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IMPORTANCE OF A TIME VARIABLE IN LENGTH-WEIGHT RELATIONSHIPS FOR BLUE AND CHANNEL CATFISHES IN KENTUCKY LAKE AND LAKE BARKLEY

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ABSTRACT—A time variable was included in the standard logarithmic transformed regression model (ln weight = B_0 + B_1 ln length) to account for seasonal fluctuations in the length-weight relationships for blue catfish (*Ictalurus furcatus*) and channel catfish (*Ictalurus punctatus*) from Kentucky Lake and Lake Barkley, Kentucky. The new regression model reduced the error of estimating weight by 2.30% over the standard equation. A time variable and seasonal samples provided better estimates of weight when only length data were available for harvest estimates. The addition of small, nonmarketed fish to the regression analysis improved the estimation of the weight of the marketed fish by only 0.05%.

Commercial yield of catfishes (*Ictalurus*) can be estimated from samples of fish measured for length, and weight can be estimated from a length-weight regression. Individual weight measurements from lake samples are often precluded by time constraints of weighing large live catfish and interviewing active fishermen in their small boats, especially during inclement weather. Calculation of length-weight relationships for blue catfish (*Ictalurus furcatus*) and channel catfish (*Ictalurus punctatus*) usually have been confined to the standard equation ln weight = B_0 + B_1 ln length (Conder and Hoffarth, 1962; DeRoth, 1965; Matthai, 1972; Perry and Carver, 1972; Freeze, 1977). Polynomial regression equations have been used to reduce error in predicting the weights of blue catfish from the Tombigbee River, Alabama (Kelley, 1968).

Predictions of commercial yield by regression analysis might be improved by inclusion of seasonality in the equation and inclusion of small, nonmarketed fish in the data set. Length-weight relationships for catfish in Kentucky Lake may vary with season. Seasonal changes in condition factors for catfish in Kentucky Lake and Lake Barkley were observed by Johnson and Sickel (1979). Condition factors, based on the relationship of length to weight, were higher in the spring than following spawning in the late spring and early summer. Also, Ricker (1975) reported that the addition of small fish in regression analysis improves the estimation of fish the next size larger. Often only harvestable-sized fish (>35 cm) were used in establishing length-weight relationships for catfish from Kentucky Lake (Matthai, 1972; Johnson and Bronte, 1981). The objectives of the present study were to: establish regression equations for the length-weight relationship of blue catfish and channel catfish that can account for seasonal changes in the weight of the fish; compare the regression model with the standard equation; and determine the importance of including small, nonmarketed fish in the analysis.

MATERIALS AND METHODS

Length and weight data were collected for blue and channel catfishes from Kentucky Lake and Lake Barkley, Kentucky, during a 1984, onboard, observer survey of the trotline fisheries (Johnson, 1985). Fish were weighed to the nearest 0.03 kg, and the total length was measured to the nearest 0.5 cm. Accuracy of the scale was checked against standards of known weight throughout the study.

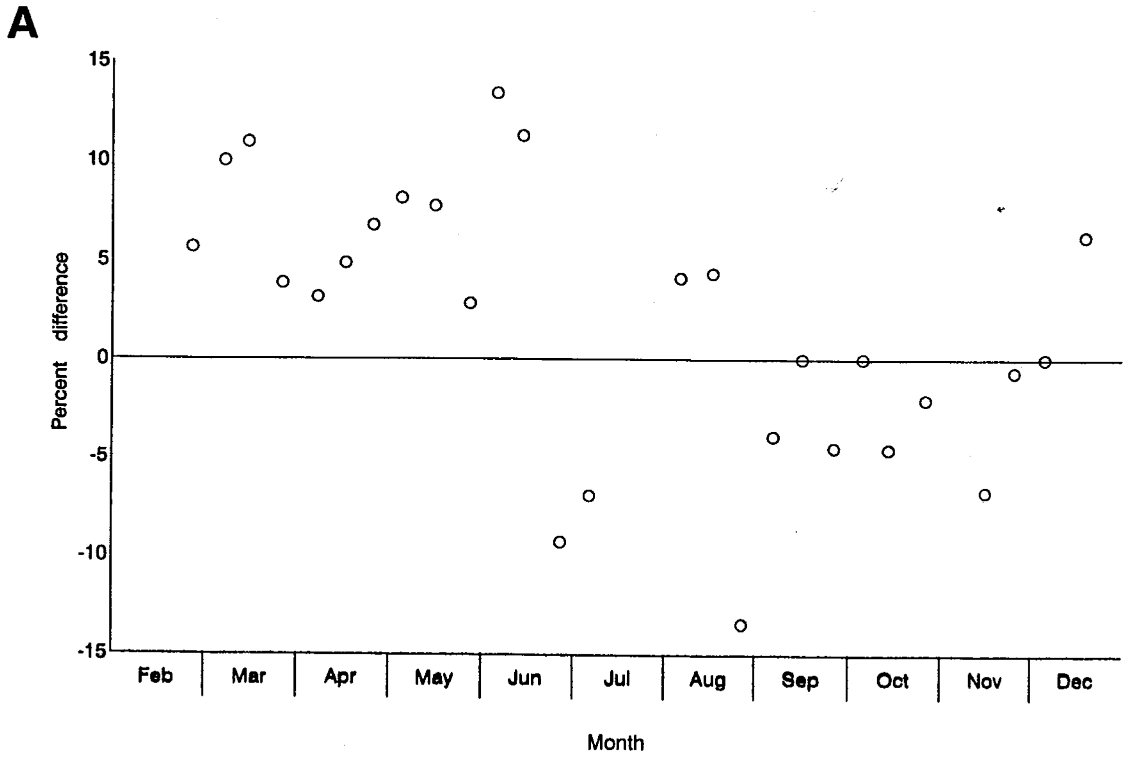
Regression analysis of length and weight was performed with the Statistical Analysis Systems package (SAS Institute, Inc., 1982). Seasonal fluctuations in length-weight relationships were incorporated into the regression model by adding a time variable. Comparisons were made between models established with marketed fish alone (total length ≥ 35 cm) and models established with both marketed fish and nonmarketed fish (total length < 35 cm).

An "all possible regression procedure" was performed to determine the "best fit" regression model (Kleinbaum and Kupper, 1978). The model was selected on the basis of the R^2 and partial F-values. Dummy-variable models were used to conduct F-tests for differences in length-weight relationships (i.e., test for coincidence) within and between species (Kleinbaum and Kupper, 1978). Additional blue and channel catfishes were collected and weighed in 1985 to validate the models by comparing predicted and actual weights. Percent difference was calculated as:

$$\frac{\text{actual weight - estimated weight}}{(\text{actual weight + estimated weight})/2} \times 100.$$

RESULTS AND DISCUSSION

Length-weight relationships were determined from 956 blue catfish from Lake Barkley, 1,892 blue catfish from Kentucky Lake, 847 channel catfish from Lake Barkley, and 437 channel catfish from Kentucky Lake (includes marketed and nonmarketed fish). Seasonal changes in length-weight relationships using the standard regression equation for blue and channel catfishes are shown in Fig. 1. Over- or under-estimation of the annual harvest using length data could result if the length-weight equation is based on fish collected only in one season. Seasonal availability of food may be a factor. For example, threadfin shad (*Dorosoma petenense*) are an important winter food in Kentucky Lake for both channel catfish and blue catfish (Davis, 1979). Threadfin shad were killed by cold water temperatures in late December 1984 through



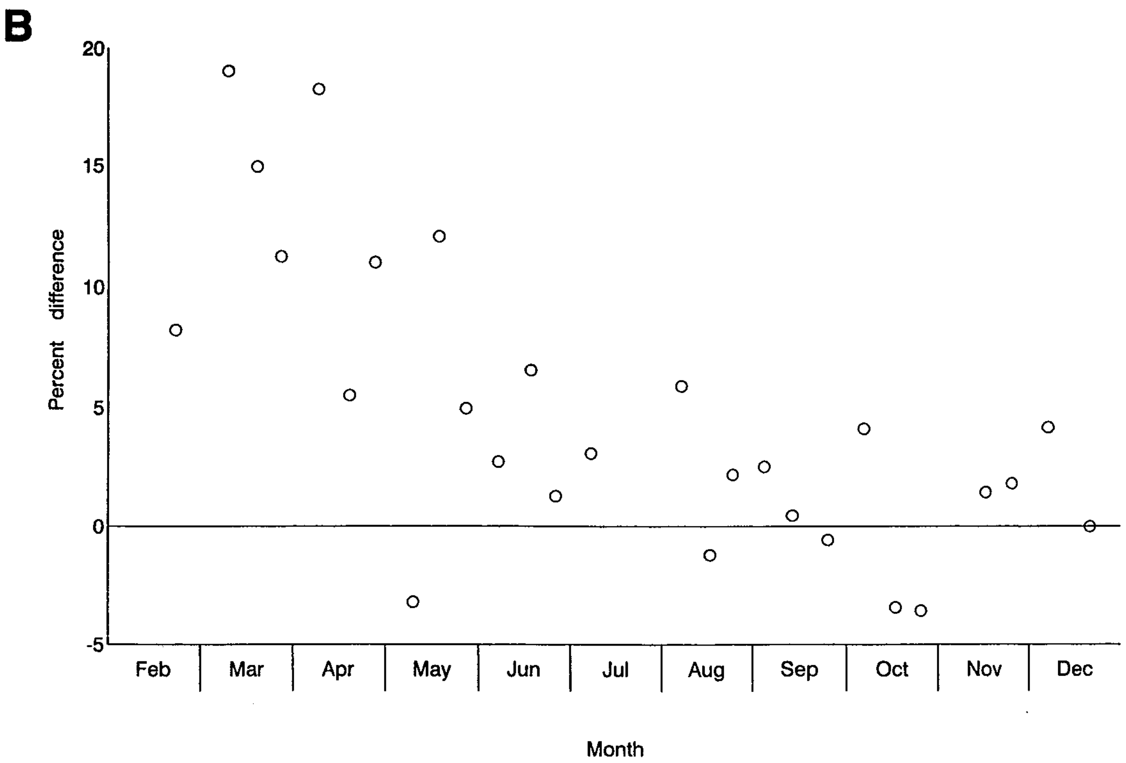


FIG. 1. Changes in length-weight relationship of blue catfish (A) and channel catfish (B) harvested from Kentucky Lake and Lake Barkley from February through December 1984. Estimated weights were determined from the standard regression equation established from data collected in September and October 1984.

early February 1985. Increased feeding on shad could initially increase the weight of fishes at a given length. Thus, a length-weight relationship with a time variable could improve the accuracy of estimating the annual harvest.

Blue catfish showed no statistical difference in length-weight relationships between lakes ($P = 0.331$, Table 1). Thus, one regression equation described both populations of blue catfish: ln weight = 0.46478 (ln length)^2 + 4.44047 X 10^{-6} (day)^2 - 0.00229 (day) - 6.69534, where ln weight = natural logarithm of the weight in kilograms, ln length = natural logarithm of the total length in centimeters, and day = day of the year with day = 1 for 1 January 1984 and day = 366 for 31 December 1984. Length-weight relationships of channel catfish were statistically different between lakes ($P = 0.001$, Table 1), and separate regression equations were selected: for Lake Barkley, ln weight = 0.47921 (ln length)^2 + 3.50903 X 10^{-6} (day)^2 - 0.00166 (day) - 6.96870; for Kentucky Lake, ln weight = 0.47307 (ln length)^2 + 7.54876 X 10^{-6} (day)^2 - 0.00366 (day) - 6.69174. The equations estimate the natural logarithm of the weight during any particular day of the year.

The three multiple regression equations improved the accuracy of estimating the total fish weight by an average of 2.34% over the estimates based on the standard regression equation (ln weight = B_0 + B_1 ln length). The multiple regression equations were tested by estimating the weight of 2,721 blue catfish and 519 channel catfish of known weight collected in 1985 from Kentucky Lake. The estimated total weight dev ated a mean of 0.31% (0.33% for blue catfish and 0.28% for channel catfish) from the actual weight compared to a mean of 2.22% error (2.44% for blue catfish and 1.98% for channel catfish) in the estimate based on the standard equation. The addition of small, nonmarketed fish to each regression analysis improved the estimate of the weight of marketed fish by an average of only 0.05% (0.04% for blue catfish and 0.06% for channel catfish). Thus, a time variable in the equation improved estimates of weight while inclusion of small, nonmarketed fish in the data set only slightly improved estimates.

TABLE 1. Results of *F*-tests for coincident length-weight regression models for blue and channel catfishes from Lake Barkley versus Kentucky Lake from onboard, observer data.

Fish	*F*-value	*d.f.*	*P*-value
Blue catfish	1.151	4,2848	0.331
Channel catfish	4.518	4,1284	0.001

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