

The Effects of Flooding on the Growth Rates of Fishes in Lake Texoma

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Growth rates of four fishes during 1982, a flood year, were compared to those of previous years by back calculation from scales and, for one species, by comparison with previous mean length measurements. Calculated growth increments in 1982 were significantly larger than in the previous years for blacktail shiner (*Notropis venustus*), smallmouth buffalo (*Ictiobus bubalus*), and tidewater silverside (*Menidia beryllina*). Striped bass (*Morone saxatilis*) did not exhibit increased growth rates in 1982. Two extreme flood events during and prior to the 1982 growing season are postulated to have been the cause of the observed changes in growth rates. These events caused large increases in the area flooded by the reservoir and in the allochthonous inputs to the reservoir. Decreased abundance of some fishes due to emigration via floodgates also occurred. The mechanism by which the flood events caused higher growth rates in some fishes is unknown, but may be related to a change in reservoir productivity due to increased inputs and/or to density-dependent growth in some fishes. Striped bass growth rates may have decreased in 1982 due to a winterkill of the threadfin shad (*Dorosoma petenense*) population, which reduced prey availability.

INTRODUCTION

Lake Texoma is a large (36,000 ha), multipurpose reservoir located in Oklahoma and Texas. The reservoir was impounded in 1944 by the Denison Dam, at the confluence of the Red and Washita rivers. The water level exhibits large annual fluctuations due to evaporation, drawdown, flood control, and removal of water by the city of Dallas, Texas. Comparison of weekly average water levels from 1980 through 1983 demonstrates a seasonal trend of peak floods in the spring and occasional floods at other times of the year (Fig. 1). The exceptionally large floods of October 1981 and May/June 1982 caused an increase in the surface area to over 50,000 ha. These large floods led to the deposition of large amounts of suspended materials from the Red and Washita rivers and to a decrease in the number of fishes in the reservoir due to releases downstream through the flood gates (1). Changes in the reservoir caused by increased allochthonous inputs, increased area, and decreased numbers of some fishes are hypothesized to have caused an increase in growth rates for some fishes during the flood year.

Between-year variations in the growth rates of fishes have been associated with year-class strengths, food availabilities, and temperature differences (2-4). Although

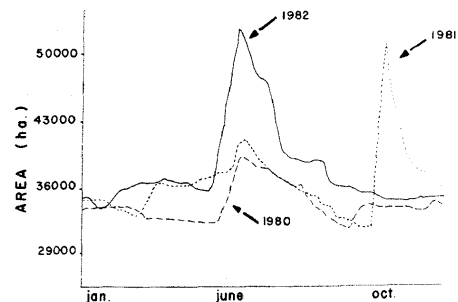


FIGURE 1. Weekly average surface area of Lake Texoma (Data from U.S. Army Corps of Engineers, Denison Dam).

the influence of allochthonous inputs on the productivity of reservoirs is known to be important (5), no published data were found on the effect of fluctuations in the amount of allochthonous inputs on the relative productivity of a reservoir in temperate regions. In contrast, the role of the magnitude of annual floods in the productivity of tropical river systems is well established (6, 7). Southern plains reservoirs such as Lake Texoma provide a situation analogous to African river systems described by Welcomme (6) in that floods are seasonal and result in large organic matter inputs. Likewise, variation in the amount of allochthonous inputs may be a cause of changes in growth rates of temperate-reservoir fishes, as it is in some tropical systems (7). Density-dependent growth regulation is another possible cause of year-to-year variation in the growth rates of reservoir fishes.

The occurrence of two flood events of a large magnitude in Lake Texoma prior to and during one growing season (1982) provided an opportunity to examine the influence of flooding on reservoir fishes. We compared growth rates of four fishes between an extreme flood year and previous years.

METHODS

During June and July of 1983 and 1984, fishes were sampled in the Red River arm of Lake Texoma, in and near Mayfield Cove (see published description (8)). Striped bass (*Morone saxatilis*) were sampled with a 1.8-m x 90-m gill net with 6-cm bar mesh set at midwater depths (5 m in 10 m water). Smallmouth buffalo (*Ictiobus bubalus*) were sampled with a 1.8-m x 90-m gill net with 10-cm bar mesh set on the bottom, at depths of 7 to 12 m. Striped bass and smallmouth buffalo were sampled in 1983. Scale samples and total length measurements were taken on both of these species.

Blacktail shiner (*Notropis venustus*) and tidewater silverside (*Menidia beryllina*) were sampled from the littoral area of Mayfield Cove with a 2-m x 12-m, 1-cm-mesh bag seine and preserved in 5% formalin. Scale samples and total length measurements were taken on preserved blacktail shiners sampled in 1983 and 1984. Because the maximum age of tidewater silversides in Lake Texoma is about 16 months (9), only one year-class of adults is available for sampling in summer. Since sampling occurred in 1983 and the intent was to compare growth in 1982 with previous years, back calculation of growth rates was not conducted for this species. Instead, total length measurements of the 1982 year-class were taken in June 1983 and compared to similar ones taken in 1980 (9). The measurements taken by Hubbs (9) were for females only, while the 1983 sample included an unknown percentage of males, which are smaller than females (9).

Scale samples from the three other species were examined for putative annuli and aged by back calculation (10). The lack of validation of age determination from scales limits the conclusions of this study (11). Comparisons of calculated mean growth increments were made within age classes for three species. These were tested for significant differences using a *t*-test for unequal sample size (12). The mean lengths for all adult silversides measured in 1983 were compared to ripe females measured in 1980 (9) by an unequal variance *t*-test (12).

RESULTS

The mean length of the 1982 year-class tidewater silverside was significantly greater than that of the 1979 year-class ($P < 0.001$). The mean length measured in 1983 was 86.6 mm (95% CI = 82.3,90.9; SE = 2.0 mm; $n = 21$), while the mean length of those measured in 1980 was 75.5 mm (95% CI = 74.1,76.9; SE = 0.5 mm; $n = 361$). The occurrence of a bimodal length distribution separated adults and juveniles. Therefore, adult length measurements taken in 1983 represented growth in 1982 and early 1983.

The growth rates of blacktail shiners in 1982 were higher for all three age classes than growth rates in 1981 or 1980 ($P < 0.001$) and higher than age II growth rates in 1983 ($P < 0.01$; Fig. 2). Growth rates of 1983 and 1982 age I blacktail shiners were not significantly different. The blacktail shiner had a maximum estimated age of 3 years and data from the second summer allowed comparisons of all three age classes. The results presented here include pooled estimates of the three age

classes in which estimates were obtained during both study years.

Growth rates of age II and age III smallmouth buffalo in 1982 were greater than pooled averages of previous years' growth rates ($P < 0.01$ and 0.1 , respectively; Fig. 3). Growth of age I smallmouth buffalo in 1982 was not significantly different than in previous years.

Striped bass growth was not consistently different in 1982 than in previous years (Fig. 4). The only difference among calculated lengths was that age II growth in 1982 was less than in 1981 ($P < 0.05$), which in turn was less than growth in 1980 ($P < 0.01$). Growth rates of age III striped bass were not significantly different in 1982 and 1981. Since no age I striped bass was sampled in 1983, growth of that age group cannot be estimated for 1982.

DISCUSSION

One possible explanation for the changes in growth rates between 1982 and previous years is Lee's phenomenon (13). While this cannot be negated owing to the lack of long-term data and scale validation, there are several reasons for doubting Lee's phenomenon as the causal agent of observed changes in growth rates. Back calculation was not used in determining growth rates of tidewater silversides, which exhibited the most distinct increase in growth of the species studied. As can be seen with the three species for which back calculation was used, a linear decrease in growth rates with older age classes (as would be predicted from Lee's phenomenon) did not occur and there appears to be a large amount of year-to-year variation in the growth of these species in Lake Texoma (Figs. 2,3, and 4).

Higher growth rates in 1982, as compared to previous years, were found for most observed age classes in three of the four species. The fourth species, striped bass, had no similar trend in its calculated growth rates. These species are diverse in size, habitat use, and trophic position. Possible causes for the observed increase in growth rates for the three species include changes in temperature, food abundance, or fish density.

The only observed difference in the water temperature of Lake Texoma in 1982 as compared to the other years in this study was a slower warming of the waters in 1982, presumably because of the increased volume of the reservoir (W.J. Matthews, Univ. of Okla. Biological Station, personal communication). If slower warming had any effect, it would probably be to decrease the growth rates of these warmwater fishes.

Matthews et al. (1) reported that large but unquantified numbers of striped bass and presumably other fishes were passed through the flood gates of Denison Dam in 1982. Along with changes in the distribution and condition of larval fishes noted by Matthews (14), this decrease in the number of fishes in Lake Texoma could have created the opportunity for density-dependent changes in growth rates. The effects of density on the growth of some warmwater fishes has been quantified by Swingle and Smith (15) and is presumed to

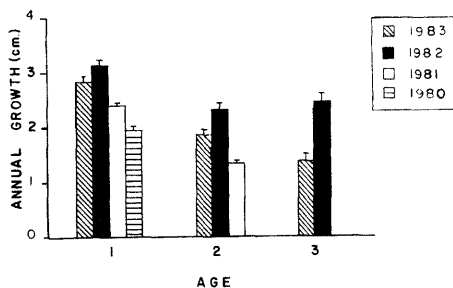


FIGURE 2. Calculated mean yearly growth increments of blacktail shiners in Lake Texoma, displayed by year in which growth occurred (i.e. 1982 age II growth was growth of the 1981 year-class in 1982; error bars are 1 SE).

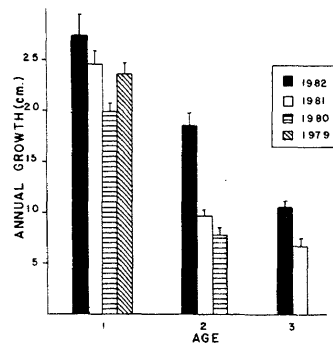


FIGURE 3. Calculated mean yearly growth increments of smallmouth buffalo in Lake Texoma, displayed by year of growth.

be one of the major controlling factors in fish growth (16).

The large input of allochthonous materials and the increase in flooded lowlands caused by the fall 1981 and spring 1982 floods in Lake Texoma could have increased the productivity of the system and thereby influenced the growth rates of some fishes. Presumably, increased inputs of nutrients and detritus would differentially affect the growth of some fishes, depending on whether an increased input was being directly consumed (i.e., a detritivore) or being taken up by prey such as zooplankton. The timing of increased growth and the relative contribution of increased allochthonous inputs, increased habitat, or density-dependent effects on growth were not discernible from our data.

The bottom-feeding smallmouth buffalo is an opportunistic feeder which presumably would take advantage of the increased inputs and forage area (17). Age I smallmouth buffalo, which did not show an increase in growth in 1982, may reside upstream from the reservoir where spawning occurs and not be able to take advantage of the influence of a flood event in the reservoir. In contrast, tidewater silversides and blacktail shiners are wide-ranging forage fishes that frequent shallow, in-shore areas during daylight (18). These species could have taken advantage of the newly flooded land and seasonably shifting food supply. Tidewater silversides are also known to exhibit growth responses to population density (19).

In Lake Texoma, striped bass feed almost exclusively on gizzard (*Dorosoma cepedianum*) and threadfin shad (*D. petenense*) (W.J. Matthews, personal communication). A winterkill of threadfin shad in 1981-1982 nearly eliminated this species from the lake in 1982 (14). Decreased forage supply may have caused the decrease in growth rate of age II striped bass in 1982.

The role of allochthonous inputs into reservoirs becomes increasingly important in the aging, dystrophication stage (20). Any effects of year-to-year variation in the magnitude of allochthonous inputs will also become more pronounced in older reservoirs. Matthews (14) has shown that the turbid inputs of major floods in Lake Texoma affect the distribution and condition of some larval fishes. In addition, we have demonstrated changes in growth rates of some individual fishes during a flood year. While growth rates apparently increased for some individual fishes, the lack of population dynamics information precludes the description of this phenomenon as an increase in total fish production in Lake Texoma.

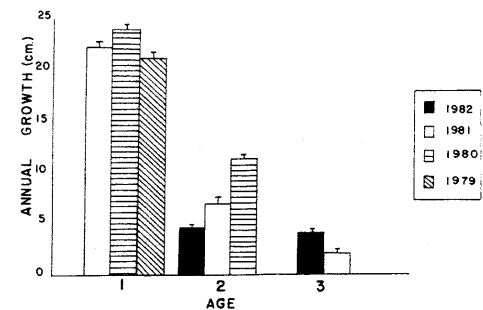


FIGURE 4. Calculated mean yearly growth increments of striped bass in Lake Texoma, displayed by year of growth.

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