ANNUAL PROGRESS REPORT

FACTORS INFLUENCING LARGEMOUTH BASS RECRUITMENT: IMPLICATIONS FOR THE ILLINOIS MANAGEMENT AND STOCKING PROGRAM

John Hoxmeier, Ken Ostrand, Joe Parkos, Todd Kassler, David Philipp, and David Wahl
Center for Aquatic Ecology, Illinois Natural History Survey

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EXECUTIVE SUMMARY: Largemouth bass are frequently stocked in many Illinois impoundments to compensate for variable recruitment. Even so, the long-term contribution of stocked fish to recruitment and harvest of natural bass populations is unknown. Because stocking is only one of several management options for this species, it is critical that additional information on factors limiting recruitment processes be identified. In addition, information on the importance of rearing technique, size of stocked fish, forage base, cover, resident predators, physical-chemical conditions, and stocking stress in determining largemouth bass stocking success is needed to optimize use of hatchery produced fish. The ultimate goal is to develop management strategies that maximize growth, recruitment, and harvest of largemouth bass in Illinois impoundments.

The ability to reliably identify stocked fish is an essential component to successful population assessment. In job 101.1 we are attempting to determine the most reliable and cost-effective method for mass-marking fingerling largemouth bass. We evaluated fin clips, fin clips followed by freeze cauterization, and freeze branding. Preliminary results suggest that freeze brand marks are longer lasting and more distinguishable than fin clips and fin cauterized marks. However, seasonal variability in mark visibility for freeze branded fish is potentially problematic and will need to be assessed in subsequent years. We will continue to sample these marked fish at 6-month intervals and continue to evaluate growth rates, long-term mark retention and ease of readability to determine if these results hold true as largemouth bass continue to increase in size and age.

Stocking of largemouth bass is often used to compensate for poor recruitment in an already existing bass population. Surprisingly, few studies have looked at the effectiveness of different largemouth bass stocking strategies. In job 101.2 we examined the contribution of 4-inch fingerlings, compared size specific survival and growth among different sizes of stocked largemouth bass and compared intensive and extensive rearing techniques.

We conducted stocking evaluations of 4-inch largemouth bass fingerlings in 15 lakes across Illinois. Contribution of largemouth bass fingerlings varied considerably across lakes, ranging from 0 to 23 stocked bass per hour of electrofishing. We did not see any effect of natural recruitment levels on largemouth bass stocking success. We are currently examining the importance of predators and prey resources in determining growth and survival of stocked bass.

Four size classes of largemouth bass were stocked into lakes Homer, Mingo, and Woods. Largemouth bass were stocked as small fingerlings (55 mm) in July, medium fingerlings (96 mm) in August, large fingerlings (138 mm) in October and yearlings (210 mm) in May of the following year. Large fingerlings had the highest survival in the first fall compared to small and medium fingerlings. Large fingerlings and yearlings had the highest survival in the spring. Predation was observed on fingerlings and was related to size in Lake Mingo which has a high predator density. Yearlings were never found in any predator diets. Stocking stress in largemouth bass was low compared to other species, however, it was size related. We did not observe any stocking mortality in large fingerlings or yearlings. Pond reared bass had higher survival than hatchery reared bass in both Walton Park and Jacksonville. These results may be attributed to larger size bass produced in the rearing ponds as opposed to the hatchery.

Many species of fish, including largemouth bass, are cultured in hatcheries for release into lakes and streams in an effort to establish new or supplement existing populations.

Although it is assumed that subsequent increases in the standing stock are the direct result of those stocking efforts, little data exist to either refute or support that idea. In job 101.3 our objective is to evaluate the long-term contribution of stocked largemouth bass to the numbers of harvestable and reproducing adults. For this job, largemouth bass to be stocked in each selected study lake were those produced at the Little Grassy Hatchery bred specifically to be fixed for the MDH-B2B2 genotype as a genetic tag. Analysis of LMB fingerlings from the Little Grassy Fish Hatchery confirmed they all had the MDH-B2B2 genotype (Forbes Lake N=92 and Lake Shelbyville N=115) Background allele frequencies were collected on each study lake before largemouth bass were stocked. Background frequencies of LMB from five of the six study lakes have revealed low numbers of individuals with the MDH B2B2 genotype. Following introductions, the relative increase in the frequency of individuals in that year class with that rare MDH-B2B2 genotype will be used to determine the relative success of the stocking. Once those year classes reach maturation, the contribution of the stocked individuals relative to resident, native individuals will be determined from the increase over original, preintroduction values in the frequncy of the MDH-B2 allele in the naturally spawned YOY for several successive year classes.

Largemouth bass recruitment depends on a variety of both biotic and abiotic factors such as prey availability, predator abundance, population structure, vegetation, water level, temperature, and spawning habitat. Our objective in job 101.4 is to determine important mechanisms affecting largemouth bass recruitment in Illinois impoundments and develop recruitment indices for management. We sampled 13 lakes to assess the influence of various factors on largemouth bass recruitment. Seven lakes were sampled every two weeks, while the remaining six lakes were sampled monthly from May to October. The lakes chosen for this study varied in surface area, latitude, and trophic state. In addition, we chose lakes with poor, medium, and good largemouth bass recruitment.

Densities of young of year largemouth bass were different across lakes suggesting recruitment is related to biotic and abiotic differences among lakes as well as large scale environmental events. Environmental events such as below normal temperatures or above average rainfall will also likely influence recruitment across years. The importance of these variables can only be assessed thru multi-year evaluations. Our preliminary results suggest it is likely that the number of successful spawners, predation, and available prey have a large influence on growth and survival of juvenile largemouth bass. Growth of largemouth bass also differed across lakes and became more pronounced through fall. We did not find any significant relationships between largemouth bass growth and prey resources, however, our growth estimates were based on size through time and not age of the fish. We are currently in the process of ageing YOY bass using daily growth rings to get a better estimate of growth across lakes. Additional study years will help to us to identify factors controlling largemouth bass growth and survival.

An early index of largemouth bass recruitment is important for fisheries managers in order to make timely stocking decisions. We found a strong relationship between YOY bass densities in June and YOY bass densities in August. We will continue to examine this relationship in order to develop an early recruitment index.

Removal of spawning males by angling in the spring could have detrimental effects on largemouth bass recruitment. In job 101.5, our objective was to assess the level of angling for nesting bass in Illinois and to determine its impact on reproductive success and annual recruitment. To examine the relationship between reproductive success and recruitment in largemouth bass, we monitored nesting success in Lincoln Trail Lake and six one-acre ponds. We produced a good range of nesting success in the one-acre ponds. After draining these ponds in the fall, we found a positive relationship between reproductive success and fall recruitment. The critical period for fall recruitment for young-of-the-year largemouth bass appeared to be at the egg stage. To confirm this relationship, we stocked ten male and twelve female largemouth bass spawners into seven one-acre ponds in April, 2000. The seven ponds will be monitored and censussed in the same manner as the previous year. In the future, we will use these ponds to examine the effect of angling on bass nesting success and relate the resulting nesting success to juvenile recruitment. Our data from Lincoln Trail shows a low rate of nest abandonment due to electrofishing. These results need to be expanded with large sample sizes, but suggest that spring sampling with electrofishing equipment will not affect largemouth nesting success. Further work is also needed on the potential effect of angling on nest guarding by parental largemouth, but preliminary results show about a 30% abandonment rate due to capture with hook and line. Sample sizes also need to be increased for these experiments.

During the spawning season, we monitored largemouth bass tournaments to determine if nesting males were most at risk from anglers. Sex ratios of bass caught in tournaments during the spring of 2000 at Forbes were heavily skewed toward males.

There are a number of potential options that can be used to help manage bass populations in Illinois, including a variety of different harvest regulations such as size and bag limits, closed seasons, and spawning sanctuaries. In job 101.6, we are working on a model to evaluate the effects of various angling scenarios and pressures on Illinois bass recruitment and size structure. As a starting point, we have constructed a conceptual model based on a population of bass in a hypothetical lake to describe how reproductive success is impacted by fishing. During this segment we used data collected from Lincoln Trail to begin to calibrate the model. To refine the model, we need to get more data on how various parameters vary in Illinois and why they vary. That will involve conducting field experiments using different populations of largemouth bass. In addition, we will advance the model from the conceptual stage to a mathematical one so we can acquire better predictive capabilities. Once these models are constructed, we will test them using large scale manipulative experiments.

Job 101.1 Evaluating marking techniques for fingerling largemouth bass

OBJECTIVE: To determine the most reliable and cost-effective method for mass-marking fingerling largemouth bass.

INTRODUCTION: The ability to reliably identify stocked fish is an essential component to successful population assessment. The choice of a particular fish marking technique depends primarily on the scope of the management question. In some instances, short-term marks can provide sufficient information to address management questions. Often times, however, it is important to identify marked fish throughout their lifetime. In Illinois, freeze branding (Mighell 1969) has been a commonly used method for mass-marking largemouth bass fingerlings. Although this technique permits marking large numbers of hatchery fish both quickly and inexpensively, long-term retention of freeze brands in centrarchids is variable (Coutant 1972). Because uncertainty about mark retention compromises the quality of recapture data by making the true contribution of hatchery fish unknown, it is important that a reliable, long-term mark is established. An ideal mark should be inexpensive, easy to apply, have long-term retention, and have minimal impact on the health of the fish.

Several marking techniques have the potential to produce long-term physical marks on largemouth bass. Fin clipping can permanently mark largemouth bass if all fin rays are carefully clipped at the point of attachment to the bone (Wydoski and Emery 1983). Partial or incomplete removal of fin rays, however, can result in fin regeneration and preclude our ability to identify stocked fish. Boxrucker (1982; 1984) used a combination of fin clipping followed by freeze cauterization of the wound to create a long-term mark on fingerling largemouth bass. This technique required more man-hours than fin clipping or freeze branding alone (Boxrucker 1982).

PROCEDURES: To evaluate long-term retention rate on larger fingerlings, we marked 4" fish using fin clips, fin cauterization or freeze branding. Groups of fingerling bass with each mark (75-100 each) were then stocked into 3 outdoor ponds (1/3 acre) at a total density of 250 fish/pond (Table 1). Fish used in these experiments were previously identified as either the1:1, 1:2, or 2:2 MDH-B genotype. At the beginning of the experiment, fish with known genotypes were assigned to a specific physical mark so that they could be genetically identified if marks disappeared or could not be positively identified in the field (Table 1). Fingerling bass were stocked into ponds on December 14, 1998 and first sampled on May 27, 1999, October 26, 1999, and March 20, 2000 to assess differences in mark retention rates and percent re-growth among marking techniques.

Fin clips were obtained by removal of the right pelvic fin. Removing both pelvic fins and 'freeze-branding' the wound with liquid nitrogen made fin cauterizations. Freeze branding was accomplished by holding fish for 2 s against a branding iron chilled to -190 °C with liquid nitrogen. Freeze brands were located on the left side of individual fish, just below the dorsal fin.

Short term experiments with 2 inch fingerlings were also conducted using fin clips, freeze brands, fin cauterization, OTC, or photonic dye. Methods for these experiments are given in last years report.

FINDINGS: In the long-term pond experiments (4" fingerlings), fin cauterized marks were the longest lasting and most distinguishable marks followed by fin clip and freeze brands. All three marks were easily discernable until approximately 10 months, when 8% of fin clip, 2% of fin cauterized, and 18% of freeze brand marks were no longer visible (Figure 1). Freeze brand marks were clearly visible (100%) during the spring of 1999 and 2000, whereas only 82% of freeze brands were distinguishable in the fall of 1999. Freeze brand marks were less visible in the fall of 1999 because of darker external coloration. Conversely, fin clips and fin cauterized marks were distinguishable regardless of season (i.e., fish coloration). Fin clips and fin cauterized marks had considerable amounts of fin re-growth that could make them less desirable than freeze brands for long term marks. Fin cauterized marks had 20% less fin re-growth than fin clips. Less fin re-growth in fin cauterized marks made them more obvious than fin clips and required less handling time.

Growth appears to be unhampered by freeze brand, fin cauterized, and fin clip marks (Table 1) and was similar among all three marking techniques ($\bar{x}$ = 162 mm, TL; March 2000). Freeze brand marked fish had the greatest growth rate followed by fin cauterized and fin clip marked fish during the growing season (i.e., 27 May 1999 to 26 October 2000). Growth of fin cauterized fish was much lower in spring, 2000 than for the other two techniques. The removal of a pelvic (e.g., fin clip) or both pelvic fins (e.g., fin cauterized) could impact foraging success or energy allocation.

Results of the short term retention experiments with 2 inch fingerlings given in last years report, differed slightly from the results of the long term experiments with 4 inch fish. Retention rates were higher for fish marked with fin clips (83%) and freeze brands (76%) than for fish marked with fin cauterization (30%) or photonic dyes (0%). The lower retention rate of fin cauterization marks in 2 inch fish compared to 4 inch fish is the result of the 2 inch fish being to small to effectively cauterize their pelvic fins.

RECOMMENDATIONS:

Preliminary results suggest that fin cauterized marks are longer lasting and more distinguishable than fin clips and freeze brands. The seasonal variability in mark visibility for freeze branded fish is potentially problematic and will need to be assessed in subsequent years. Re-growth of fin clip and fin cauterized marks will also need to be assessed over the long term to evaluate its effect on choice of mark. We will continue to sample these marked fish at 6-month intervals and continue to evaluate growth rates, long-term mark retention and ease of readability to determine if these results hold true as these largemouth bass continue to increase in size and age. These long-term experiments will allow us to estimate loss rate for the most common physical marks used on largemouth bass. In addition, we will analyze the OTC-marked fish data collected in the short term experiments to compare these marks against other techniques used on 2 inch fingerlings.

Job 101.2. Evaluating various production and stocking strategies for largemouth bass.

OBJECTIVE: To compare size specific survival and growth among different sizes of stocked largemouth bass fingerlings and to compare various rearing techniques.

INTRODUCTION: Stocking of largemouth bass is often used as a management tool across the U.S. Surprisingly, few studies have examined the effectiveness of different largemouth bass stocking strategies. Of the studies that have examined the success of largemouth bass stocking, most were conducted on a single lake over a short period of time (Lawson and Davies 1979; Boxrucker 1982), and results have been variable.

Stocking of fingerling largemouth bass (4 inch) is often used to compensate for poor recruitment in an already existing bass population. However, contribution is often difficult to assess because the fish often are not marked or only a few lakes are examined. Because of the variability across lakes, large scale stocking evaluations in lakes of varying latitude, size, and biotic characteristics are needed. Natural recruitment may also affect the survival of stocked largemouth bass. For example, stocked walleye in Minnesota have much higher survival rates in lakes without natural reproducing walleye populations (Li et al. 1996). Determining which lakes are most suitable for stocking will help us to maximize our use of hatchery fish.

In addition to stocking bass in appropriate lakes, the size of largemouth bass fingerlings produced by Illinois hatcheries and timing of their release into recipient populations could greatly affect the success of largemouth bass stocking efforts. New or rehabilitated lakes in Illinois are often stocked with two inch fingerlings, however, most supplemental stockings occur in the fall with four inch fingerlings. In addition, some recent programs in Illinois have used eight inch fingerlings to stock populations in the spring. Advantages of the latter strategy include being able to stock same age fish after a weak year-class has been identified and potentially higher survival of larger stocked fish. Disadvantages include increased cost and hatchery space required to rear larger fish. In addition, stocking size may interact with the availability of appropriate forage, the ability of the stocked fish to switch to piscivory, and the level of competition from their naturally-spawned cohort to influence growth. Smaller bass may be more vulnerable to predation than larger bass and may not survive as well overwinter. Resident predators can be an important source of mortality for stocked fishes and can have important implications for when and where fish are introduced (Wahl and Stein 1989; Santucci and Wahl 1993). However, stocked species differ in their vulnerability to predation and the importance that it plays in determining survival and for stocked largemouth bass is unknown (Wahl 1995; Wahl et al. 1995).

In addition to size and timing, differences in rearing method (e.g., intensive raceway versus extensive ponds) of the largemouth bass fingerlings may influence growth and survival. Largemouth bass raised on commercial food pellets have been shown to grow better when stocked into rearing ponds than those fed a diet of fathead minnows (Hearn 1977). A number of Illinois reservoirs and impoundments are stocked with largemouth bass raised extensively in nursery ponds. These and other lakes can also be stocked using largemouth bass raised at state hatcheries. The relative merits of these two rearing techniques has not yet been assessed.

PROCEDURES: We conducted stocking evaluations of 4-inch largemouth bass fingerlings in 15 lakes across Illinois. Fingerlings were stocked in mid-August 1999 at a rate of 25/acre and averaged 96 mm TL. Each bass was given a right pelvic clip before being stocked for future identification. Lakes chosen for stocking ranged in size, latitude, and natural recruitment of largemouth bass.

Initial stocking mortality was determined for several stockings by holding a subsample (N = 100) of largemouth bass in replicate mortality cages (N = 3). The number of largemouth bass surviving after 24 hours was recorded. For each stocking, a subsample (N = 100) of largemouth bass was weighed (nearest g) and measured (nearest mm). Dissolved oxygen and water temperature were measured at the time of stocking. Predation on stocked largemouth bass was evaluated by conducting diet analysis of resident predators prior to and after stocking.

We monitored growth and survival of stocked bass during the first fall and spring after they were stocked. Largemouth bass were collected using day AC electrofishing in the fall by the INHS and Division of Fisheries. All largemouth bass were examined for marks, measured, and weighed. Fish collected for growth measurements were also analyzed for food habits. Diets from smaller bass were taken by stomach flushing (Foster 1977), while diets from larger bass were taken by using an acrylic tube (Van Den Avyle and Roussel 1980). On selected lakes, prey availability was assessed by collecting zooplankton, larval fish, macroinvertebrates, and juvenile fish at monthly intervals. The role of forage base in determining growth and survival of stocked largemouth bass will be evaluated by comparing bass diets with species composition, density, and size distribution of prey available at the time of stocking.

We evaluated the success of four size groups of stocked largemouth bass in three lakes (Homer, Mingo, and Woods). Largemouth bass were stocked as small fingerlings (55 mm) in July, medium fingerlings (96 mm) in August, large fingerlings (138 mm) in October and yearlings (210 mm) in May of the following year (Table 2). Each size group was given a distinctive mark for identification during subsequent sampling. Small fingerlings were immersed in oxytetracycline (OTC), while larger fingerlings were marked with distinctive fin clips. Following stocking, we evaluated the importance of stocking stress, physicochemical properties, predation, and prey availability, on the growth and survival of the different size groups of stocked largemouth bass with the methods described earlier.

The effects of rearing techniques on growth and survival of stocked largemouth bass were evaluated in lakes Jacksonville, Shelbyville and Walton Park during fall 1999. Lake Shelbyville was stocked with 17,123 largemouth bass fingerlings from a nearby rearing pond on 7 October and 8,800 largemouth bass fingerlings from Jake Wolf Fish Hatchery on 30 July. Fingerlings from the rearing pond averaged 104 mm TL and were given a left pelvic clip while fingerlings from the hatchery averaged 120 mm TL and were given a right pelvic clip. Jacksonville was stocked in August with 5,000 hatchery produced bass and in October with 6,629 pond reared bass. Walton Park was stocked both by Little Grassy Fish Hatchery (pond production) and Jake Wolf Fish Hatchery (raceway production). Different clips were given at each hatchery; intensive fish were given left pelvic clips and extensive fish were given right pelvic clips. Electrofishing was conducted during fall and spring to assess the contribution of largemouth bass from rearing ponds and raceways. All bass were examined for clips, weighed, and measured.

FINDINGS:

Initial Contribution:

Contribution of stocked largemouth bass varied across lakes during the first fall after stocking (Figure 2). Pierce Lake had the highest CPUE of stocked largemouth bass (23/hr) whereas no stocked bass were collected in Homer, Shelbyville, and Spring Lake North. The absence of stocked bass in our collections for Lake Shelbyville may have been due to the large size of the lake. Lake Shelbyville is an order of magnitude larger than the other study lakes which makes it more difficult to find the small number of stocked bass. Across all lakes, CPUE of stocked bass in the spring was similar to the previous fall (Figure 3).

Factors regulating the success of stocked largemouth bass are most likely related to predation and prey resources and not natural recruitment levels. The success of stocked bass was not influenced by the level of natural largemouth bass recruitment ($r^2 = 0.04$; $P = 0.56$; Figure 4). Therefore, factors influencing the success of stocked bass are not necessarily those that influence natural recruitment. In addition, there is no natural recruitment threshold for good survival of stocked bass. Abiotic factors also did not affect survival of bass fingerlings. Initial stocking mortality was low across all lakes ($\bar{x} = 3.6\%$) and was not related to water temperature. Prey and predator densities are currently being evaluated and will be examined for their influence on stocked largemouth bass growth and survival.

Stocking size:

Large fingerlings had the highest survival across all three study lakes. Small and medium fingerling survival was low and did not differ from each other (Figure 5). Although CPUE decreased for large fingerlings in the spring, it was still higher than medium fingerlings (Figure 6). Yearling bass also were collected in higher numbers than small and medium fingerlings in the spring, however, collections were made only a few days after stocking. At the time of this report, small fingerlings were not differentiated from naturally reproduced bass in the spring. Future analysis of OTC marks will be required to make these comparisons.

The differential size at stocking was still evident in the fall (Table 3). Similar to 1998, largemouth bass grew faster under hatchery conditions than in lake conditions. This differs from the results found for stocked walleye in Illinois where fish grew faster in the lakes (Hoxmeier et al. 1999). Walleye stocked as fry and 50-mm fingerlings were often larger when the 100-mm walleye were stocked from the hatchery. In contrast, naturally spawned bass were always smaller than stocked bass and therefore stocked fish may have had a competitive advantage.

Initial stocking mortality was low across all size classes and lakes (Table 3). Although water temperatures varied considerably across stocking dates, it did not effect initial mortality. Because of such low stocking mortality, we believe that the differences found in survival of different size classes are not a result of stocking stress. Again, prey and predator abundance are probably important factors influencing the growth and survival of stocked bass. There was similar low predation across all size classes in three lakes, however, Lake Mingo had a higher rate of predation on small and medium fingerlings compared to large fingerlings (Table 4). Yearlings were never found in diets of any predators across all lakes.

Rearing techniques:

Thirty-four percent of the largemouth bass stocked into the Jacksonville rearing pond survived and were stocked into Lake Jacksonville, whereas, 45 percent of the bass from Fin and Feathers rearing pond survived and were stocked into Lake Shelbyville. Pond reared fish had higher CPUE than hatchery reared fish in all lakes where fish were collected (Figure 7). We did not collect any stocked largemouth bass from Lake Shelbyville in 1999, but did collect both hatchery and pond reared bass in 1998. One reason for the higher survival of pond reared than raceway reared largemouth bass may be the size of fish at stocking. Pond reared largemouth bass were larger at stocking than hatchery reared bass in both Jacksonville and Walton Park (Table 5).

RECOMMENDATIONS: Contribution of 4-inch largemouth bass fingerlings was highly variable across lakes and was not related to natural recruitment. We are currently examining the importance of predators and prey resources in determining growth and survival of stocked bass. Additional data from fall 2000 should help us to determine what lake characteristics are best suited for stocking of largemouth bass.

Large fingerling largemouth bass had higher survival rates than small and medium fingerlings across all three study lakes. Yearling bass also had high survival based on preliminary electrofishing samples conducted late this summer. Additional samples will need to be collected to assess the contribution of this size class of stocked fish. Cost associated with producing different sizes of bass need to be calculated in order to determine the best size to stock in terms of cost/benefit. During the next several years we will monitor the long-term survival of stocked fish in these lakes to determine which size contributes most to the adult largemouth bass population. In the summer and fall of 2000, we will stock Lake Charleston and Homer Lake with 2, 4, 6, and 8 inch largemouth bass to confirm whether large fingerlings and yearling bass are the best size to stock in terms of survival. As part of these evaluations, we will continue to assess the importance of various biotic and abiotic factors in determining size specific growth and survival.

Stocking of pond reared bass produced better results than stocking hatchery reared bass. Comparisons of these two techniques will be conducted again in Walton Park in 2000. Jacksonville and Shelbyville could not be stocked in 2000 due to rearing pond water levels and renovations. These lakes will be stocked again in future segments. In addition, attempts will be made to stock bass from both techniques at similar sizes to determine if mechanisms other than size cause differences in survival between intensively and extensively reared fish.

Job 101.3. Assessing the long-term contribution of stocked fish to largemouth bass populations.

OBJECTIVE: To evaluate the long-term contribution of stocked largemouth bass to the numbers of harvestable and reproducing adults.

INTRODUCTION: Many species of fish, including both largemouth and smallmouth bass, are cultured in hatcheries for release into lakes and streams in an effort to establish new or supplement existing populations. Although it is assumed that subsequent increases in the standing stock are the direct result of those stocking efforts, little data exist to either refute or support that idea. Furthermore, even if the stocking effort does indeed increase the standing stock of adult bass, it remains unclear how that increase could or would impact the level of reproduction and recruitment in subsequent generations.

Both largemouth and smallmouth bass likely home back to natal areas to spawn (Kassler, Philipp, Svec, and Suski, unpublished data and Ridgway, personal communication), therefore it is possible that introduced bass may not compete successfully with resident bass for optimal spawning sites or may simply make poor choices in selecting nesting sites on their own. Under either of these scenarios, the level of reproductive success of stocked bass would be lower than that of resident bass. Preliminary results of largemouth bass stocked into Clinton Lake during 1984 (Philipp and Pallo, unpublished results) indicated that survival of the stocked fish to at least age 4 was good (approximately 8-10% of that year class), however those individuals made no discernable contribution to any later year classes.

To justify continued stocking efforts for largemouth bass in Illinois, it is important to determine the actual contribution that stocked fish make to bass populations. The objective of this job is to compare the survival and reproductive success of stocked bass to resident bass. In this way, we can assess the costs and benefits of the bass stocking program in a long-term timeframe.

PROCEDURES: Largemouth bass to be stocked in each selected study lake were those produced at the Little Grassy Hatchery bred specifically to be fixed for the MDH-B2B2 genotype as a genetic tag. These fish were either stocked directly into a target lake, or were first introduced into rearing ponds near the target lake before being stocked. Six study lakes were stocked and sampled; Lake Shelbyville and Forbes Lake during 1998, and Walton Park, Murphysboro, Mcleansboro, Sam Parr, and Shelbyville in 1999.

Prior to actual stocking, samples of fish from the hatchery rearing ponds were sampled, and protein electrophoretic analysis (Philipp et al., 1979) was used to determine if 100% of those fish had the MDH B2B2 genotype. Also prior to stocking, a sample of naturally produced largemouth bass were collected from each study lake and analyzed to determine the inherent background frequency of the two alleles at the MDH-B locus. Collections made after stocking will then be analyzed to determine if the frequency of the MDH B2 allele has increased through reproduction of the stocked fish.

FINDINGS: Analysis of LMB fingerlings from the Little Grassy Fish Hatchery confirmed they all had the MDH-B2B2 genotype (Forbes Lake N=92 and Lake Shelbyville N=115). Background frequencies of LMB from five of the six study lakes have revealed low numbers of individuals with the MDH B2B2 genotype (Table 6). The higher frequency of the MDH B2B2 genotype from McCleansboro is potentially the result of sampling stocked fish. As a result, that sample could have an inflated background frequency.

RECOMMENDATIONS: The contribution of stocked largemouth bass to the reproductive success of a given lake will be determined by calculating the frequency of the MDH B2 allele before and after stocking. Random size distributions of largemouth bass were sampled from each lake to determine the pre-stock frequency of the MDH B2 allele prior to stocking. Once the stocked fish reach maturation, the frequency of the MDH B2 allele will be calculated to determine a post stock frequency in each lake. An increase in the MDH B2 allele from each lake will provide evidence that stocked fish contributed to the reproductive success of a lake.

Numbers of individuals of the 98 and 99 year classes collected need to be increased, hopefully approaching 100 for each study lake. In addition, the number of lakes included in this study needs to be increased if feasible, and the populations sampled annually to assess the genetic makeup of each year class.

Job 101.4. Evaluating factors that influence largemouth bass recruitment in Illinois.

OBJECTIVE: To determine important mechanisms affecting largemouth bass recruitment in Illinois impoundments and develop recruitment indices for management.

INTRODUCTION: Largemouth bass recruitment depends on a variety of both biotic factors (e.g., prey availability, predator abundance, population structure, vegetation, etc.) and physical factors (e.g., spring water levels and temperature, spawning habitat, human disturbance such as angling) (Kramer and Smith 1962; Carline et al. 1984; Gutreuter and Anderson 1985; DeVries and Stein 1990). Many of these factors can be altered through management actions. As a result, the need to identify which of these factors influence year-class strength and to be able to predict recruitment of largemouth bass has been highlighted as an essential component to successful management of the species. Most previous studies have focused on a single factor or lake (Kramer and Smith 1962) with no comparison across lakes of which factors are most important in determining recruitment.

Determining the critical period(s) and the factors influencing recruitment of largemouth bass populations would enable biologists to better predict management needs, such as stocking and vegetation control. Understanding the underlying biological mechanisms important to largemouth bass recruitment would provide biologists a means to evaluate and potentially improve recruitment. Size of spawning females, for example, has been positively correlated to survival of YOY largemouth bass (Miranda and Muncy 1987). Hence, management actions that protect large females or increase growth rates for adult fish may have a positive influence on recruitment. Moreover, our studies on bass in Canada indicate that year class strength is positively correlated to reproductive success; thus, human actions and biotic conditions that increase spawning opportunities/success or decrease spawning disturbance/failure will affect recruitment. Brood predation, for example, may be linked to removal of males from their nests and, therefore, could be affected through alternative management action. A better understanding of the timing of critical periods in the recruitment dynamics of largemouth bass will allow development of new indices the can help guide management decisions.

Other important biotic factors such as food availability (Olson 1996; Garvey et al. 1998), predation (Ludsin and DeVries 1997), and cover (Davies et al. 1982; Durocher et al. 1984) have been linked to growth and survival of young largemouth bass. Abundance of invertebrate prey, for example, can have important implications for growth of YOY largemouth bass which in turn can affect timing of ontogenetic diet shifts (e.g. to piscivory) and survival of YOY bass (Olson 1996). Similarly, fish prey composition can affect growth of young largemouth bass. In Ohio reservoirs, for example, YOY largemouth bass exhibited greater growth variability in shad *Dorosoma spp.* dominated systems than in bluegill *Lepomis macrochirus* dominated systems, implying that recruitment dynamics may be linked to assemblage structure of available prey species (Garvey and Stein 1998). Similarly, vegetation type and percent cover play an important role in providing invertebrate prey and shelter for juvenile largemouth bass and have been positively linked to year-class strength in bass populations (Durocher et al. 1984). Other biotic factors, such as size of spawning females, have also been positively correlated to survival of YOY largemouth bass (Gutreuter and Andersen 1985; Miranda and Muncy 1987). Earlier spawning by larger females results in a size advantage to young largemouth bass that has been correlated to overwinter survival and first-year recruitment (Ludsin and DeVries 1997; Keast and Eadie 1985). Work in northern Illinois found overwinter mortality to be unrelated to size of fish entering winter, but rather to events occurring earlier in life (Fuhr et al. in review). Whether these relationships occur over a wider geographic range and and types of reservoirs is unclear.

Physical factors such as water temperature (Olson 1996), water level (Miranda et al. 1984) and wind and wave action (Kramer and Smith 1962) have also been correlated to recruitment dynamics in largemouth bass. In Lake Shelbyville, Illinois, for example, spring water level fluctuations (increasing and decreasing) have been negatively linked to year class strength in largemouth bass (Kohler et al. 1993). As a result, timing of water level manipulations in flood control reservoirs might be altered to improve spawning conditions and recruitment for largemouth bass (Miranda et al. 1984). To date, most evaluations of recruitment dynamics in largemouth bass have been carried out on limited spatial scales (e.g. single lakes or reservoirs). Studying effects of physical and biotic factors across a gradient of lake types (e.g. reservoirs, state impoundments, cooling reservoirs, etc) will identify mechanisms important in Illinois aquatic habitats. Large-scale, comparative studies will increase our understanding of factors important to growth and survival of young-of-year largemouth bass and help provide management alternatives that improve year-class strength in bass populations.

PROCEDURES: We sampled 13 lakes to assess the influence of various factors on largemouth bass recruitment. Seven lakes were sampled every two weeks, while the remaining six lakes were sampled monthly from May to October. The lakes chosen for this study varied in surface area, latitude, and trophic state. In addition, we chose lakes with poor, medium, and good largemouth bass recruitment.

Largemouth bass recruitment was assessed by shoreline seining and electrofishing. Seining was conducted using a 9.2-m bag seine pulled along the shoreline at fixed transects. All fish were counted and up to 50 fish were measured for each species. Thirty young of year (YOY) largemouth bass were retained from each sampling date for diet and age analyses. Electrofishing was used to collect YOY largemouth bass in the fall after they were no longer vulnerable to the seine.

Prey resources were estimated by sampling benthic invertebrates, zooplankton, larval fish, and small forage fish. Benthic invertebrates were sampled at six sites in each lake during June and August by using a modified stovepipe sampler. The benthos was sieved through a 250-μm sieve bucket and preserved in ETOH and rose bengal. Invertebrates were sorted, identified, and measured at the lab. Zooplankton was collected at four offshore and four inshore sites with a 0.5-m diameter zooplankton net with 64-μm mesh. Samples were taken either from the thermocline or from the bottom (if the lake was not stratified) to the surface. Zooplankton samples were preserved in a 4% Lugols solution and returned to the lab for processing. Zooplankton subsamples were counted until 200 organisms from two taxonomic groups were counted. Measurements were taken on 30 individuals of each species from two of the inshore and two of the offshore sites. Larval fish were sampled at six sites on each lake using an 0.5-m diameter larval push net with 500-μm mesh. The larval net was mounted to the front of the boat and pushed for 2.5 minutes along the shoreline and an additional 2.5 minutes offshore. Larval fish were preserved in ETOH for later sorting and identification. Forage fish were collected by shoreline seining as described for the YOY largemouth bass.

Physical and chemical variables important to largemouth bass recruitment were sampled in each of the study lakes. Aquatic vegetation was identified and mapped in each lake to estimate percent vegetative cover in June and August. Water level was monitored throughout the spring and summer. Water temperature and dissolved oxygen was measured at 1-m intervals using a YSI oxygen meter. In addition, thermographs were placed into three lakes and recorded water temperature at 2 hour intervals through out the year. Water samples for chlorophyll-*a* and phosphorous were collected using an integrated tube sampler lowered to twice the secchi depth. Chlorophyll was measured using a flourometer, while total phosphorous was measured with a spectrophotometer.

FINDINGS:

Largemouth bass recruitment was highly variable across study lakes (Figure 8). Young of year largemouth bass densities ranged from 0 to 28 per meter shoreline in June. The variation in YOY bass densities declined during the summer as densities decreased across lakes in August and September. This pattern suggests some evidence for density dependent mortality between June and August with high density lakes suffering higher mortality. Important sources of mortality are occurring during these time periods and need to be assessed. Similar to 1998, there was a positive relationship between June and August YOY bass densities ($r = 0.73$; $P = 0.04$). This relationship could be useful in providing an early index of recruitment. Combining 1998 and 1999 data strengthens this relationship ($r = 0.75$; $P < 0.01$). Biologists may be able to use June YOY largemouth bass densities to plan a variety of management strategies, including determining whether to stock largemouth bass in the fall.

Growth of largemouth bass differed across lakes and became more pronounced through fall (Figure 9). Bass were collected by seines from June to September and by electrofishing in October. Size biases associated with each collection method may explain the dramatic changes in apparent growth between September and October for several lakes. Alternatively, the large apparent increase in growth in Pierce and LOTW could be the result of the smaller sized bass in these lakes not surviving into October.

Prey resources were different across the study lakes and across seasons. Larval fish density ranged from < 1 to 30 fish/m^3 and peaked June (Figure 10). A second peak in larval fish density occurred in August in several of the study lakes. Juvenile bluegill density was used as a measure of available fish prey for YOY largemouth bass. Similar to the previous year, bluegill densities were extremely high in Ridge Lake compared to other study lakes (Figure 11). The effects of variable prey density on stocked bass growth and survival will be examined in future reports.

RECOMMENDATIONS: Densities of young of year largemouth bass were different across lakes suggesting recruitment is related to biotic and abiotic differences among lakes as well as large scale environmental events. Environmental events such as below normal temperatures or above average rainfall also likely influence recruitment across years. The importance of these variables can only be assessed thru multi-year evaluations. Our preliminary results suggest it is likely that the number of successful spawners, predation, and available prey have a large influence on growth and survival of juvenile largemouth bass. We will continue to monitor prey resources, physicochemical characteristics, and predation pressure to determine how these variables interact to determine largemouth bass recruitment. Diets of YOY largemouth bass are currently being identified and should provide valuable information on which food resources are most important. These results will be presented in subsequent reports.

An early index of largemouth bass recruitment is important for fisheries managers in order to make timely stocking decisions. We found a strong relationship between YOY bass densities in June and YOY bass densities in August. We will continue to examine this relationship in order to develop an early recruitment index.

We will continue to examine abiotic and biotic factors that control bass recruitment in Illinois. By better understanding what factors influence recruitment, we will be able to make appropriate management recommendations to enhance this valuable fishery.

Job 101.5 Assessing the impact of angling on bass reproductive success, recruitment, and population size structure.

OBJECTIVE: To assess the level of angling for nesting bass in Illinois and to determine its impact on reproductive success and annual recruitment, as well as to determine how much long term exploitation of Illinois bass has changed the size structure of those populations.

INTRODUCTION: Removal of spawning males by angling in the spring have unknown effects on largemouth bass recruitment. In the spring, male largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*) build solitary, highly visible saucer-shaped nests in the substrate in order to court and spawn with females (Kramer and Smith 1962; Pflieger 1966; Coble 1975). Once spawning is completed, females leave the nesting area and the males alone remain to provide all parental care for the developing offspring, a period that may last four or more weeks (Ridgway 1988). While male bass are providing parental care for their broods, they are extremely aggressive (Ridgway 1988) and, therefore, highly vulnerable to many angling tactics (Neves 1975; Kieffer et al. 1995). Even though this vulnerability has never been assessed accurately, many fisheries management agencies have invoked closed fishing periods, catch-and-release regulations, and various length and harvest limits in different combinations in an attempt to limit harvest of male bass during the spawning season (see Schramm et al. 1995). This strategy of maximizing reproductive success by protecting the successful spawners from angling harvest and even disturbance operates under the assumption that there is some positive relationship between reproductive success and recruitment. The standard dogma in fisheries recruitment historically has been that there is no relationship between standing adult stock and recruitment. Although much of the data behind that belief was collected for marine species, that belief has been generalized to freshwater species as well, even those species for which there is extended parental care (e.g., largemouth and smallmouth bass). The error in logic has been compounded further by extending the dogma to include the "lack of relationship" to recruitment and reproductive success. That extension clearly makes little sense for species such as the basses which have been shown to have high levels of variability in the percentage of adults that choose to spawn in any given year. In addition, because there is also a substantial and variable level of natural brood abandonment, the numbers of successful broods would not at all be expected to be related to the numbers of adults. One objective of this job is to assess how well reproductive success correlates with recruitment, at least through the establishment of YOY class strength.

Because male largemouth bass and smallmouth bass experience reduced levels of food consumption while providing parental care (Kramer and Smith 1962; Pflieger 1966; Coble 1975), this period in the reproductive cycle is characterized by a continual decrease in energy storage and somatic growth. The quality of post swim-up parental care provided is influenced by the energy reserves of the nesting male (Ridgway and Friesen 1992). As a result, any energetically costly activity, such as the type of exhaustive exercise experienced during angling, could result in a decreased ability or willingness of that male to provide continued parental care (Kieffer et al. 1995) and thus, negatively impact offspring survival. In fact, Philipp et al. (1997) have confirmed that preseason angling of nesting bass, even on a catch-and-release basis, results in increased brood predation and male abandonment rates. It is likely, therefore, that substantial levels of catch-and-release, much less catch-and-harvest, angling for nesting bass would have negative impacts on the production of black bass fry at the population level. Moreover, because female black bass choose to spawn preferentially with the largest males (Wiegmann et al. 1992), the largest males have the largest broods. Furthermore, because parental investment decision rules dictate that those males with the largest broods will defend those broods most aggressively, we would expect that the individual nesting males that are the most at risk in a catch-and-release (even full harvest) scenario are the largest ones, i.e., those that have enjoyed the most mating success. This is indeed what we have observed; angling efforts disproportionately target that portion of the male population that is most productive and, therefore, most important with respect to reproductive success.

PROCEDURES: To examine the relationship between reproductive success and recruitment in largemouth bass, we stocked six one-acre ponds with 18 adult bass, eight males and ten females, on April 28, 1999. In addition, each pond was stocked with 958 bluegills in order to have a background assemblage of brood predators. Water temperatures and secchi depths were monitored for the duration of the observation period. Snorkel surveys were conducted by swimming the shoreline of each pond and mapping the locations of bass nests. Each nest was given a tag and assigned a score based on how many eggs or fry it contained, with scores ranging from one (lowest) to five (highest). Visual estimates were made of the sizes of the males guarding the nests. In order to create a range of reproductive success, we removed the fry from one nest each in three of the ponds on May 7, 1999. Observations were made for a period of 35 days. In October 1999, we drained the ponds and censussed bluegill and young-of-the-year largemouth bass.

Snorkel surveys were also used to assess the extent of bass spawning activity, size structure of spawning males, and the effects of angling and electrofishing on nesting success in Lincoln Trail Lake. Nine sites were monitored from 5-3-00 to 5-23-00. We gave each nest a tag and recorded egg score (1-5), water depth of the nest location, and the life stage of the eggs and fry. Spawning date was estimated from the egg or fry stage present in the nest. We made visual estimates of the total length of the males guarding the nests and noted the presence of any hook wounds. To assess the potential effect of electrofishing on nest guarding by males, we snorkel surveyed nests at seven of the sites, electrofished all the males off the nests, gave each male a caudal clip, and then snorkel surveyed each site again to see if the captured males abandoned their nests. We also used assessed the effects of angling on nest guarding by parental males. We hook and line angled all nests at three of the sites and recorded the nests from which we were able to remove the males. The next day, we swam the angled sites and recorded whether or not the nest was abandoned.

During the spawning season, we monitored bass tournaments at Mill Creek, Mattoon, and Forbes Lakes to determine if nesting males were more at risk from anglers than either non-nesting males or females. The total length, sex, and reproductive condition of each fish brought to weigh-in was recorded.

FINDINGS: Bass began spawning almost immediately after being stocked into the one-acre ponds. Two of the ponds were turbid (average secchi readings 38 and 71 cm respectively) during the first four days of the survey period, making observations difficult. The number of nests per pond ,in the remainder, ranged from three to seven with mean nest scores of 3.5 to 4.0. To determine the reproductive success for a particular pond, a nest index score was calculated by multiplying the number of nests by the mean nest score for that pond. Nest index scores extended from a low of 12 to a high of 26. Positive correlations were found between the number of nests with eggs and the number of nests with fry and between nest index and fry index values. Final young-of-the-year largemouth bass biomass was positively related to nest index (r=0.95; P=0.01; Figure 12), but not fry index (r=0.64; P=0.17). Final young-of-the-year biomass was not related to CPUE from seines in any month: June (r=0.46; P=0.36), July (r=0.52; P=0.29), or September (r=0.58; P=0.23). Average young-of-the-year density did not affect final young-of-the-year length (r=-0.72; P=0.17).

Bass spawned in Lincoln Trail from 4-24-00 to 5-18-00. Two spawning events were observed: 4-24 to 5-3 and 5-12 to 5-18. A total of 128 nests were found in the nine surveyed sections. Average total length of the nesting males was 325 mm with a range of 279 to 406 mm. Only five bass were found to have hook wounds. We found a very similar distribution of spawning behavior and spawner sizes in 1999 from Lincoln Trail surveys that were examined from the same six sites. We found a low rate of nest abandonment from electrofishing that removed male largemouth from their nests (Table7). More parental males abandoned their nest after being caught by hook and line angling than by electrofishing (Table 7).

Tournament anglers in the spring appear to target spawning bass. Fifty-five percent of fish captured in spring tournaments during 1999 and 2000 were engaged in some stage of spawning. The percentage of bass that were reproductively active ranged from 28.4% to 97.1% of all fish captured (Table 8). Tournament anglers tended to capture more males than females (Table 8), which may indicate that anglers are targeting males on nests or actively guarding offspring. Sex ratios (males : females) ranged from 1:1 to 3.6:1 across lakes Mattoon, Mill Creek, and Forbes in 1999 and 2000. Males were smaller than females and had total lengths that ranged from 351.5 mm to 431.9 mm. The higher number of immature bass caught in Mill Creek coupled with smaller average total lengths during 1999 may be attributable to a 12 to 15 inch slot limit. Conversely, Mattoon and Stephen Forbes have a 14-inch minimum size limit and thus may have a higher percentage of larger and actively spawning bass.

RECOMMENDATIONS: We produced a good range of nesting success in the one-acre ponds. After draining these ponds in the fall, we found a positive relationship between reproductive success and fall recruitment. The critical period for fall recruitment for young-of-the-year largemouth bass appeared to be at the egg stage. To confirm this relationship, we stocked ten male and twelve female largemouth bass spawners into seven one-acre ponds in April, 2000. The seven ponds will be monitored and censussed in the same manner as the previous year. In the future, we will use these ponds to examine the effect of angling on bass nesting success and relate the resulting nesting success to juvenile recruitment. Our data from Lincoln Trail shows a low rate of nest abandonment due to electrofishing. These results need to be expanded with larger sample sizes, but suggest that spring sampling with electrofishing equipment will not affect largemouth nesting success. Further work is also needed on the potential effect of angling on nest guarding by parental largemouth, but preliminary results show about a 30% abandonment rate due to capture with hook and line. Sample sizes also need to be increased for these experiments. To understand how to minimize negative impacts of catch and release angling, future experiments need to determine which factors are most important for influencing the parental decision to abandon, and to understand when and how these important factors interrelate in natural systems. These experiments should test nest abandonment and male aggression towards nest predators for fish that are experimentally angled and in controls that are not manipulated.

In conjunction with our angling experiments, we will continue to monitor bass tournaments in order to assess if large, reproductively active males are being preferentially caught. Data from two of the three lakes examined suggests that this may be the case during spring tournaments. Using this data, we will be able to make predictions about how angling will affect fall recruitment of largemouth bass.

Job 101.6. Evaluating the impact of harvest regulations on largemouth bass recruitment in Illinois.

OBJECTIVE: To develop a model to evaluate the effects of various angling scenarios and pressures on Illinois bass recruitment and size structure.

INTRODUCTION: There are a number of potential options that can be used to help manage bass populations in Illinois, including a variety of different harvest regulations such as size and bag limits, closed seasons, and spawning sanctuaries. Each of these has a different impact on the population, by affecting numbers and/or sizes of adults. Some regulations have the potential for impacting recruitment more than others, but little information is available comparing those impacts. We need to develop a theoretical framework by which we can assess how and why management regulations impact populations. To accomplish that task, we need to develop a conceptual model of how reproductive success is impacted by these various management actions, then develop a set of parental care decision rules that are based on field-developed parameters, and combine those to devise a predictive model that can help evaluate how best to manage bass populations under varying conditions.

The model we are developing is designed to determine how the reproductive success of a population changes under varying levels of fishing pressure, and how various management options affect that change. To establish baseline data, we need to determine a variety of parameters, some of which include density of nesting males along a shoreline (including how much variation exists within and among lakes), size and age of the nesting males, natural levels of brood abandonment (including how much variation exists among lakes and years), fishing pressure during the spawning season, vulnerability of nesting males to fishing (including how much variation exists among lakes as well as among male sizes), etc.

The objective of this job is to use a combination of data gathered from studies in Illinois (including the creel and FAS databases), data gathered from our studies in Ontario, and literature studies to build this model.

PROCEDURES: In last years report, we constructed a conceptual model based on a population of bass in a hypothetical lake to describe how reproductive success is impacted by fishing. The hypothetical lake has 10 km of shoreline, a surface area of 1500 acres, and an annual spawning population of 1000 adult males (i.e., 1000 males receive eggs in a nest they construct). Factors affecting the number of successful nests in this model include fishing pressure, minimum length limits, abandonment rates, and protected spawning areas. We used abandonment rates determined from Lincoln Trail and used this model to examine the effects of fishing pressure on nesting success.

FINDINGS: The abandonment rate for catch and release angling on Lincoln Trail was 30 percent (see job 101.5). Using this rate in the model, we would predict little change in the number of successful nests with changes in fishing pressure (Figure 13). We need additional information on nest abandonment rates at a range of fishing pressures to test predications of the model.

RECOMMENDATIONS: To refine the model, we need to get better data on how the various parameters vary in nature and why they vary. That should involve conducting a variety of field experiments using different populations of largemouth bass, and eventually smallmouth bass. In addition, we need to advance the model from the conceptual stage to the mathematical one so we can acquire better predictive capabilities. Once these models are constructed, however, we need to test them using large scale manipulative experiments.

Job 101.7. Analysis and reporting.

OBJECTIVE: To prepare annual and final reports summarizing information and develop management guidelines for largemouth bass in Illinois.

PROCEDURES and FINDINGS: Data collected in Jobs 101.1 - 101.6 were analyzed to develop guidelines for largemouth bass regarding stocking and management techniques throughout Illinois.

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Table 1. Stocking density and growth rates for 4" largemouth bass marked with fin clips (FC), freeze brands (FB), or fin cauterization (FCFB). Fish were stocked into three 0.3 acre ponds on 14 December 1998 and sampled 27 May 1999, 26 October 1999, and 20 March 2000. Genotypes for each mark are given.

Physical mark	Genotype	Stocking density (No./pond)	Growth rate(g/d) 12/14/98 to 5/27/99	Growth rate(g/d) 5/27/99 to 10/26/99	Growth rate(g/d) 10/26/99 to 3/20/00
FC	1:1	75	0.101	0.186	0.052
FB	1:2	100	0.091	0.233	0.046
FCFB	2:2	75	0.095	0.218	0.026

Table 2. Study lakes stocked with fingerling largemouth bass in 1999. Catch per unit effort (CPUE) is based on the number of fish collected per hour of AC electrofishing. Total length (TL) is the average length of stocked bass collected in the fall and spring. Data for Jacksonville and Walton Park is based on intensively reared fish only.

			Stocking	CPUE		TL	
Lake	Date	#/acre	size	Fall	Spring	Fall	Spring
Bloomington	08/25/99	25	98	4.0	-	105	-
Charleston	08/23/99	25	98	10.2	2.7	110	109
Forbes	07/29/99	12.6	127	7.0	6.4	154	167
Homer	08/16/99	25	94	1.0	1.2	101	111
Jacksonville	08/16/99	25	97	1.2	0.0	138	-
Kakusha	08/05/99	30.6	100	1.3	0.0	114	-
Leaquana	08/08/99	29.5	100	4.0	2.4	115	132
Mcleansboro	07/28/99	25	119	4.0	0.7	159	198
Mingo	08/17/99	25	98	0.4	1.1	99	128
Murphysboro	07/27/99	25	119	6.0	2.7	130	163
Pierce	08/05/99	27	100	22.7	25.0	141	140
Sam Parr	07/29/99	25	114	-	2.0	-	147
Shelbyville	07/30/99	0.8	127	0.0	0.0	-	-
Spring Lake North	08/23/99	25	98	0.0	0.0	-	-
Spring Lake South	08/23/99	25	98	1.0	1.3	100	123
Woods	08/16/99	25	97	0.7	0.2	108	113
Walton Park	08/19/99	22.3	127	3.0	-	142	-

Table 3. Comparison of stocking success of four sizes of largemouth bass in lakes Charleston, Homer, Mingo, and Woods. Catch per unit effort (CPUE) is measured as number of fish per hour of AC electrofishing during the following fall and spring. Each size class was given a distinct mark for future identification. Stocking mortality was estimated by holding stocked bass in 3 mesh holding cages and counting the number dead after 24 hours.

Lake	Date	TL at Stocking (mean ± SD)	Number Stocked	Stocking Mortality	CPUE		Total Length (mm)	
					Fall	Spring	Fall	Spring
Charleston	07/23/98	57 ± 6.9	10,000	0	0.9	0.0	82	-
	08/19/98	100 ± 9.7	7,020	0	1.8	1.0	137	143
	09/17/98	146 ± 8.4	3,100	0	33.7	5.0	154	163
	05/17/99	183 ± 12.7	1,500	0	-	4.7	-	187
Homer	07/14/99	55 ± 3.1	4,000	1	2.0	-	96	
	08/16/99	94 ± 6.5	2,000	0	1.0	1.16	101	111
	10/12/99	143 ± 11.4	800	0	13.0	2.09	139	142
	05/31/00	204 ± 12.6	400	0	-	-	-	-
Mingo	07/14/99	55 ± 3.4	8,500	1	0.4	-	79	-
	08/17/99	98 ± 6.5	4,250	6.7	0.4	1.09	99	128
	10/12/99	131 ± 11.6	2,250	0	28.6	4.35	137	164
	05/11/00	223 ± 15.2	1,600	0	-	-	-	-
Woods	07/14/99	56 ± 3.4	1,400	0	0.4	-	90	-
	08/16/99	97 ± 7.9	700	7.8	0.7	0.23	108	113
	10/12/99	141 ± 10.6	280	0	18.3	1.82	139	151
	05/31/00	203 ± 10.0	140	0	-	-	-	-

Table 4. Predation on recently stocked bass in four Illinois reservoirs. Numbers represent percentage of stocked bass found in predator diets.

	Size at stocking (inch)			
Lake	2	4	6	8
Charleston	1	3	2	0
Homer	2	4	0	0
Mingo	20	27	7	0
Woods	2	0	12	0

Table 5. Largemouth bass stocking summaries for lakes Jacksonville, Shelbyville and Walton Park. Intensively reared bass were raised in raceways while extensively reared bass were raised in ponds. Catch per unit effort (CPUE) is based on the number of fish collected per hour of day electrofishing during October-November.

Lake	Date	Rearing Technique	Number Stocked	Total Length at Stocking	Fall CPUE
Jacksonville	08/16/99	Intensive	5,000	98	1.2
Jacksonville	10/09/99	Extensive	6,629	123	8.4
Shelbyville	08/28/98	Intensive	8,900	120	0.2
Shelbyville	10/09/98	Extensive	11,500	104	0.4
Shelbyville	07/30/99	Intensive	8,800	120	0.0
Shelbyville	10/07/99	Extensive	17,123	104	0.0
Walton Park	08/19/99	Intensive	625	100	3.0
Walton Park	07/30/99	Extensive	625	127	8.0

Table 6. Frequencies of MDH B2B2 from six study lakes in Illinois prior to stocking.

			Genotypes			Allele Frequencies	
Lake	Sample Size	Sample Date	1/1	1/2	2/2	1	2
Forbes	41	Fall 98	16	20	5		
Forbes	47	Summer 99	32	10	5		
Forbes	(Total)		48	30	10	0.716	0.284
McCleansboro	19	Summer 99	4	5	10	0.342	0.658
Murphysboro	58	Summer 99	48	6	4	0.879	0.121
Sam Parr	8	Fall 98	4	3	1		
Sam Parr	53	Summer 99	40	11	2		
Sam Parr	(Total)		44	14	3	0.836	0.164
Shelbyville	60	Summer 98	43	16	1		
Shelbyville	103	Summer 99	77	20	6		
Shelbyville	(Total)		120	36	7	0.847	0.153
Walton Park	17	Summer 99	12	5	0	0.853	0.147

Table 7. Abandonment rate of male largemouth bass collected from nests with either electrofishing gear or hook and line angling.

Sample Date	Treatment	Number Nests	Number Abandoned	% Abandonment
5/11/00	Electrofishing	37	3	8
5/16/00	Electrofishing	14	0	0
5/11,16/00	Angling	10	3	30

Table 8. Sex ratios, average TL (mm), and percent spawning bass from tournaments at Mill Creek, Mattoon, and Stephen Forbes Lakes 1999 and 2000. Percent spawning bass are given for males, females, and all fish combined.

Lake	Sex Ratio (males:females)	Mean TL (mm)		Percent Spawning		
		Males	Females	Males	Females	Total
Mill Creek						
1999	3.6:1	351.5	342.8	19.4	9.0	28.4
Mattoon						
1999	1.8:1	397.8	408.9	61.8	35.3	97.1
2000	1:1	431.9	432.6	36.4	100.0	63.6
Forbes						
1999	1:1.1	407.0	429.0	7.8	33.4	41.2
2000	3.3:1	428.8	435.9	40.0	55.5	43.6

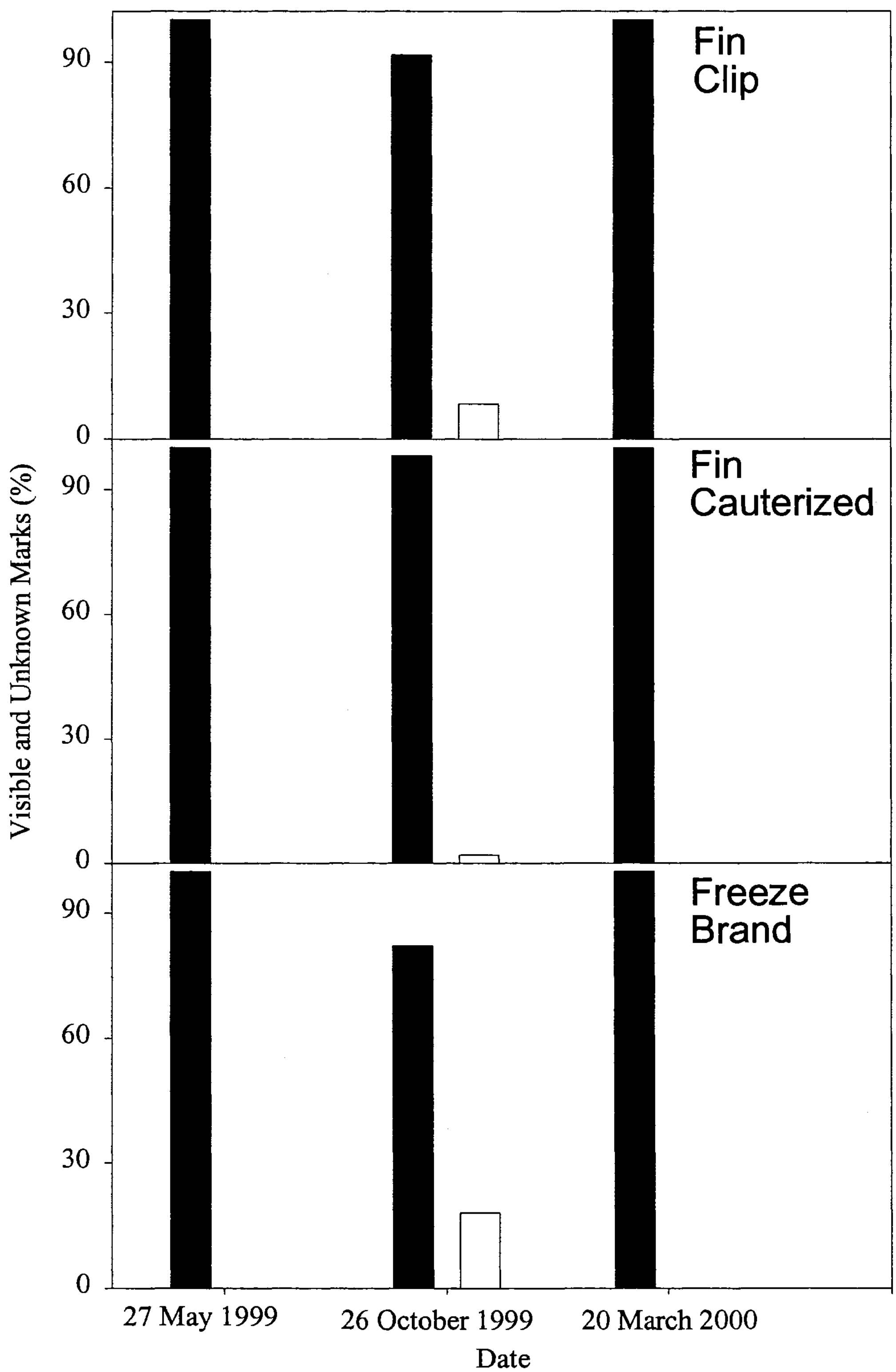

Figure 1. Percent of visible marks (dark bars) and those that were undiscernable (light bars) and identified by gentic markers, for fin clip, fin cauterized, and freeze brand marks.

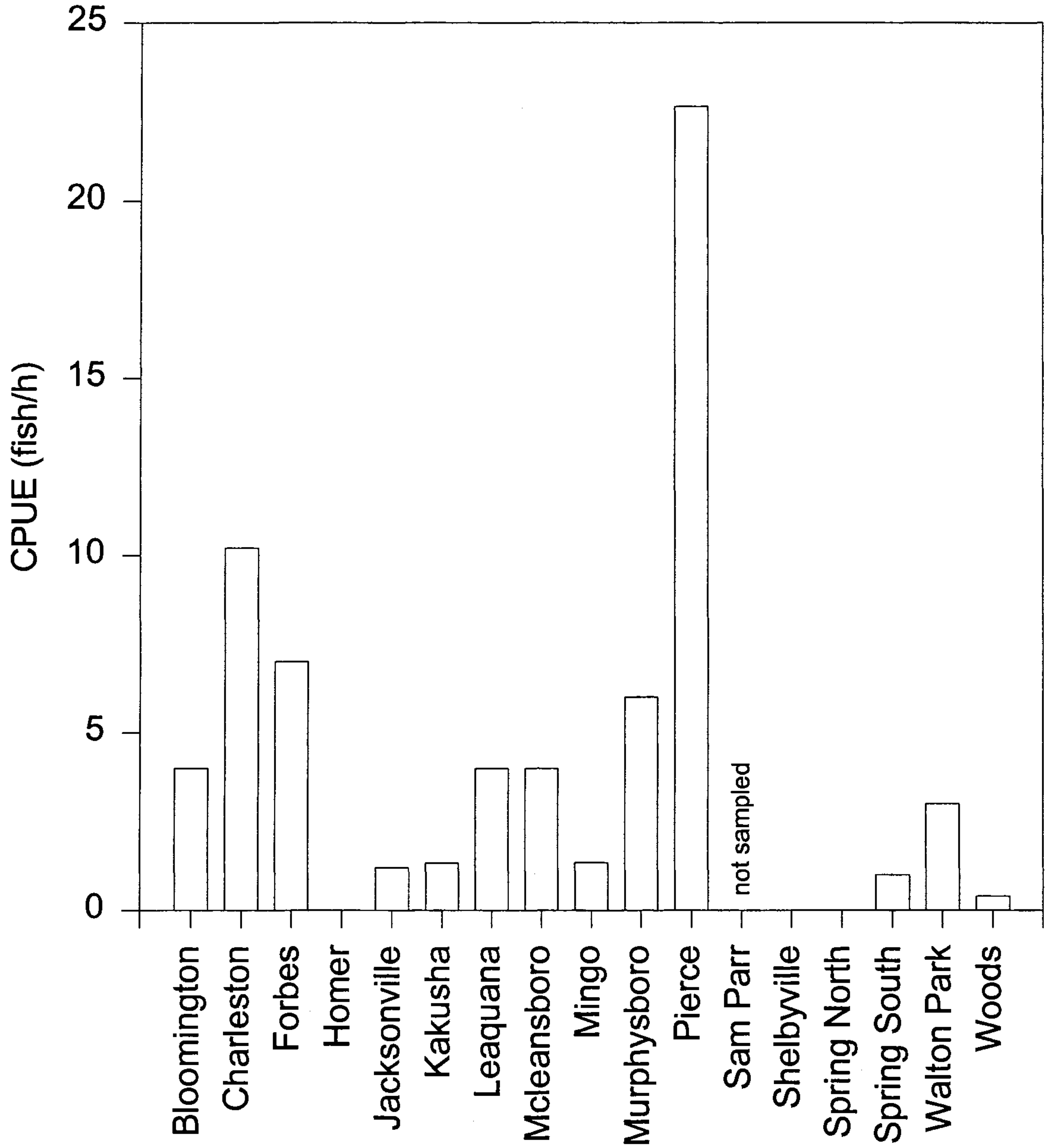

Figure 2. Catch per unit effort (fish/h) of stocked largemouth bass collected in the fall by AC electrofishing. Fingerlings were stocked at 25/acre in August and averaged 96 mm TL.

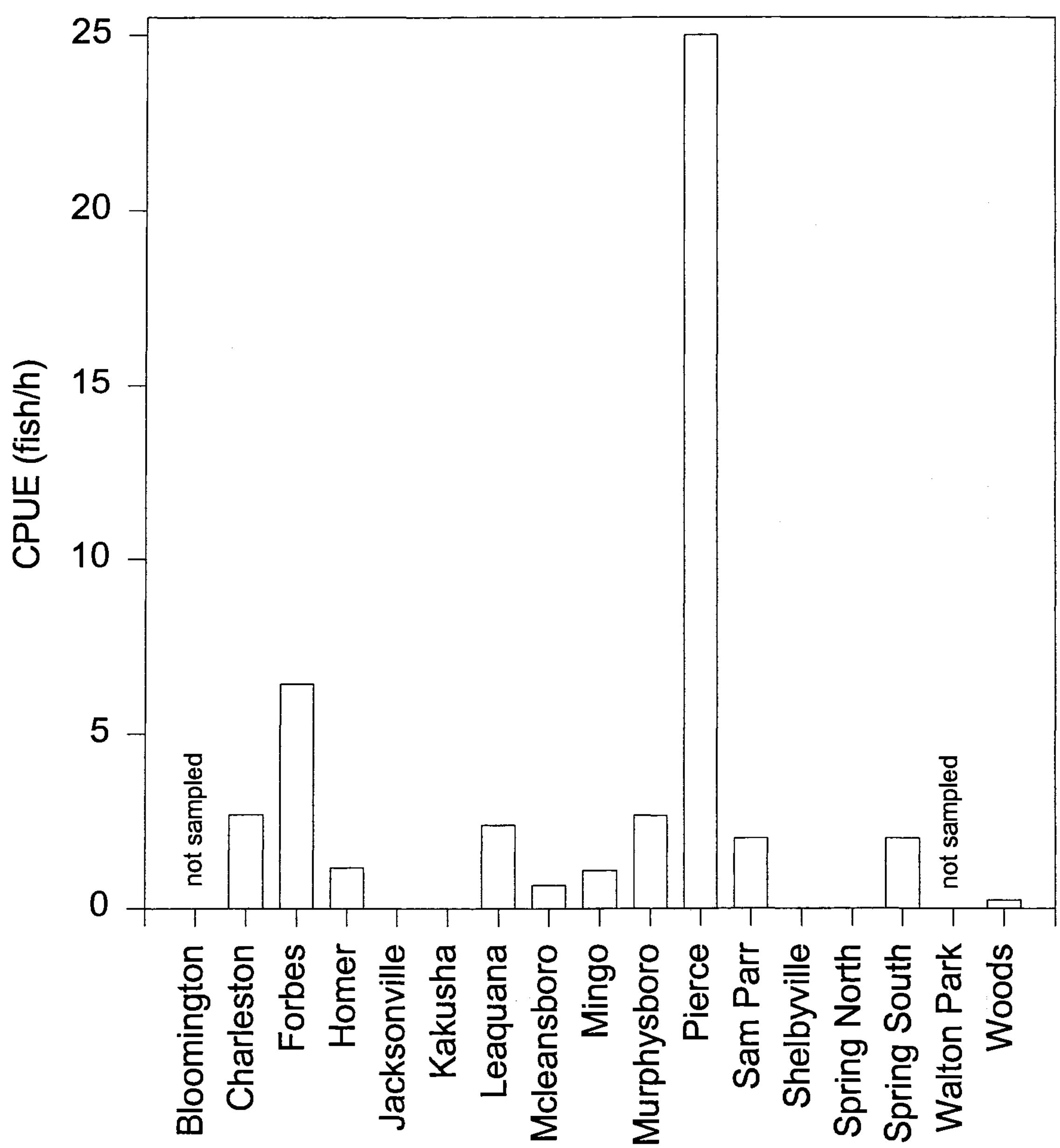

Figure 3. Catch per unit effort (fish/h) of stocked largemouth bass collected in the spring by AC electrofishing. Fingerlings were stocked at 25/acre in August in the previous year.

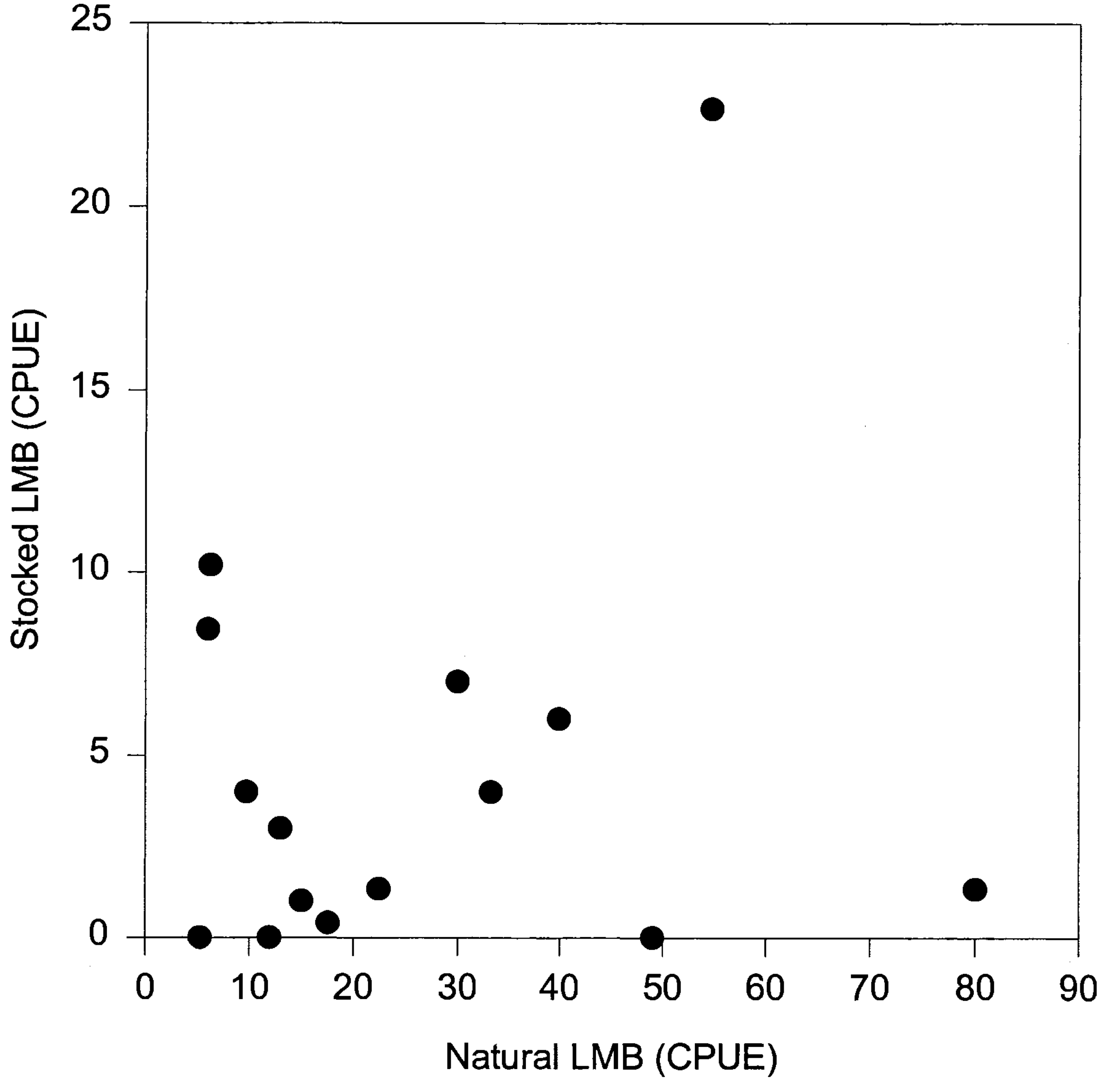

Figure 4. Relationship between stocked and natural largemouth bass catch per unit of effort. CPUE is based on fall AC electrofishing and is measured as number of bass caught per hour. Bass were stocked in August at 96-mm.

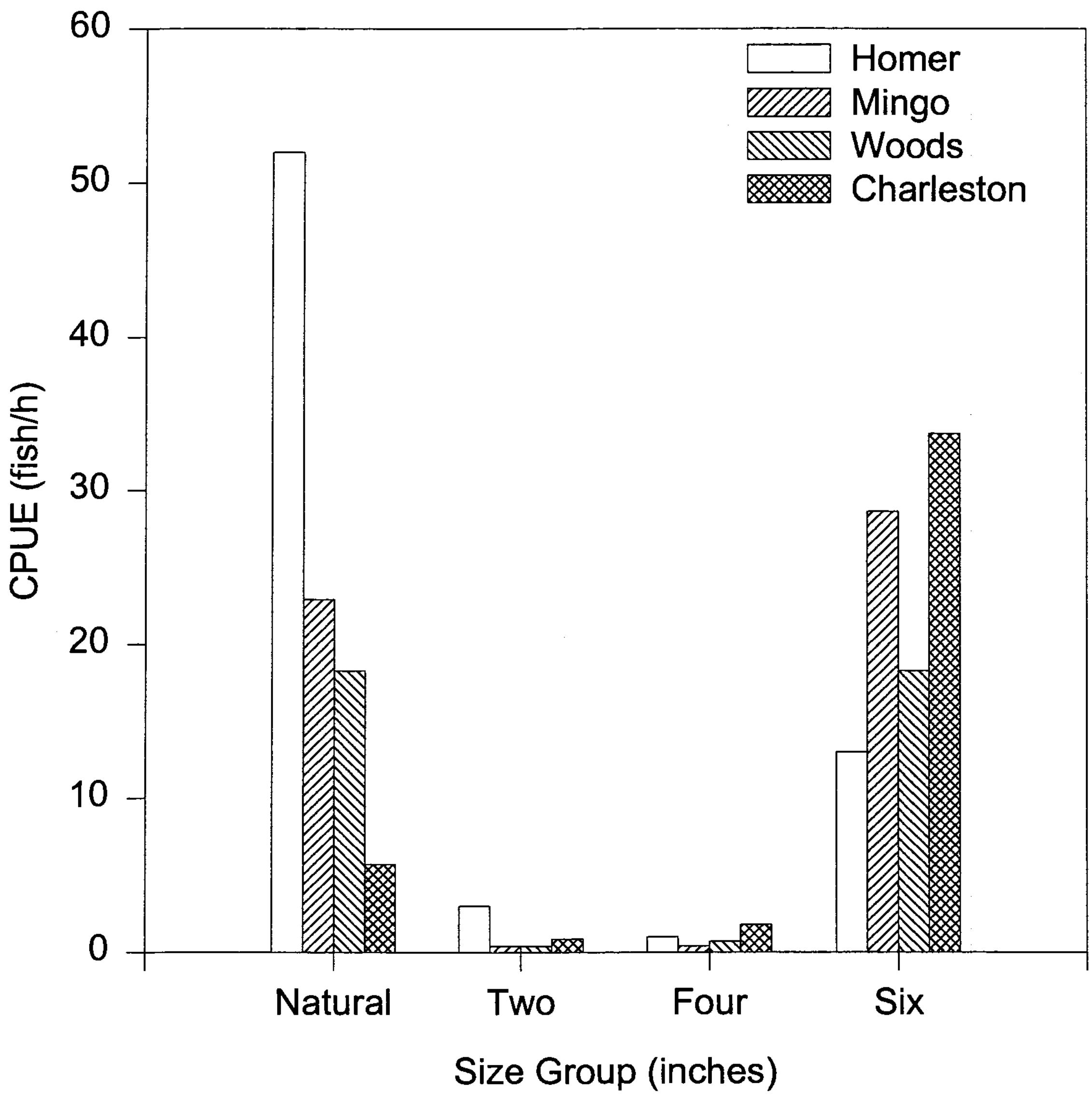

Figure 5. Catch per unit effort (fish/h) of natural and stocked largemouth bass in four Illinois reservoirs based on fall daytime AC electrofishing. Bass fingerlings were stocked at three different sizes (2, 4, and 6 inches).

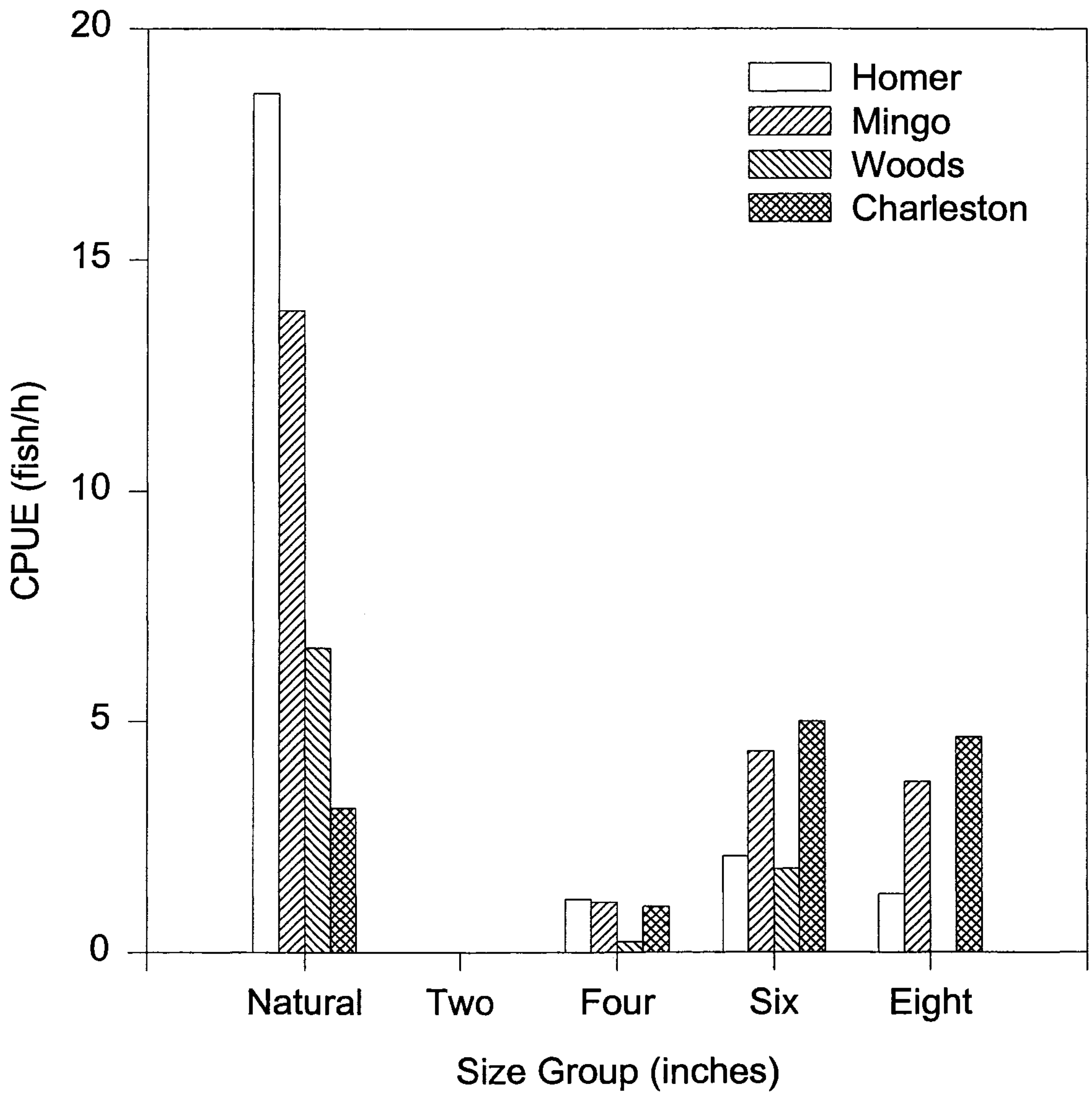

Figure 6. Catch per unit effort (fish/h) of natural and stocked largemouth bass in four Illinois impoundments based on spring daytime AC electrofishing. Bass fingerlings were stocked at four different sizes (2, 4, 6 and 8 inches). Woods Lake was not sampled for 8 inch bass.

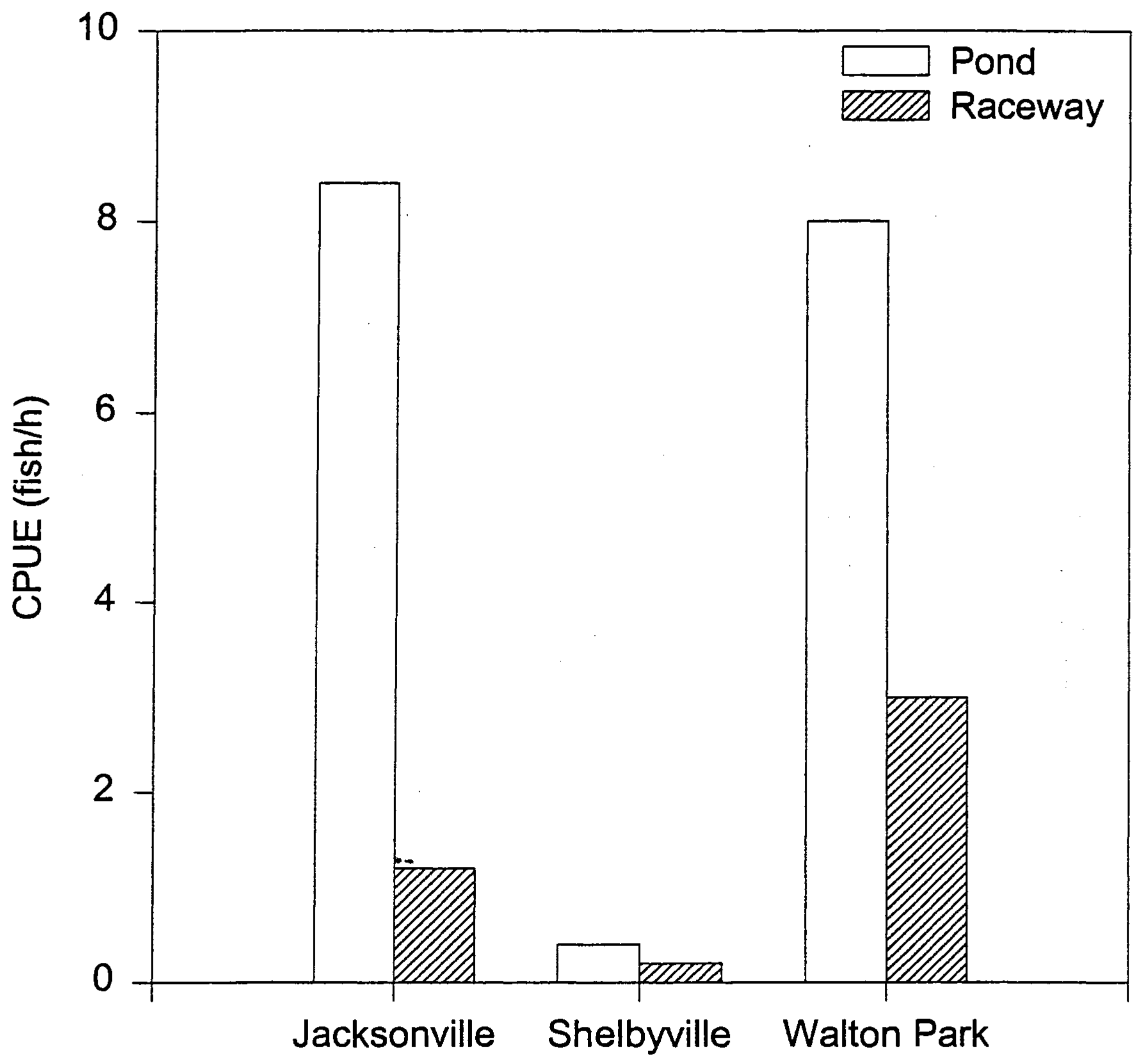

Figure 7. Catch per unit effort (fish/h) of stocked largemouth bass in three Illinois lakes based on daytime AC electrofishing. Bass were either extensively (pond) or intensively (raceway) reared.

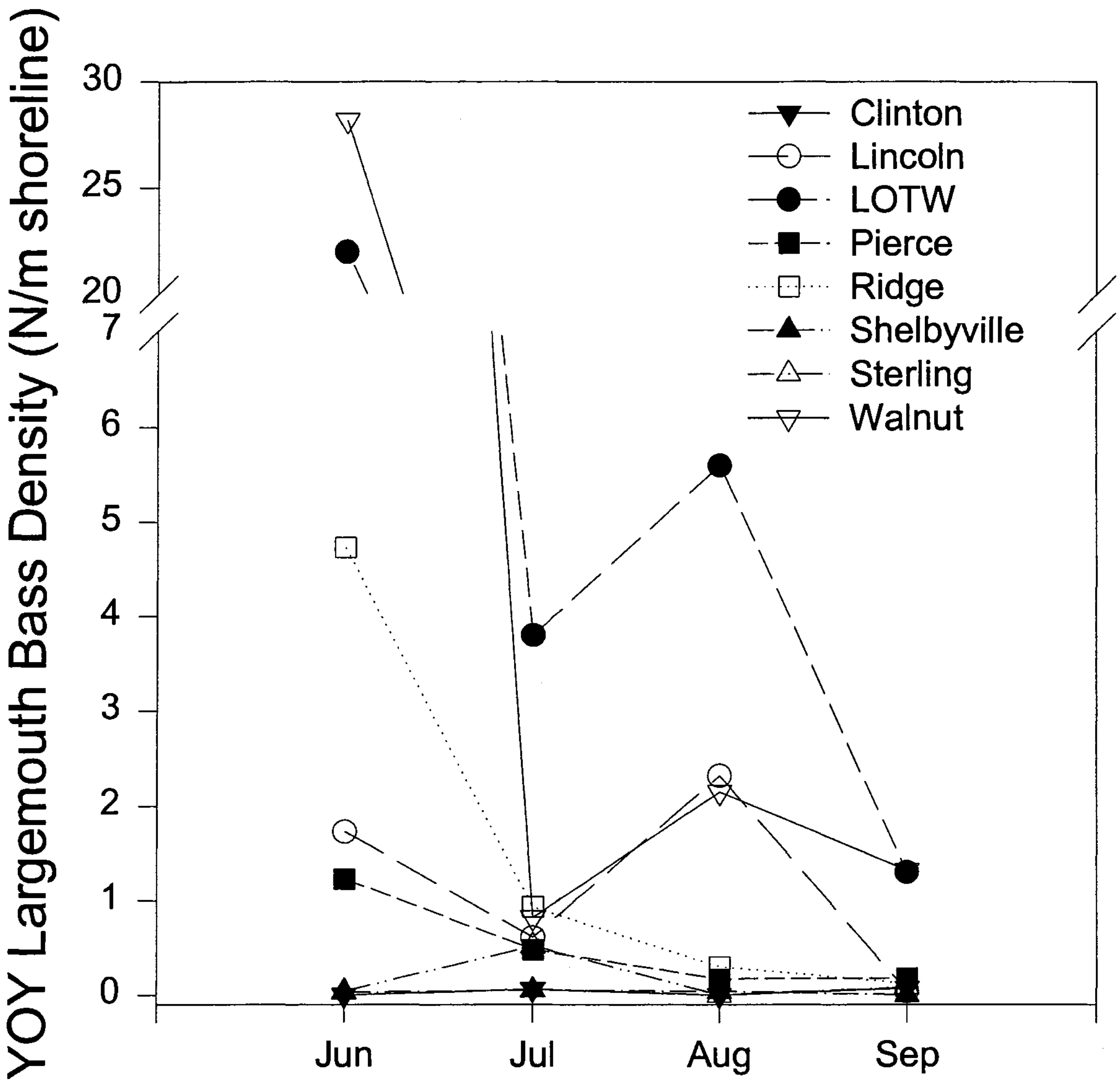

Figure 8. Average monthly young of the year (YOY) largemouth bass densities (N/m shoreline) for 10 study lakes. Largemouth bass were collected from 4 sites in each lake with a 6.7-m bag seine. Closed symbols represent lakes with shad, whereas, open symbols represent lakes without shad.

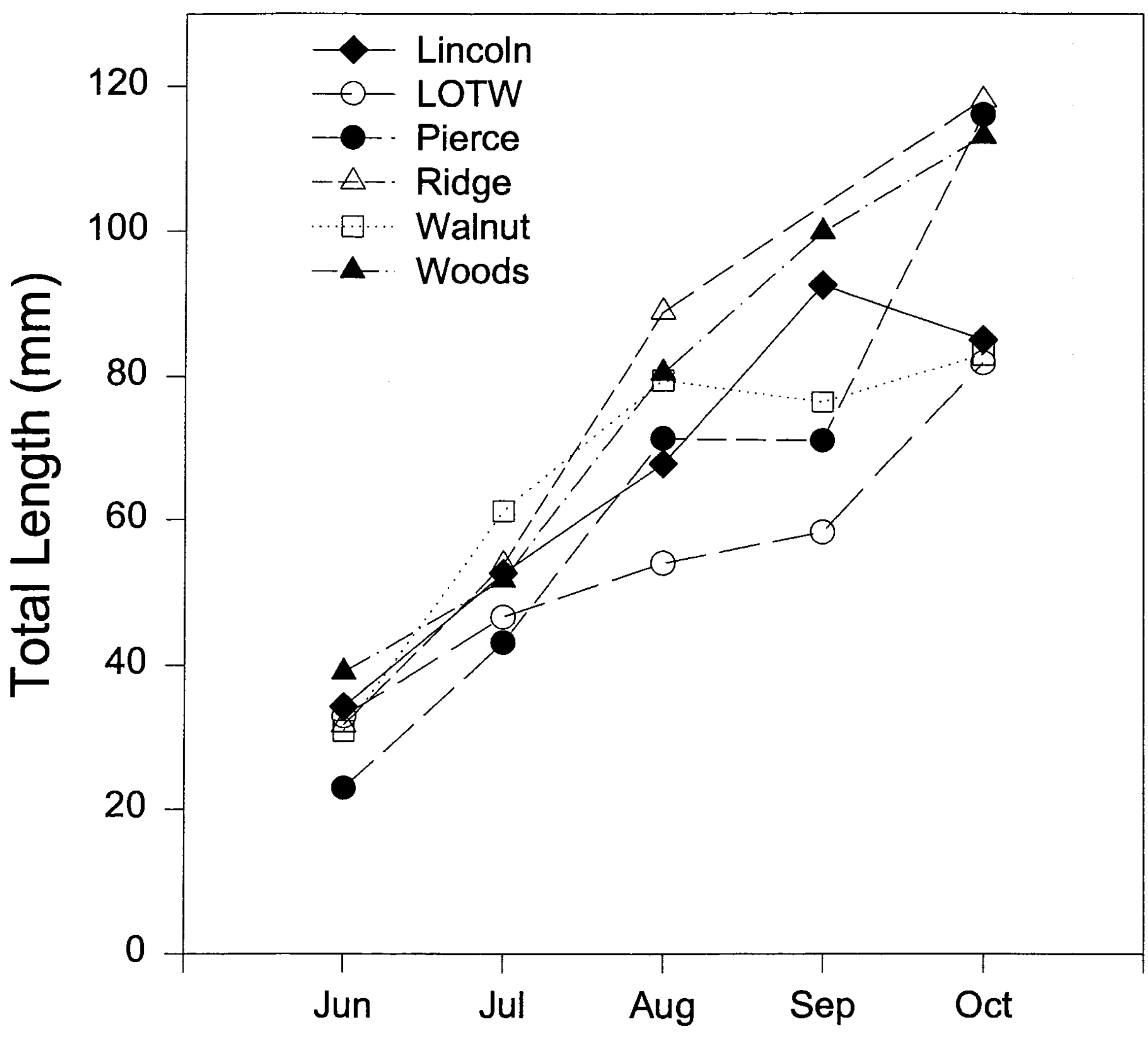

Figure 9. Average total length of young of the year largemouth bass collected from 8 study lakes. Closed symbols represent lakes with shad, whereas open symbols represent lakes without shad.

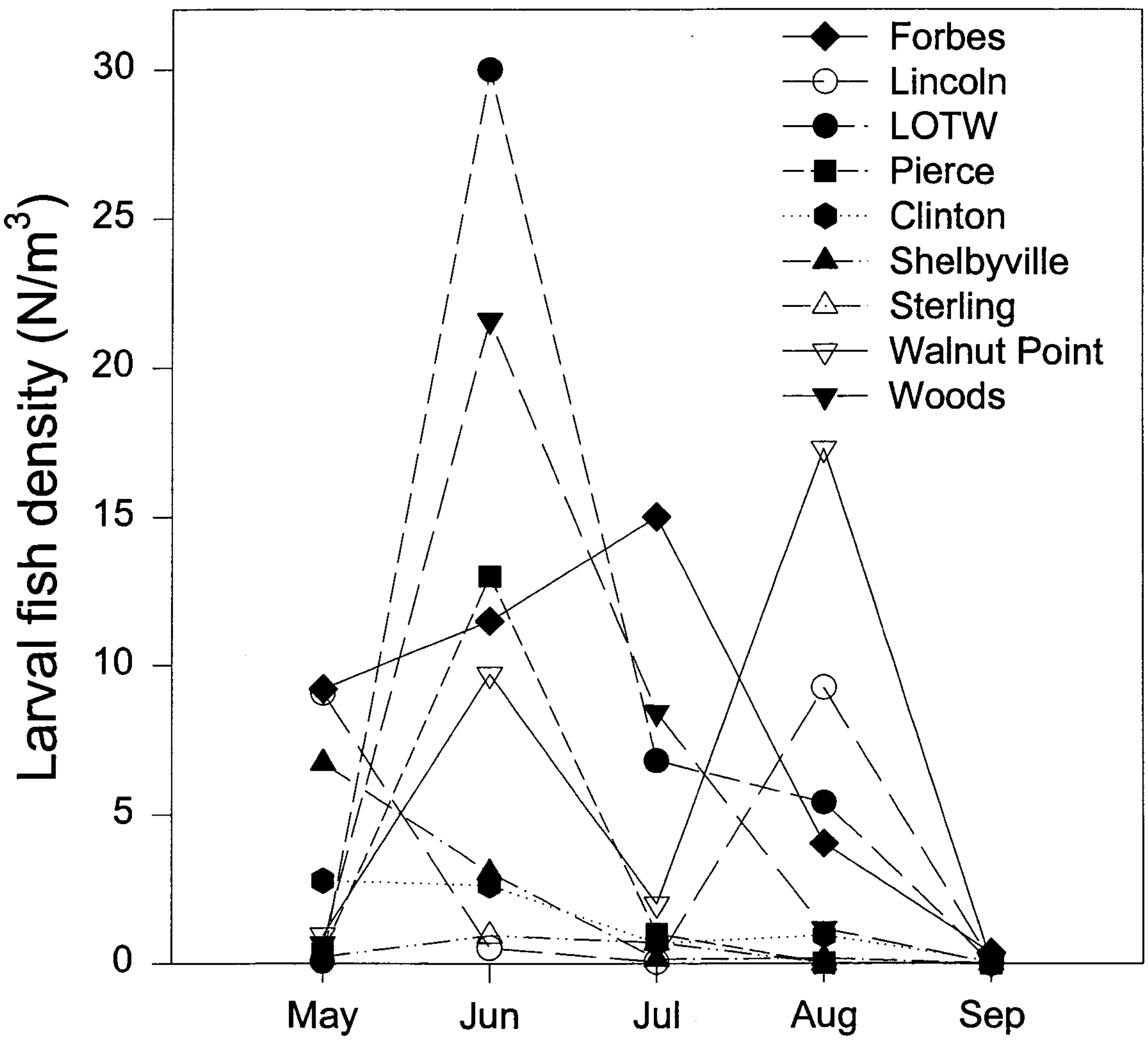

Figure 10. Larval fish densities (N/m^3) from 9 study lakes. Larval fish were collected using 0.5-m diameter push net with 500-μm mesh at 6 sites within each lake. Closed symbols represent lakes with shad, whereas open symbols represent lakes without shad.

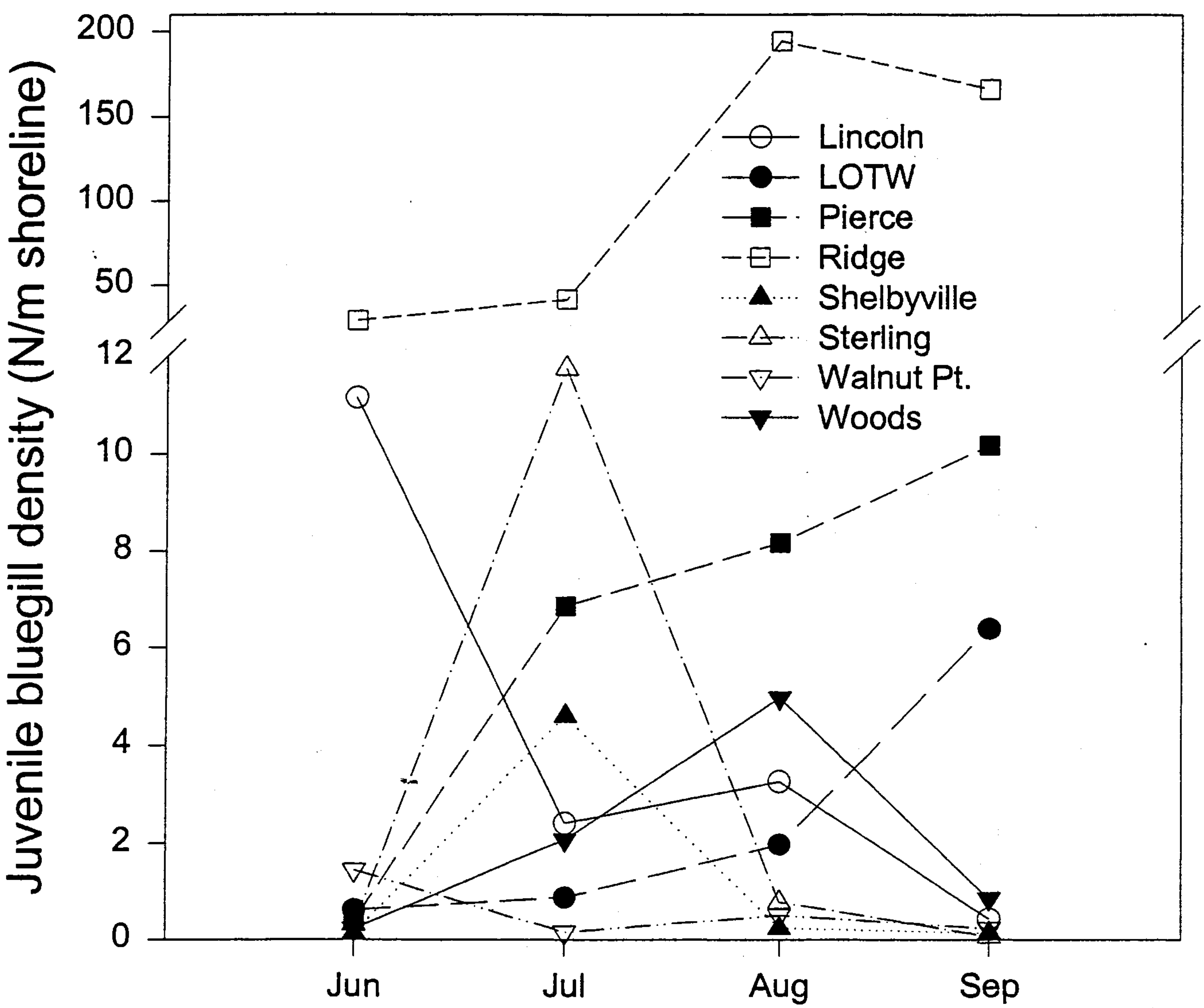

Figure 11. Mean juvenile bluegill density (N/m shoreline) as measured by shoreline seining for 8 study lakes. Juvenile bluegill ranged from 15 to 60 mm total length. Closed symbols represent lakes with shad, whereas open symbols represent lakes without shad.

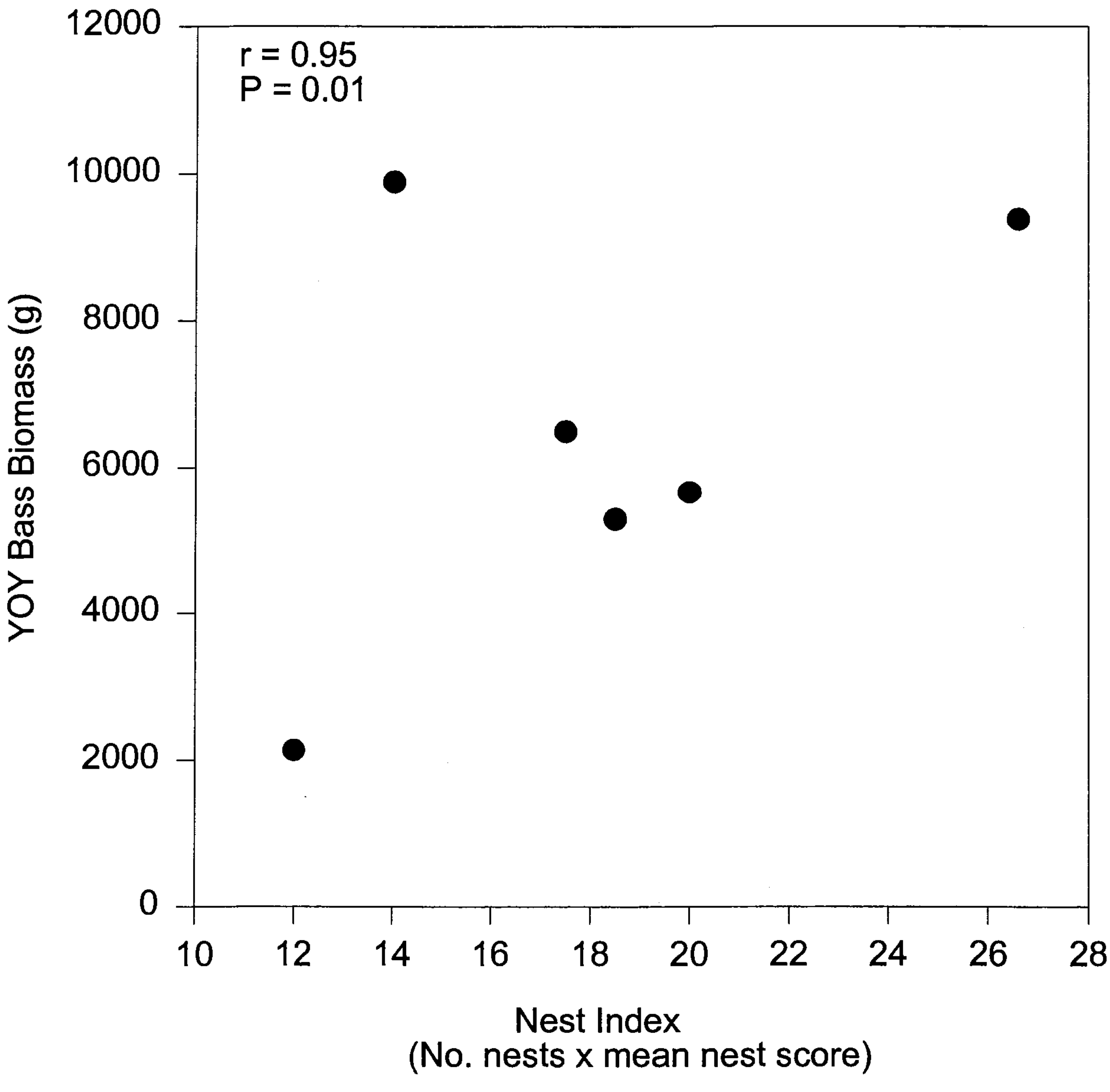

Figure 12. Relationship in ponds between fall biomass of young-of-the-year (YOY) largemouth bass and nest index score.

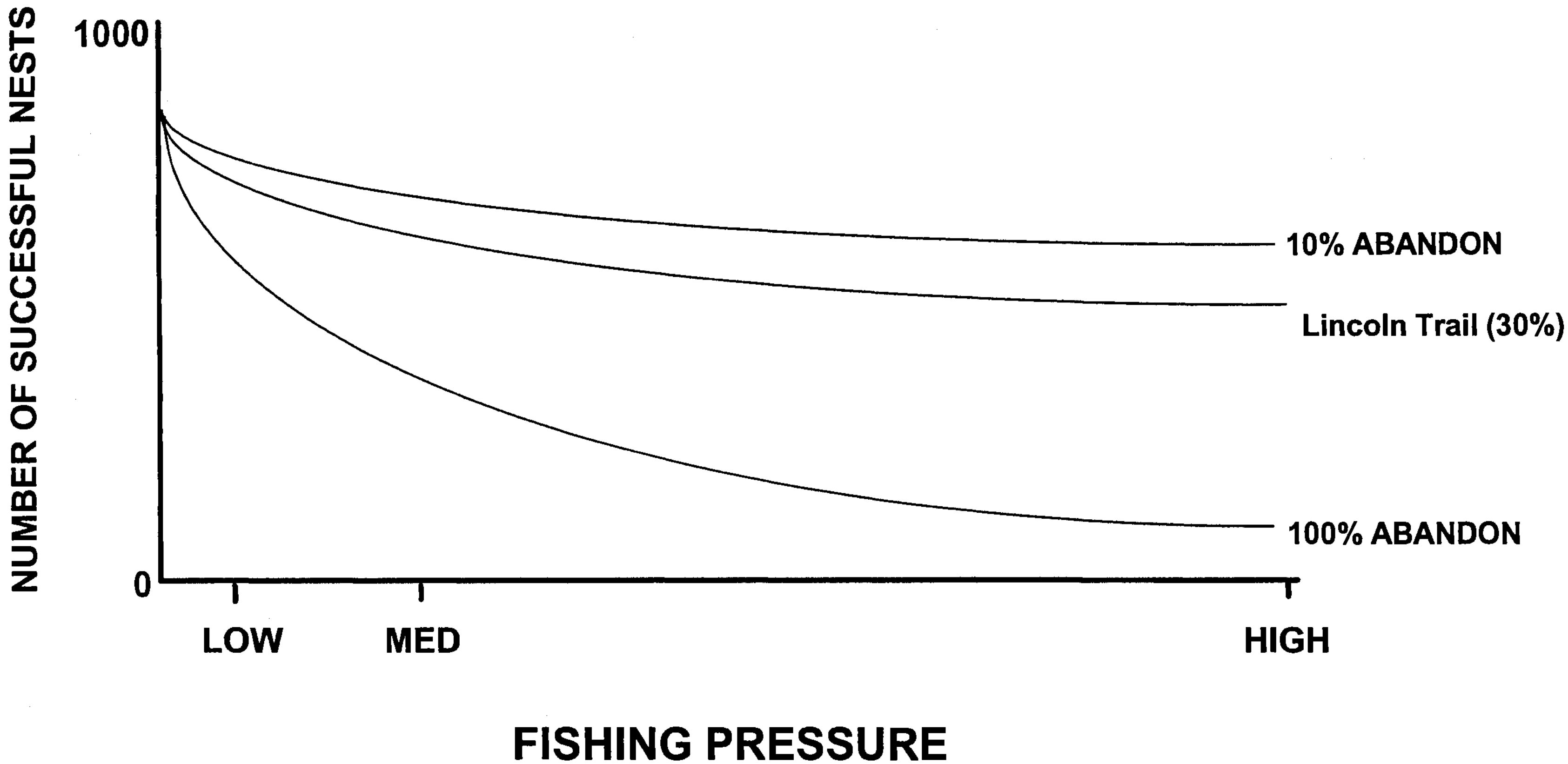

Figure 13. Effect of fishing pressure on the number of sucessful largemouth bass nests in Lincoln Trail with comparisons of 10 and 100 percent abandonment rates predicted from the model.