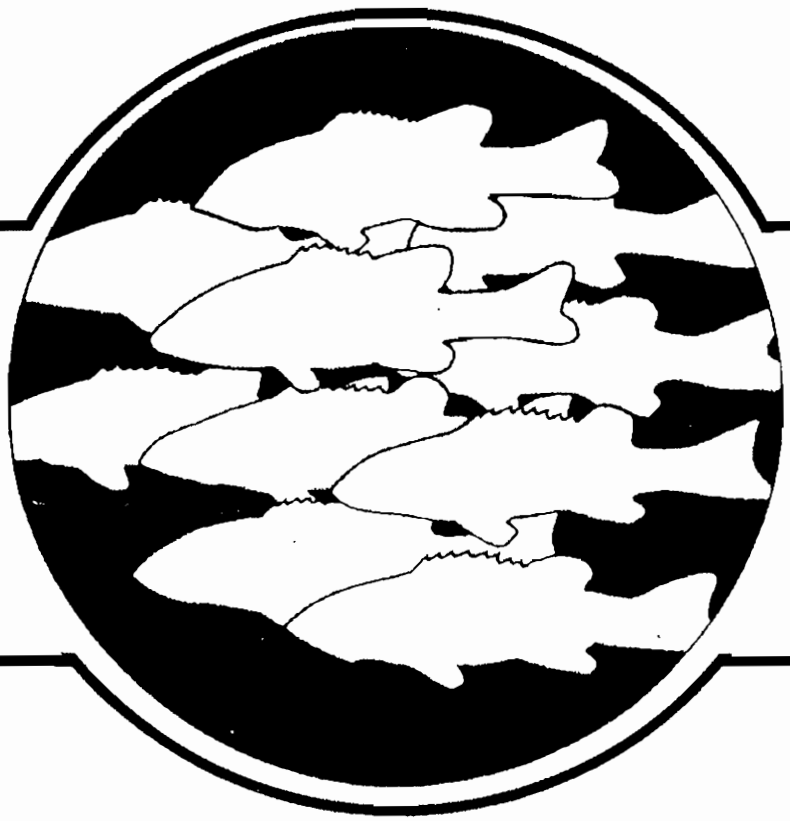

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by

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ABSTRACT

The 15-inch minimum size limit on black bass was evaluated at Grayson Lake from 1982-1990, following 4 years of a 12-inch limit in 1978-1981 and a 10-inch limit before 1978. Mean biomass of all fish during years of the 15-inch limit was more than 50% higher than during years of the 10-inch limit. Based on cove-rotenone data, there was a positive increasing trend in total fish standing stock and largemouth bass biomass during 1973-1988. This may be due to increased nutrients in the lake as chlorophyll-a (TSI) values improved from 33 in 1978 to 40 in 1989. Mean biomass of largemouth bass decreased under the 10-inch limit to 10.0 lb/acre under the 15-inch limit. The biomass of 12-inch group and larger largemouth bass increased by a factor of 2.5 during years of the 15-inch limit. Mean biomass of spotted bass decreased from 2.8 lb/acre under the 10-inch limit to 2.6 lb/acre under the 12-inch limit and 2.1 lb/acre under the 10-inch limit. The ratio by weight of largemouth bass:spotted bass went from 1:1 under the 10-inch limit to 4.2:1 under the 15-inch regulation. The ration by number went from 1:4.3 under the 10-inch limit to 2.8:1 under the 15-inch limit. Largemouth bass and spotted bass grew slower during the 15-inch limit than during 12- and 10-inch limits. Mean largemouth bass survival was higher under the 12-inch limit (36.3%) than under the 12-inch limit (30.8%. Fishing pressure by black bass anglers ranked second to pressure by anglers seeking no specific kind of fish. Percent of all fishing trips by black bass anglers increased from 18% in 1982 to 35-40% in 1983-1986. Mean number of black bass harvested decreased by 85% from the 10- to the 12-inch limit, and 57% from the 12- to the 15-inch limit. Weight of black bass creeled during the 15-inch limit was similar to weight creeled under the 12-inch limit. Catch rates for 12-inch and longer black bass increased from 0.06 fish/hour in 1982 to 0.23 fish/hour in 1986, which was mainly due to the catch and release (0.19 fish/hour) of 12-14.9 inch long black bass. The 15-inch size limit was considered a success based on angler satisfaction (75%) and the achievement of most objectives.

INTRODUCTION

The importance of reservoir fisheries management in the United States grew with increasing numbers of reservoirs constructed, as evident in Reservoir Fishery Resources Symposium (1967), Hall (1971), and Hall and Van Den Avyle (1986). As reservoir construction expanded, new problems, and opportunities in fisheries arose; thus, new approaches to fisheries management were necessary as indicated by Parsons (1957), Hulsey (1959), and Jenkins (1974). Many of the new reservoirs were constructed in the Southeast, where it was recognized that the top predator fish species was the largemouth bass (*Micropterus salmoides*). Their importance becomes obvious by such works as Stroud and Clepper (1975) and Newburg (1975). Largemouth bass importance in reservoirs was pointed out by Jenkins (1975) and carried over into the management of small impoundments (Funk 1974 and Novinger and Dillard 1978). Anderson (1975) probably summed it up best in stating that "the largemouth bass deserve a number one priority in fishery research and management because they are not only the most widely distributed and sought-after game fish in North America, but are also a major predator of other fishes. Bass populations influence the state of balance of fish communities and the quality of fishing for other sport fishes."

One of the ways of managing predatory species in reservoirs for long term fishing is through size-limit restrictions. Saila (1957) discussed negative aspects of reduced restrictive regulations and the elimination of size limits in many states. He felt that size limits were needed to assure a maximum number of large fish in a catch also containing a proportion of small fish. Anderson (1974a) believed that restrictive harvest regulations should be used as "tools for the manipulation and enhancement of community structure, population dynamics, catch, harvest and yield, and the quality of fishing"; eluding to the importance of optimum sustained yield as opposed to maximum sustained harvest. Anderson (1974 a and b, 1976) discussed bass overharvest and reasons for various regulations. He gave reasons, although not agreeing with them, as to why length limits were dropped in the early 1960's. Until that time, length limits were primarily enacted to protect young adult bass until they could spawn at least once, but research showed that the protection of these bass was not necessary to assure reproduction. Thus, size limit regulations began to become less restrictive.

In the mid- to late 1960's and early 1970's, length-limit regulations for black bass became popular once again, and many states adopted statewide minimum-length regulations (Redmond 1986). Research began to show that blanket statewide regulations were probably not in the best interest of the fishery resource. Rasmussen and Michaelson (1974) pointed out that each lake will respond differently to a length limit. They go on to say, "in order to do justice to the resource, each (lake) should be managed as a separate entity which could lead to separate regulations." Of size limits, Fox (1975) said, "size limits appear to be the only method of regulation that has the potential to directly and predictably affect population structure of both bass and forage fish. He also stated, "statewide or general size-limit regulations would therefore seem unfounded at best, and probably disadvantageous to sound management programs." Anderson (1976) stated "of all the methods for controlling mortality that have been tried so far, length limits have proven to be the most reliable." Keith (1978) gave reasoning why there should not be a statewide size limit in Arkansas (defending the no size-limit regulation),

but did not give any reasoning for lake-by-lake management.

Many size-limit restrictions that have been evaluated; a summary of a few follow: Hickman and Congdon (1974) reviewed no length limit to a 12-in length limit and a 15-in regulation; Ming and McDannold (1975) evaluated a pre- and post-12-in minimum-size limit; Gabelhouse (1980) summarized many of the studies regarding size-limit regulations and evaluated size limits in Kansas; Novinger (1984) reported on the use of size limits for bass in large impoundments; Anderson (1984) discussed the role of length limits for bass and reservoir fish management; Eder (1984) reported on the effectiveness of a slot limit and provided a good review of slot-limit regulations; Garrett (1985) evaluated length limits on largemouth bass from Texas reservoirs; Goddard and Redmond (1986) concluded that the 12-in size limit emplaced on a newly constructed reservoir (Stockton Lake, MO) was responsible for the maintenance of a stable, high quality bass fishery which included a catch-and-release element, and avoided the "boom and bust" cycle typical of new lakes; Dent (1986 a and b) discussed methods and parameters used in evaluating a size limit and reported on the results of a 15-in regulation in a Missouri Lake; Novinger (1986 and 1987) and Richards (1986) also reported findings of a 15-in regulation from Missouri lakes; Ager (1988) evaluated a 16-in regulation in Alabama; and Mayers (1988) reviewed minimum and slot limits within several smaller lakes. Kruse (1988) recently developed a largemouth bass assessment strategy similar to that developed by Colvin and Vasey (1986) for crappie.

Kentucky followed much of the trends of the Southeast and elsewhere (Buynak et al a. In Press). Throughout most of the 1940's, Kentucky had a statewide black bass size limit of 11-in then 10-in. From 1955-1968, there was no statewide size limit on black bass, with few exceptions (Jones 1968). During most of the 1960's and 1970's, except a few selected waters, Kentucky had a statewide 10-in minimum-size limit for black bass; which the Fisheries Division did not fully support. In 1978, the Kentucky Department of Fish and Wildlife Resources (KDFWR) initiated a statewide 12-in minimum-size limit for black bass.

Angler dissatisfaction prompted a closer look at the problems and potential for improvement at Grayson Lake. A fish management plan that included a 15-in minimum-size limit for black bass at Grayson Lake was approved and adopted by the Commission. In 1982, Grayson Lake became the first lake in Kentucky to have a 15-in minimum-size limit for black bass. The importance of managing Kentucky's black bass populations was supported in findings by Kinman and Hoyt (1984), a fisherman attitude survey, which revealed that black bass was the most preferred type of fish in Kentucky and more trips were made fishing for black bass than any other species. In reservoirs, black bass rank about equal to crappie in preference and fishing pressure based on creel surveys.

Part of the management plan for Grayson Lake called for a below normal winter pool drawdown during the winter of 1981-1982. Lake rehabilitation such as a drawdown can have several favorable outcomes such as described by Hulsey (1959), Dunst et al. (1974), and Keith (1975). Among the goals for the Grayson Lake drawdown included rejuvenating littoral areas, hopes of flushing out some of the excess crappie, allowing predators (primarily black bass) a better opportunity to feed on small crappie, allowing the construction of brush attractors, and netting and removal of excess crappie. A drawdown that would reduce reservoir volume by 50% of the normal winter pool storage volume

was requested. Unfortunately, the drawdown was accomplished early in the fall of 1981 while the lake was still under a 12-in minimum size limit for black bass. Due to the reduced reservoir volume, anglers were able to have excellent success at harvesting largemouth bass. Anglers claimed that the fishing was better than they had ever experienced within the lake. The removal of harvestable-size bass at this time, however, negatively influenced the bass fishery the first few years after the 15-in size limit was enacted in 1982.

Another problem at Grayson Lake during years of the 10- and 12-in size limit was poor recruitment of largemouth bass fingerlings to the intermediate-size range (5-11 in), despite adequate reproduction. This problem was not as obvious among the spotted bass population. This recruitment phenomenon apparently is not that uncommon, as the problem has been discussed by Aggus and Elliott (1975), Jenkins (1975), Anderson (1984), and Miranda and Muncy (1987). These authors emphasize that there is no correlation between numbers of young adult bass in a population and resulting reproduction or recruitment. Aggus and Elliott (1975) and Miranda and Muncy (1987) go on to report that there was a high correlation between rate of growth of age 0 largemouth bass and the number recruited at age 1. In hopes of boosting the intermediate-size largemouth bass numbers (primarily age 1 fish), an important part of the management plan at Grayson Lake was the stocking of 15,000 largemouth bass (10 fish/acre) in 1982; these bass averaged 7.7-in long. Stocking has always been controversial among fisheries biologists. Loska (1982 a and b) gives an excellent account regarding the subject, stating that good reasoning and a definite purpose is needed prior to any stocking effort, as stocking generally does not provide much return.

Smallmouth bass (*M. dolomieui*) were stocked into Grayson Lake in 1980; all three black bass species were stocked in 1982 (Table 1). Local anglers expressed further interest in smallmouth bass for Grayson Lake and the area Commissioner requested that this species be stocked into Grayson Lake on a more consistent basis. Black Bass Research Biologist Buynak responded to these demands based on his findings regarding preferred black bass habitat statewide (Buynak 1986). It was determined that Grayson Lake could not support or sustain a smallmouth bass fishery through natural reproduction at a level of at least 10% of total black bass population in the lake and make up $\geq$10% of the total black bass harvest without supplemental stocking. These smallmouth bass stockings began in 1986 and were to take place for 5 years, after which the smallmouth bass fishery would be evaluated.

The primary objective of the 15-in minimum size limit at Grayson Lake was to provide a better quality bass fishery, improve catch-and-release of quality-size black bass; and enhance the overall fishery within the lake. Although three black bass species co-existed in the lake, the regulation was expected to primarily benefit the largemouth bass fishery. Objectives of the 15-in size limit at Grayson Lake are as follows: (1) a black bass standing crop of 15 lb/acre, of which 10 lb/acre is comprised of largemouth bass; (2) five lb of largemouth bass $\geq$12-in long per acre; (3) a PSD for largemouth bass of 40-60% and a RSD_{15} for largemouth bass of 10-25%; (4) maintain a ratio of at least 60% largemouth bass to 40% spotted bass; (5) young to adult ratio (YAR) of 1-10 desired for largemouth bass; (6) relative weight values (Wr) of 95-100% for 8-11.9, 12-14.9, and $\geq$15-in groups for black bass of each species; (7) harvest rate of at least 1 largemouth bass $\geq$15-in long per acre; (8)

improve the catch rate of ≥12-in long black bass to 0.25 fish/hour by bass anglers; (9) improve the harvest rate of ≥15-in long black bass to at least 0.1 fish/hour by bass anglers; (10) increase in fingerling (0-3 in) shad biomass; (11) increase the number of quality-size (≥8.0 in) white crappie.

STUDY SITE

Grayson Lake (Figure 1), a highland reservoir, completed in 1968, is a 1,510-acre flood control impoundment located at mi 51.2 on the Little Sandy River. Maximum depth of the lake is 60 ft, with a mean depth of 19.7 ft. Seasonal pool elevation is 645 ft above mean sea level (msl); at this stage the lake is 1,510 acres in size. At winter pool, (637 ft msl), the lake is 1,160 acres in size. Water retention time averages 73.4 days. Grayson Lake is relatively narrow and 19.7 mi long, having a shoreline length of 74.2 mi. The watershed area is approximately 125,400 acres (196 mi^2), draining portions of Carter and Elliott counties.

Grayson Lake lies within the Kanawha Section of the Appalachian Plateau physiographic region. The terrain within the drainage area is represented by narrow, serrated ridges and steep slopes which are considered to be excessively drained. Steep (up to 150 ft high) sandstone cliff walls, representing what once was a deep gorge, make up much of the shoreline in the upper lake area, with more gentler slopes near the dam. Underlying much of the area are rocks of the Early and Middle Pennsylvanian and Late Mississippian periods. Sandstone, shales, and coals of the Lee and Breathitt Formation make up much of the Pennsylvanian System, while limestones, sandstones, and shales of the Merrimac and Chester Series make up the bulk of the Mississippian System.

At times, the water quality within portions of the Grayson Lake drainage have been impacted by leakage of acid material and erosion from several abandoned surface mines in the headwater reaches. Problems with the extraction of gas and oil from wells located within the drainage area have also impacted portions of Grayson Lake (Corps of Engineers 1987).

Based on Carlson TSI (chlorophyll-a) values, Grayson Lake was rated as being oligotrophic. Mean TSI for years evaluated by the Kentucky Division of Water (1984, 1988, and personal communication) was 39, which is at the upper end of the range for oligotrohic lakes (0-40). When determined, TSI values were:

1977	1978	1979	1981	1988	1989
35	33	40	41	44	40

The Kentucky Division of Water also indicated that warmwater aquatic habitat was threatened by salinity (brine) due to petroleum activities.

METHODS

The black bass fishery at Grayson Lake consists of largemouth, smallmouth, and spotted bass *M. punctulatus*. Smallmouth bass were first introduced in 1980 and will only be discussed superficially in this report.

Shoreline electrofishing was conducted from 1982-1990 as the primary method of collecting bass. Nocturnal spring electrofishing was carried out in May to

collect fishes in order to determine proportional stock density (PSD) (Anderson 1976) for bass and bluegill, relative abundance, length/frequency, and catch-per-unit-effort data. At this time, scales were collected from bass for age and growth determinations. Stock, quality, and preferred lengths to determine PSD and RSD values were based on modifications by Gabelhouse (1984). Changes for the largemouth bass PSD balanced range suggested by Weithman et al. (1979) were used as well. Nocturnal electrofishing in October was carried out to determine relative weight (Wr) indices on bass (Wege and Anderson 1978), as well as the other previously-mentioned indices. Electrofishing effort was increased in 1986-1990. Electrofishing data prior to the 15-in size limit (1982) is virtually non-existent. During the early years of the 15-in size limit (1985-1987), fish were measured by inch group (i.e. 1.5-2.4 in = 2-in group), while fish captured from 1988 to present were measured by inch class (i.e. 2.0-2.9 in = 2-in class). However, under both classifications when fish were measured precisely, they were measured to the nearest 0.1 in and weighed to the nearest 0.01 lb. In order to compare old and new data, inch group categories will be utilized for this report.

Cove-rotenone surveys were carried out to estimate fish standing stock using standard sampling techniques described by Charles (1969). Figure 1 shows the location of the survey coves. Cove-rotenone surveys were carried out annually from 1973-1988 at Grayson Lake. Two survey coves totaling 3.4 acres were sampled from 1973-1978. In 1979, one of the cove sites was changed. The two coves sampled from 1979-1988 totaled 3.0 acres. Cove-rotenone data was used as the primary sampling tool to compare changes in the black bass population during years of the 10-, 12-, and 15-in size limits. This was necessary as no nocturnal electrofishing was carried out at Grayson Lake during years of the 10- and 12-in size limits (1973-1981). Predator-prey relationships were calculated from cove-rotenone data by using the available prey biomass/predatory biomass (AP/P) formulations described by Jenkins and Morais (1976).

Age and growth determinations were made from bass scale samples removed from an area below the lateral line and near the tip of the pectoral fin (when depressed). Most scales were read using a microfiche projector (Micron 750) or in some cases, a Bausch and Lomb Tri-Simplex Microprojector. Appropriate measurements were obtained to determine back-calculated growth rates using a correction factor determined by Crowell or Buynak (personal communication), depending upon black bass species. Formula followed the modification of the Lee Method (Everhart and Youngs 1981). No differentiation between bass sexes was made. Comparisons were made based on standard errors, 95% confidence intervals, between largemouth and spotted bass, and among each species under each size limit.

Exploitation, natural mortality, and survival rates for black bass from Grayson Lake during years of the 12-in size limit were determined by Crowell (1984). Tagging efforts were carried out in 1978 and 1979. Crowell did not separate exploitation results among the two bass species. This was due to too few spotted bass $\geq$12-in long being tagged. Survival estimates were determined, during years of the 15-in size regulation, using age and growth data obtained from scales and relative abundance of bass from fish population studies. Mortality rates (survival rate), other than that above, were figured using the Robson and Chapman formulation according to Ricker (1975).

Stratified, random, non-uniform probability creel surveys were conducted at Grayson Lake as described by Pfeiffer (1966). Creel survey data were obtained from 1974-1977 during years of the 10-in black bass size limit; 1978-1979, years of the 12-in size limit; and 1982-1986, years of the 15-in size limit. Creel surveys ran from March 01 - October 31 in 1974-1979 and from April 01 - October 31 during 1982-1986. Creel surveys were conducted by local conservation officers.

Catch and release data were unavailable from creel data during the 1974-1979 surveys. Anglers interviewed during the 1982-1986 creel surveys were asked how many 12-15 in long bass were caught and released, how many legal-size bass ($\geq$15 in) were caught and released, and the number and size of smallmouth bass caught and released. During 1983, anglers were asked two social questions: (1) do you favor the 15-in minimum-size limit for black bass at Grayson Lake?, and (2) do you think bass fishing has improved because of the 15-in minimum size limit at Grayson Lake?

Correlation analysis utilizing Spearman Correlation Coefficients and analysis of variance were computed using SAS statistical software on the following parameters:

Standing stock: expressed as pounds per acre for the total fish population, gizzard shad, white crappie, largemouth bass, spotted bass, and smallmouth bass; also number per acre for largemouth, spotted, and smallmouth bass in the $\leq$7, 8-11, 12-14, and $\geq$15-in groups.

Electrofishing catch per hour (CPH): for total largemouth bass, largemouth bass in the $\leq$7-in group, largemouth bass in the 8-11 in group, largemouth bass in the 12-14 in group, largemouth bass in the $\geq$15-in group, total spotted bass, spotted bass in the $\leq$7-in group, spotted bass in the 8-11 in group, spotted bass in the 12-14 in group, and spotted bass in the $\geq$15-in group;

Creel survey data: total fishing pressure (man-hours/acre), total bass harvest (lb/a), and catch-and-release of 12-14.9 in long bass.

These data were compared for all years, separately, as well as grouped for years under each size-limit regulation. Primarily, only the parameters by year and by regulation will be discussed in this report.

RESULTS AND DISCUSSION

Largemouth bass

Based on spring electrofishing, no discernible trend or significant difference could be seen in the CPH of total largemouth bass numbers sampled in 1983-1990 under the 15-in size limit. However, the catch per hour (CPH) of $\leq$7, 8-11, and 12-14 in group largemouth bass increased dramatically from 1982 to 1983. The increase in 8-11 and 12-14 in group bass was possibly influenced by the stockings of 15,170 8-in largemouth bass in 1982. There were also 90 16-in largemouth bass stocked that year, but the CPH of $\geq$15-in group bass in 1983 did not increase. The mean CPH of largemouth bass in 1983-1990 was 66 fish/hour (Figure 2a); CPH exceeded the mean in 1983, 1988, and 1989. Catch

rates were similar in 1984-1986 and 1987, being at or near 40 largemouth bass/hour.

The greatest density of largemouth bass sampled in the ≤7-in group occurred in 1987 at 29 fish/hour (Figure 2b); the lowest density was 2 fish/hour in 1982. The mean CPH for this size group was 19 fish/hour. Mean catch per hour for the 8-11 in group largemouth bass was 27 fish/hour in 1983-1990 (Figure 2c). The highest CPH of 8-11 in group bass was 51 fish/hour in both 1983 and 1990, followed by 41 fish/hour in 1988. The large stocking of intermediate-size largemouth bass in 1982 likely contributed to the high CPH in 1983. Catch rates for 8-11 in group bass ranged from 11-21 bass per hour during other years within the 1983-1990 period. The highest CPH for 12-14 in group bass was 28 fish/hour in 1990, followed by 19 fish/hour in 1988 (Figure 2d). Catch rates for 12-14 in group bass in 1983, 1984, and 1986 were similar at 12-16 fish/hour, which are close to the mean of 14 fish/hour for this size group. Low catch rates for this size group occurred in 1985, 1987, and 1989, ranging from 5-8 fish/hour. The mean catch rate for ≥15-in largemouth bass was 5 fish/hour (Figure 2e). The best CPH for this size bass was 13 fish/hour in 1988. The CPH was within 3 fish/hour of the mean during the remaining 9 years.

The 8-11 in group bass were most abundant based on percent occurrence from spring electrofishing as compared to ≤7-in, 12-14 in, and ≥15-in groups for 1983-1990, years of the 15-in size limit (Table 2). Prior to the 15-in size limit, relatively low numbers of 8-11 in group largemouth bass were found in Grayson Lake. However, there were no significant trends for any individual inch group of largemouth bass under the 15-in size limit (1983-1990).

Spotted bass

Mean CPH for spotted bass from 1983-1990 was 56 fish/hour (Figure 3a). The best CPH occurred in 1988 (91 fish/hour) and the lowest in 1984 (36 fish/hour). Based on CPH, spotted bass gradually increased under protection of the 15-in regulation in 1982-1985 and even under the no-length limit in 1986-1990, but more than half of these numbers were in the ≤7-in group.

The mean CPH for ≤7-in group spotted bass in 1983-1990 was 33 fish/hour and was at or near this figure in 1985-1986 and 1989-1990 (Figure 3b). The highest CPH occurred in 1988 (57 fish/hour); the lowest CPH was in 1984 (14 fish/hour). The CPH for the last 4 years in 1987-1990 were above the mean, which follow the elimination of a length limit on spotted bass in Grayson Lake in 1986. There were two peak years for CPH of 8-11 in group spotted bass, 1988 and 1990, with each having a CPH of 29 fish/hour. The mean for all years for this size spotted bass was 18 fish/hour (Figure 3c). More spotted bass were sampled within the 12-14 in group in 1985 than any other year (9 fish/hour); the mean CPH among the years sampled for this size fish was 4 fish/hour (Figure 3d). Few spotted bass were sampled that were in the ≥15-in groups (Figure 3e). Of the 9 years of spring electrofishing, only four spotted bass were sampled in the ≥15-in group, and relatively few were captured in the 12-14 in group.

The 15-in size limit included protected of spotted bass in 1982-1985, which kept them from being harvested virtually their entire life span at Grayson Lake. Jenkins (1975) reported that in reservoirs where largemouth bass or

smallmouth bass, or both are present, the spotted bass ranks last in angler preference and because of this, should have low priority in management considerations. Buynak (1986) reported that under a 12-in size limit, very few harvestable-size spotted bass were collected from Kentucky waters. A similar situation existed at nearby Cave Run Lake (Buynak et al. In Press). Thus, to better manage the bass fishery and to allow some spotted bass harvest, the size limit restriction for spotted bass was removed from that lake when the 15-in minimum length limit for largemouth and smallmouth basses was implemented in 1985. Based on recommendations from research at Cave Run Lake, the size limit restrictions for spotted bass was removed at Grayson Lake in 1986 and; subsequently, statewide in 1988. Novinger (1986 and 1987) stated that spotted bass could be better managed in Missouri with a lower length limit. The author believes that a reduced length limit or separate management strategies for the spotted bass will become more commonplace in fishery management.

When spotted bass were protected at Grayson Lake with a 15-in length limit in 1982-1985, the 12-14 in group fish gradually increased in number. By 1989 and 1990, after the removal of the size limit for spotted bass, the lowest CPH for 12-14 in group spotted bass occurred.

Spotted bass in the $\leq$7-in group were collected with greater frequency than all other size groups every year but in 1984 (Table 3). The mean percent occurrence for all years for the $\leq$7-in group was 58.7%, 8-11 in group - 33.0%; 12-14 in group - 7.4%, and $\geq$15-in group - 0.9%. The percent occurrence of the 12-14 in group spotted bass decreased annually after 1985, going from 16.7% in 1985 to 1.5% in 1990. Apparently, anglers are utilizing this species to a greater degree than previously thought, at least those in the 12-14 in group, although similar declines were not noted for the 8-11 in group fishes. There was a significant (0.10) increasing trend for total spotted bass CPH; this was primarily due to the $\leq$7-in long spotted bass numbers. There was no significant trends from 1983-1990 for any other spotted bass size group. Spotted bass may become stockpiled below a certain "angler preferred size" and this could cause competition with largemouth bass of this size.

Proportional Stock Density (PSD)

The desirable PSD range for largemouth bass according to Anderson (1976) was 45-65%. Reynolds and Babb (1978) determined that largemouth bass PSD of 40-60% was best for small impoundments. Weithman et al. (1978) modified the PSD values to better fit shad forage-based largemouth bass populations for larger reservoirs; their value of a balanced largemouth bass population was 50-70%. Using their values at Grayson Lake, largemouth bass PSD was only within the desirable range of 50-70% during 1984 (Figure 4). Anderson (1980) listed a largemouth bass PSD of 40-70% as balanced, coupled with a relative stock density (RSD_{15}) of 10-25%, YAR of 1-10, and a Wr of 95-100. The mean largemouth bass PSD from Grayson Lake (1983-1990) was 40%, the mean RSD_{15} was 12, the mean YAR was 1.89, and the mean Wr (all sizes) was 89. Therefore, according to the above, the Grayson Lake largemouth bass population can be considered to be well-balanced during years of the 15-in limit; although values were in the low range and mean Wr values were not within the desired range.

The PSD for largemouth bass slowly responded in 1982 and 1983 (Figure 4) to

the 15-in limit or possibly the 8-in bass stockings in 1982. The PSD values remained fairly stable from 1984-1990. Relative stock density (RSD_{15}) increased from 1983-1985. The RSD_{18} increased in 1987. These increases could be a result of the 1982 stocking of largemouth bass or the 15-in limit. Dent (1986a) stated that PSD alone was not sufficient to determine why bass populations responded differently to size limits and later used electrofishing CPH data as an index of abundance. Proportional stock density values, as well as RSD values, for the other two black bass species and bluegill are presented in Table 4.

Relative Weight (Wr) Indices

The Wr values for all black bass species and size groups were usually below the suitable range of 95-100 (Table 5). Findings from Grayson Lake are in general agreement with Anderson (1984), where he states that the sizes of bass that are protected under a restrictive length limit often exhibit relatively low Wr in large reservoirs. In some cases, the sample sizes were relative small, particularly for the ≥15-in category. One of the reasons for variation in Wr values according to Gilliland (1985) were small numbers of bass in a given length group. Small sample sizes were used for all bass species within the ≥15-in category, and sample size was generally small for spotted and smallmouth bass in the 12-14.9 in group range. Wege and Anderson (1978) felt that a sample of 10-20 bass (8-11.9 in long) was sufficient to estimate Wr ±3 with 90% confidence. Dent (1986a) felt that Wr indices were not essential in evaluating bass length limits at the lake he studied. Due to inaccuracies in weighing smaller bass in the field at night, which resulted in wide fluctuations of Wr, the ≤7-in size group will not be discussed further. Data is, however, provided in Table 5 for this group.

Largemouth bass Wr was generally highest (usually less than 95, but over 90) for the ≥15-in fish, as it was for the other black bass species of this size. This is typical, as large bass generally don't have a problem finding adequate prey and bass ≥15-in long are generally represented by relatively low numbers in the total fish population. Largemouth bass, 12-14.9 in long, had a mean Wr of 90.

Spotted bass Wr values were generally lower than largemouth bass Wr values within all size groups (Table 5). In 1987, largemouth bass Wr values for 8-11.9 in fish were unusually low, as they were for all size groups of spotted bass that year. It is not known what caused this phenomena. Forage fish showed a decline in standing stock (see cove-rotenone section) in 1986-1988, and were the lowest recorded in 1988, yet Wr values that year were higher than Wr values in 1987.

Relatively few smallmouth bass were collected and most were ≤7-in long. Their Wr values are compared with the other black bass in Grayson Lake in Table 5.

Relative weight values for black bass from Grayson Lake show that they are generally in poor condition, despite AP/P values (Jenkins and Morais 1978) that indicate sufficient prey was available to predators in Grayson Lake (Figure 7). However, there may be interspecific competition within or among predatory species (primarily largemouth bass, spotted bass, and white crappie) particularly at certain sizes. Numbers of smaller size spotted bass have shown a general increase under the 15-in regulation in 1982-1985 as well as

years following the removal of the size limit for spotted bass after 1985, possibly causing increased competition with other black bass species.

In comparing the spring electrofishing results to fall electrofishing results, 8-11 in group largemouth bass were the most abundant group collected from both sample periods as shown below. One would surmise that the smaller (≤7 in) largemouth bass would be more numerous in the fall electrofishing sample due to recruitment from that year's spawn, but that was not the case. It was, however, with spotted bass, where the ≤7-in group was the dominant size group collected during fall sampling. Variability between sample periods appears to be much less for largemouth bass as observed below. Mean CPH values for largemouth and spotted bass from 1983-1990 spring and 1983-1989 fall sampling of various inch groups are as follows:

	Inch group range				
	≤7	8-11	12-14	≥15	Total
Largemouth bass					
Spring	19	27	14	5	66
Fall	15	26	5	3	49
Spotted bass					
Spring	33	18	4	0.5	56
Fall	72	17	3	trace	92

Spring electrofishing generally yielded better samples of largemouth bass, a mean of 52% of the black bass totals (1982-1990), compared to fall electrofishing, where largemouth bass only represented a mean of 32% of the black bass collected. Larger size largemouth bass were also collected with greater frequency during spring sampling. Reynolds and Simpson (1978) suggested that spring electrofishing be used to assess centrarchid populations, particularly largemouth bass. Weithman, et al. (1979) recommended spring electrofishing provided the most representative sample of largemouth bass. Findings from this study, at least for largemouth bass sampling, are in agreement with other research which reported that if only one sampling technique is to be used in evaluating bass populations, spring electrofishing should be the chosen method (Reynolds and Simpson 1978; Woodrum 1978; Weithman, et al. 1979; Garrett 1985; and Dent 1986). However, if relative weight values are of importance, fall sampling must be carried out.

Cove-Rotenone Fish Population Surveys

Cove-rotenone surveys were carried out from 1973-1988; standing stock values of fishes recovered can be found in Tables 6-8 for the different size-limit restrictions. The mean biomass of all fishes for the 16 years was 189.9 lb/acre, with the lowest biomass recorded in 1976 (93.6 lb/acre) and the highest in 1985 (264.8 lb/acre) (Figure 5). The mean standing stock per regulation displays an increasing trend (Figure 6) from 141.5 lb/acre (10-in size limit) to 179.1 lb/acre (12-in size limit), and 214.8 lb/acre (15-in size limit). Mean biomass for game fishes, panfishes, and commercial fishes was highest under years of the 15-in regulation, while food and forage fish biomass was greater under the 12-in regulation (Table 9). Fish that had higher biomass values under the 10-in regulation were spotted bass (although fairly similar under all 3 regulations), longear sunfish, spotted sucker,

bullheads, cyprinids, and darters. Those fish that had a biomass greater under the 12-in size limit were white bass, channel and flathead catfishes, green sunfish, redhorses, and gizzard shad. All other fish biomass values were higher during years of the 15-in size limit.

The regression of fish standing stock versus years was significant and positive, indicating an increase in biomass through time (Figure 5). This increase is probably related to a gradual increase in nutrient levels within the lake over time. The mean chlorophyll-a (TSI) value from Grayson Lake was 39; it increased from 33 in 1978 to 40 in 1989 (see Study Site section). The lower standing stock values found in 1987-1988 under the 15-in size limit could be due to drought conditions experienced during those years. Buynak et al. (in press) discussed this phenomenon as it related to changes in fish biomass at Barkley and Kentucky lakes, although situations there were somewhat different.

One of the problems managers must consider when implementing more restrictive size-limit regulations on predator (game) fish is: will there be enough forage (prey) to feed the additional predators protected as well as the other predatory fishes within the body of water in question. Several indices have been used over the years to determine the ratio of predator to prey and/or determining balanced fish populations such as those described by Swingle (1950). Since then, entire treatise have been devoted to the complex predator-prey systems (Clepper 1979). Swingle's (1950) parameters included F/C (F = total weight of all forage fish, C = weight of all carnivorous fish; later changed to NP/P), Y/C (Y = weight of F species small enough to be eaten by the average C individual), and A_T or total availability value) (% of the weight, or population, composed of harvestable-size fish).

For a number of years, these indices were calculated from cove-rotenone surveys for trend and comparison purposes. Periodic modifications (based on current literature) were made to best develop standards that best suited Kentucky's needs and better fit large reservoir situations. The original formulations by Swingle (1950) were generally derived to be used in pond or small lake situations where species associations are not very complex. A comparison of these parameters under each size limit regulation follows. The mean F/C (used here as NP/P) at Grayson Lake was 6.7 (1.5-15.0) under the 10-in regulation, 3.3 (1.1-5.9) under the 12-in regulation, and 2.1 (0.8-4.8) under the 15-in regulation. The mean F/C for all years in 1973-1987 was 4.0 (Table 10). Values of 3 to 6 indicate a balanced ratio, 0 to 3 an overabundance of C, or predatory fish, and ≥ 7 an overabundance of F, or prey species. Mean Y/C values (Table 10) were 1.2 (0.9-1.5), 2.2 (0.9-4.1), and 2.3 (1.1-5.2) for years under the 10-, 12-, and 15-inch size limits, respectively. The mean Y/C for all years was 2.0. The most desirable range is 1.0-3.0. The overall (1973-1987) mean A_T value (Table 10) was 40, with the mean A_T under the 10-in size limit being 43 (25-56). The mean A_T under the 12-in regulation was 40, and 38 for the 15-in regulation. The most desirable range for the A_T value is 60-85; balanced values should be within a range of 33-90 (with 33-40 the inefficient range); values of 0-40 are considered to be unbalanced fish populations. Based upon the above computations, F/C values generally indicated that the Grayson Lake fish population was in balance under the 10- and 12-in size limit, but had an overabundance of predatory fish under the 15-in size limit. The Y/C values indicated balanced populations under all three regulations, while A_T values showed that numbers of harvestable-size

fish available was within the balanced, but inefficient range, in most years.

Jenkins and Morais (1978) developed a more useful method for estimating prey-predator relationships in reservoirs. Their findings led to eventual development of the available prey (AP) biomass to predator (P) biomass or AP/P ratio, a much better index for reservoir use. The AP/P model indicated a sufficient prey to predator ratio (>1:1) under each size limit regulation (Figure 7), despite an increase in percent of total pounds of game fish and a decrease in percent biomass of forage fish (Table 11). The mean ratios for larger size predators indicated that there was somewhat less prey available under each more restrictive regulation, but more prey available for smaller size predators during the same periods.

Black Bass Standing Stock

There was a significant increasing trend in total largemouth bass biomass through time in 1973-1988 (Figure 8). The largemouth bass biomass under the 10-in size limit decreased, but not significantly, from a high of 4.8 lb/acre in 1974 to 1.2 lb/acre in 1977 (Tables 12 and 13). Under the 12-in size limit, the biomass for largemouth bass varied with no discernible trends (Tables 12 and 14). There was a positive, but not significant, increase in largemouth bass biomass under the 15-in regulation (Tables 12 and 15) despite the bass stocking in 1982. The largemouth bass biomass, however, increased from a mean of 2.8 lb/acre under the 10-in regulation to a mean of 3.3 lb/acre under the 12-in size limit, and finally averaged 10.0 lb/acre under the 15-in size limit (Figure 9). The mean standing stock of largemouth bass from 170 reservoirs compared by Jenkins (1975) was 8.9 lb/acre. He also reported the combined black bass standing stock averaged 10.1 lb/acre from these same reservoirs.

Findings from cove-rotenone studies in 1973-1988 indicated a slight declining trend for spotted bass biomass (Figure 10). The mean standing stock of spotted bass declined from 2.8 lb/acre under the 10-in size limit to 2.6 lb/acre under the 12-in size limit and to 2.1 lb/acre under the 15-in regulation (Figure 9). According to Jenkins (1975), the mean standing stock of spotted bass from 69 reservoirs was 2.0 lb/acre, which was similar to the mean spotted bass biomass at Grayson Lake.

The mean biomass of fingerling-size ($\leq$4-in group) largemouth bass more than tripled under years of the 12-in size limit (0.97 lb/acre) compared to years during the 10-in size limit (0.31 lb/acre), then doubled during years of the 15-in regulation (1.82 lb/acre) (Figure 11). Mean numbers per acre of fingerling size ($\leq$4-in group) largemouth bass were 23 fish/acre during years of the 10-in size limit, 84 fish/acre under the 12-in regulation, and 304 fish/acre during years of the 15-in regulation.

The mean pounds per acre of $\leq$4-in group spotted bass declined with each more restrictive regulation, with values of 0.87 lb/acre during years of the 10-in size limit, 0.76 lb/acre under the 12-in regulation, and 0.51 lb/acre during years of the 15-in size limit (Figure 12). However, mean number per acre of fingerling-size spotted bass was highest under the 12-in regulation at 164 fish/acre, with a mean of 122 fish/acre under years of the 10-in limit, and 108 fish/acre during years of the 15-in regulation.

Mean pounds per acre for largemouth bass under years of the various size limits for intermediate-size (5-11 in group) fish show the greatest and most obvious change occurred under the 15-in size limit (4.54 lb/acre) (Figure 11). There was nearly a four-fold increase in mean biomass for this size bass under the 15-in limit compared to that during the 12-in size limit (1.04 lb/acre); it was 1.18 lb/acre under the 10-in size limit. Numbers per acre of this size group showed a similar trend with 7 fish/acre, 5 fish/acre, and 22 fish/acre under the 10-, 12-, and 15-in size limits, respectively.

Size-limit regulation changes appeared to have no obvious bearing on the biomass of the intermediate-size (5-11 in long) spotted bass (Figure 12). Their mean biomass was greatest under the 12-in regulation (1.42 lb/acre), but was not much different than that found under the 10- (1.16 lb/acre) or 15- (1.06 lb/acre) in regulation.

Mean pounds per acre for quality-size (≥12-in group) largemouth bass under each regulation (Figure 11) were similar under the 10- (1.32 lb/acre) and 12- (1.31 lb/acre) in regulation, but the mean biomass nearly tripled during years under the 15-in regulation (3.36 lb/acre). The number per acre of this size fish was three times greater under the 15-in regulation at 3 fish/acre compared to 1 fish/acre for both the 10- and 12-in limits.

Even though ≥12-in group spotted bass were protected up to 15 in under the 15-in size limit in 1982-1985, biomass for ≥12-in group fish did not increase correspondingly (Figure 12). Few ≥12-in group spotted bass were collected from spring electrofishing, as the mean CPH was only 4 in 1983-1990 under the 15-in size limit.

Although low in numbers (0.6 fish/acre) during years of the 15-in limit, the number per acre of ≥15-in largemouth bass was three times greater than during the 10- and 12-in limits. The biomass of largemouth bass ≥15-in group (1.13 lb/acre) nearly doubled that found during years under the 10- (0.62 lb/acre) or 12- (0.48 lb/acre) in size limit (Figure 11). No ≥15-in group spotted bass were found in 16 years of cove-rotenone studies; only 4 spotted bass of this size were collected in 9 years of spring electrofishing and 2 fish in 8 years of fall electrofishing. Thus, under a 15-in regulation, nearly the entire population of spotted bass was made up of fish that never obtained legal length (≥15-in long). These findings initiated the removal of the size limit for spotted bass at Grayson Lake in 1986.

The mean percent composition of largemouth bass and spotted bass collected from cove-rotenone studies is shown below (smallmouth bass were excluded).

	No./acre		Lb/acre	
	% largemouth	% spotted	% largemouth	% spotted
10-in limit (1973-1977)	19	81	50	50
12-in limit (1978-1981)	34	66	56	44
15-in limit (1982-1988)	74	26	83	17

This data shows a change in the black bass population from a population primarily dominated by spotted bass under the 10-in limit to one dominated by largemouth bass during the 15-in limit. The same trend was true for spring electrofishing data (table 16). Jenkins (1975) found the mean black bass stock (lb/acre) to be 66% in largemouth bass, 22% in spotted bass, and 12% in smallmouth bass when all three species are present in a reservoir.

Other species

White crappie, gizzard shad, bluegill, and carp contributed the greatest biomass to the fish standing stock in Grayson Lake. Due to the importance of gizzard shad as bass forage, findings regarding this species are discussed briefly as follows. Gizzard shad biomass showed a declining, but not significant, trend in 1973-1988 (Figure 13). There was a positively significant decline during years under the 10-in regulation and again during the period under the 15-in size limit. Mean gizzard shad biomass was greatest during years under the 12-in regulation (62.21 lb/acre). Mean biomass for this species was 41.66 lb/acre under the 10-in regulation and 47.47 lb/acre under the 15-in size limit. Gizzard shad are the primary prey species in Grayson Lake; thus, significant declines may impact the black bass fishery. Drought conditions may be partially responsible for reduced gizzard shad populations during years of the 15-in regulation. Relative weight values for smaller bass were low during 1986, 1987, and 1988 (Table 5), perhaps as a result of the gizzard shad decline coupled with the increased abundance of protected bass and greater numbers of small spotted bass.

Black Bass Age and Growth

Generally, mean growth per age for largemouth bass was less under the 12- and 15-in size limits compared to the 10-in regulation (Figure 14). The only statistical difference was for growth of age 2 largemouth bass which was significantly less under the 15-in regulation versus growth determined during years of the 10- and 12-in limits.

Under the 10-in regulation, most largemouth bass reached 10 inches in length by age 3 (Table 17); it took until age 3+ for largemouth bass to reach this length under the 12- and 15-in limits (Tables 18-19). Largemouth bass achieved 12 inches in length at age 4+ under the 12- and 15-in size limits; whereas, they reached a length of 12 in at age 3+ under the 10-in size limit. Under the 10-in regulation, largemouth bass reached 15 inches in length at age 4+; it took largemouth bass an additional year, at age 5+ on the average, to

reach this same length during the years under the 12- and 15- in length restriction.

Age and growth data was too scant for spotted bass to compare statistically or to calculate using a correction factor. Therefore, age and mean growth of spotted bass under the 10- and 12-in regulations are only reported using the direct proportion method (Table 20). Growth for spotted bass was also generally less under the 15-in regulation than years of the 10- and 12-in limits. Spotted bass reached 10-in long at age 3+ under the 10-in regulation, while it took 1 year longer, at age 4+ on the average to reach this size under the 12- and 15-in limits. It took spotted bass until age 4+ to reach 12-in long under years of the 10- and 12-in limits, and 5+ years to reach this length under the 15-in limit. During years of the 10-in size limit, spotted bass reached 15-in long at age 6+. No spotted bass $\geq$15-in long were aged under years of the 12- and 15-in limits.

Novinger (1987) found that growth rates for largemouth and spotted bass were slower under a 15-in regulation and it took both species an additional year to reach 15-in after the implementation of a 15-in regulation in a Missouri reservoir. This was true for largemouth bass in Grayson Lake under the 12- and 15-in regulation compared to being under the 10-in size limit.

Mortality and Survival

Survival rates for both largemouth and spotted bass at Grayson Lake are poor. Anderson (1975) felt that for sustained fishing quality, the annual mortality should not exceed 50%. Mean percent survival rates for largemouth bass at Grayson Lake were generally higher (36.3%) under the 15-in regulation (Table 22) than during the 12-in regulation (30.8%) (Table 21). During the 15-in regulation, mean survival rate from age 0 to age 1 for largemouth bass was poor, and less than survival calculated during the 12-in regulation. Aggus and Elliott (1975) found that there was a highly positive relationship between relative numbers of fast-growing fish during the first summer and the number of fish that survive to age 1. Their data suggested that small, slow-growing fish suffer nearly 100% mortality during the winter opposed to fast-growing individuals of which many survive. This appears to be the case at Grayson Lake. Survival of largemouth bass from age 1 to age 2 was considered to be fair and similar under both the 12- and 15-in regulations at Grayson Lake. Survival from age 2-3 was good and was similar under both regulations as well; survival of largemouth bass within the older age groups under the 15-in regulation was above 50%.

Spotted bass survival rates under both the 12-in and 15-in regulations (Table 23 and 24) averaged much higher than those for largemouth bass. Survival of spotted bass was generally greater under the 12-in regulation (46.7%) compared to years with the 15-in size limit (43.3%). Mean percent survival rates for spotted bass from age 0 to age 1 was very poor under the 12- and 15-in regulations. Survival from age 1 to age 2 was excellent under the 15-in regulation and poor under the 12-in regulation. Survival rates from age 2 to age 3 were fair under the 15-in limit and good under the 12-in limit. Survival from age 3 to age 4 was better under the 12-in regulation and survival from age 4 to age 5 was better under the 15-in regulation. No spotted bass greater than age 5 was collected during years of the 15-in regulation; but, survival from age 5 to 6 under the 12-in regulation was >50%.

Based on the above findings, the 15-in regulation appears justified for largemouth bass. Anderson (1974b) maintained that a minimum length limit in a population with adequate recruitment and high mortality might be 12 in, but when recruitment is low and mortality is high, such as at Grayson Lake for some age groups, a higher minimum length of 14 in or higher might be considered.

The mortality data was tabulated using percent of bass from cove-rotenone fish population surveys and percentages of known aged bass (using inch groups). Too few data were available under years of the 10-in regulation to make any comparison. Crowell (1984) reported the following for black bass from Grayson lake in 1978 and 1979; annual exploitation rate - 35.9%, natural mortality - 46.4%, and survival rate - 17.8%.

Tagging Studies

The only tagging studies carried out at Grayson Lake were reported by Crowell (1984). Unfortunately, data was not separated by bass species. The mean annual exploitation rate in 1978-1979, under the 12-in regulation, was 36.9%. Graham (1974) demonstrated, from research ponds, that a 40% harvest rate provided the most reliable bass population in terms of growth and recruitment. Redmond (1974) found that where no size limit was in effect, harvest rates in excess of 40% may eventually lead to a bass population consisting of few quality-size fish ($\geq$12 in) and an overpopulation of subharvestable prey species (bluegill).

Creel Surveys

Mean fishing pressure (22.9 man-hours/acre) and total weight of fish (5.27 lb/acre) was greatest during years of the 10-in size limit. However, total biomass harvested declined every year under the 10-in size limit from 7.7 lb/acre in 1973 to 2.1 lb/acre in 1977. This drop in harvest every year is probably related to the end of the "boom" fishing years that often occur the first few years after a reservoir is constructed (Goddard and Redmond 1986). Only slight differences in the average man-hours/acre of fishing pressure was noted during years of the 12- (15.3 man-hours/acre) and 15- (15.7 man-hours/acre) inch limits. However, mean total weight of fishes harvested was somewhat higher under the 15-in size limit (2.25 lb/acre) compared to years during the 12-in limit (1.41 lb/acre).

An overall significant decline in total man-hours of fishing pressure occurred from 1973 (29.0 man-hours/acre) to 1988 (9.7 man-hours/acre) (Figure 15). Under the 10-in regulation, fishing pressure declined, but not significantly. Unfortunately, the creel was run for only 2 years under the 12-in regulation; fishing pressure increased from 1978 to 1979. There was a significant decline in total fishing pressure under the 15-in regulation, 20.0 man-hours/acre in 1982 to 9.7 man-hours/acre in 1988. The decline in fishing pressure in the 1970's could be due to the creation of nearby Cave Run Lake in 1974, which would have gone through its best fishing period during the mid 1970's. For the same reasons, the decline after 1982 could be due to nearby Paintsville Lake which was impounded in 1984. Both of these events may have attracted anglers which normally would have fished Grayson Lake. The increase in fishing pressure the first year of the 15-in regulation (1982) could be due to

anticipation" of the new regulation or learning that 15,000 intermediate-size largemouth bass had been stocked. The decline after 1985 may be attributed to the anticipated affect of the 15-in regulation at Cave Run Lake, which was implemented in 1985.

Ming and McDannald (1975) reported that number of trips and hours declined 37.0% before a 12-in regulation (they believed that this decline suggested a drop in the quality of the fishery), but increased after the 12-in regulation. At Grayson Lake, fishing pressure had declined from 17.2 man-hours/acre in 1977 (the year prior to the 12-in limit) to 13.4 man-hours/acre, the year of the 12-in size limit, and increased to 17.1 man-hours/acre the year following the implementation of the 12-in size limit. Ager (1988) revealed that total fishing pressure declined 50% the first year of a 16-in minimum size limit at West Point Reservoir, Alabama, but increased to normal levels within 1 year. Probably, the simplest explanation was given by Kruse (1988) that angling effort on a given reservoir may be related to the reservoir's current "reputation" among anglers.

Generally, decline in harvest (no. and lb) for each kind of fish closely followed fishing pressure trends (Tables 25-27). Numbers and pounds of each kind of fish harvested was higher when total fishing pressure was high and fell when fishing pressure declined. The majority of the anglers interviewed during any given year were fishing for any type of fish ("anything" fisherman); this angler intent represented 54, 59, and 45% of all fishing trips under the 10-, 12-, and 15-in size limits, respectively. Fishing trips for black bass were next in importance, with 33, 30, and 34% of all trips for black bass during the 10-, 12-, and 15-in size limits, respectively. Crappie fishing trips came in third in importance at 12, 10, and 17% of all fishing trips under the 10-, 12-, and 15-in limits, respectively.

Black Bass Creel Statistics

Man-hours per acre of fishing for black bass closely followed total fishing pressure (man-hours/acre) trends (Figure 15), except in 1982, the first year of the 15-in size limit, when total fishing pressure increased while fishing for bass decreased. The percent of bass fishing trips increased from 18% in 1982 to 35-40% in 1983-1986, due to reduced fishing trips for other fish. While evaluating a 15-in size limit, Novinger (1987) noted that fishing for bass doubled even though anglers could not keep as many bass. Apparently in later years, bass anglers at Grayson Lake began to realize that fishing had improved; at least in catch. Dent (1986b) also evaluated a 15-in size limit and found no change in bass fishing pressure under a 15-in regulation compared to before the regulation. Similarly, at Grayson Lake, black bass fishing pressure decreased from the 10-in limit period (6.6 man-hours/acre) to the 12-in limit period (5.7 man-hours/acre), but was fairly similar under the 12- and 15-in limits (5.6 man-hours/acre).

Other black bass creel statistics are accounted for in Table 28. Crowell (1984) noted a gradual but steady decline in black bass fishing pressure and harvest under the 10-in limit. With the imposition of the 12-in limit in 1978, bass harvest declined more rapidly, but slight increases in fishing pressure by bass anglers was observed.

No differentiation was made between black bass species in 1982-1986 by the

creel clerk, except for smallmouth bass. The only parameters asked of anglers regarding black bass were number of ≥15-in fish harvested, ≥15-in fish released, and 12-15 in fish caught and released. However, largemouth bass was the species generally harvested since few spotted bass achieved a length of 15 in. No smallmouth bass ≥12-in long were recorded in the creel.

Black bass harvest declined significantly from 1973 (3.0 lb/acre) to 1977 (0.7 lb/acre) under the 10-in size limit, both in numbers and pounds (Figures 16 and 17). Black bass harvest by weight declined from 1978 (0.4 lb/acre) to 1979 (0.3 lb/acre), the only 2 years creeled under the 12-in regulation. Although fluctuating from year to year, mean black bass harvest by weight remained somewhat similar each year under the 15-in regulation (0.3 lb/a) compared to years under the 12-in limit.

The mean number of black bass harvested annually at Grayson Lake decreased by 85% during the 12-in limit years compared to years under the 10-in limit (Figure 17). There was also a decrease of 57% in number of black bass harvested initially under the 15-in limit versus the 12-in limit. Thus indicating just how few quality-size bass (≥12 in) were available for harvest at that time. The majority of the bass were stockpiled at sizes just under the 10-in minimum size limit. Stockpiling can occur under any size limit, and was beginning to occur under the 12-in regulation. Rasmussen and Michaelson (1974) found that in every 12-in size limit they investigated, stockpiling of bass under the legal size limit occurred. The question is: what provides better quality fishing, the stockpiling of bass just under 10-in, 12-in, or 15-in long below respective length limits of 10, 12, and 15 in? Anglers likely prefer to catch 12-15 in long bass under a 15-in limit as opposed to 9-12 in long bass under a 12-in limit. Tagging studies by Crowell (1984) under the 12-in regulation revealed a relatively high mean exploitation rate of 37% on black bass at Grayson Lake, which may help to explain the decline in numbers harvested during the 12-in limit as a result of overharvest. As depicted in Figure 16, anglers were depleting bass stocks under the 10-in limit.

Despite low harvest rates of black bass during the 15-in limit, catch and release of 12-14.9 in long black bass plus black bass harvested ≥15-in long in number and weight nearly equaled numbers and weights creeled after harvest peaked in 1975-1976. Admittedly, it is not known to what extent catch and release was practiced under the 10- and 12-in regulations. Compliance is another factor that is important to the success of a more restrictive harvest regulation. During 3 years of evaluating length limits, Mayers (1988) found an average of 29% of the total bass harvested were of protected sizes. Knowing that it takes very little fishing pressure to remove a high percent of a black bass population, Redmond (1986) reminded "that a little non-compliance with a harvest regulation can significantly affect tangible results." This is a difficult parameter to measure and no doubt non-compliance occurs at some unknown level at Grayson Lake.

A dramatic decline in total number of black bass harvested under each more restrictive regulation is apparent. The mean number harvested were 2,572 black bass for the 4 years surveyed under the 10-in limit, 379 black bass for the 2 years creeled under the 12-in limit, and 164 black bass during the 5 years surveyed under the 15-in limit. This parallels Novinger's findings (1984) that bass harvest may be 50% of the number it was before a minimum size

limit. Even though <50% of the number of bass were harvested under the 15-in limit at Grayson Lake compared to the 12-in limit, the differential in pounds harvested was not as great. Under the 12-in size limit, a mean of 453 lb were harvested; a mean of 390 lb were creeled under the 15-in limit. This is due to the fact that although fewer black bass numbers were harvested under the 15-in limit, the average length and weight of the individual fish were greater than those harvested under the 12-in size limit (Table 28). An important consideration, as depicted in Figures 16 and 17, is the benefit of catch and release for 12-14 in black bass under the 15-in limit. When comparing the mean catch and release of 12-14.9 in black bass from 1983-1986 (1,658 fish) to the harvest of 10-in long and longer black bass from 1974-1977 (2,571 fish), its obvious that the catch and release aspect of the 15-in limit is an extremely important aspect of the 15-in minimum size limit.

Investigations by Fox (1975), Gabelhouse (1980), Novinger (1986 and 1987), Dent (1986 b), and Richards (1986) reported that catch rates, not harvest rates, increase under a 15-in minimum size limit for black bass; that was true for this study as well. The increase in catch rate for quality-size ($\geq$12 in) black bass was one of the main objectives for increasing the size limit at most of the reservoirs in the aforementioned studies and this study. Novinger (1984) pointed out that "even though catch rates may be higher, some anglers will be disappointed if they do not catch a harvestable-size bass regardless of number and size of sublegal fish caught." These same complaints have been received from both tournament and non-tournament bass anglers fishing Grayson Lake. However, most bass anglers confess that they do not want to see the regulation changed back to a 10- or 12-in limit at Grayson Lake. Despite these observations, Kinman and Hoyt (1984) found that 72% of Kentucky anglers did not believe they had to keep a bass to have a satisfying fishing trip. I am in agreement with Quinn (1989) that we need to de-emphasize the importance of harvest as the traditional measure of fishing success.

Several questions were asked anglers fishing Grayson Lake the last year of the creel survey in 1986 under the 15-in limit (Table 29). When asked, do you favor the 15-in limit for black bass, 76% of the black bass anglers said that they did, 57% of the crappie anglers felt the same, but only 31% of the "anything" anglers were in favor; 20% of all anglers had no opinion. When asked do you think fishing has improved due to the 15-in limit on black bass at Grayson Lake, 68% of the black bass anglers thought fishing had improved, followed by 52% of the crappie anglers and 26% of the "anything" anglers; 30% of all anglers had no opinion.

Summary of Objectives

There were several fish management objectives established for the 15-in black bass limit at Grayson Lake beginning in 1982. They are listed here with a brief summary regarding their outcome.

(1) A black bass standing stock of 15 lb/acre of which 10 lb/acre is comprised of largemouth bass; prior to the 15-in size limit, there were 6 lb/acre of black bass.

Species	Mean lb/acre of black bass				
	10-in limit (1973-1977)	12-in limit (1978-1981)	15-in limit[a] (1982-1986)	15-in limit[b] (1987-1988)	Mean for (1982-1988)
Largemouth	2.81	3.32	7.78	15.50	9.98
Spotted	2.76	2.60	2.08	2.14	2.10
Smallmouth			0.17	0.39	0.23
All black bass	5.57	5.92	10.02	18.01	12.31

[a]After 5 years.
[b]next 2 years.

Mean black bass standing stock (lb/acre) by year under the 15-in limit

Species	Year							Mean
	1982	1983	1984	1985	1986	1987	1988	
Largemouth	7.82	7.46	8.14	7.11	8.35	20.69	10.30	9.98
Spotted	2.13	1.31	1.45	3.24	2.26	3.01	1.27	2.10
Smallmouth	0.53	0.12	0	0.04	0.15	0.57	0.17	0.23
Total	10.48	8.89	9.59	10.39	10.76	24.27	11.74	12.31

Objective no. 1 was realized by 1987 and 1988. The biomass of largemouth bass under the 15-in limit doubled the biomass recorded during years of the 10- and 12-in size limits. Black bass populations in Grayson Lake during years of the 15-in limit were quite similar to the findings by Jenkins (1975) from 171 reservoirs he studied from across the Nation (primarily the Southeast). He found mean standing stock of largemouth bass to be 8.9 lb/acre (170 reservoirs), spotted bass - 2.0 lb/acre (69 reservoirs), and smallmouth bass - 1.4 lb/acre (45 reservoirs); combined black bass mean standing stock was 10.1 lb/acre (171 reservoirs).

(2) Five pounds of largemouth bass ≥12-in long per acre.

There was a mean standing stock of 1.32 lb/acre in 1973-1977 (10-in limit) and 1.31 lb/acre in 1978-1981 (12-in limit) prior to the 15-in size limit.

Lb/acre of largemouth bass ≥12-in long during the 15-in limit.

1982	1983	1984	1985	1986	1987	1988	Mean
1.49	1.92	4.15	2.26	3.74	9.21	2.62	3.63

The mean standing stock of largemouth bass ≥12-in long during the first 5 years was 2.71 lb/acre and averaged 3.63 lb/acre from 1982-1988. Objective no. 2 was achieved only in 1987; however, the mean standing stock of ≥12-in largemouth bass increased by about three-fold compared to the 10-in and 12-in limit.

(3) A PSD for largemouth bass of 40-60% (50-70 preferred); PSD was 31% in 1982. A RSD_{15} for largemouth bass of 10-25%, it was 17% in 1982.

	1982	1983	1984	1985	1986	1987	1988	1989	1990	Mean
PSD(%)	31	26	52	36	45	40	42	38	41	39
RSD_{15}(%)	17	3	6	15	12	22	16	15	8	13

The mean PSD for the 9 years under a 15-in limit was 39. The PSD was above 40 during 5 of the 9 years, but only above 50 in one year - 1984. Mean RSD_{15} for the 9-year period was 13. The RSD_{15} was lower than the desired range in 3 of the 9 years. Like PSD, RSD_{15} values at Grayson Lake were generally within, but usually at the low range, of preferred values.

(4) Maintain a ratio of at least 60% largemouth bass to 40% spotted bass. Based on numbers, this ratio was reversed prior to the implementation of the 15-in size limit and similar (closer to 50-50) based on lb/acre values (values based on cove-rotenone data).

	Mean % composition					
	10-in limit (1973-1977)		12-in limit (1978-1981)		15-in limit (1982-1988)	
	LMB[a]	SPB[b]	LMB	SPB	LMB	SPB
No./acre	19.1	80.9	34.0	66.0	73.8	26.2
Lb/acre	50.4	49.6	56.1	43.9	82.6	17.4

[a]Largemouth bass
[b]Spotted bass

Jenkins (1975) reported a mean percent composition of 66% in largemouth bass, 22% in spotted bass and 12% in smallmouth bass in reservoirs containing all three species. The ratio of largemouth bass to spotted bass in Grayson Lake was less than 60% in largemouth bass and more than 40% in spotted bass from 1973-1981. From 1982-1988, however, the ratio of the number of largemouth bass to spotted bass was greater than 60% in largemouth bass (74%) to 40% in spotted bass (25%). The mean percent of pounds per acre in each species was nearly 50:50 under the 10-in regulation and close to that under the 12-in regulation. The mean biomass became better than 80% in largemouth bass from 1982-1988.

Based on CPH from spring electrofishing, the ratio of largemouth bass to spotted bass was >60:40 only in 1982 and 1983; the ratio of largemouth bass to spotted bass was always greater; except in 1985. From 1986-1988, the CPH ratios were close to 50:50.

(5) A young to adult ratio (YAR) of 1-10 for largemouth bass. Reynolds and Babb (1978) determined that target values for ratio of young ($\leq$6-in long) to adults ($\geq$12-in long) (YAR) for largemouth bass to be 1-3. Values of 1-10 for YAR are apparently indicative of optimal reproduction, assuming moderate adult densities. Values below are based on inch groups; fall

electrofishing was used in order to pick up recruitment for that year.

	1982	1983	1984	1985	1986	1987	1988	1989	Mean
YAR	0.33	2.08	0.53	7.88	0.92	1.09	0.42	2.25	1.94

The mean YAR for the first 5 years of the 15-in limit was 2.35, while the mean during 1982-1989 was 1.94. The YAR values fell within the desired 1-10 range in 1983, 1985, 1987, and 1989, and within the 1-3 range in 1983, 1987, and 1989.

(6) Relative weight values (Wr) of 95-100% for 8-11.9, 12-14.9, and ≥15-in groups for black bass of each species, based on fall electrofishing.

8.0-11.9 in long largemouth bass: exceeded 90% in 1982 and 1983; Wr was ≤90% in years that followed.

12.0-14.9 in long largemouth bass: only equal to 95% in 1986; above 90% during 1982, 1984, and 1985; near 90% in 1983, 1987, and 1989.

≥15-in long largemouth bass: Wr was 100% in 1984; above 90%, but less than 95% during all other years.

For spotted bass, the Wr was never above 95% and only above 90% one year for 8-11.9 in long spotted bass. Small sample sizes of fish ≥12 in precluded Wr calculations for this size spotted bass. The available prey to predator values (AP/P) indicated sufficient prey for the predator population in Grayson Lake. As discussed under that section, it does not reveal where the problem might lie. Apparently, according to the relatively low Wr values, there is a prey crunch at some point, particularly for the smaller basses.

(7) Harvest rate of one largemouth bass, ≥15-in long, per acre.

The mean largemouth bass harvest rate during years under the 10-in limit was 1.7 fish/acre; however, it declined steadily from 1974 (2.7 fish/acre) to 1977 (0.7 fish/acre). Largemouth bass were harvested at a rate of 0.25 bass/acre under the 12-in limit. The mean harvest rate during years of the 15-in limit was 0.10 largemouth bass per acre, which was vastly lower than the objective. A harvest rate of 1 fish/acre (>15 in) translates to 1,510 largemouth bass, which is probably an unrealistic objective. If catch and release of 12.0-14.9 in black bass is added to the harvest, the mean catch rate during 1982-1988 was 1.03 fish/acre.

Buynak (1986) reported a strong positive relationship regarding the black bass harvest and nutrient levels in Kentucky lakes. Based on six oligotrophic lakes under a 12-in size limit, the average harvest values in 1978-1984 were 0.9 lb/acre, 0.8 bass/acre, and 0.1 bass/hour for all bass species. The mean black bass harvest rates for three mesotrophic lakes were 1.6 bass/acre, 1.91 lb/acre, and 0.1 bass/hour. Therefore, the harvest objective of 1 largemouth bass per acre under a 15-in size limit from a lake in the upper oligotrophic range, such as Grayson Lake, was too optimistic.

(8) Improve the catch rate of ≥12-in long black bass to 0.25 fish/hour by bass anglers; it was 0.05 black bass per hour prior to the 15-in limit.

The catch rate (includes harvest and catch and release of ≥12-in bass) increased every year from 0.06 black bass/hour in 1982 to 0.23 black bass/hour in 1986. These rates were better than under the 12-in limit, and as good as, or better than, some years under the 10-in limit. The catch and release factor represented 0.21 of the 0.23 fish/hour in 1986.

(9) Improve the harvest rate of ≥15-in long black bass to at least 0.1 fish/hour by bass anglers; it was 0.02 fish/hour in 1982.

At Grayson Lake, the mean harvest rate by bass anglers under the 10-in limit (1974-1976) was 0.17 black bass/hour, 0.04 black bass/hour under the 12-in limit (1978-1979), and 0.02 black bass/hour under the 15-in limit (1982-1986). The harvest rate for black bass improved under the 15-in limit from 0.02 black bass/hour in 1982 to 0.04 black bass/hour in 1986 (including largemouth bass ≥15 in caught and released) - see discussion under objective 7. Buynak (1986) reported the harvest rate for all bass averaged 0.1 black bass/hour in oligotrophic and mesotrophic lakes under a 12-in length limit.

(10) Increase in fingerling (0-3) shad biomass.

The mean fingerling size shad biomass under the 10-in limit was 0.03 lb/acre, 1.30 lb/acre under the 12-in limit, and 1.43 lb/acre during the first 5 years (1982-1986) under the 15-in limit. However, the shad biomass recorded during the following 2 years was 0 in 1987 and 0.19 lb/acre in 1988 for this size shad. These latter years were affected by the drought, since lower shad numbers were observed in many Kentucky reservoirs.

(11) Increase the lb/acre of quality-size (≥8.0 in) white crappie.

The mean white crappie biomass for ≥8-in long fish was 16 lb/acre under the 10-in regulation, 9.8 lb/acre during years of the 12-in regulation, and 12.6 lb/acre during the first 5 years under the 15-in black bass regulation. Pounds of white crappie of this size increased from 1982 to 1986 under the 15-in limit. However, the biomass of quality-size crappie was low during the next 2 years in 1987-1988, which were drought years - <0.05 lb/acre in 1987 and 6 lb/acre in 1988.

CONCLUSIONS

The main goal of the 15-in limit at Grayson Lake was to protect bass, particularly largemouth bass 12-14.9 in long, in order to provide a better quality black bass fishery at Grayson Lake. Prior to the 12-in regulation, the bass population was heavily exploited and declining. The 12-in regulation did not improve the black bass fishy. Our goal was accomplished, based on catch rates for ≥12-in black bass. However, this was accomplished at the expense of harvest.

The 15-in limit at Grayson Lake protected spotted bass practically their

entire life span, with few ever growing large enough to be harvested. The removal of the size limit for this species at Grayson Lake in 1986 eliminated this problem and helped the angler better accept the more restrictive largemouth and smallmouth bass regulation.

Catch rates of ≥12-in black bass in 1986 nearly equaled the best catch rate recorded in 1975. The biomass of ≥12-in group largemouth bass increased by a factor of 2.6. A majority of the 11 objectives were achieved or nearly met. Most anglers who had an opinion supported the 15-in limit. Based on these results, the 15-in limit was deemed successful.

RECOMMENDATIONS

Benefits of the 15-in size limit in improving the largemouth bass population and general fish population are fairly well accepted, and it is recommended that the 15-in minimum size limit remain in effect at Grayson Lake for largemouth and smallmouth bass. The no-size limit for spotted bass should also remain in effect. However, I do believe the possession limit of 10 bass is too high for largemouth and smallmouth bass. However, to prevent problems, whatever possession limit is implemented, it should apply to all three black bass species. I recommend that the possession limit be lowered to 4 black bass at Grayson lake; a 2 fish limit would be more realistic for largemouth and smallmouth bass, but probably unacceptable to the angling public. The primary reason for lowering the possession limit is to improve the angler's perception regarding possible success. Fox (1975) summed this up rather well, "maximum limit of any kind almost automatically becomes a target or goal for fishermen". Consequently, if the limit is 10 fish, and the average catch is 2 or 3 fish per day, fishermen consider the quality of fishing to be poor; whereas, if the creel limit is 4 fish, then a catch of 2 or 3 fish is considered excellent. In the mind of the fisherman, fishing quality would have improved markedly without any actual increase in catch.

Electrofishing should continue in the spring to obtain black bass population parameters and to evaluate the smallmouth bass stocking. Cove-rotenone studies should be carried out periodically to help document changes in the forage fish population and to help evaluate the stockings of smallmouth bass, black crappie, and threadfin shad. Fall electrofishing should be carried out in order to obtain relative weight information and to see if threadfin shad stocking has improved these values. Fall trap netting should be used to evaluate the black crappie stocking, beginning the third year after initial stocking (1991).

An adequate up-to-date creel survey has never been run at Grayson Lake. In order to evaluate the smallmouth bass and black crappie stockings, a creel should begin no later than 1992 (preferably 1991) and be run for 4 consecutive years by a hired creel clerk. The creel should be designed to determine the utilization of spotted bass as the size limit was removed in 1986, the year of the last creel survey; the affects of that regulation have not been properly evaluated. The creel should also gather information such as how many largemouth and smallmouth bass are harvested ≥15-in long, how many are caught and released ≥15-in long, how many are caught and released 12-14.9 in long, how many are caught and released <12-in long by size. For spotted bass and black crappie, questions should include number and sizes harvested and numbers

and sizes caught and released.

One of the problems that needs to be addressed by the Fisheries Division, not just on Grayson Lake, is the perception that fish stocking is the panacea for all fishing ills. It does have its place, but fisheries managers should determine when, where, how many, and what kinds. Another problem is the difficulty in catching harvestable-size (≥15 in) bass from the relatively infertile eastern Kentucky reservoirs. Anglers, who enjoy fishing, enjoy catching and releasing 12-14.9 in long bass, with the possibility of catching them ≥15-in long. But tournament anglers, on the other hand, must catch ≥15-in long bass in order to win or weigh in any bass; although they are subsequently returned.

A great deal of effort regarding planning and public involvement went into the management plans at Grayson lake and nearby Cave Run lake. What Parsons (1957) stated still holds true today, "education of the public, as slow as it might be, is vitally important if results of investigations are to be applied and reservoir fisheries properly exploited". Every fisheries (and resource) manager realizes the importance of user education and their need for accepting and complying with regulations - this remains one of our greatest challenges. The 1980's have provided a great wealth of information regarding innovative fisheries managers face is selling these potential benefits to the fishing public and encouraging change if needed. This can be difficult in light of the many conflicts of interest often faced. One of the questions needed seriously asked, especially in popular, heavily fished waters is: are we going to manage for quality and/or quantity (harvest or catch-and-release). Anderson (1975) asked the following question 15 years ago that we still need to address it today: "Can an educational effort be developed that will promote understanding and support? If not, the game will be lost - variable, but generally less than satisfying fishing quality will be rule in public waters."

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Figure 1. Grayson Lake, showing the two cove rotenone sampling sites represented by squares.

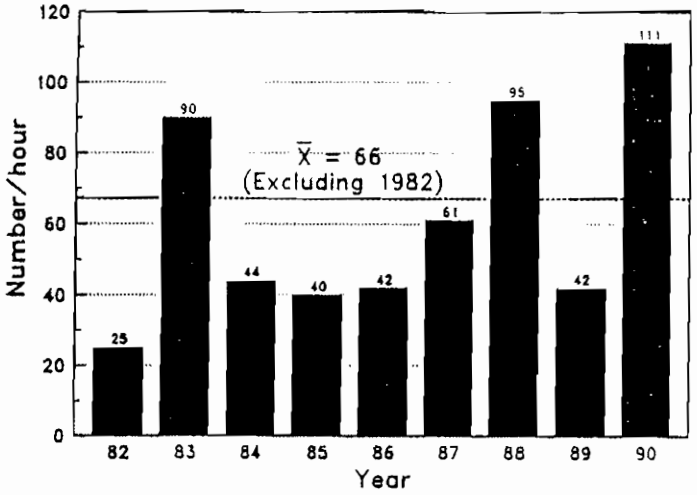

Figure 2a. Catch per hour for largemouth bass captured during spring electrofishing at Grayson Lake.

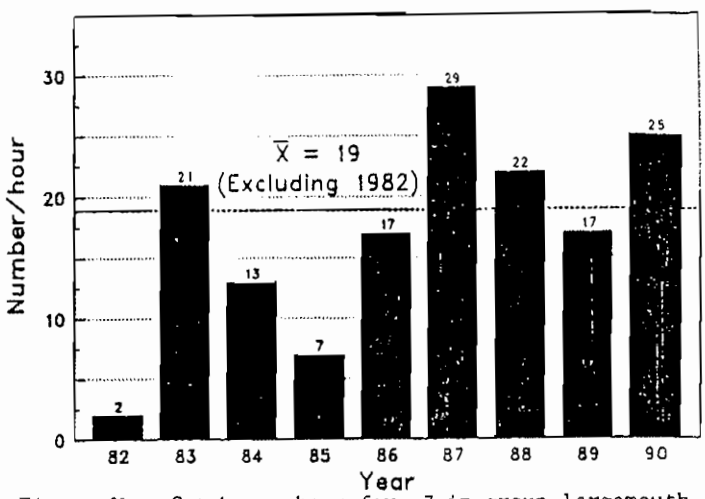

Figure 2b. Catch per hour for ≤7 in group largemouth bass during spring electrofishing at Grayson Lake.

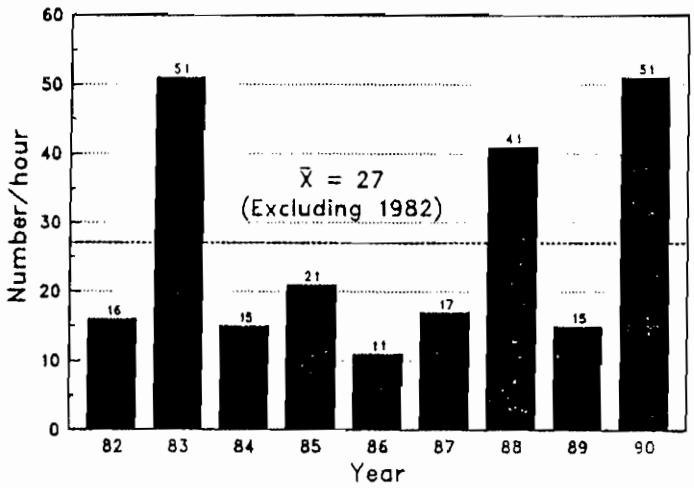

Figure 2c. Catch per hour for 8-11 in group largemouth bass during spring electrofishing at Grayson Lake.

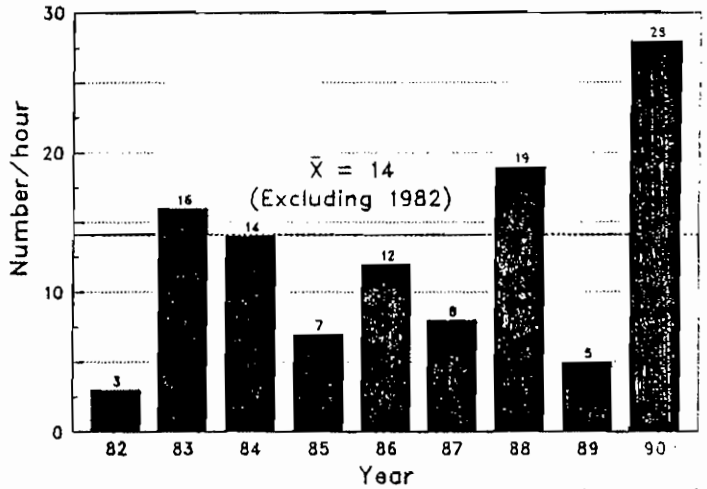

Figure 2d. Catch per hour for 12-14 in group largemouth bass during spring electrofishing at Grayson Lake.

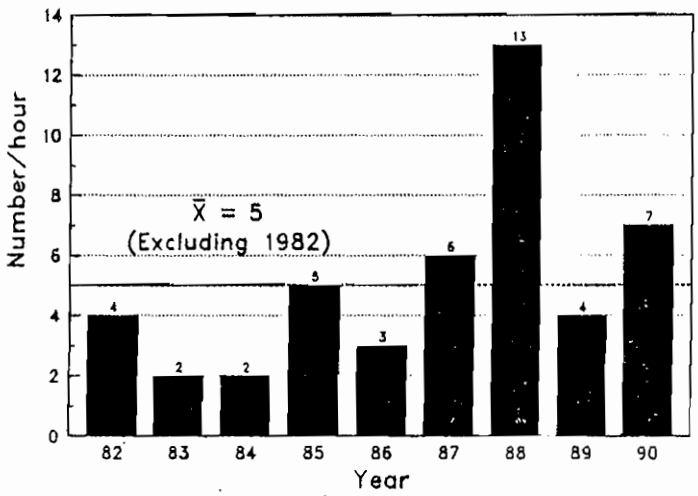

Figure 2e. Catch per hour for ≥15 in group largemouth bass spring electrofishing at Grayson Lake.

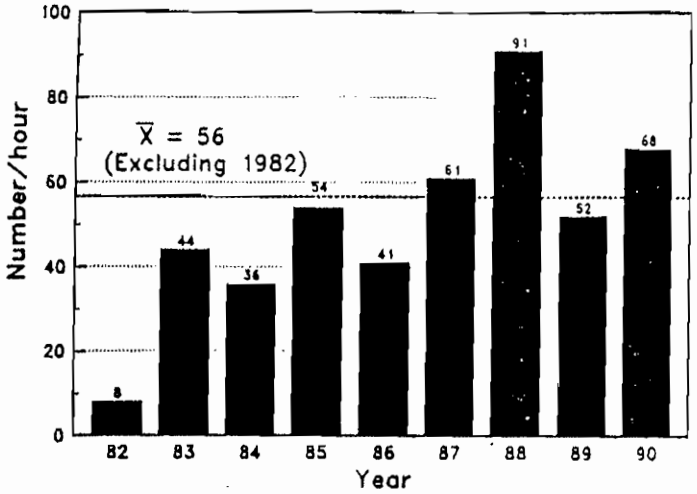

Figure 3a. Total spotted bass catch per hour based on spring electrofishing at Grayson Lake.

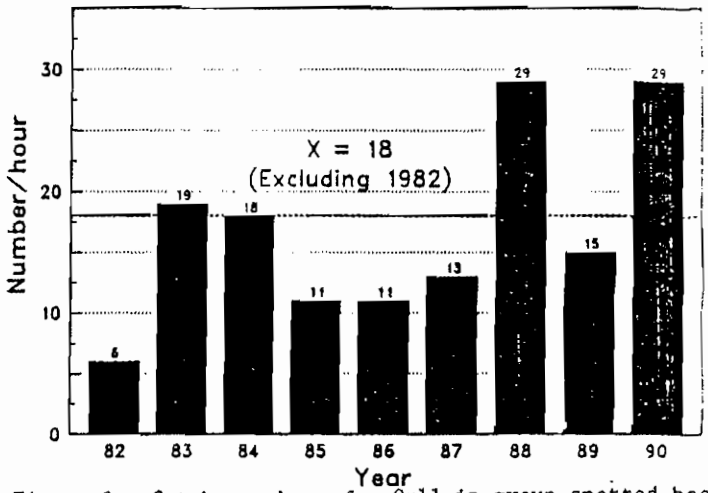

Figure 3c. Catch per hour for 8-11 in group spotted bass based on spring electrofishing at Grayson Lake.

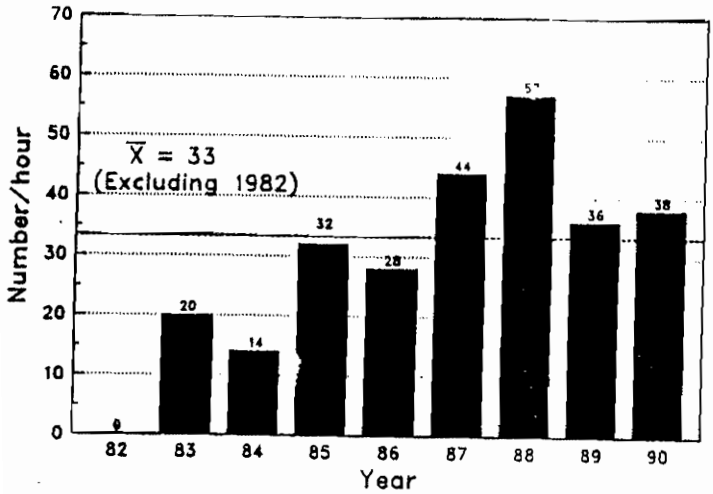

Figure 3b. Catch per hour for ≤7-in group spotted bass based on spring electrofishing at Grayson Lake.

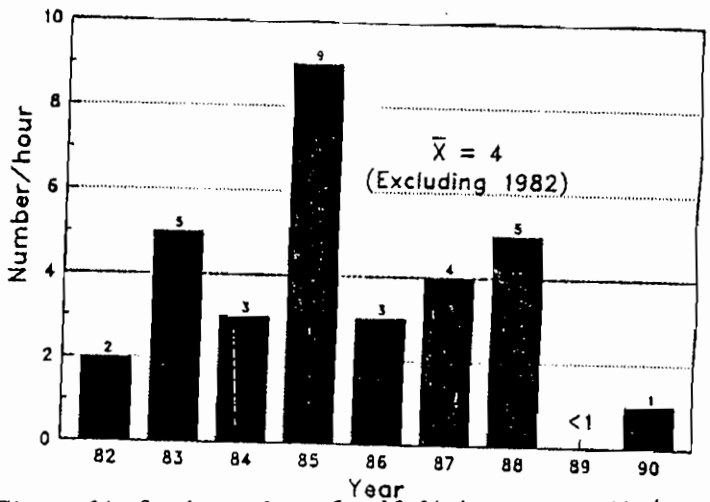

Figure 3d. Catch per hour for 12-14 in group spotted bass based on spring electrofishing at Grayson Lake.

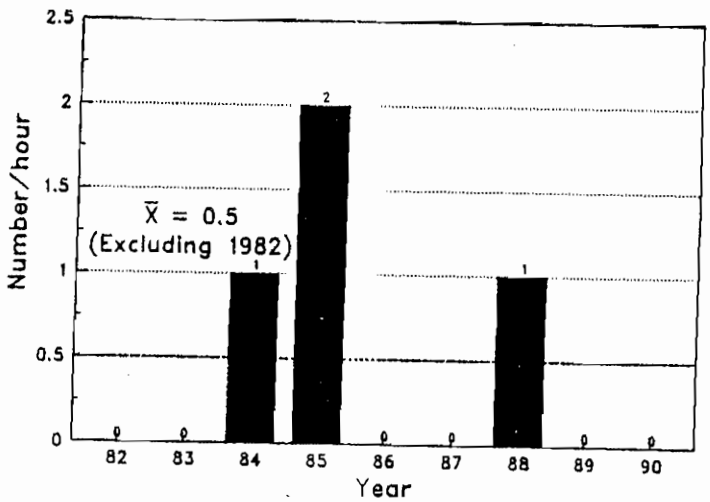

Figure 3e. Catch per hour for ≥15-in group spotted bass based on spring electrofishing at Grayson Lake.

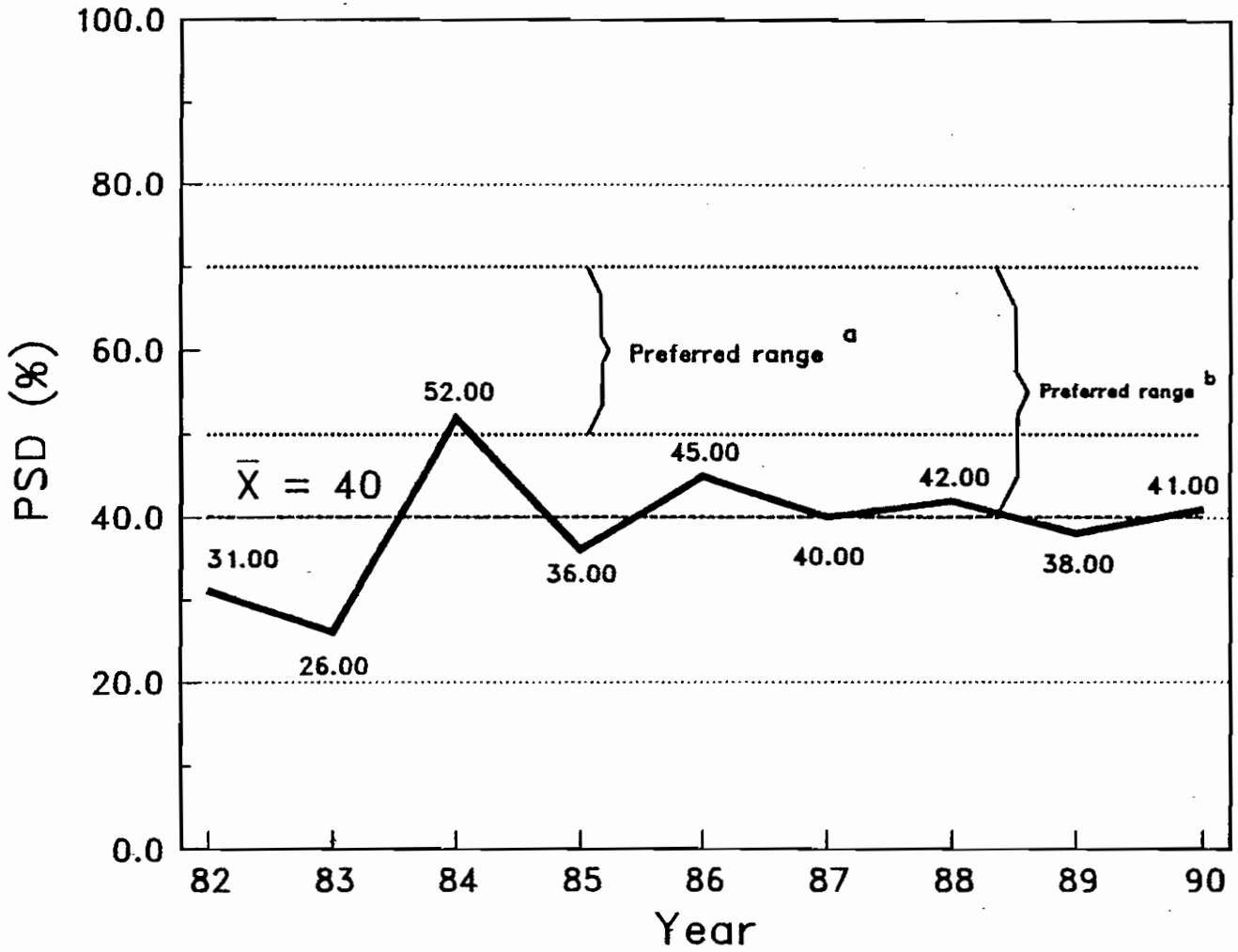

Figure 4. Largemouth bass proportional stock density (PSD) from spring electrofishing in 1982–1990.

[a]Weithman et al (1978).
[b]Anderson (1980).

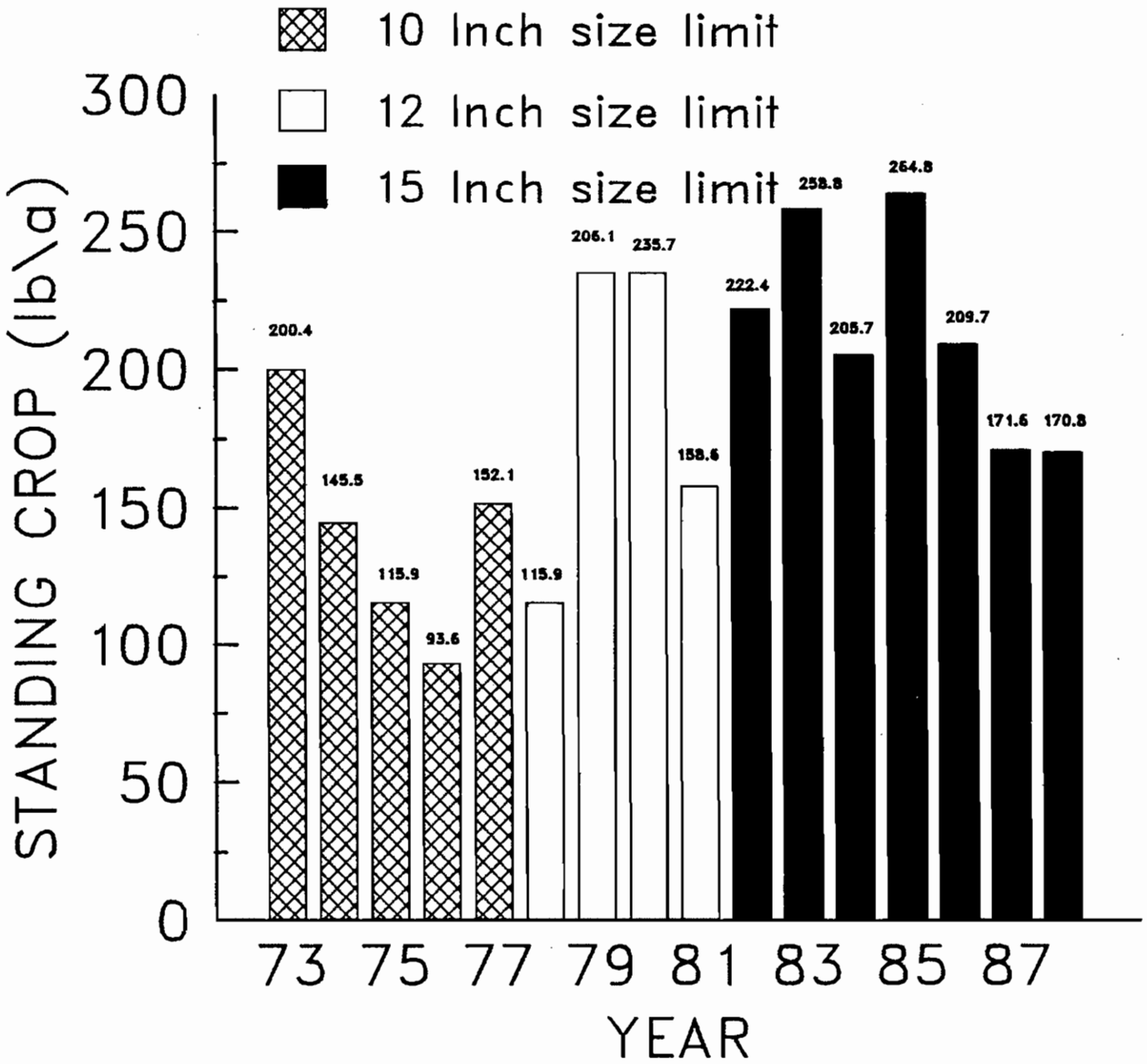

Figure 5. Standing stock (lb/acre) of all fish for each year in 1973-1988 at Grayson Lake.

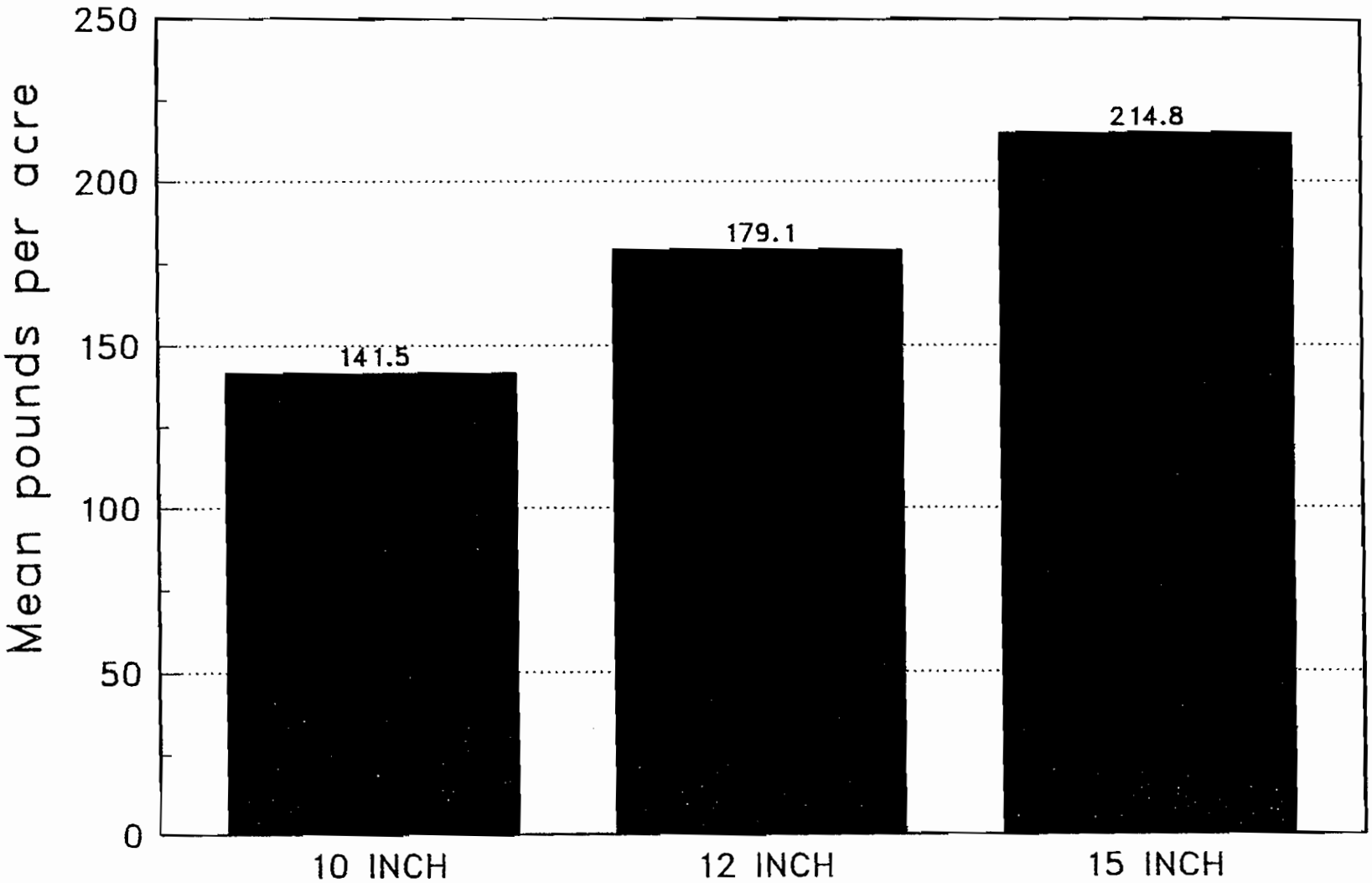

Figure 6. Mean pounds per acre of all fish under each size limit regulation.

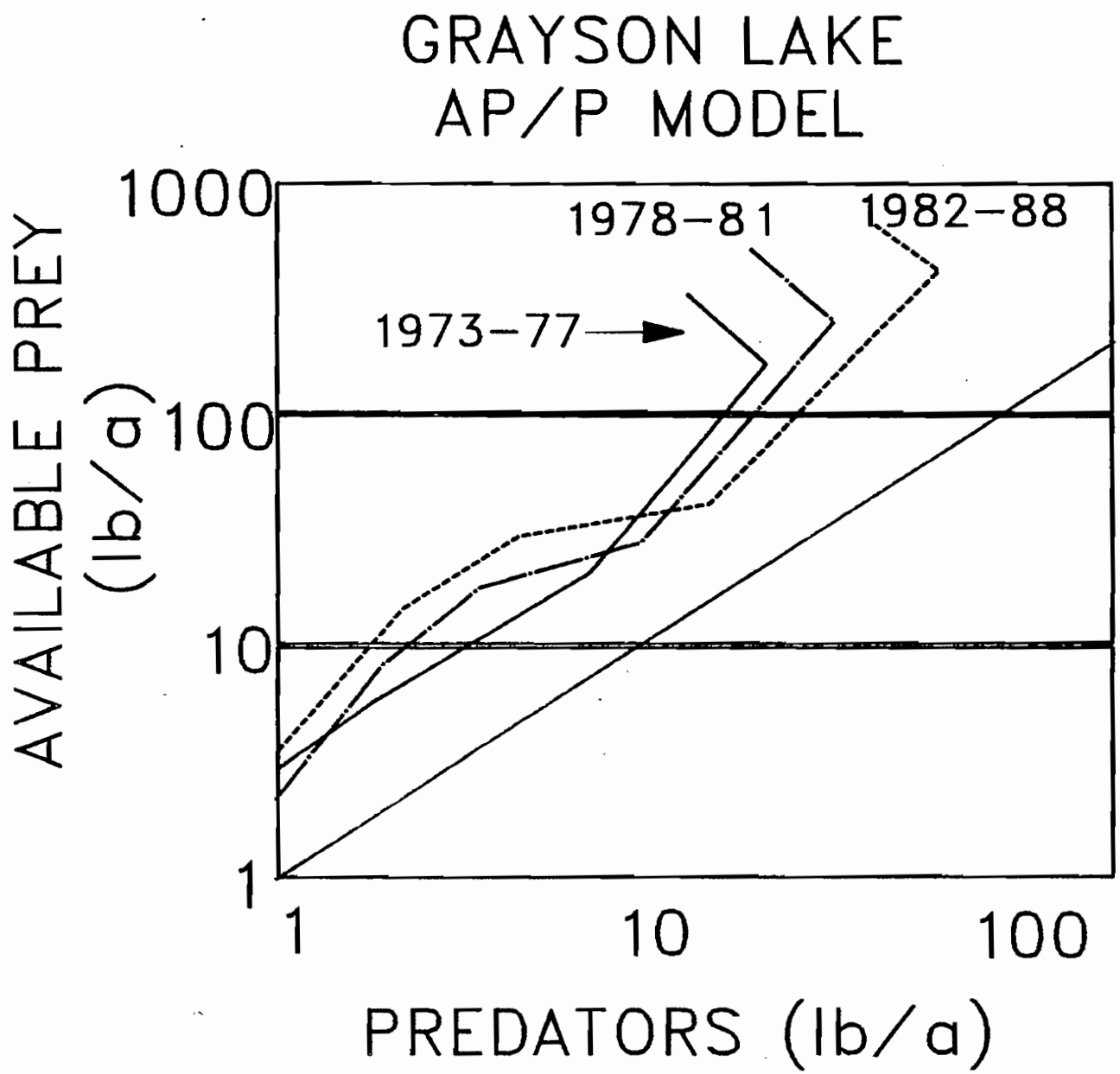

Figure 7. Available prey to predator (AP/P) ratios at Grayson Lake under various black bass minimum size limits.

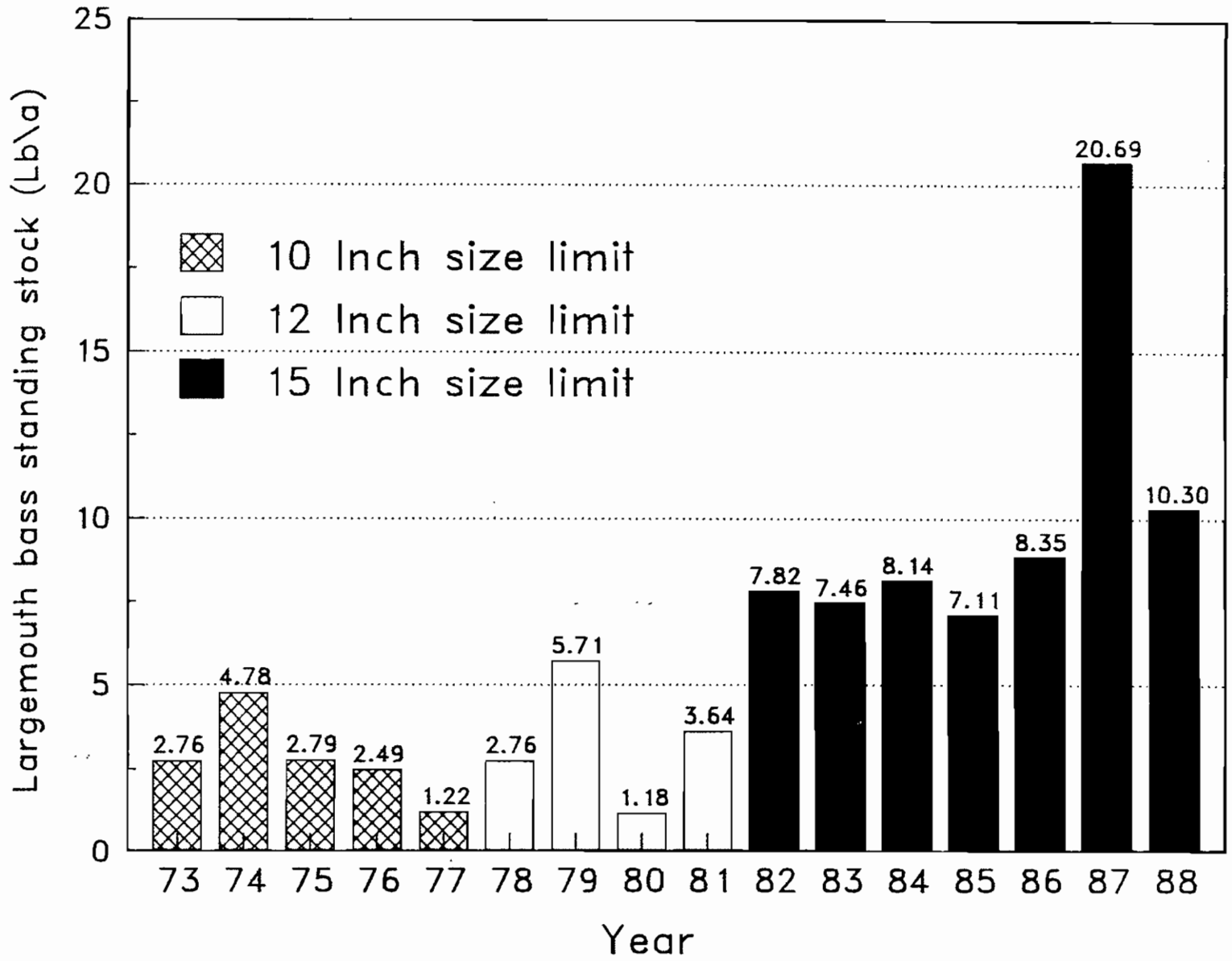

Figure 8. Largemouth bass standing stock (lb/acre) from 1973-1988 at Grayson Lake.

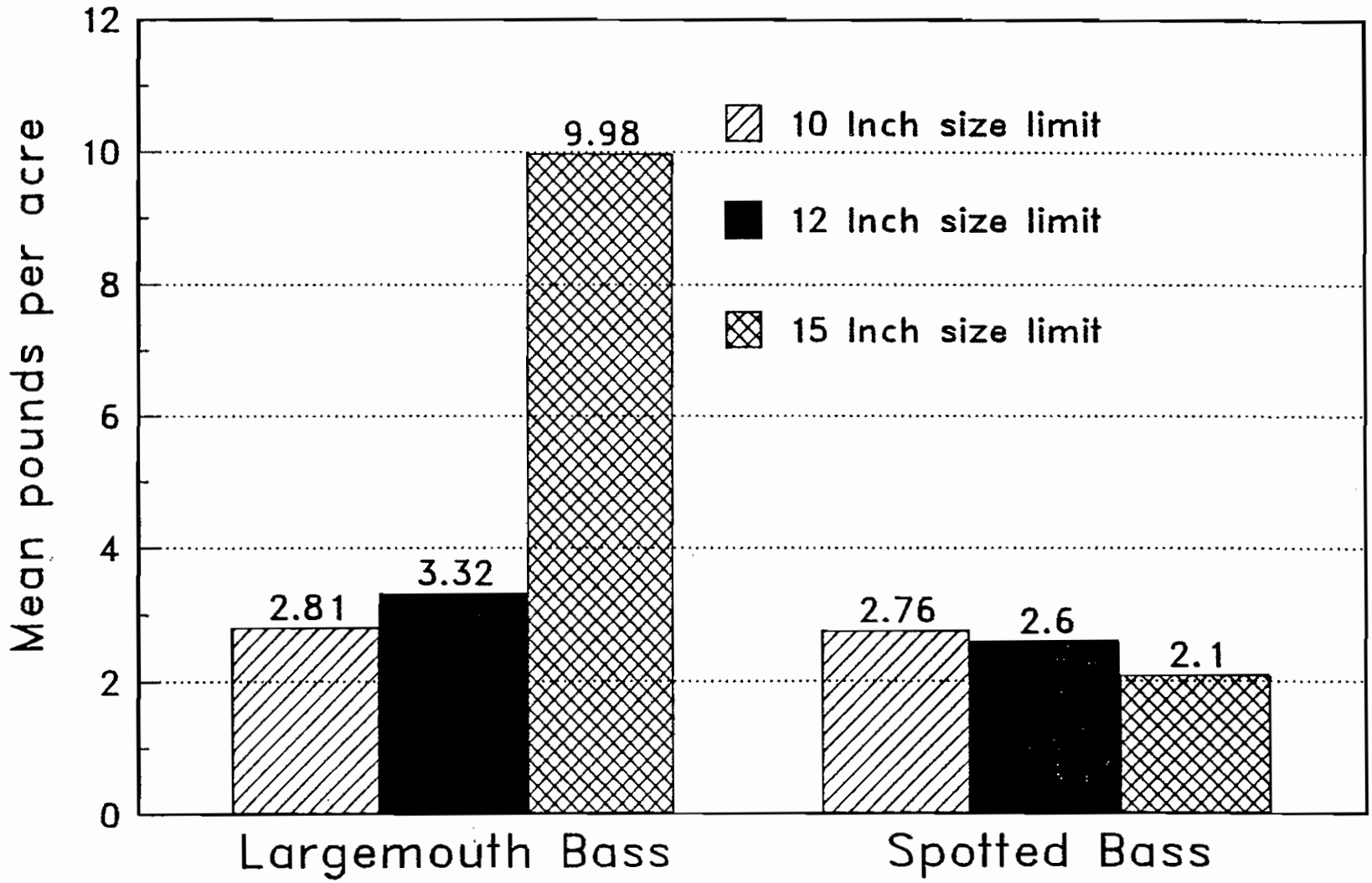

Figure 9. Mean standing stock of largemouth and spotted bass (lb/acre) under each size limit regulation at Grayson Lake.

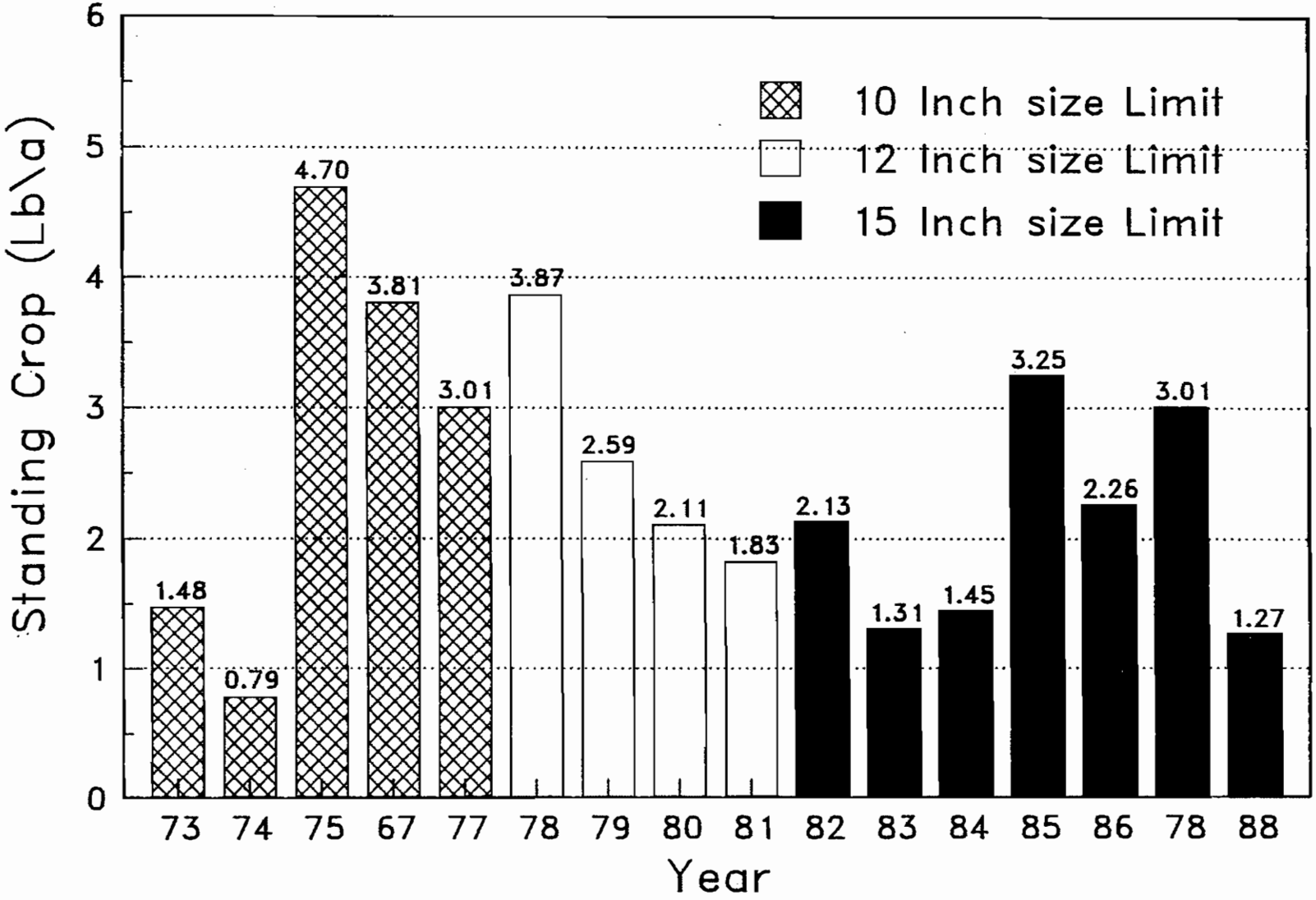

Figure 10. Spotted bass standing stock (lb/acre) from 1973-1988 at Grayson Lake.

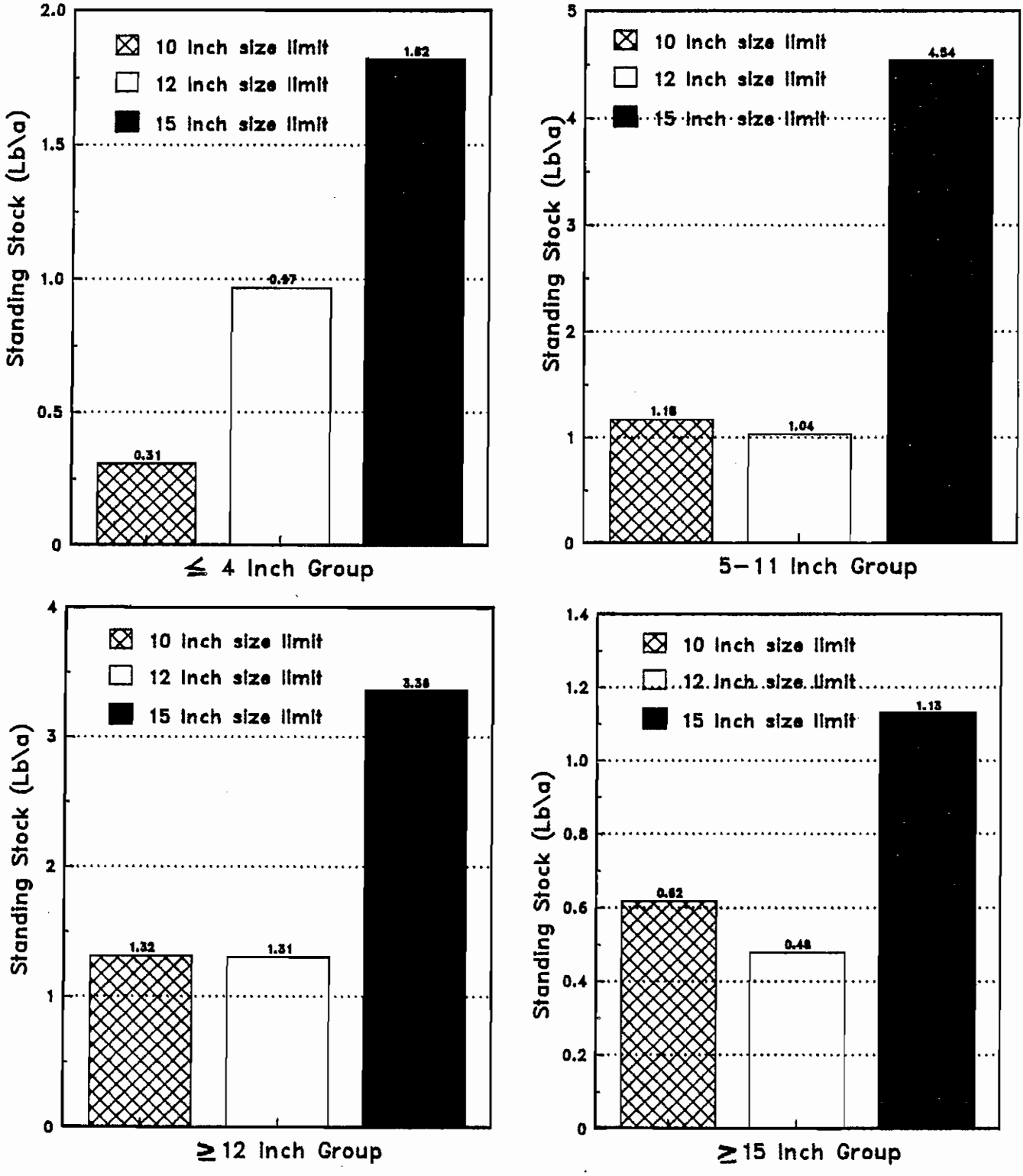

Figure 11. Mean largemouth bass standing stock (lb/acre) for various inch groups under three length limit regulations at Grayson Lake.

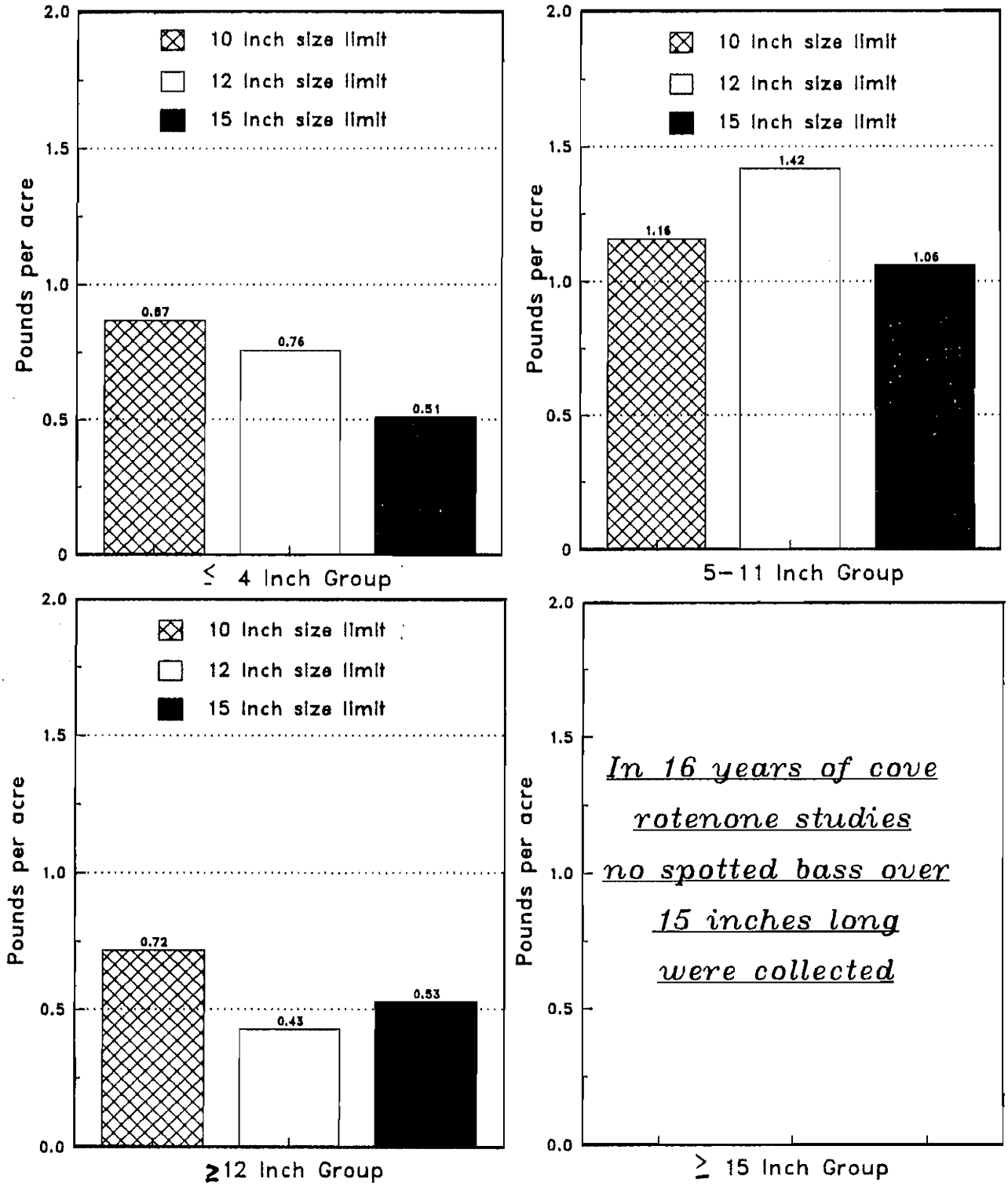

Figure 12. Mean spotted bass standing stock (lb/acre) for various size categories under three length limits at Grayson Lake.

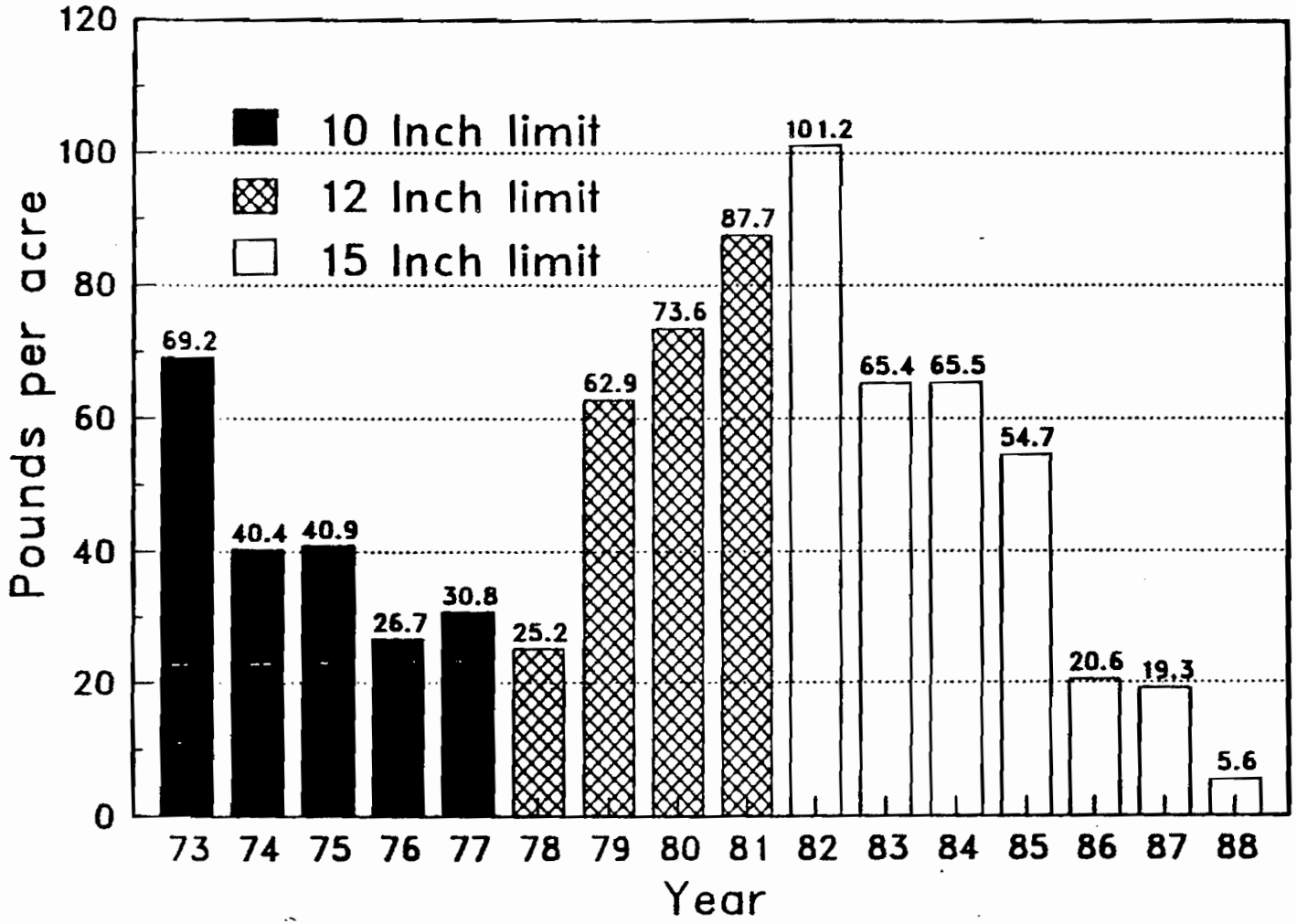

Figure 13. Gizzard shad pounds per acre at Grayson Lake in 1973-1988 during the 10 in (1973-1977), 12 in (1978-1981), and 15 in (1982-1988) limits on black bass.

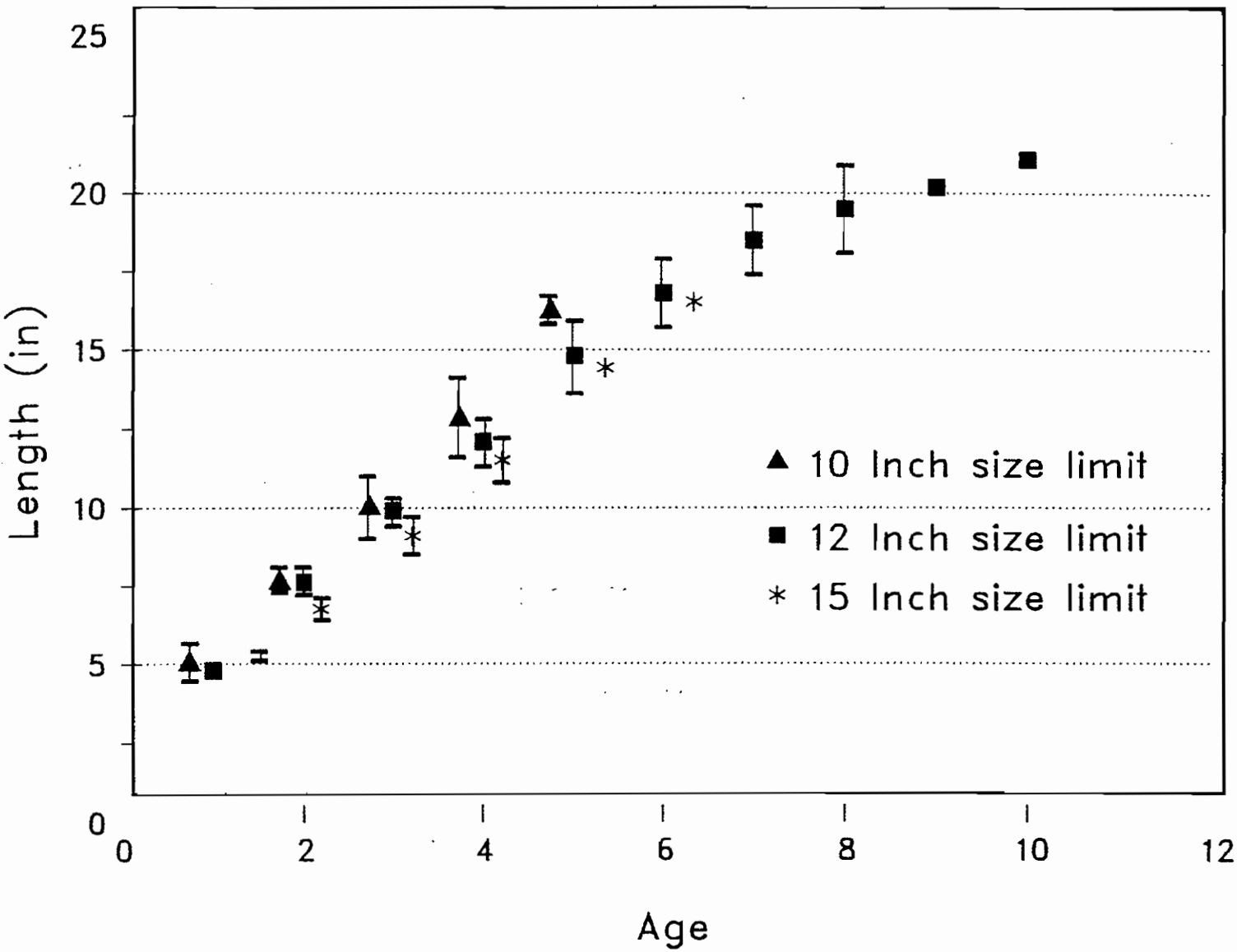

Figure 14. Mean back calculated length (in) at each age for largemouth bass showing confidence interval (95%) from Grayson Lake under three different size limit regulations.

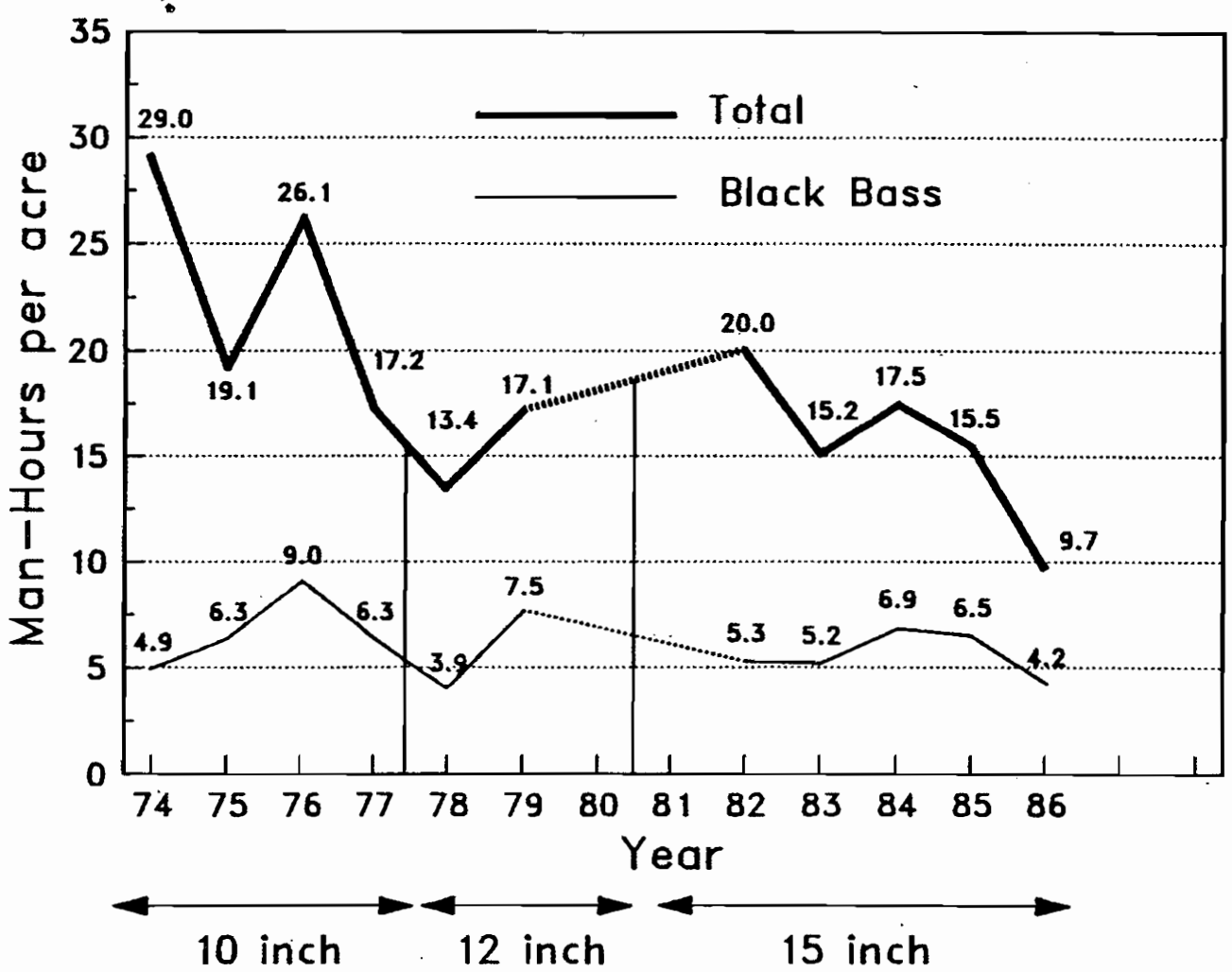

Figure 15. Man-hours per acre of total fishing pressure during years under the black bass size limits as compared to black bass fishing pressure at Grayson Lake.

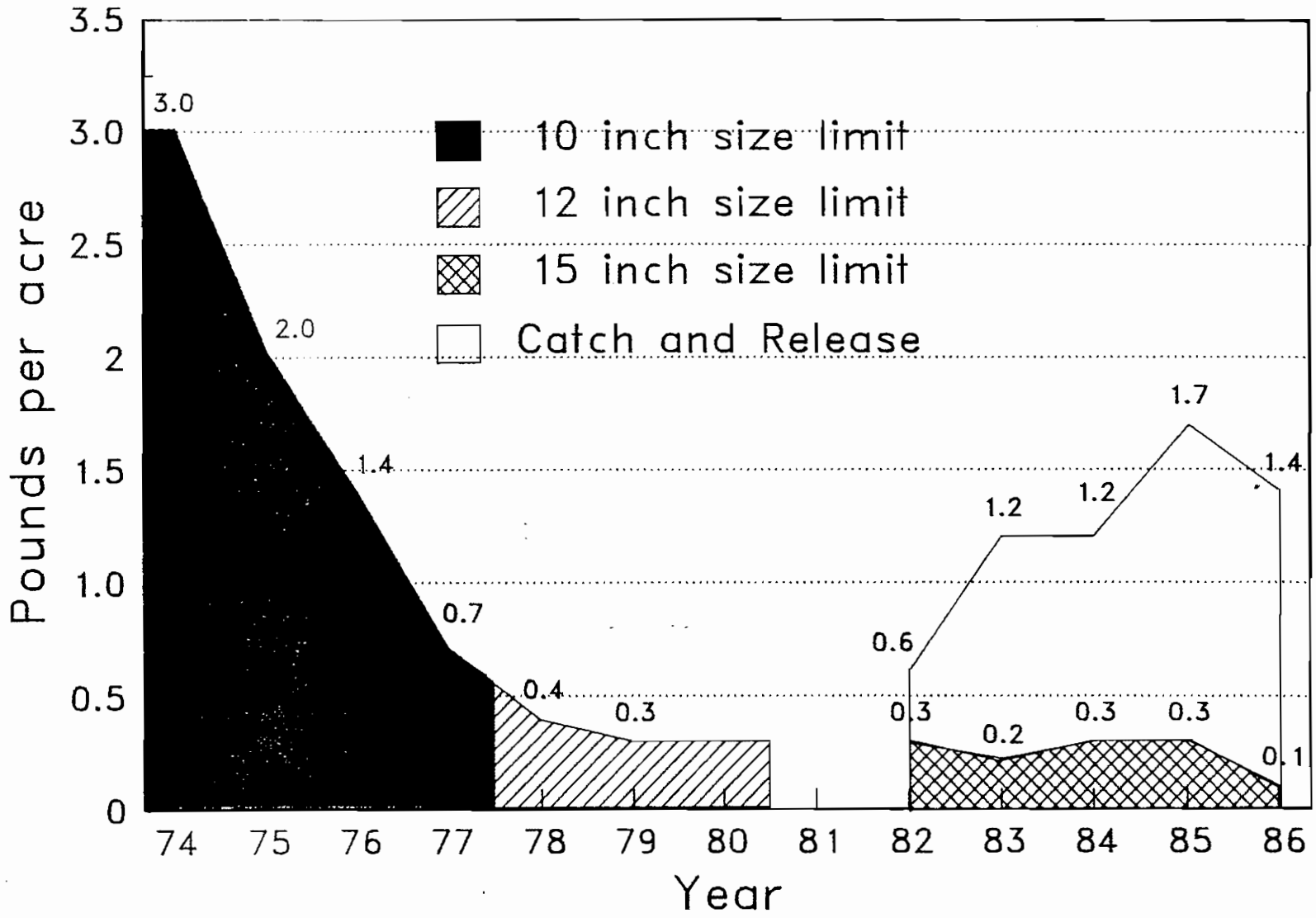

Figure 16. Total black bass harvest (lb/acre) during years under 3 black bass limits at Grayson Lake.

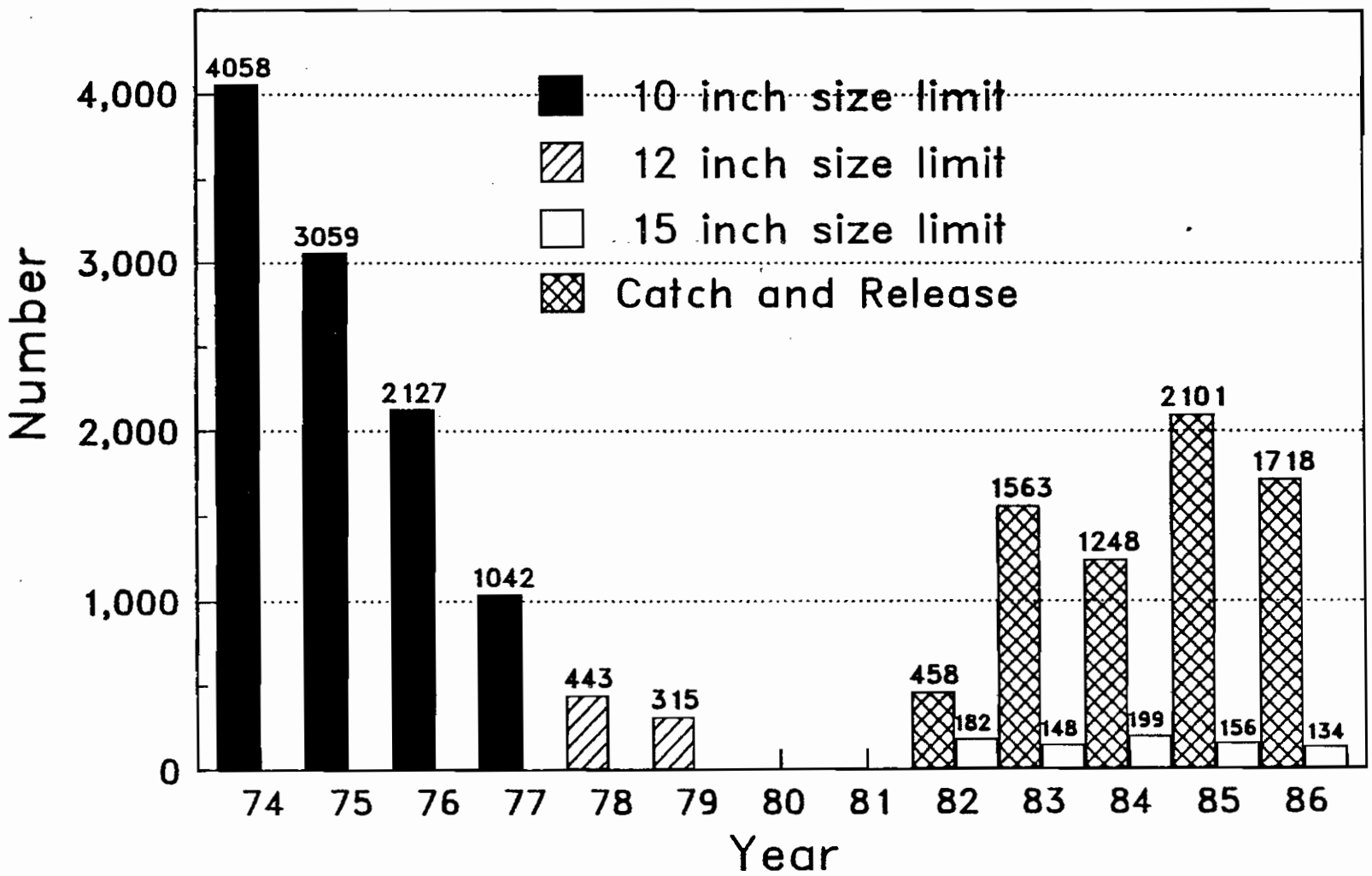

Figure 17. Total number of black bass harvested by year under each size limit with catch and release of 12-15 in black bass shown for years under the 15 in limit.

Table 1. A list of fishes stocked into Grayson Lake from 1973-1989.

Year	Species	No.	Approximate size (in)
1969	Muskellunge	20,000	1
1970	White bass	196	adults
1971	Threadfin shad	4,000	adults
	White bass	163	adults
	Redear sunfish	5,000	1.5
	Channel catfish	2,500	6-11
	Channel catfish	39,663	4
	Channel catfish	17,120	2-3
1972	Walleye	35,000	1.5
1973	Muskellunge	3,900	5
1974	Muskellunge	65	7-8
	Minnows	110,000	
1976	Largemouth bass	10,074	1.5
1977	Largemouth bass	3,087	3-5
1980	Smallmouth bass	75,874	2-4
	Smallmouth bass	48	brood size
	Threadfin shad	4,400	adults
1982	Largemouth bass	15,170	8
	Largemouth bass	90	16
	Smallmouth bass	9	16
	Smallmouth bass	455	11
	Spotted bass	62	7-13
	Spotted bass	6,075	1.9
1986	Smallmouth bass	36,825	1.1
1987	Threadfin shad	3,000	2.5
	Smallmouth bass	36,333	1.6
1988	Threadfin shad	9,000	adults
	Smallmouth bass	65,450	fry
	Smallmouth bass	49,005	1.7
1989	Threadfin shad	6,000	adults
	Smallmouth bass	50,000	1.4
	Smallmouth bass	32,212	fry
	Largemouth bass	47,261	fry
	Black crappie	61,782	2.7

Table 2. Percent occurrence of largemouth bass by inch group collected during spring electrofishing at Grayson Lake.

Year	Inch group			
	≤7	8 - 11	12 - 14	≥15
1983	23.3	56.7	17.8	2.2
1984	29.5	34.1	31.8	4.5
1985	17.5	52.5	17.5	12.5
1986	40.5	26.2	28.6	7.1
1987	47.5	27.9	13.1	9.8
1988	23.2	43.2	20.0	13.7
1989	40.5	35.7	11.9	9.5
1990	22.5	45.9	25.2	6.3
Mean	30.6	40.3	20.8	8.2

Table 3. Percent occurrence of spotted bass by inch group collected during spring electrofishing at Grayson Lake.

Year	Inch group			
	≤7	8 - 11	12 - 14	≥15
1983	45.5	43.2	11.4	0
1984	38.9	50.0	8.3	2.8
1985	59.3	20.4	16.7	3.7
1986	66.7	26.2	7.1	0
1987	72.1	21.3	6.6	0
1988	62.0	31.5	5.4	1.1
1989	69.2	28.8	2.0	0
1990	55.9	42.6	1.5	0
Mean	58.7	33.0	7.4	0.9

Table 4. Proportional and Relative Stock Densities (PSD and RSD) for black bass and bluegill from Grayson Lake (nocturnal spring electrofishing) 1982-1989.

	Largemouth bass			Spotted bass		Smallmouth bass		Bluegill	
Year	PSD	RSD_{15}	RSD_{18}	PSD	RSD_{14}	PSD	RSD_{14}	PSD	RSD_{8}
1982[a]	31	17	2.7	33	17	60	0	10	0
1983	26	3	0	22	0	0	0	6	0
1984	52	6	3.2	39	4	0	0	18	0
1985	36	15	0	47	13	0	0	6	0
1986	45	12	0	28	3	25	0	3	0
1987	40	22	4.0	22	3	17	17	10	0
1988	42	16	4.8	17	3	40	0	13	0
1989	38	15	4.8	6	0	33	11	23	0
1990	41	8	1.6	8	0	7	7	10	0
Mean	40	12	2.3	24	3	24[b]	7[b]	11	0

[a]1982 data not used in mean.
[b]1986-1990 mean.

Table 5. Relative weight (Wr) values of various size groups of the three black bass species (largemouth bass - LMB, spotted bass - SPB, and smallmouth bass - SMB) in Grayson Lake 1982-1989.

Year/Species		Wr (no.) per length range (in)			
		≤7	8 - 11	12 - 14	≥15
1982	LMB	91(12)	94(69)	90(3)	0
	SPB	98(9)	91(9)	86(1)	0
	SMB	137(2)	82(3)	0	
1983	LMB	95(30)	90(22)	88(6)	93(5)
	SPB	98(22)	85(12)	0	0
	SMB	84(1)	0	0	0
1984	LMB	90(8)	87(20)	93(12)	100(2)
	SPB	86(32)	83(18)	92(4)	0
	SMB	0	83(2)	0	0
1985	LMB	105(15)	87(5)	92(3)	94(5)
	SPB	119(29)	87(18)	87(4)	0
	SMB	87(1)	90(1)	0	0
1986	LMB	77(9)	83(33)	95(9)	92(1)
	SPB	86(120)	82(38)	82(12)	83(1)
	SMB	81(10)	89(3)	93(1)	92(1)
1987	LMB	60(16)	78(55)	89(16)	91(3)
	SPB	73(226)	79(63)	78(3)	0
	SMB	71(20)	81(1)	87(1)	0
1988	LMB	84(70)	80(119)	84(17)	94(9)
	SPB	83(279)	84(64)	81(4)	0
	SMB	90(80)	83(7)	0	87(3)
1989	LMB	105(33)	83(158)	88(23)	90(5)
	SPB	93(167)	83(82)	83(2)	90(1)
	SMB	99(43)	82(12)	82(1)	88(1)
Mean	LMB	88	85	90	93
	SPB	92	84	84	87[a]
	SMB	81	84	87[ab]	89[a]

[a]Small sample size.
[b]1983 not included in mean.

Table 6. Standing stock (lb/acre) derived from cove-rotenone samples at Grayson Lake under a 10-in minimum black bass size limit in 1973-1977.

	1973	1974[a]	1975	1976	1977
GAME FISHES					
White bass	0.43	0.11	1.37	-	1.06
Walleye	0.42	-	-	-	-
Largemouth bass	2.76	4.78	2.79	2.49	1.22
Spotted bass	1.48	0.79	4.70	3.81	3.01
Black crappie	-	-	0.03	-	0.97
White crappie	37.45	2.59	10.48	1.10	47.86
Total	42.54	8.27	19.37	7.40	54.12
FOOD FISHES					
Channel catfish	8.26	0.81	3.48	0.01	5.26
Flathead catfish	0.89	-	1.50	0.98	1.15
Total	9.15	0.81	4.98	0.99	6.41
PISCIVOROUS TOTAL	51.69	9.08	24.35	8.39	60.54
PANFISHES					
Rock bass	-	-	-	0.36	0.51
Bluegill	17.50	33.95	10.76	12.34	16.02
Green sunfish	0.02	0.48	0.42	0.14	0.15
Longear sunfish	5.17	7.65	3.46	4.18	4.41
Redear sunfish	0.06	0.41	-	-	-
Total	22.75	42.49	14.64	17.02	21.09
COMMERCIAL FISHES					
Redhorse	2.80	2.71	2.81	2.11	4.13
Spotted sucker	8.94	17.97	8.30	8.39	4.08
Carp	42.10	28.13	22.10	27.12	28.84
Bullhead	1.35	3.52	0.18	0.42	0.55
Total	55.19	52.33	33.39	38.04	37.60
FORAGE FISHES					
Gizzard shad	69.46	40.44	40.89	26.67	30.83
Threadfin shad	-	-	0.02	-	-
Misc. cyprinids	0.22	0.41	0.48	1.55	0.48
Madtom	0.40	0.16	0.81	0.61	0.47
Logperch	-	-	0.72	1.07	0.72
Other darters	0.57	-	t	0.01	0.01
Brook silverside	0.12	0.11	0.56	0.24	0.34
Total	70.77	41.12	43.48	30.15	32.85
NON-PISCIVOROUS TOTAL	148.71	135.94	91.51	85.21	91.54
GRAND TOTAL	200.40	145.02	115.86	93.60	152.07

[a]In 1974, only one cove sampled; all other years, two coves sampled.

Table 7. Standing stock (lb/acre) derived from cove-rotenone samples at Grayson Lake under a 12-in minimum black bass size limit in 1978-1981.

	1978	1979	1980	1981
GAME FISHES				
White bass	0.20	3.54	0.30	3.61
Largemouth bass	2.76	5.71	1.18	3.64
Spotted bass	3.87	2.59	2.11	1.83
White crappie	8.82	50.65	92.58	11.75
Total	15.65	62.49	96.17	20.83
FOOD FISHES				
Channel catfish	9.89	4.22	4.29	1.11
Flathead catfish	1.17	0.23	13.92	1.21
Total	11.06	4.45	18.21	2.32
PISCIVOROUS TOTAL	26.71	66.94	114.38	23.15
PANFISHES				
Rock bass	0.49	0.55	0.72	0.89
Bluegill	14.21	22.12	11.88	15.13
Green sunfish	0.36	0.35	0.16	0.41
Longear sunfish	4.29	5.02	2.32	1.91
Total	19.35	28.04	15.08	18.34
COMMERCIAL FISHES				
Redhorse	4.70	4.89	3.01	4.03
Spotted sucker	8.04	5.39	2.66	3.95
Carp	30.11	36.43	25.26	19.27
Bullhead	0.12	0.15	0.33	0.29
Total	42.97	46.86	31.26	27.54
FORAGE FISHES				
Gizzard shad	24.58	62.91	73.64	87.69
Threadfin shad	-	-	0.05	0.17
Misc. cyprinids	0.83	0.06	0.01	0.03
Madtom	0.35	0.33	0.21	0.18
Logperch	0.59	0.64	0.58	0.76
Other darters	0.01	0.05	0.03	t
Brook silverside	0.50	0.27	0.45	0.79
Total	26.86	64.26	74.97	89.62
NON-PISCIVOROUS TOTAL	89.18	139.16	121.31	135.50
GRAND TOTAL	115.89	206.10	235.69	158.65

Table 8. Standing stock (lb/acre) derived from cove-rotenone samples at Grayson Lake under a 15-in minimum black bass size limit in 1982-1988.

	1982	1983	1984	1985	1986	1987	1988
GAME FISHES							
White bass	0.54	0.06	2.08	3.61	-	-	0.21
Largemouth bass	7.82	7.46	8.14	7.11	8.35	20.69	10.31
Smallmouth bass	0.53	0.12	-	0.04	0.15	0.57	0.17
Spotted bass	2.13	1.31	1.45	3.24	2.26	3.01	1.28
White crappie	45.70	95.04	49.69	96.00	99.25	0.82	10.09
Total	56.72	103.99	61.36	110.00	110.01	25.09	22.06
FOOD FISHES							
Channel catfish	1.88	3.59	1.46	1.60	2.43	2.68	3.53
Flathead	12.64	1.43	4.83	1.81	1.69	1.96	3.34
Total	14.52	5.02	6.29	3.41	4.12	4.64	6.87
PISCIVOROUS TOTAL	71.24	109.01	67.65	113.41	114.13	29.73	28.93
PANFISHES							
Rock bass	0.44	0.96	1.09	0.65	0.73	1.41	1.52
Bluegill	14.63	28.55	24.52	25.63	23.66	35.16	26.72
Green sunfish	0.19	0.35	0.63	0.11	-	0.11	0.05
Longear sunfish	1.78	1.94	1.07	1.74	0.72	1.18	1.69
Total	17.04	31.80	27.31	28.13	25.11	37.86	29.98
COMMERCIAL FISHES							
Redhorse	4.10	2.23	3.96	8.66	2.18	2.53	-
White sucker	-	-	0.06	0.06	-	-	-
Spotted sucker	4.59	2.06	5.38	4.61	3.19	7.57	0.55
Carp	22.47	46.43	34.10	52.78	41.95	71.15	103.86
Bullhead	0.15	0.12	0.02	0.26	0.49	0.19	0.69
Total	31.31	50.84	43.52	66.37	47.81	81.35	105.10
FORAGE FISHES							
Gizzard shad	101.21	65.35	65.53	54.71	20.56	19.33	5.58
Threadfin shad	-	-	-	-	-	-	0.07
Misc. cyprinids	0.02	0.05	t	0.65	0.30	1.10	0.35
Madtom	0.18	0.55	0.38	0.32	0.30	0.30	0.16
Logperch	0.60	0.59	0.67	0.48	0.99	0.56	0.41
Other darters	0.05	0.01	0.01	0.05	t	0.03	t
Brook silverside	0.71	0.60	0.58	0.64	0.47	1.30	0.23
Total	102.77	67.15	67.17	56.85	22.62	22.62	6.80
NON-PISCIVOROUS TOTAL	151.12	149.79	138.00	151.35	95.54	141.83	141.88
GRAND TOTAL	222.36	258.80	205.65	264.76	209.67	171.56	170.81

Table 9. Mean standing stock (lb/acre) derived from cove-rotenone samples at Grayson Lake in 1973-1988.

Group/species	10-in size limit (1973-1977)	Mean % occurrence	12-in size limit (1978-1981)	Mean % occurrence	15-in size limit (1982-1988)	Mean % occurrence
GAME FISHES						
White bass	0.59		1.91		0.93	
Walleye	0.08		-		-	
Largemouth bass	2.81		3.32		9.98	
Smallmouth bass	-		-		0.23	
Spotted bass	2.76		2.60		2.10	
White crappie	19.90		40.90		56.66	
Black crappie	0.20		-		-	
Total	26.34	17.4	48.78	22.6	69.90	31.0
FOOD FISHES						
Channel catfish	3.56		4.88		2.45	
Flathead catfish	0.90		4.13		3.96	
Total	4.46		9.01		6.41	
PISCIVOROUS TOTAL	30.80	3.0	57.79	5.6	76.31	3.1
PANFISHES						
Rock bass	0.17		0.66		0.97	
Bluegill	18.11		15.84		25.55	
Green sunfish	0.24		0.32		0.21	
Longear sunfish	4.97		3.38		1.45	
Redear sunfish	0.09		-		-	
Total	23.58	17.1	20.20	12.3	28.18	13.6
COMMERCIAL FISHES						
Redhorse	2.91		4.16		3.38	
White sucker	-		-		0.02	
Spotted sucker	9.54		5.01		3.99	
Carp	29.66		27.77		53.25	
Bullhead	1.20		0.22		0.27	
Total	43.31	31.5	37.16	23.4	60.91	30.2
FORAGE FISHES						
Gizzard shad	41.65		62.20		47.47	
Threadfin shad	t		0.06		0.01	
Misc. cyprinids	0.63		0.23		0.31	
Madtom	0.49		0.27		0.34	
Logperch	0.50		0.65		0.58	
Other darters	0.12		0.02		0.08	
Brook silverside	0.27		0.50		0.61	
Total	43.66	31.0	63.93	36.1	49.40	22.1
NON-PISCIVOROUS TOTAL	110.55		121.29		138.49	
GRAND TOTAL	141.35		179.08		214.80	

Table 10. A comparison of various indices calculated from cove-rotenone data at Grayson Lake.

Year	Indices			
	NP/P	Y/C	A_T	AP/P
10-in regulation				
1973	2.88		25.01	
1974	14.95		48.12	15.40
1975	3.76		47.00	7.33
1976	10.15	1.45	56.10	9.36
1977	1.51	0.88	40.20	9.67
Mean	6.65	1.17	43.29	10.44
12-in regulation				
1978	3.34	1.30	68.16	5.60
1979	2.08	2.27	40.15	7.53
1980	1.06	1.31	25.64	10.99
1981	5.85	4.08	24.94	9.47
Mean	3.08	2.24	39.72	8.40
15-in regulation				
1982		1.14	27.10	7.68
1983	1.37	5.19	27.52	15.24
1984	2.04	1.89	37.05	7.63
1985	1.33	2.20	35.55	9.03
1986	0.84	2.20	35.39	
1987	4.77	1.24	63.09	2.13
1988				3.11
Mean	2.07	2.31	37.62	7.47
GRAND MEAN 1973-1988	4.00	1.99	40.07	8.58

Table 11. Percent of total fish weight from cove-rotenone studies by year and fish groups at Grayson Lake.

Year	Game fish	Food fish	Panfishes	Commercial fish	Forage fish
10-in limit					
1973	21.2	4.6	11.3	27.5	35.3
1974	5.7	0.6	29.3	36.1	28.3
1975	16.7	4.3	12.6	28.8	37.5
1976	7.9	1.1	18.2	40.6	32.2
1977	35.6	4.2	13.9	24.7	21.6
Mean	17.4	3.0	17.1	31.5	31.0
12-in limit					
1978	6.4	11.0	17.7	40.2	24.7
1979	30.3	2.2	13.6	22.7	31.2
1980	40.8	7.7	6.4	13.3	31.8
1981	13.1	1.5	11.6	17.4	56.5
Mean	22.6	5.6	12.3	23.4	36.1
15-in limit					
1982	25.5	6.5	7.7	14.1	46.5
1983	40.2	1.9	12.3	19.6	25.9
1984	29.8	3.1	13.3	21.2	32.7
1985	41.6	1.3	10.6	25.1	21.5
1986	52.4	2.0	12.0	22.8	10.8
1987	14.6	2.7	22.1	47.4	13.2
1988	12.9	4.0	17.6	61.5	4.0
Mean	31.0	3.1	13.6	30.2	22.1

Table 12. Black bass standing stock as determined from cove-rotenone data collected from Grayson Lake in 1973-1988.

Species		Fingerling size (per acre)		Intermediate size (per acre)		Harvestable size (per acre)		Total (per acre)		% of total (per acre)	
		No.	Lb	No.	Lb	No.	Lb	No.	Lb	No.	Lb
10-in limit											
1973	Largemouth	2	0.06	6	1.21	1	1.50	9	2.77	11.1	65.2
	Spotted	63	0.77	9	0.71	0	0	72	1.48	88.9	34.8
1974	Largemouth	16	0.52	12	2.15	2	2.11	30	4.78	50.0	85.8
	Spotted	23	0.23	7	0.56	0	0	30	0.79	50.0	14.2
1975	Largemouth	73	0.71	6	1.38	1	0.70	80	2.79	35.6	37.3
	Spotted	130	1.05	13	1.93	2	1.72	145	4.70	64.4	62.7
1976	Largemouth	14	0.15	4	0.42	2	1.92	20	2.49	6.9	39.5
	Spotted	261	1.29	7	0.97	2	1.55	270	3.81	93.1	60.5
1977	Largemouth	10	0.10	6	0.75	t	0.36	16	1.22	10.4	28.8
	Spotted	129	1.01	9	1.65	t	0.35	138	3.01	89.6	71.2
12-in limit											
1978	Largemouth	129	2.01	4	0.75	0	0	133	2.76	36.4	41.6
	Spotted	213	1.38	19	2.14	t	0.35	232	3.87	63.6	58.4
1979	Largemouth	104	1.14	5	1.21	3	3.36	112	5.71	49.3	68.8
	Spotted	107	0.68	7	1.35	1	0.56	115	2.59	50.7	31.2
1980	Largemouth	52	0.34	4	0.55	t	0.29	56	1.18	20.1	35.9
	Spotted	217	0.68	5	1.16	t	0.27	222	2.11	79.9	64.1
1981	Largemouth	44	0.40	9	1.64	1	1.60	54	3.64	30.3	66.5
	Spotted	117	0.30	6	1.01	1	0.52	124	1.83	69.7	33.5
15-in limit											
1982	Largemouth	71	0.54	29	5.79a	1	1.49	101	7.82	26.5	74.6
	Spotted	261	1.00	6	0.75	t	0.38	267	2.13	70.1	20.3
	Smallmouth	12	0.05	0	0	1	0.48	13	0.53	3.4	5.1
1983	Largemouth	304	1.94	11	3.60	1	1.92	319	7.46	70.3	83.9
	Spotted	129	0.60	5	0.45	t	0.26	134	1.31	29.5	14.7
	Smallmouth	t	t	t	0.12	0	0	t	0.12	0.2	1.4
1984	Largemouth	369	1.31	17	2.68	4	4.15	390	8.14	86.9	84.9
	Spotted	55	0.42	4	0.58	t	0.45	59	1.45	13.1	15.1
1985	Largemouth	278	2.07	13	2.78	2	2.26	293	7.11	71.6	68.4
	Spotted	101	0.55	7	1.56	1	1.13	109	3.24	26.7	31.2
	Smallmouth	7	0.04	0		0		7	0.04	1.7	0.4
1986	Largemouth	633	2.44	13	2.17	3	3.74	649	8.35	80.0	77.6
	Spotted	147	0.45	8	0.94	1	0.87	156	2.26	19.2	21.0
	Smallmouth	4	0.02	2	0.13	0		6	0.15	0.7	1.4
1987	Largemouth	282	3.53	36	7.95	6	9.21	324	20.69	83.9	85.3
	Spotted	34	0.43	15	1.97	1	0.61	50	3.01	13.0	12.4
	Smallmouth	10	0.12	2	0.45	0		12	0.57	3.1	2.3
1988	Largemouth	159	0.88	33	6.80	2	2.62	194	10.30	81.5	87.7
	Spotted	23	0.13	9	1.14	0		32	1.27	13.5	10.8
	Smallmouth	12	0.14	t	0.03	0		12	0.17	5.0	1.5

Table 12 continued.

Fingering size 0-4 in group; intermediate size 5-11 in group; harvestable size ≥12-in group. Even though the size limit was 10 in from 1973-1977 and 15 in from 1982-1988, 12 in was used for the harvestable-size category.

"15,000 intermediate size largemouth bass stocked into Grayson Lake, thus accounting for the big increase in lb/acre values for this size bass.

t = <0.5 fish.

Table 13. Number per inch group of black bass collected from cove-rotenone fish population surveys at Grayson Lake under a 10-in minimum size limit in 1973-1977.

Year/species		Inch group																Total	% of total no.	Per acre			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	19			No.	%	Lb	%
1973	Largemouth				6	5	6	2	1	3	2	1	1				1	28	10.3	9	11.1	2.77	65.2
	Spotted	11	48	93	55	15	6	6	1									235	89.7	72	88.9	1.48	34.8
1974	Largemouth	16			2	9	1	1				3	1			1		34	49.3	30	50.0	4.78	85.8
	Spotted	10	1	6	10	5	1	1	1									35	50.7	30	50.0	0.79	14.2
1975	Largemouth		104	87	59	3	6	4	4	1	1	2	3					274	35.6	80	35.6	2.79	37.3
	Spotted	1	146	237	61	13	18	1	5	3	3	2	4	1	1			496	64.4	145	64.4	4.76	62.7
1976	Largemouth		13	23	12	9	3		1		1		3		2	1		68	6.8	20	6.9	2.49	39.5
	Spotted		539	341	15	10	7		4			3	4	2				925	93.2	270	93.1	3.81	60.5
1977	Largemouth		9	22	3	7	5	7	2	1				1				57	10.7	16	10.4	1.22	28.8
	Spotted		294	114	34	11	7	4	2	3	2	3		1				475	89.3	138	89.6	3.01	71.2

Table 14. Number per inch group of black bass collected from cove-rotenone fish population surveys at Grayson Lake under a 12-in minimum size limit in 1978-1981.

Year/species		Inch group																Total	% of total no.	Per acre			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			No.	%	Lb	%
1978	Largemouth		161	218	63	2	5	2	1	2	1	1						456	36.4	133	36.4	2.76	41.6
	Spotted		482	242	7	37	13	3	5	5		2			1			797	63.6	232	63.6	3.87	58.4
1979	Largemouth		163	120	35	1		3	6	2	1	1	3	2		2	1	340	49.5	112	49.3	5.71	68.8
	Spotted		283	37	5	5	5	1	1	5	2	1	2					347	50.5	115	50.7	2.59	31.2
1980	Largemouth		95	53	8	5	4		1	2	1		1					170	20.3	56	20.1	1.18	35.9
	Spotted		617	23	10	6	1	1	1	2	1	3	1					666	79.7	222	79.9	2.11	64.1
1981	Largemouth		57	49	26	8	5	4	4	2	2	2	1	1	2			163	30.5	54	30.3	3.64	66.5
	Spotted	95	204	38	13	6	4	2	3	2	1	1	2					371	69.5	124	69.7	1.83	33.5

Table 15. Number per inch group of black bass collected from cove-rotenone fish population surveys at Grayson Lake under a 15-in minimum size limit in 1982-1988.

Year/species		Inch group																		% of total	Per acre			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	Total	no.	No.	%	Lb	%
1982	LMB		100	114	19	10	17	24	31	11	1	1	1		2	1				332	26.4	101	26.5	7.82	74.6
	SPB	1	772	82	7	9	4	2	3		2	1			1					884	70.3	267	70.1	2.13	20.3
	SMB		40										1							41	3.3	13	3.4	0.53	5.1
1983	LMB	69	566	252	50	6	6	5	3	4	4	6	2	1	1	1				976	70.5	319	70.3	7.46	83.9
	SPB	20	307	54	11	8	4		1	1			1							407	29.4	134	29.5	1.31	14.7
	SMB		1							1	2									2	0.1	1	0.2	0.12	1.4
1984	LMB	3	1034	61	26	22	5	9	5	3	3	4	6	2	1	1		1		1,186	86.7	390	86.9	8.14	84.9
	SPB	9	108	26	26	5	2	3	1			1			1					182	13.3	59	13.1	1.45	15.1
1985	LMB		566	196	86	12	2	6	9	4	7		2	2	3					895	71.6	293	71.6	7.11	68.4
	SPB	3	217	79	8	7	3	5		2	4	1	3	1						333	26.7	109	26.7	3.24	31.2
	SMB		19	2																21	1.7	7	1.7	0.04	0.4
1986	LMB	149	1590	192	1	6	18	8	5	1	2	1	4	2	2	1				1,982	80.1	649	80.0	8.35	77.6
	SPB	52	353	35	7	10	6	3	3	2			2	1						474	19.2	156	19.2	2.26	21.0
	SMB		9		3	2	3													17	0.7	6	0.7	0.15	1.4
1987	LMB		140	559	146	18	12	33	19	10	8	8	5	5	2	2	2		2	971	83.9	324	83.9	20.69	85.3
	SPB		13	73	17	16	12	13	2	2		1	1	1						151	13.1	50	13.0	3.01	12.4
	SMB		4	24	1	1	1		1	2	1									35	3.0	12	3.1	0.57	2.3
1988	LMB	9	327	144	4	10	29	24	3	12	15	6	2	3	2					591	81.3	194	81.5	10.30	87.7
	SPB	6	53	6	7	9	5	5	3	3	1									98	13.5	32	13.5	1.27	10.8
	SMB		17	19	1		1													38	5.2	12	5.0	0.17	1.5

Table 16. Percent composition of black bass from Grayson Lake according to sampling methods. Smallmouth bass were excluded.

Year	% from spring electrofishing (no./hour)		% from summer cove-rotenone (no./acre)		% from fall electrofishing (no./hour)	
	Largemouth bass	Spotted bass	Largemouth bass	Spotted bass	Largemouth bass	Spotted bass
1982	65	19	26	70	78	17
1983	67	33	70	29	67	33
1984	54	44	87	13	43	55
1985	42	56	71	27	26	67
1986	49	48	80	19	16	76
1987	48	48	84	13	17	77
1988	50	48	82	14	29	54
1989	43	53	-	-	26	63
1990	59	36	-	-	-	-
Mean	53	43	71	26	38	55

Table 17. Mean back calculated lengths (in) at each annulus for largemouth bass collected from Grayson Lake under a 10-in minimum-length limit.

Age	No.	Range		Mean	Standard error	95% C.I.	
		Low	High			Low	High
1	13	3.5	7.0	5.2	0.34	4.5	6.0
2	10	6.6	9.7	8.2	0.32	7.4	8.9
3	8	8.2	12.1	10.0	0.44	9.0	11.0
4	7	11.0	14.7	12.8	0.53	11.6	14.1
5	4	15.8	16.6	16.2	0.17	15.8	16.7
6	1	18.0	18.0	18.0	-	-	-

Total number of fish used in analysis = 13.
Intercept from regression = 1.84.

Table 18. Mean back calculated lengths (in) at each annulus for largemouth bass collected from Grayson Lake under a 12-in minimum-length limit.

Age	No.	Range		Mean	Standard error	95% C.I.	
		Low	High			Low	High
1	75	3.1	11.1	4.8	0.13	4.5	5.0
2	70	5.1	12.3	7.6	0.16	7.2	7.9
3	49	7.0	16.6	9.9	0.22	9.4	10.3
4	30	8.6	17.7	12.1	0.37	11.3	12.8
5	15	11.6	18.2	14.8	0.56	13.6	15.9
6	10	15.3	19.6	16.8	0.50	15.7	17.9
7	8	16.7	20.5	18.5	0.49	17.4	19.6
8	5	18.0	21.4	19.5	0.54	18.1	20.9
9	1	20.2	20.2	20.2	-	-	-
10	1	21.1	21.1	21.1	-	-	-

Total number of fish used in the analysis = 75.
Intercept from regression = 1.84.

Table 19. Mean back calculated lengths (in) at each annulus for largemouth bass collected from Grayson Lake in 1986 under a 15-in minimum-length limit.

Age	No.	Range		Mean	Standard error	95% C.I.	
		Low	High			Low	High
1	62	3.3	6.8	4.3	0.08	4.2	4.5
2	46	4.7	9.8	6.7	0.18	6.4	7.1
3	22	7.3	11.9	9.1	0.28	8.5	9.7
4	12	9.4	13.6	11.5	0.33	10.8	12.2
5	1	14.4	14.4	14.4	-	-	-
6	1	16.5	16.5	16.5	-	-	-

Total number of fish used in the analysis = 62.
Intercept from regression = 1.84.

Table 20. Age and mean growth for spotted bass in Grayson Lake (direct proportion method).

	Age						
	1	2	3	4	5	6	7
Under 10-in limit	3.7	6.7	9.7	11.4	13.3	14.9	
Under 12-in limit	2.9	5.8	7.9	9.3	11.0	13.0	
Under 15-in limit	2.8	5.0	7.2	9.4	10.8	12.6	13.7

Table 21. Annual mortality and survival of largemouth bass under the 12-in size limit at Grayson Lake.

Year	Instantaneous mortality (Z)	% survival rate(s)
1978	1.92	14.6
1979	0.93	39.3
1980	1.13	32.3
1981	0.99	37.1
Mean	1.24	30.8

95% confidence interval ±11.2 = 19.6 to 42.0 s.

Table 22. Annual mortality and survival of largemouth bass under the 15-in size limit at Grayson Lake.

Year	Instantaneous mortality (Z)	% survival rate(s)
1982	0.94	39.1
1983	1.09	33.6
1984	1.00	36.6
1985	1.31	27.1
1986	0.87	42.0
1987	1.20	30.1
1988	0.78	45.8
Mean	1.03	36.3

95% confidence interval ±4.8 = 31.5 to 41.1 s.

Table 23. Annual mortality and survival of spotted bass under the 12-in size limit at Grayson Lake.

Year	Instantaneous mortality (Z)	% survival rate(s)
1978	0.97	38.1
1979	0.58	55.9
1980	0.76	46.8
1981	0.78	45.8
Mean	0.77	46.7

95% confidence interval ±6.8 = 39.9 to 53.5 (s).

Table 24. Annual mortality and survival of spotted bass under the 15-in size limit at Grayson Lake.

Year	Instantaneous mortality (Z)	% survival rate (s)
1982	0.77	46.2
1983	0.98	37.5
1984	1.12	32.8
1985	0.61	54.2
1986	0.76	46.7
1987	0.88	41.7
1988	0.81	44.3
Mean	0.85	43.3

95% confidence interval $\pm$5.3 = 38.0 to 48.6.

Table 25. Sport fish harvest and fishing pressure (man-hours/acre) for kinds of fish at Grayson Lake (1974-1977) under a 10-in limit for black bass (values in parentheses are per acre values).

	Black bass	White bass	Crappie	Sunfish	Catfish	Carp
1974						
No.	4,058	0	17,084	10,959	2,563	894
	(2.71)		(11.39)	(7.31)	(1.71)	(0.60)
%	11.4	0	48.0	30.8	7.2	2.5
Lb	4,533	0	4,217	928	811	1,071
	(3.02)		(2.81)	(0.62)	(0.54)	(0.71)
%	39.4	0	36.5	8.0	7.1	9.3
Pressure	4.93	0	5.95	2.40	0.24	0.40
1975						
No.	3,059	0	13,663	20,342	375	755
	(2.04)		(9.11)	(13.56)	t[a]	t
%	8.0	0	35.5	52.9	t	t
Lb	3,067	0	3,966	2,302	631	797
	(2.04)		(2.64)	(1.53)	t	t
%	28.2	0	36.4	21.1	t	t
Pressure	6.30	0	3.35	1.26	-	-
1976						
No.	2,127	49	12,011	11,436	667	346
	(1.42)	(0.03)	(8.01)	(7.62)	(0.44)	(0.23)
%	8.0	0.2	45.1	42.9	2.5	1.3
Lb	2,140	43	1,830	1,105	461	510
	(1.43)	(0.03)	(1.22)	(0.74)	(0.31)	(0.34)
%	35.1	0.7	30.0	18.2	1.5	8.4
Pressure	9.03	-	4.64	0.14	0.36	-
1977						
No.	1,042	46	3,798	9,498	479	367
	(0.69)	(0.03)	(2.53)	(6.33)	(0.32)	(0.24)
%	6.8	0.3	24.9	62.4	3.1	2.4
Lb	1,019	19	498	1,002	242	327
	(0.68)	(0.01)	(0.33)	(0.67)	(0.16)	(0.22)
%	32.8	0.6	16.0	32.2	7.8	10.5
Pressure	6.27	-	0.63	0.56	-	-

[a]t $\leq$0.05%.

Table 26. Sport fish harvest and fishing pressure (man-hours/acre) for kinds of fish at Grayson Lake (1978-1979) under a 12-in limit for black bass (values in parentheses are per acre values).

	Black bass	White bass	Crappie	Sunfish	Catfish	Carp
1978						
No.	443	42	4,418	4,278	421	0
	(0.30)	(0.03)	(2.95)	(2.85)	(0.28)	
%	4.6	0.4	45.5	45.1	4.3	0
Lb	526	48	604	456	361	
	(0.35)	(0.03)	(0.40)	(0.30)	(0.24)	
%	26.4	2.4	30.3	22.9	18.1	0
Pressure	3.91	-	1.13	0.03	0.11	0
1979						
No.	315	0	7,805	4,921	15	36
	(0.21)		(5.20)	(3.28)	t[a]	t
%	2.4	0	59.6	37.6	t	t
Lb	380	0	1,367	461	4	27
	(0.25)		(0.91)	(0.31)	t	t
%	16.8	0	60.5	20.4	t	t
Pressure	7.52	0	2.24	0.41	-	-

[a]t $\leq$0.05%.

Table 27. Sport fish harvest and fishing pressure (man-hours/acre) for kinds of fish at Grayson Lake (1982-1986) under a 15-in limit for black bass (values in parentheses are per acre values).

	Black bass	White bass	Crappie	Sunfish	Catfish	Carp
1982						
No.	182	288	50,170	11,843	46	134
	(0.12)	(0.19)	(33.45)	(7.90)	(0.03)	(0.09)
%	0.3	0.5	79.5	18.8	t	0.2
Lb	446	177	3,938	976	44	312
	(0.30)	(0.12)	(2.63)	(0.65)	(0.03)	(0.21)
%	7.1	2.8	62.3	15.4	0.7	4.9
Pressure	5.37	-	4.51	0.43	0.40	t
1983						
No.	148	232	15,772	6,504	119	25
	(0.10)	(0.16)	(10.52)	(4.34)	(0.08)	(0.02)
%	0.7	1.0	69.4	28.6	0.5	0.1
Lb	291	124	1,639	604	71	63
	(0.19)	(0.08)	(1.09)	(0.40)	(0.05)	(0.02)
%	10.4	4.5	58.9	21.7	2.5	2.3
Pressure	5.27	0.03	3.01	0.25	-	0.10
1984						
No.	199	104	27,001	17,175	0	53
	(0.13)	(0.07)	(18.00)	(11.45)		(0.04)
%	0.5	0.2	60.5	38.5	0	0.1
Lb	398	13	3,784	1,038	0	98
	(0.27)	(t)[a]	(2.52)	(0.69)		(0.07)
%	6.1	0.2	58.1	15.9	0	1.5
Pressure	6.92	-	3.09	0.77	0	-
1985						
No.	156	34	10,525	6,295	264	33
	(0.10)	(0.02)	(7.02)	(4.20)	(0.18)	(0.02)
%	0.9	0.2	60.8	36.4	1.5	0.2
Lb	443	41	923	485	1,035	42
	(0.30)	(0.03)	(0.62)	(0.32)	(0.69)	(0.03)
%	14.9	1.4	31.1	16.3	34.9	1.4
Pressure	6.51	-	1.54	0.18	1.89	-
1986						
No.	134	0	10,291	4,169	81	18
	(0.09)		(6.86)	(2.78)	(0.05)	(0.01)
%	0.9	0	70.1	28.4	0.5	0.1
Lb	370	0	901	379	87	44
	(0.25)		(0.60)	(0.25)	(0.06)	(0.03)
%	21.0	0	51.1	21.5	5.0	2.5
Pressure	4.17	0	1.71	0.40	0.11	-

[a] t $\leq$0.005 lb/acre, 0.05%, or 0.005 man-hours/acre.

Table 28. Black bass creel statistics for Grayson Lake (values in parentheses are per acre values).

	10 in limit				12 in limit		1982		1983		1984		1985			1986		
	1974	1975	1976	1977	1978	1979	≥15 in	12-15 in[a]	≥15 in	12-15 in[a]	≥15 in	12-15 in[a]	≥15 in	12-15 in[a]	≥15 in[b]	≥15 in	12-15 in[a]	≥15 in[b]
No. of bass harvested	4,058	3,059	2,127	1,042	443	315	182	458	148	1,563	199	1,248	156	2,101	35	134	1,718	118
	(2.7)	(2.0)	(1.4)	(0.7)	(0.3)	(0.2)	(0.1)	(0.3)	(0.1)	(1.0)	(0.1)	(0.8)	(0.1)	(1.4)	(0.2)	(0.09)	(1.1)	(0.08)
% of total no. harvested	11.4	8.0	8.0	6.8	4.6	2.4	0.3		0.7		0.5		0.9			0.9		
Weight (lb) of bass harvested (per acre)	4,533	3,067	2,140	1,019	526	380	446	430	291	1,552	398	1,303	443	2,122	58	370	1,735	194
	(3.0)	(2.0)	(1.4)	(0.7)	(0.4)	(0.3)	(0.3)	(0.3)	(0.2)	(1.0)	(0.3)	(0.9)	(0.3)	(1.4)	(0.04)	(0.2)	(1.2)	(0.1)
% of total lb harvested	39.2	28.2	35.1	32.8	26.4	16.8	7.1		10.4		6.1		14.9			21.0		
No. of trips fishing for bass		4,181	5,203	3,972	3,335	4,507	3,575		4,175		5,870		4,920			2,941		
% of total fishing trips	41.4	27.4	29.6	32.1	29.3	31.2	18.1		35.2		40.2		40.0			39.1		
Hours fished for bass		9,445	13,547	9,399	5,864	11,279	8,063		7,899		10,387		9,758			6,255		
No. harvested fishing for bass[c]		2,593	1,778	818	290	275	173	294	148	898	194	886	124	1,872	35	123	1,174	116
Weight harvested fishing for bass[c]		2,682	1,827	830	376	343	425	260	291	927	384	951	342	1,891	58	352	1,186	194
No./hour harvested fishing for bass[c]	0.20	0.27	0.13	0.08	0.05	0.02	0.02	0.04	0.02	0.11	0.02	0.09	0.01	0.19	t[d]	0.02	0.19	0.02
% success fishing for bass	23.4	42.7	22.4	17.0	6.3	5.1	4.8	4.5	3.3	14.0	3.3	11.3	2.3	30.6	0.7	4.2	23.4	2.5

[a]Caught and released; this statistic is not included in harvest statistics, except for that category.

[b]Largemouth bass ≥15 in long caught and released.

[c]12-15 in category in 1982-1986 were caught and released, not harvested.

[d]t ≤0.005 fish/hour.

Table 29. Response to the following questions asked anglers during the 1986 creel survey at Grayson Lake. (1) Do you favor the 15-in minimum size limit for black bass at Grayson Lake? (2) Do you think fishing has improved due to the 15-in size limit on black bass at Grayson Lake?

	Fishing for							
	Black bass		Crappie		Anything		All anglers[a]	
	response	percent	response	percent	response	percent	response	percent
(1) Yes	104	76	27	57	57	31	194	50
No	21	15	19	36	75	40	118	30
No opinion	12	9	7	13	54	29	77	20
(2) Yes	93	68	26	52	48	26	172	45
No	21	15	9	18	67	36	97	25
No opinion	22	16	15	30	70	38	115	30

[a]Includes black bass, crappie, sunfish, catfish and anything anglers.