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Seasonal Variation in Weight-Length Relationships of Largemouth Bass in a 3-Hectare Reservoir[1]

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Lengths and weights of age 0, I, and II largemouth bass were collected during two growing seasons to evaluate seasonal trends in weight-length relationships. Average K(TL) declined significantly between August 1971 and April 1972, but significant growth in length occurred during the interval. In 1972, K(TL) increased from April to July and remained high into November. Condition was better in 1972 than in 1971 when the population density was greater.

Monthly estimates of the coefficient of condition, K(TL), and weight-length regressions were both required to interpret seasonal changes. Weight-length regressions calculated over longer collection periods in which K(TL) changed significantly generally did not represent the populations. Average K(TL) provided meaningful comparisons of condition only when monthly weight-length regressions indicated isometric growth.

INDEX DESCRIPTORS: Largemouth bass, *Micropterus salmoides*, Weight-length relationship, Condition factor.

Most published weight-length relationships for largemouth bass have disregarded seasonal trends. Predictions of weight from length and comparisons of condition between habitats, years, or age groups can be biased if the weight-length relationship changes significantly within a sampling interval. Bennett et al. (1940), Buck and Thoits (1970), and Cooper et al. (1963) reported that largemouth bass condition varied substantially within a growing season, indicating that computations of weight-length regressions or average condition from data pooled over the growing season would not have represented the populations at any single time during the year. This paper reports short-term and annual variations in condition of age 0, I, II largemouth bass collected from a 3-ha Iowa reservoir during two growing seasons and discusses factors influencing interpretation of condition factors and weight-length regressions.

The study was conducted in McFarland Lake (S½ Sec. 7, T84N, R23W), Story County, Iowa. It is a narrow reservoir that exhibited stable thermal and chemical stratification during the summer, when dissolved oxygen was absent below 3.0 m. Mean depth is approximately 2.3 m.

METHODS

In July and August, 1971, and from April through November, 1972, bass were collected from the shoreline with a 230 volt AC boom electroshocking unit. Weights in grams and total lengths in mm were measured and the fish were released after marking. Data from recaptures of bass marked with monel metal jaw tags in 1971 were deleted from further analyses because the tags interfered with growth (VanDenAvyle 1973). Fish were aged by examination of magnified scale impressions.

Coefficients of condition, K(TL), were calculated as 10^5 times the weight in grams divided by total length cubed. Monthly relationships between K(TL) and length of age 0, I, and II bass were evaluated by computing linear least-squares regressions of log weight on log length, where the slope (b) served as a measure of changes in body form versus length. If growth is isometric, (b=3.0), there is no significant change in body form or specific gravity over the length range used in the computation (Carlander 1969).

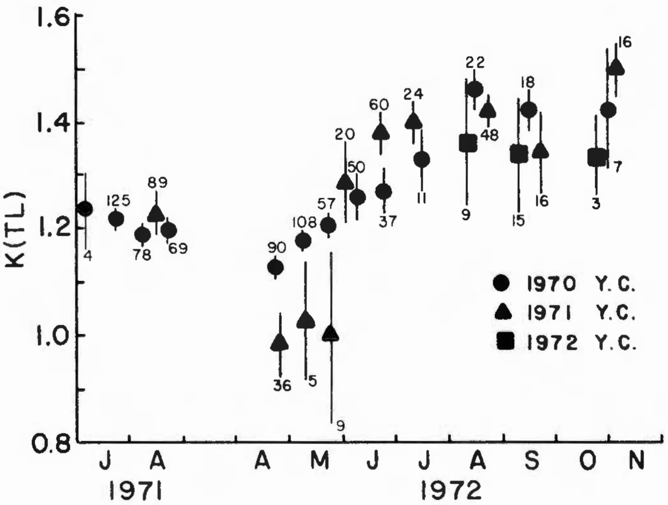

Figure 1. *Mean coefficients of condition, K (TL), for 1970, 1971, and 1972 year-class largemouth bass in McFarland Lake in 1971 and 1972. Vertical bars indicate*±2 sample standard errors and the number of specimens in each sample is indicated.

Some consequences of pooling data over time for each age group were examined by comparing parameters of weight-length regressions computed for seasonal and annual periods with the corresponding monthly values. The term "significant" is used in the paper *only* when a statistical test indicated significance at≤ 0.05.

Seasonal Trends

Average K(TL) declined significantly between August 1971 and April 1972 (Figure 1), however, mean lengths increased significantly during the same period (Table 1). In 1972, average K(TL) for age I and II bass increased from April through July and remained high until November (Figure 1). Although condition apparently improved within

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Table 1. *Log length-log weight regression equations for largemouth bass in McFarland's Lake, by month and age group.*

	Mean total length in mm	Number of fish[1]	a[2]	b[2]	95% confidence intervals for b
Age 0					
Aug. 1971	94	89	−5.934	3.516*	3.184-3.849
Aug. 1972	100	8	−5.678	3.406	2.877-3.936
Sept. 1972	121	15	−5.995	3.537	2.336-4.738
Nov. 1972	130	3	−6.578	3.783	−5.83-13.40
Age I					
April 1972	116	40	−6.077	3.516	2.848-4.185
May 1972	115	14	−4.722	2.869	2.135-3.604
June 1972	128	81	−5.611	3.350*	3.042-3.658
July 1971	157	129	−5.131	3.099	2.935-3.262
July 1972	145	24	−5.602	3.346	2.944-3.747
Aug. 1971	173	145	−5.193	3.120	2.974-3.267
Aug. 1972	176	45	−4.391	2.796	2.101-3.490
Sept. 1972	200	16	−4.210	2.711	1.761-3.660
Oct. 1972	192	4	−4.108	2.683	0.625-4.742
Nov. 1972	210	15	−4.417	2.824	2.161-3.488
Age II					
April 1972	201	91	−5.917	3.420*	3.192-3.647
May 1972	199	163	−5.562	3.277*	3.124-3.429
June 1972	199	87	−5.437	3.234	2.894-3.574
July 1972	217	11	−4.121	2.675	1.729-3.622
Aug. 1972	235	22	−6.276	3.607*	3.165-4.050
Sept. 1972	248	18	−3.975	2.634	2.203-3.066
Oct. - Nov. 1972	277	7	−3.202	2.318	0.389-4.247

[1] In some cases, the number of fish to determine mean length was greater than the number, given here, used to determine the regression equation.
[2] Log weight = a + b log total length.
* Using base 10 logarithms, b value differs from 3.0 at the 95% confidence level.

this period, direct comparisons of K(TL) over time may be erroneous because average lengths also increased (Table 1). Condition factors from fish of different lengths should not be compared except with isometric growth (LeCren 1951).

Age-specific weight-length regressions were calculated for monthly collections in 1971 and 1972 to determine if growth was isometric throughout the study (Table 1). Five of the 22 regressions had slopes significantly greater than 3.0, but none was significantly less. Only one slope for age I bass in 1972 was significantly different from 3.0, indicating little deviation from isometric growth[2] for this group and that the 1972 trend of K(TL) was not an artifact of growth in length alone. Weight-length regressions for age II fish in April and May 1972 had slopes significantly greater than 3.0 (Table 1), indicating that longer individuals were plumper than shorter members of the same age group during these months. Although mean length of the age II fish did not significantly increase between April and June 1972 (Table 1), average K(TL) consistently increased and weight-length regression slopes declined during the interval. The relative weight gains by smaller age II individuals were more rapid than by larger members during this part of the growing season. After July 1972, both mean length and average K(TL) of age II bass increased.

Since sample sizes are small, it is difficult to say whether the increase in K(TL) is associated only with increase in length or indicates improved condition. All slopes for both Age I and II bass in September to November are below 3.0, although not statistically significant, which suggests greater growth in weight for the shorter individuals.

[2]In an age-specific regression based on fish collected over a relatively short time, the regression slope is a function of the difference between slow growing and faster growing individuals rather than representing the growth of individuals.

Annual Comparisons

Average K(TL) of age 0 and I bass was higher during July and August 1972 than during the same periods in 1971 (Figure 1). For the age 0 fish, however, the difference was not significant. Mean lengths and regression slopes were similar between years (Table 1), indicating direct comparisons of average K(TL) to be appropriate measures of annual differences in condition. The population density of age I bass was approximately 400/ha in 1971 versus 150/ha in 1972 (VanDenAvyle 1973).

Effects of Pooling Data Over Time

Data within each year and age group were pooled and regressions were computed for periods approximating spring, summer, and fall in

Table 2. *Log length-log weight regression equations for largemouth bass in McFarland's Lake, by season and age group.*

	Number of fish	a	b	95% confidence interval for b
Age 0				
July-Aug. 1971	89	−5.934	3.516*	3.184-3.849
Aug.-Nov. 1972	26	−5.307	3.211	2.850-3.572
Age I				
April-June 1972	135	−7.145	4.057*	3.781-4.333
July-Aug. 1972	69	−4.992	3.064	2.905-3.222
July-Aug. 1971	274	−5.010	3.041	2.939-3.143
Sept.-Nov. 1972	35	−4.921	3.031	2.542-3.520
Age II				
April-June 1972	341	−5.594	3.290*	3.158-3.430
July-Aug. 1972	33	−6.111	3.535*	3.145-3.925
Sept.-Nov. 1972	25	−3.936	2.619	2.204-3.035

Iowa (Table 2). Slopes of the resulting composite regressions usually fell within the 95% confidence intervals of the corresponding monthly regressions, however, slopes of the seasonal regressions were not predictable from the monthly calculations when average K(TL) changed appreciably between months. When K(TL) declined within a season, slopes of the composite regressions were lower than the monthly values (age 0, August-November 1972; age I, July-August 1971), and when K(TL) increased within a season, the composite slopes were higher than monthly values (age I, April-June 1972; age I, September-November 1972). The unusually high b of 4.057 for the age I fish in April-June 1972 particularly illustrates the influence of changing K(TL) during the computation interval. Longer fish in this regression were collected in June when K(TL) increased significantly (Figure 1). The 95% confidence interval about this slope (3.781-4.333) did not include any of the corresponding monthly slopes and, consequently, this seasonal regression did not represent the population at any single time during the April-June sampling interval.

The seasonal regression estimates for age II bass in 1972 (Table 2) fell within the ranges of the slopes of the monthly regressions even though K(TL) steadily increased during the spring and summer. The rate of change of K(TL) for this age group was less than that observed for the age I fish (Figure 1), and sample sizes during summer and fall were too low to detect any potential influence of changing body form on the composite weight-length regressions. The monthly age-specific regressions describe the weight-length relationships of both slower versus faster growing individuals, whereas the longer term regressions also include the changes with growth of the individuals.

DISCUSSION

Previous publications have indicated no consistent seasonal pattern of condition for young largemouth bass. Bennett et al. (1940) reported that the condition factor of yearling bass in Fork Lake, Illinois, gradually declined from April to November. In three Illinois ponds, condition factors improved from spring to late July and fluctuated thereafter in a pattern similar to that observed in this study (Buck and Thoits 1970). Causes of annual or seasonal trends of condition often have been attributed to differences in growth rate and food availability. When an extensive die-off of aquatic plants permitted bass to feed more readily on small fish, average K increased from 1.39 in August to 1.68 in October in an Illinois reservoir (Bennet 1948, 1971). Cooper et al. (1963) found that seasonality and magnitude of K of yearling bass were related to growth rate and population size. During a year of rapid growth and low yearling abundance, K was highest in July (1.05-1.50); but in a year of slower growth and high abundance, K was highest in May (1.14-1.32). Mean length also differed between the two years, so the higher K in the year of rapid growth may have been due to the usual changes in body form with increased length as well as density dependent factors. Largemouth bass weight-length regressions usually have slopes above 3.0 (Carlander 1977). Our study indicated that condition was inversely related to population density even though lengths were not affected.

Estimates of K(TL), and weight-length regressions were both required during the same periods to fully interpret seasonal trends in condition of young largemouth bass. Weight-length regressions for age I fish suggested isometric growth during most months, indicating that K(TL) was a meaningful index of condition throughout the 1972 growing season. Regressions also indicated that average K(TL) for age II bass in 1972 did not reflect changes in condition of all members of the group, but resulted from a more rapid weight gain by smaller individuals in combination with changing body form within the 200 mm to 280 mm length range.

Comparison of seasonal and monthly weight-length regressions showed that computations covering long time periods were subject to error when body form changed during the sampling interval. Analyses for these influences should precede development of generalized or pooled weight-length regressions to be used for analytical or predictive purposes in population studies.

The use of the relative condition factor of LeCren (1951) to correct body length change would be invalid since the regression slopes differ for various periods and the slope for the combined data is not representative for any time period.

Ricker (1973, 1975) indicated that functional regressions may be better than the predictive regressions used in this paper for weight-length analysis. Functional regression slopes were 0.042 to 0.549 higher than the predictive regression slopes in Table 1 and 10 were significantly greater than 3.0 compared to 5 in Table 1, but the other conclusions would be identical.

The use of multiple regression models to avoid some of the errors in the logarithmic transformations (Zar 1968) has the disadvantage of not relating to a simple geometric principle characteristic of the allometric equation. Since volume (and thus weight of fishes which must remain at a fairly constant specific gravity) varies as the cube of any linear measurement if the shape remains the same, the deviation of slope from 3.0 is a measure of change in shape with increased linear measurement.

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