Seasonal Analysis of Predator-Prey Size Relationships in West Point Lake, Alabama-Georgia

Richard J. Stiefvater, *Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, AL 36849*

Stephen P. Malvestuto, *Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, AL 36849*

Abstract: The relationships between largemouth bass (*Micropterus salmoides*) length and lengths of bluegill (*Lepomis macrochirus*) and gizzard shad (*Dorosoma cepedianum*) consumed by largemouth bass were explored seasonally in West Point Lake during April-November 1981. There were no significant differences in the predator-prey size relationships for largemouth bass and bluegill across seasons; however, there was a significant increase in the size of gizzard shad preyed upon during the fall as compared to earlier in the spring-summer. This seasonal shift was not a normal fall occurrence and likely was caused by a 4.2-m drop in the summer lake level which increased crowding of predator and prey and enhanced the predatory effect of largemouth bass on gizzard shad. Analysis of the relative abundance of prey species over a 7-year period (1975–1981) showed that in 1977, 2 years after impoundment, bluegill and gizzard shad were the dominant prey species. By 1981, bluegill had declined in abundance and the gizzard shad population was composed primarily of large, adult individuals; threadfin shad (*Dorosoma petenense*) had increased tenfold in abundance and were a major component of the diet of small and intermediate size (<300 mm) largemouth bass.

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One of the challenges of trying to effectively manage a reservoir sport fishery is maintaining adequate stocks of prey within size ranges vulnerable to predators of interest (Noble 1981). In reservoirs in the southeastern United States, the largemouth bass is typically a major predator. The prey species most often utilized by largemouth bass are bluegill, gizzard shad, and threadfin shad. Although these prey species are abundant in reservoirs, they often grow too large to provide food for all sizes of largemouth bass; this is particularly true of bluegill and gizzard shad. The net effect is limited energy transfer from primary production to harvestable fish flesh (Carver et al. 1976).

Controlling gizzard shad populations in southeastern reservoirs is a chronic problem. Gizzard shad often comprise up to 45% of the total fish biomass in a system (Jenkins 1967) and adult individuals are too large for most largemouth bass to prey upon. One possible solution is to re-structure the predator population through harvest restrictions so that they can more effectively utilize the larger shad, thus converting shad biomass into harvestable largemouth bass biomass. A slot limit, or protected size range of 380 to 450 mm (Anderson and Weithman 1978), or a large minimum size limit (Davies and Malvestuto 1983), depending on bass growth and mortality dynamics, would serve to preserve bass in the system at a size large enough to prey on the larger shad. In the end, the shad population should become more dynamic, producing abundant, edible-sized prey which, in effect, should increase the transfer efficiency from primary production to harvest by man.

Predator-prey relationships in West Point Lake have been monitored since 1975 (Shelton et al. 1979, Timmons and Pawaputanon 1980). Early data (1975–1977) showed that gizzard shad were available to juvenile largemouth bass, but that they were not utilized until the bass were longer than 250 mm (Timmons et al. 1981). The predator-prey size relationship developed for largemouth bass and gizzard shad showed that, on the average, largemouth bass were consuming gizzard shad that were 30% of their length. Thus, largemouth bass 400 mm (16 in) in total length were consuming gizzard shad of about 130 mm (5 in) in total length (Timmons et al. 1980). According to the relationship developed by Jenkins and Morais (1976), adult largemouth bass should be able to consume gizzard shad that are 60% of their length, but this was not happening in West Point Lake despite the fact that, based on cove rotenone sampling, gizzard shad comprised about 50% of the fish biomass and there was an average of 5,600 individuals per hectare in the 150–200 mm length range during 1976–1979. At that time, bluegills were the most abundant small prey available and were eaten primarily by largemouth bass less than 200 mm in length; threadfin shad were found in small numbers and were insignificant as a prey species.

In 1981, as part of an intensive sampling effort on West Point Lake, it was decided to re-examine the predator-prey size relationships, this time 6 years after impoundment, with particular emphasis on seasonal changes which may normally occur. In previous studies on West Point Lake, data from several sampling gears were combined over seasons to give 'generalized' predator-prey size relationships. Specific objectives for the 1981 study were to develop regression relationships between lengths of largemouth bass and lengths of prey fishes consumed on a seasonal basis; to test the hypothesis that predator-prey size relationships do not change across seasons; and to evaluate these results relative to fluctuations in prey species abundance which have occurred since impoundment.

From an applied standpoint, a more detailed evaluation of predator-prey interactions was warranted at this time because the states of Alabama and Georgia were contemplating the imposition of a minimum size limit regulation on largemouth bass, one of the objectives of which would be to reduce gizzard shad biomass through predation.

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Methods

The study area, West Point Lake, is a U.S. Army Corps of Engineers impoundment of the Chattahoochee River along the Alabama-Georgia border. It lies just above the fall line in the Piedmont physiographic region. It was impounded in October 1974 and filled to full power pool by May 1975. The lake level is maintained at 194 m above mean sea level except for a 3-m drawdown in the winter for flood control. At summer pool elevation, the surface area is 10,482 ha, the shoreline length is 845 km and the average depth is 7.1 m (Shelton and Davies 1977).

All largemouth bass examined in this study were obtained by electrofishing. Two electrofishing boats were used during the study: a 4.9-m Smith-Root model SR-16 with a 240V, 5,000W generator; and, a 4.9-m Polar Kraft with a 120–240V, 3,500W generator. Both generators were equipped with pulsator units that provided pulsed direct current. The amount of voltage varied between boats, but amperage was held constant at 5.

Largemouth bass were collected for stomach analysis during the months of April, June, and August 1981 as part of a larger project involving cove rotenone and gillnet sampling. Electrofishing was conducted during 2-week periods in each of these months with 8 45-minute samples conducted each week, 4 during the day and 4 at night. Night sampling began approximately 2 hours after sunset. Fish were measured in the field subsequent to each collection.

In addition to the above samples, bass were collected by electrofishing on 2 days each month during May and from September through November. These collections consisted of 4, 45-minute samples per day, all taken during daylight beginning at about 0800 hours. Captured bass were put into plastic bags, placed on ice to prevent regurgitation and then examined later that day.

The following data were recorded for each largemouth bass collected: total length (mm), weight (g), sex, and stomach contents. Items found in largemouth bass stomachs were identified to species, if possible, and counted. The lengths of fishes found in stomachs were measured to the nearest millimeter.

Data were analyzed using the Statistical Analysis System (Helwig and Council 1979). Regression relationships of prey length versus predator length were generated for each prey species (gizzard shad and bluegill), time period (day or night) and season (spring: April and May; summer: June and August; and fall: September-November). The within species relationships were compared using analysis of covariance. Threadfin shad, although present in largemouth bass stomachs, were not included because their uniform size precluded the possibility of a positive regression relationship.

Trends in abundance (number/ha) of prey fish populations over a 7-year period (1975–1981) were documented using cove rotenone data available from July-August collections (4 coves per year were sampled). Rotenone sampling was conducted as per techniques given in Davies and Shelton (1983).

Results and Discussion

The present study showed no significant differences in the sizes of bluegill consumed by largemouth bass over time (day versus night) or season (spring, summer, fall); therefore, all bluegill data were pooled in order to describe the predator-prey size relationship (Fig. 1). The results showed that sizes of bluegill preyed upon by largemouth bass in 1981 were nearly identical to those sizes preyed upon during the period 1975–1979.

For gizzard shad, no significant day/night differences were found in the sizes of individuals consumed by largemouth bass, but there were significant differences between the spring and summer seasons combined as compared to the fall (Figs. 2 and 3). Threadfin shad are plotted with gizzard shad to compare size ranges of largemouth bass that utilized these 2 species, but threadfin shad are not included in the regression analysis.

The predator-prey size relationship of gizzard shad consumed during the spring-summer season of 1981 was similar to earlier findings at West Point Lake based on data collected from 1975–1979 (Timmons and Pawaputanon 1980). Statistical comparison of the 2 regression lines showed that the slopes and intercepts were not significantly ($P > 0.05$) different (Fig. 4). The slope of the regression line in the fall, however, was significantly ($P < 0.05$) steeper than either of the other 2 lines, indicating that lengths of gizzard shad preyed on by largemouth bass in the fall had increased. The mean length of shad found in bass stomachs in the spring-summer was 91 mm as compared to 131 mm in the fall. The relationships suggest

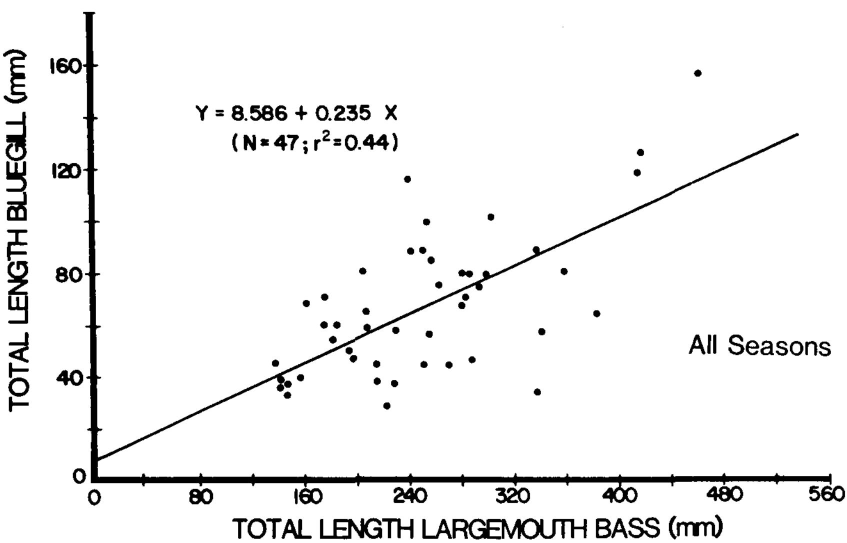

Figure 1. Scatter plot and best-fit regression line of bluegill total length on largemouth bass total length for all seasons combined on West Point Lake.

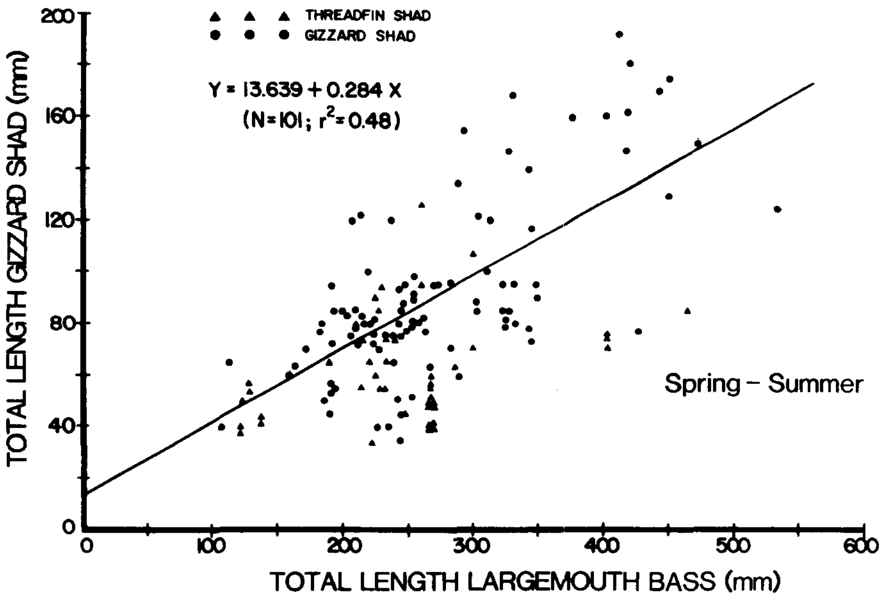

Figure 2. Scatter plot and best-fit regression line of gizzard shad total length on largemouth bass total length for April, May, June, and August from West Point Lake.

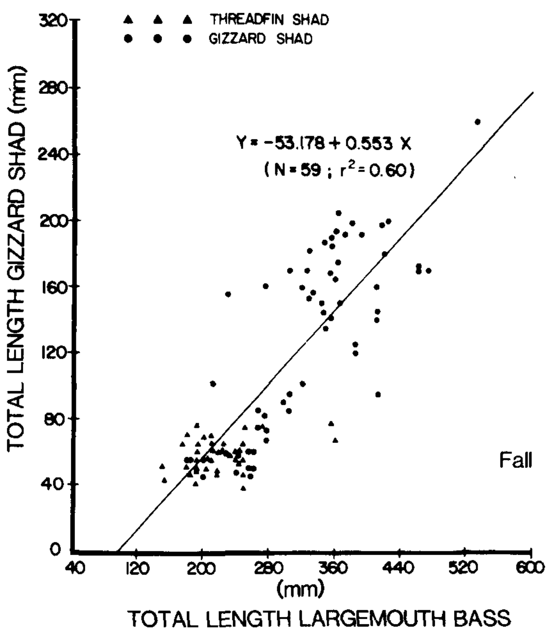

Figure 3. Scatter plot and best-fit regression line of gizzard shad total length on largemouth bass total length for September, October, and November, West Point Lake.

that largemouth bass 400 mm in length, on the average, were feeding on gizzard shad 125 mm in length during the spring-summer and 160 mm in length during the fall. The fall relationship shows that largemouth bass were feeding on gizzard shad of sizes close to the maximum consumable sizes as indicated by the relationship of Jenkins and Morais (1976) (Fig. 4).

The reason for the seasonal shift in sizes of gizzard shad consumed by largemouth bass in 1981 is not immediately clear. Since 1979, the gizzard shad population has been 'locked up' with virtually no change in the length structure of the stock and minimal reproduction. The spring rotenone samples in 1981 showed that no young-of-year (YOY) gizzard shad were present in the lake and the length structure of the population remained relatively constant across seasons. Thus, the shift in sizes of gizzard shad consumed cannot be explained by growth of gizzard shad over the study period.

To determine whether the relationship measured during the fall of 1981 represented a normal fall occurrence, an effort was made to isolate the fall data from previous data collected. We were able to successfully isolate data from fall of 1977 and 1979. The predator-prey size relationships for these 2 fall seasons were generated separately and compared using analysis of covariance; differences between the regression lines could not be documented ($P > 0.05$) and thus the data were pooled to represent a general fall relationship prior to 1981 ($N = 57$; $r^2 = 0.52$). This regression line is shown in Fig. 4 and is obviously similar to the general 1975–1979 relationship and to the spring-summer relationship measured in 1981. So, the shift in the fall of 1981 does not appear to be a normal fall phenomenon.

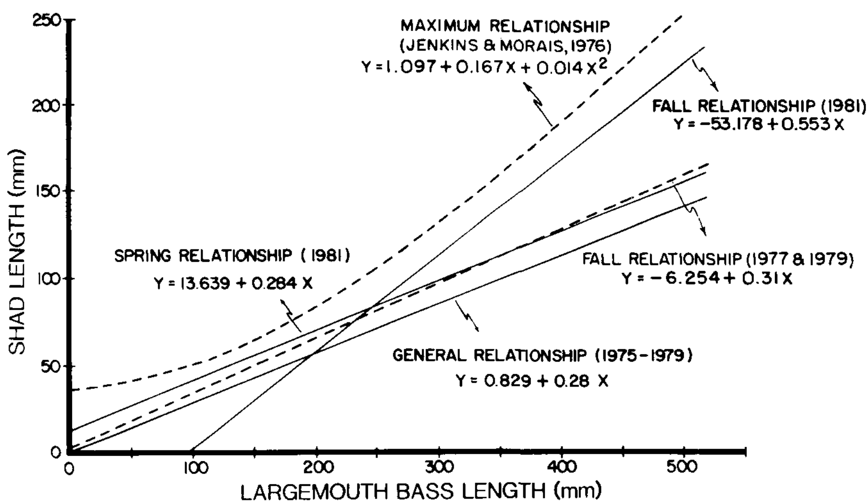

Figure 4. Spring-summer and fall predator-prey regression lines from the present study with the general relationship from West Point Lake (Timmons et al. 1981) and with the maximum relationship (Jenkins and Morais 1976).

The most apparent change that occurred at West Point Lake during late summer and fall of 1981 was a severe drop in water level caused by unusually low rainfall. By September, the water level had dropped 4.2 m, the lowest lake level since impoundment in 1975, which represented a 38% reduction in the surface area of the lake. Predator and prey were unusually crowded during this period, perhaps allowing largemouth bass to more readily feed on larger gizzard shad. Reduction in the gizzard shad biomass in Lake Hamilton, Arkansas, because of enhanced predation by largemouth and spotted bass on larger (>125 mm) gizzard shad after purposeful drawdown, has been reported by Filipek (1985). The implication of these observations, with respect to management alternatives designed to increase predators and decrease undesirable forage fish, is that length limits, acting in concert with a drawdown schedule, could be very effective. The 2 management options would augment each other to the greatest degree if drawdowns were timed to coincide with optimal feeding seasons for largemouth bass (or other predators), or when water temperatures are between 15° and 27° C. Obviously, the potential benefit of a drawdown for controlling predator-prey relationships must be weighed against possible negative effects on other water uses.

In addition to the seasonal shifts in predator-prey size relationships discussed above, there have been particular long-term shifts in prey abundance since 1975. The numbers per hectare of the 3 main forage species (bluegill, gizzard shad, and threadfin shad), as measured during August of each year from cove rotenone samples, are plotted over time (Fig. 5). Initially, gizzard shad was the dominant species and in 1977 there was an increase in the number of YOY gizzard shad (< 114 mm) and YOY bluegill (<64 mm). The following year, gizzard shad reproduction dropped off dramatically and the number of YOY gizzard shad present since then has remained relatively low (< 1,000/ha). Bluegill followed the same pattern: after the population declined in 1978, the number of YOY bluegill has remained more or less constant at about 6,000/ha. Threadfin shad, however, were found in small numbers in West Point Lake until 1978 and subsequently they have increased steadily with a substantial rise in 1981, the year of the present study. Noble (1981) reported that threadfin shad may partially displace gizzard shad in a reservoir and this may be the trend in West Point Lake. As evidenced by the points plotted in Figs. 2 and 3, threadfin shad have become an important component of the diet of largemouth bass < 300 mm in length.

In summary, regression relationships were developed between largemouth bass lengths and the lengths of prey species found in largemouth bass stomachs during spring-fall 1981. The hypothesis that predator-prey size relationships remained constant across seasons was found to be true for bluegill, but false for gizzard shad. During fall 1981, largemouth bass were feeding on gizzard shad of sizes close to the maximum consumable as per Jenkins and Morais (1976). We suggest that a severe decline in the water level of West Point Lake during summer 1981 caused concentration of predator and prey so that largemouth bass were able to feed more effectively in the fall on significantly larger gizzard shad. Long-term shifts in the abundance of prey species since impoundment have resulted in increased utilization of threadfin

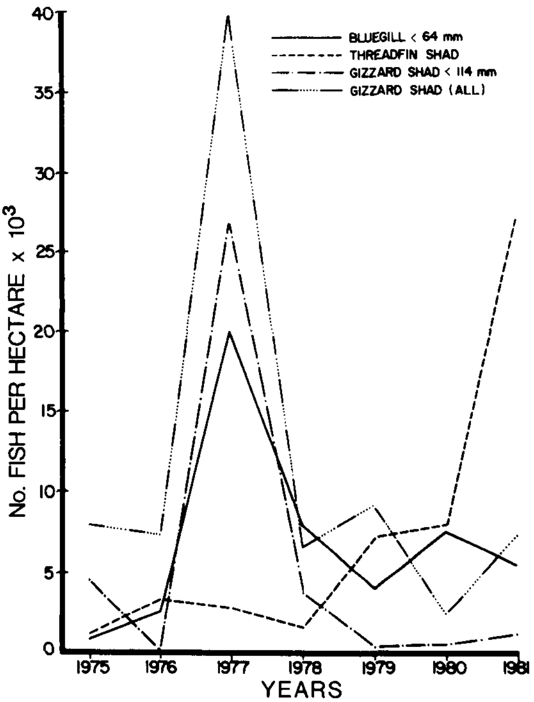

Figure 5. Fluctuations in the number/ha of bluegill, threadfin shad and gizzard shad from 1975 to 1981 in West Point Lake based on cove rotenone samples taken in late July and early August of each year.

shad relative to bluegill by largemouth bass < 300 mm in total length. Management implication is that predatory control of larger gizzard shad, as for example through length limit regulation, most likely can be enhanced under lowered water level conditions.

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