The Impact of Drought on Lake Elmdale Largemouth Bass

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Abstract: Low water levels, sustained high temperatures, and potential increases in predatory pressure appear to have adversely affected the largemouth bass (*Micropterus salmoides*) population of Lake Elmdale, Arkansas. An estimated population of 3,916 bass were present in 1981 compared to previous estimates of 11,770 in 1977 and 8,937 in 1979. Size overlap between 2- and 3-year-old bass is indicative of differential states of sexual maturity and associated reproductive activity during the harsh drought conditions.

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Small impoundments provide excellent opportunities to observe the effects of naturally occurring and artificially managed parameters upon a fishery. They respond quickly to the dynamics of weather patterns and are equally as responsive to changes in their surrounding watershed. Their size encourages and facilitates select management practices while their general distribution and accessibility throughout the South stimulates utilization of their resources.

As part of an ongoing program in small reservoir research, we conducted a study of the largemouth bass fishery in Lake Elmdale, a small, shallow, eutrophic impoundment in northwest Arkansas. Earlier investigations of this reservoir, with regards to its largemouth bass fishery, have been

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conducted by Wofford (1980) and Zdinak et al. (1980). Our objectives were to evaluate the long term dynamics of largemouth bass growth and population parameters in this lake, and more specifically, to discover what impact the severe 1980 drought had on these fish in Lake Elmdale.

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Methods

Lake Elmdale, impounded in 1953, is located in Washington County, northwest Arkansas. The lake is subject to widely fluctuating water levels due to underground structural deficiencies but has an average surface area of 80 ha and a shoreline of 5.8 km. It is relatively shallow and has extensive exposed shoreline in its upper end during low water periods. Near the dam, due to the steep slope of surrounding hardwood hills, there are rocky points and somewhat deeper water habitats. Agricultural practices in the immediate surrounding area provide occasional large influxes of nutrients.

A total of 650 largemouth bass was collected by a boat mounted electroshocker on 7 nights from shoreline areas of Lake Elmdale during 8-16 September 1981. The entire perimeter of the lake was sampled each night.

Scale samples were taken from all bass at the tip of the appressed left pectoral fin for age determination. Total length of each fish to the nearest millimeter was recorded and, with the exception of fish collected on 16 September, all bass were fin-clipped for mark-recapture population estimates. Fish caught on 16 September were taken to the laboratory and weighed to establish length-weight relationships. Scales from 10% of the total catch were randomly selected from representative size classes, pressed in plastic, and read at a magnification of 40× with an Eberbach scale projector.

Results and Discussion

Northwest Arkansas was subjected to severe drought during the summer of 1980. Record high average monthly temperature (Fig. 1) and low precipitation (Fig. 2) were recorded for the months of July and August of that year. Effects of the drought were intensified by the propensity of Lake Elmdale to loose appreciable amounts of water through underground seepage. The drought had the general effect of elevating temperatures and evaporation, reducing the area of the lake, and concentrating the fish fauna.

Growth parameters of largemouth bass in Lake Elmdale have remained

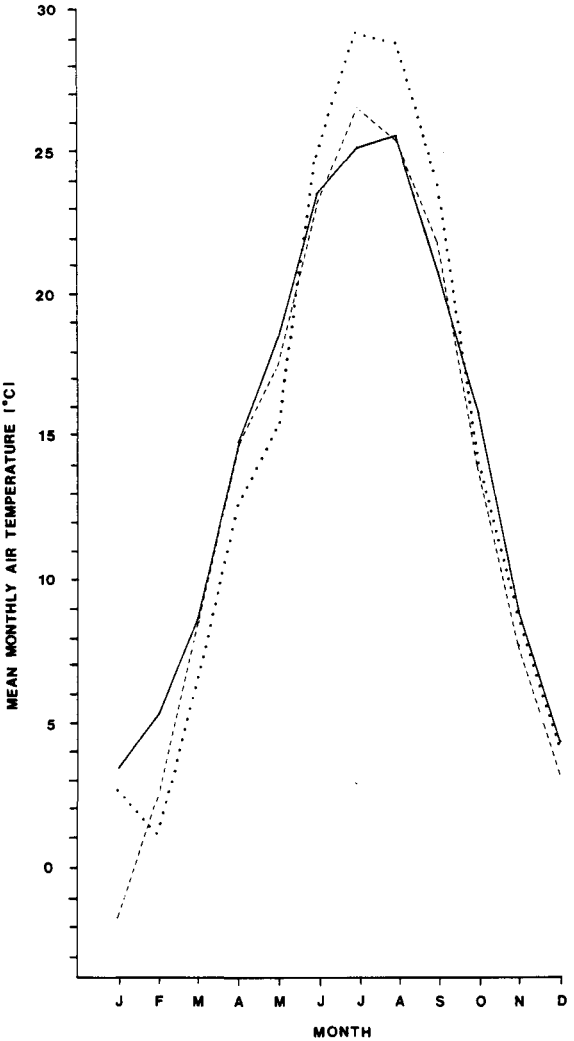

Figure 1. Mean monthly air temperature (——— 1951–1981, ------ 1976–1981, ... 1980)

relatively stable during the period 1977–1981 (Wofford 1980, Zdinak et al. 1980). The length-weight relationship of Lake Elmdale largemouth bass collected during September 1981 is expressed by the equation:

$$W = 0.00001041\ L^{3.04}$$

where W = weight of the fish (grams); L = the length of the fish (millimeters). Our study and those of Wofford (1980) and Zdinak et al. (1980) indicate that Lake Elmdale bass exhibit isometric growth (b = 3.0), hence

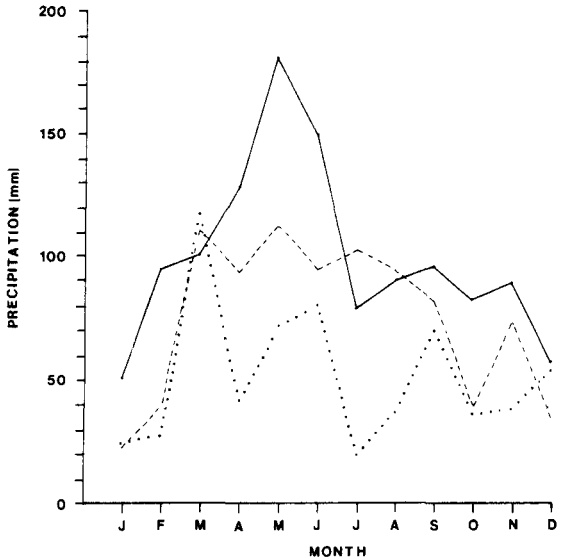

Figure 2. Monthly precipitation (mm) (——— 1951–1981, ------ 1976–1981, ... 1980)

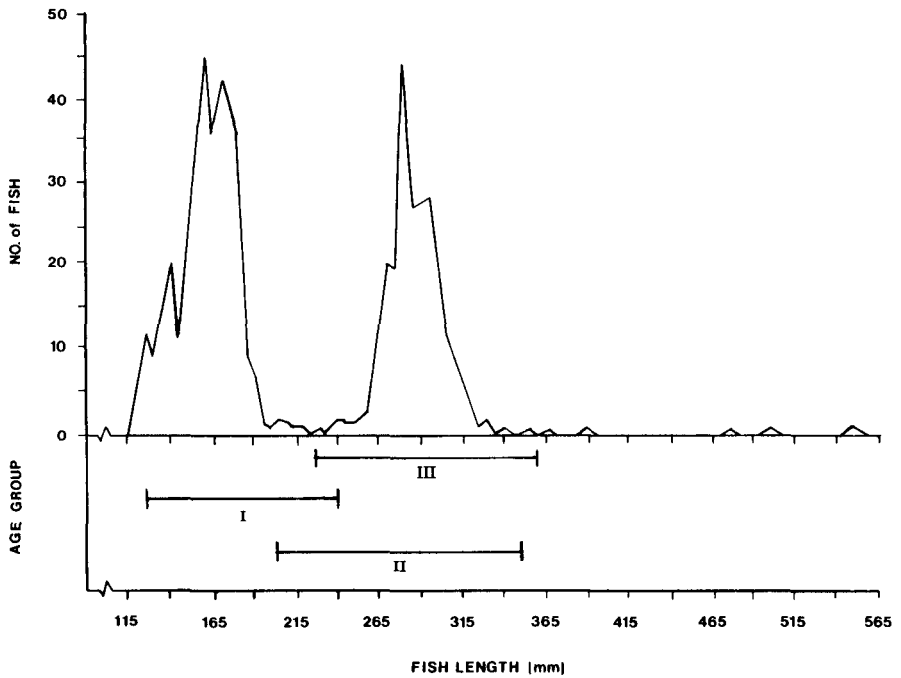

Figure 3. Length frequency distribution of Largemouth bass collected from Lake Elmdale, Arkansas during September 1981, 1 year after the severe 1980 summer drought.

the length-weight relationship of these fish is relatively stable from year to year.

Average lengths of largemouth bass collected during September 1981 are presented in Table 1. Length frequency distribution (Fig. 3) indicates an overlap between 2- and 3-year-old fish collected in 1981, a condition previously unreported for Lake Elmdale largemouth bass (Wofford 1980, Zdinak et al. 1980). This differential growth rate may be related to a greater propensity for 2-year-old fish (3 years old in 1981) to spawn than 1-year-old fish (2 years old in 1981). It has been observed (James 1939) that sexual maturity is associated with size rather than age, with bass usually becoming sexually mature at approximately 200-250 mm. This size range is normally not achieved in Lake Elmdale largemouth bass until their second year. Spawning activities and associated physiological stress may have prevented 2-year-old bass from maintaining previous rates of growth. Potential increases in prey availability associated with the decline in lake area may have encouraged an increased rate of growth in these younger fish which were not spawning (i.e. 1-year-old fish in 1980). The observed length overlap would be indicative of such a situation (Olmsted 1974, Hinton 1978, Rademacher 1978, Shuter et al. 1980).

From the Bertalanffy growth equations calculated for each of the years investigated, values of $L\infty$ (maximum attainable size) were 600, 650, 682 mm for the years 1977, 1979 and 1981 respectively and reasonably consistent. This particular parameter is reported to be primarily influenced by available food and food consumption (Beverton and Holt 1957). Kilambi (1981) and Kilambi et al. (1978) reported stable $L\infty$ values from year to year in Crystal Lake, Arkansas and that fluctuations in food availability affect the number and survival rate of bass in the population but not the size of the individual fish.

The Schnable method (Ricker 1975) was used as an index to estimate

Table 1. Average Lengths of Lake Elmdale Largemouth Bass Collected in September 1981

Age Group	n	Length (mm)
YOY	18	149.4 ± 33.55
1+	18	183.4 ± 56.80
2+	14	276.4 ± 74.56
3+	11	292.8 ± 67.49
4+	4	324.0 ± 143.79
5+	1	310.0
6+	2	513.5
7+	1	504.0

the number of bass in Lake Elmdale for each of the years investigated. We believe there was a consistent sampling bias in these investigations against smaller bass which are generally in the young-of-the-year age group. This being the case, estimated populations expressed are reflective of fish 1 year old or older although some of the larger young-of-the-year bass are included and generally fall within the first mode of length frequency analysis.

In 1981 we found the population of bass (Table 2) to be much lower than previously reported for the lake (Wofford 1980, Zdinak et al. 1980) although actual percentage composition of specific age groups of bass has remained relatively stable from year to year.

In 1976–1977 approximately 20,000 fingerling bass were stocked by the Arkansas Game and Fish Commission (Berry Beavers, pers. commun.). Wofford (1980) reported the effects of this stocking in her 1977 population estimates which indicated 72% of the bass to be 1 year old or younger. Bennet (1937) has noted that the direct effect of stocking probably fades within 2 years in established fisheries, allowing previously existing age group structures to be re-established. Zdinak et al. (1980) found these younger fish to comprise 47% of the bass population in 1979. We found that approximately 60% of the population was 1 year old or younger in 1981.

It is probable that in Lake Elmdale, these younger bass normally comprise roughly 50% of the total population although actual numbers of fish may fluctuate from year to year.

Several factors may be involved in the observed reduction in the bass population which coincided with the drought of 1980. Actual cause and effect relationships are difficult to determine due to the fact that the sampling was conducted post-drought. We think however that some speculation may be in order in our attempts to interpret the situation which we encountered.

Although spawning activities were for the most part completed by the time the drought reached full intensity, residual activities of late spawning bass guarding nests or fry may have been affected to some degree. Rademacher (1978) and Hinton (1978) reported stress on spawning bass and

Table 2. Estimated Population Size and 95% Confidence Intervals for Lake Elmdale Largemouth Bass

Year	Lower Limit	Estimated Population	Upper Limit
1977[a]	7,819	11,770	18,771
1979[b]	7,835	8,937	10,037
1981	2,759	3,916	5,023

[a] Wofford (1980).
[b] Zdinak et al. (1980).

disrupted reproductive cycles due to low water levels resulting from drought conditions. With prolonged high temperatures, spawning activities cease, male fish stop guarding nests and fry and return to feeding (Shuter et al. 1980). Fish experiencing such stress will seek out preferred temperatures if possible (Jobling 1981), but in shallow reservoirs are often unable to do so. A deoxygenated hypolimnion can trap fish in upper water layers where temperature may exceed tolerance levels.

Martin et al. (1981) has noted significant reduction of young centrarchids in a reservoir during low water periods. McCormick and Wegner (1981) note that temperature related stress is especially severe on small fish, eggs and embryos. The reduction in water level and corresponding exposure of vegetation in littoral zones, reduces potential sanctuary areas which provide cover for young bass. Lack of cover can lead to intensified predation, including cannibalism of young bass by older and larger bass (Cooper 1936). Lack of protection from direct sunlight can also be a factor of consideration. Sunlight intensity has been shown to reduce fry survival of striped bass-white bass hybrids in shallow ponds (Rees and Cook 1982).

The combined effects of reduced water levels and probable increases in predation, extremes in temperature and associated physiological stresses occurring in conjunction with the drought conditions of 1980, are considered to be responsible for the reduction in the Lake Elmdale largemouth bass population.

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