numbers and growth rates of males and females collected were not significant ($P > 0.05$). Fish were separated into age groups using length-frequency distributions and by counting annuli on otoliths. Only 2 distinct age groups were discernible by length-frequency analysis, whereas 6 to 8 groups were identified by otolith aging. Mean lengths of age groups obtained from length-frequency were overestimated 3 of the 4 study years when compared to otolith aging. Length range overlap from otolith aged groups varied from 15.2% to 100% and averaged 69.3%. Year class overlap occurred as early as years 1 and 2 and indicated a bias when relying on length-frequency evaluation alone.

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Length-frequency analysis has been used as a tool by research biologists and fishery managers to age fish cohorts within fish populations for years, and Florida biologists have been no exception (Huish 1953; Ager et al. 1978, 1979, 1980; Crumpton et al. 1979; Schramm et al. 1981). With length-frequency's use so widely accepted by fishery scientists over the years, Barlow's (1984) assumption was justified when he stated that, "as a whole, scientists had assumed that ages could be determined with no error by age-frequency distributions." As late as 1983, Jearld (1983) indicated that even if individual fish could not be aged reliably, population size structure could be analyzed for age grouping by frequency distribution. However, he qualified his statement by saying, "due to overlapping sizes, the usefulness was restricted to no more than 4 years for most populations." These situations may hold true for areas with less temperate climates than Florida. Recent data collected on black crappie from the St. Johns River, Florida, indicated that age grouping by length-frequency may not be accurate at any age due to the amount of size overlap between age groups.

Methods

Black crappie were collected by electrofishing, hoop net, pound net, and trawl from December to April 1982 to 1985. Individual fish were measured [total length (TL) in mm], weighed (g), and sexed based on extrudable sex products and/or by dissection. Since fish were collected during or near peak spawning periods, even gonads of smaller black crappie were easily recognizable.

Pairs of sagittal otoliths were removed from each fish by cutting through the isthmus (at the base of the gills) with bone cutting scissors. The exposed tissue covering the area of the otic capsule was removed and the boney surface, at the mid point of the capsule, was scored with bone cutting scissors. Pressure was equally applied to the head and body, breaking the otic capsule across the scored area. The exposed otoliths were removed with forceps, dried and stored in labeled coin envelopes.

Ages were determined in 1982 first by counting annuli on whole otoliths submerged in water with the aid of a sub-illuminated dissecting microscope (7X to 40X), and then by counting annuli on transverse sections of the same otoliths under a sub-illuminated compound microscope (25X to 400X). A drop of water or emersion oil was added to the section to clarify the annuli.

Transverse sections were derived by breaking an otolith, dorso-ventrally, across the nucleus. The anterior section, held by plastic locking forceps, was ground and polished on the nucleus side using Fine-120 adhesive sanding discs mounted on a 1/15 hp electric motor controlled by a variable speed foot-operated pedal. The section was then mounted to a glass slide, nucleus side down, with thermoplastic cement and ground on the sanding disc to a thickness of 1 to 2 mm.

Age determinations from whole otoliths and transverse sections were 100% in agreement in 235 black crappie from the St. Johns River, Florida, and 100 black crappie from Lake Okeechobee, Florida, in 1982. As a result, ages were determined only from whole otoliths during 1983 to 1985.

Sex ratios were determined from black crappie collected. Student's t-tests were conducted to determine if differences in numbers and sizes between sexes were significant.

Results

Eighteen hundred and thirty-four black crappie ranging from 63 to 368 mm TL, were collected from the St. Johns River and associated lakes in Florida from 1982 to 1985. The study encompassed an area from Lake Harney, downstream (north) to Doctor's Lake near Jacksonville, a distance of approximately 240 km.

Differences in numbers of males and females during each of the four study years were not significant ($P > 0.05$). The authors were concerned that if growth differentials in males and females occurred in black crappie, as they did in largemouth bass (Crumpton and Smith 1975), a sex related bias in size overlap among age groups would be possible. However, there was no significant difference in growth between males and females ($P > 0.05$), so there was no sex related bias.

Two age groups were discernible with confidence by length-frequency evaluation each of the 4 study years (Fig. 1), while 6 to 8 age groups were discernible by otolith evaluation.

When comparing mean lengths of black crappie grouped by frequency distribution and otolith aging, mean lengths were overestimated by length-frequency for age I (9.5 mm) and age II (30.2 mm) in 1982. Means were virtually the same for age I and overestimated for age II (24.6 mm) in 1983, underestimated for age I (4.8 mm) and age II (10.2 mm) in 1984 and overestimated for age I (6.3 mm) and age II (5.1 mm) in 1985.

While mean differences in length for length-frequency distribution and otolith aged black crappie seemed to be comparable, tests comparing sizes of fish within length-frequency and otolith age groups indicated the contrary. In 1982, differences between sizes of age I black crappie were significant at $P \leqslant 0.01$ and age II at $P \leqslant 0.001$. Differences were significant at $P \leqslant 0.001$ for 1983 age II fish, significant at $P \leqslant 0.05$ for 1984 age I and II fish, and significant at $P \leqslant 0.05$ for 1985 age I fish.

Percentages by number of black crappie in age groups that fell within length ranges of older age groups are illustrated in Table 1. When utilizing length range overlap between age groups generated from otolith aged black crappie (1982 to 1985), an average of 53.7% of all age I fish fell within length ranges of age II fish and older. An average of 51.9% of all age II fish fell within length ranges of age III fish and older, and an average of 72.8% of all age III fish fell within ranges of age IV and older. An average of 74.6% of age IV fish were within length ranges of age V fish and older, an average of 94.0% of age V fish were within ranges of age VI and older, and an average of 68.4% of age VI fish fell within ranges of age VII and older. No percentages were derived between age VII and VIII year fish since only one age VII black crappie was collected in the 1985 sample.

Discussion

Crumpton and Smith (1975) indicated that differences in growth rates (size differences) for female largemouth bass were significantly greater than for males ($P \leqslant 0.001$) when comparing all length groups examined from 15 natural populations in Florida. Differences were not significant ($P > 0.05$) for the black crappie collected from the St. Johns River, Florida, between 1982 and 1985.

Differences in numbers of male and female black crappie were non-significant ($P > 0.05$), and overall sex ratios were identical to those reported by Huish (1953) for black crappie collected from Lake George, Florida, a lake in the St. Johns River system, in 1949 and 1950 (1.3 male: 1.0 female).

The 2 age groups of black crappie discernible by length-frequency distributions from collections during 1982 to 1985 were less than the 4 groups indicated by

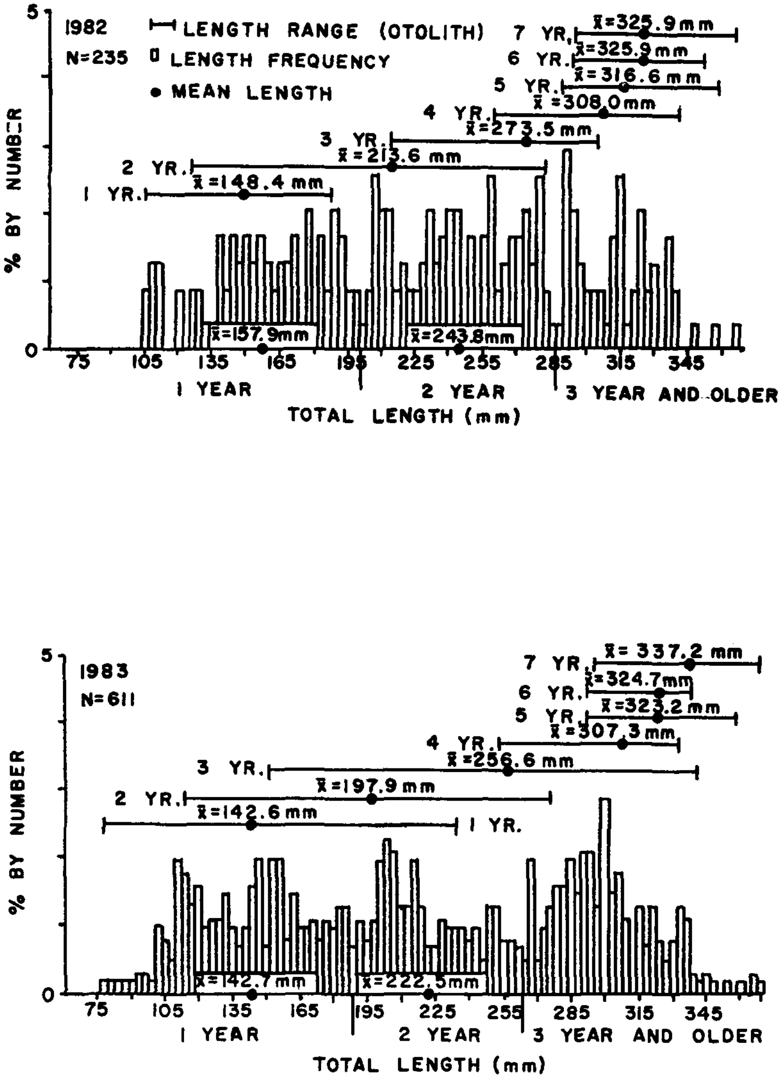

Figure 1. Age groups, length ranges and mean lengths as derived by length-frequency and otolith aging from black crappie from the St. Johns River, Florida, January to March, 1982 to 1985.

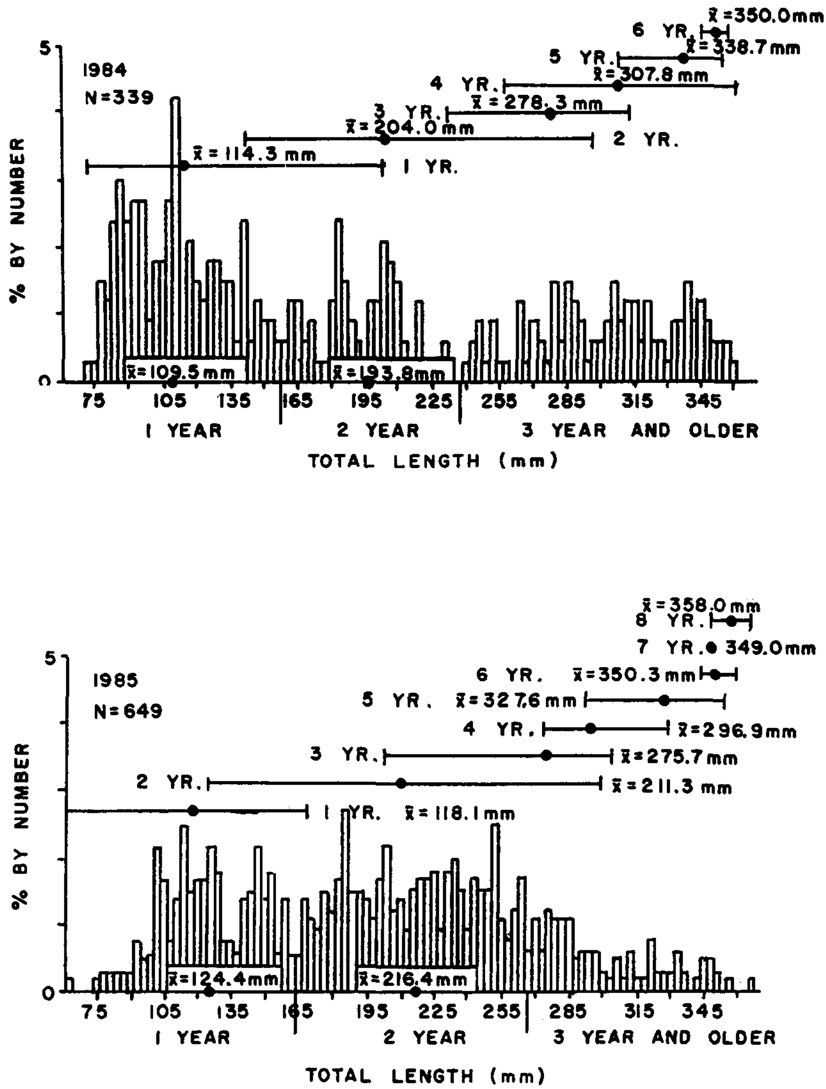

Figure 1, *continued*

Table 1. Percent by number of black crappie in age groups that fell within length ranges of older age groups from the St. Johns River, Florida, 1982 to 1985.

% Fish within length ranges	1982	1983	1984	1985	$\bar{x}$
Age 1 within age 2 or older	82.5%	79.9%	15.2%	37.3%	53.7%
Age 2 within age 3 or older	47.8%	85.6%	17.5%	56.7%	51.9%
Age 3 within age 4 or older	82.2%	58.4%	80.0%	70.6%	72.8%
Age 4 within age 5 or older	91.7%	87.8%	52.0%	66.7%	74.6%
Age 5 within age 6 or older	90.9%	100.0%	100.0%	85.2%	94.0%
Age 6 within age 7 or older	77.8%	94.1%		33.3%	68.4%
Age 7 within age 8				0.0%[a]	0.0%

[a]Only one seven-year-old fish collected.

Jearld (1983), the 3 to 4 age groups indicated by Ager et al. (1978, 1979, 1980) from Lake Okeechobee, Florida, and the 4 age groups shown by Huish (1953) from Lake George, Florida. This "damping" of modal peaks occurs commonly in length-frequency analysis according to Jearld (1983) but normally is not manifested until year group 3 or 4. Such was not the case in this study. It was concluded that this damping occurred between age groups 1 and 2 and was compounded by the effect of multiple crappie spawns which were observed during each year of the study. McNew and Summerfelt (1978) also observed multimodal size distributions in largemouth bass and indicated they were the results of prolonged spawning seasons in their study on Carl Blackwell and Boomer Lakes, Oklahoma.

The lack of ability to confidently assign black crappie to age groups by length-frequency and the percentage of overlap indicated in length ranges resulting from otolith aging make length-frequency a less than desirable technique for age grouping. Year class overlap, occurring as early as age 1 and 2, indicates a potential bias when relying on length-frequency evaluation alone.

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