ILLINOIS NATURAL HISTORY SURVEY

DIVISION OF ECOLOGY AND CONSERVATION SCIENCES

ANNUAL PROGRESS REPORT

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

Matt J. Diana, Joseph J. Parkos III,
Michael Nannini, David P. Philipp, and David H. Wahl

Submitted to
Division of Fisheries
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Disclaimer:
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EXECUTIVE SUMMARY:

During the past segment, all activities outlined in the annual work plan were accomplished and within the specified budget. The goal of this study is to develop management strategies that maximize growth, recruitment, and harvest of largemouth bass *Micropterus salmoides* in Illinois impoundments. 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 and we are addressing these questions. 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.

There was no new activity in Job 101.1 as final recommendations were presented in previous reports. In Job 101.2 we are assessing stocking strategies for largemouth bass. Supplemental stocking is a widely used management tool for increasing the standing stock of an existing population. We evaluated four sizes of stocked fish (50, 100, 150, and 200 mm) that were stocked in four lakes in previous segments. Survival of stocked largemouth bass fingerlings to adult size was relatively low and ranged from 0 to 2.7 stocked fish per hour of electrofishing during the spring and fall of 2006. Scales were collected from each adult stocked fish and will be aged in order to determine which year each fish was stocked and what size it was at stocking. We did not observe any stocked largemouth bass in Lake Mingo and Woods Lake in the fall of 2006, however there were stocked fish collected in Lake Charleston and Homer Lake. We continue to find large (300 to 550 mm) stocked bass in the adult population and will continue to monitor these fish for growth and survival differences.

Initial stocking mortality was low among different sizes of stocked bass. Stocking mortality was related to temperature at the time of stocking suggesting stocking during cooler times of year to reduce mortality. Predation rates varied on stocked fish and were high among all sizes of stocked fish. Fifty mm fish experienced the highest level of predation and may be more susceptible to bass predation than other sizes of stocked largemouth bass. Despite initial differences in size and catch per unit effort (CPUE), all stocked bass were found in similar relative abundances and at similar mean size from the first summer after stocking throughout the following seasons. Cost analysis showed that growing bass to 150 or 200 mm increased the overall cost of producing and stocking largemouth bass. Our recommendation is to stock four inch bass because small fingerlings do not survive well and we find no differences in long-term survival between medium, large, and advanced fingerlings.

The relative survival of intensively and extensively reared largemouth bass varied between lakes. All stockings were completed in previous segments and in this segment we continued to evaluate long-term survival and growth. Thus far, no differences in survival have been observed between intensively and extensively reared fish in any of the three study reservoirs. We are continuing to collect stocked fish in all three lakes stocked with intensive and extensively reared fish. All stocked fish were adults and it was difficult to assign a stocking year based on length alone. Scales were collected from these fish and will be aged in the next segment in order to evaluate the long-term survival differences of the fish reared from these different techniques. Based on our results thus far, the usefulness of supplemental stocking as a management strategy will vary by individual lakes. We will initiate an additional stocking experiment in the next segment to examine the advantages and disadvantages of point and dispersed stocking. We will stock four lakes using both stocking at the boat ramp and stocking into habitat at locations around the lake. We will evaluate differences in growth and survival through time in order to make management recommendations regarding these techniques. Additional research regarding the importance of predator and prey populations, habitat, and abiotic factors are needed to determine lake characteristics most favorable for stocking largemouth bass.

In this segment, we also evaluated the long-term contribution of four-inch stocked largemouth bass *Micropterus salmoides* from three annual stockings in 15 reservoirs. Stocked largemouth bass were marked with fin clips and sampled for five years. Contribution of stocked fish to the population was highest for young of year (21%) and juvenile bass (17%), but decreased dramatically in adult fish (5%). Catch per unit effort (CPUE) from electrofishing samples was also low for stocked largemouth bass as adults resulting in small contributions to the population. Young of year abundance of natural largemouth bass was positively correlated with young of year abundance of stocked bass, but only through the first fall suggesting similar factors may influence initial survival. Macroinvertebrates, zooplankton and bluegill prey were not correlated with growth or abundance and do not appear to be important factors influencing stocking success. Adult stocked largemouth bass CPUE was not correlated to young of year stocked bass CPUE, but was positively correlated with CPUE of juveniles indicating recruitment is not determined until one year after stocking. Adult and juvenile stocked largemouth bass CPUE was positively correlated with the mean size of stocked bass in the first fall after stocking and the following spring, providing evidence that lakes with higher growth rates have increased contribution of stocked largemouth bass to the population. Our results suggest limited contribution of stocked fish to adult largemouth bass populations and the need for additional assessment of mechanisms influencing survival.

The objective of Job 101.3 is to evaluate the survival and reproductive success of stocked largemouth bass to the resident population. To determine the contribution of stocked fish to a population, fingerlings were produced at the Little Grassy Fish Hatchery with the MDH B2B2 allele as a genetic tag. These genetically tagged fingerling were then stocked into six study lakes. Once these fish reach sexual maturity, it is possible to assess their reproductive success and recruitment to the population by comparing the pre-stocking MDH B2 allele frequencies with the post-stocking MDH B2 allele frequencies. Young-of-the-year produced in 2006 were collected from each of the six study lakes and their allele frequencies for the MDH B2 allele will be determined. Although 2006 sample have yet to be worked up, 2005 samples showed that five of the six lakes showed an increase in the MDH B2 allele. Further yearly sampling is needed to fully evaluate the long-term impacts of stocked fingerlings in these populations and to fully assess the costs and benefits of largemouth bass stocking programs.

In Job 101.4, we assessed the importance of a variety of abiotic and biotic factors on largemouth bass recruitment. This segment covers recruitment of the 2006 year class and associated environmental conditions in 11 study lakes. Variation among lakes in recruitment to age-1 was related to survival of YOY bass to fall, but not to any differences in measured abiotic and biotic factors. YOY bass growth was strongly density dependent and variation in year class strength at the end of the growing season was related to among lake differences in reproductive output, water quality, and spring plankton prey. Differences among lakes in peak density of YOY largemouth bass were also evident as differences in production of larval Lepomis. As gizzard shad increased in abundance, the density of juvenile bluegill, an important fish prey for YOY bass, decreased. We are currently collecting our final year of multiple-lake data on largemouth bass recruitment. This data will be added to our previous years of data in order to construct our final models of the mechanisms behind variation among lakes and years in largemouth bass recruitment.

We also began to evaluate the influence of vegetation and woody habitat on young-of-year largemouth bass and other fish. We sampled 6 enclosures on Lincoln Trail, 3 with vegetation, 3 without. We observed greater average densities of largemouth bass, bluegill, and all other fish in the vegetated enclosures. These differences however were small and we plan to continue this work in Lincoln Trail and expand to additional lakes. In the future, we will initiate an experiment to examine the effects of manipulating vegetation. We have identified two low vegetation lakes where we will increase aquatic vegetation. We have also identified three high vegetation lakes where we will decrease vegetation levels. We will monitor these lakes before and after the vegetation treatments to evaluate the effects on largemouth bass recruitment and the fish community. We will also develop pond experiments that vary the amount and complexity of woody habitat to examine changes in largemouth bass recruitment. We will also examine woody habitat in the existing study lakes and relate them to largemouth bass recruitment. These studies will allow us to make recommendations on vegetation and woody habitat management in order to increase largemouth bass recruitment in Illinois reservoirs.

In Job 101.5, we snorkeled bass nests in order to assess survival of various cohorts, as well as map nesting habitat and behavior. Bass spawning in Lincoln Trail Lake was observed between 4/16/2007 and 5/30/2007. Largemouth bass were found spawning over a variety of substrates and showed preference for less vegetation and increased proportion of gravel. Bass exhibited varying levels of aggressiveness, but we did not observe high levels of nest predation by crayfish, bluegill and other sunfish. We will continue to monitor nests for substrate preferences and factors influencing nest predation and aggressiveness of guarding male bass. We also evaluated the contribution of each nesting week to the fall year class of largemouth bass. Young-of-year largemouth bass were collected in Lincoln Trail in August and otoliths were removed and daily rings were counted to determine the spawn date for each fish. The number of new nests on a date was related to the number of fish surviving to the fall. Results for two years suggest there is no differential survival depending on when the fish were spawned. Additional years of data will be included in this analysis in future segments to evaluate if these relationships occur in other years with different patterns of spawning activity.

There is potential for angling to have a large influence on largemouth bass populations. In particular, competitive tournament fishing for black bass has grown rapidly in the United States over the past several years. Previous work has shown high levels of mortality associated with these tournaments in other parts of the United States. We continued to monitor bass tournaments in order to assess if reproductively active males are being preferentially caught. Data from three of the four lakes examined suggests that this may be the case during both spring tournaments and the post-spawning period. Preliminary information provided by tournament angler surveys suggests that the culling and release of smaller males for larger females is minimal and not skewing sex ratio estimates. Additional research to determine the implications of angling bass from the nest on the overall bass population and year class strength are needed. We have begun an experiment at Ridge Lake examining the population effects of angling largemouth bass from the nest. Largemouth bass tournaments were held during the spawning period at Ridge Lake that has historically been closed to fishing during this time. We will evaluate changes in largemouth bass recruitment and populations associated with the initiation of tournaments. We will also continue to determine sex and ages of largemouth bass in lakes with varying fishing exploitation. We will examine how angling activities influence sex specific characteristics such as growth, longevity, and age of maturity. Using this data, we will be able to make predictions about how angling will affect recruitment of largemouth bass.

In Job 101.6 a portion of Clinton Lake that was closed to fishing was sampled to determine the effects of the refuge on largemouth bass populations. Electrofishing samples yielded a higher abundance of adult largemouth bass in the refuge than in the main lake. Some increase in the number of largemouth bass has also been observed throughout the lake. Seine samples however showed higher abundance of young-of-year largemouth bass and other species of fish in the main lake in the fall of 2006 and spring of 2007. Sampling will continue at Clinton Lake to monitor largemouth bass populations for changes resulting from the refuge. We also have identified Otter Lake as an additional location to evaluate refuges. We will begin sampling in the future and plan to implement the refuge after several years of monitoring pre refuge conditions in the lake.

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.

RECOMMENDATIONS: No activity in this segment. Final recommendations were presented in previous reports.

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: Supplemental stocking of largemouth bass Micropterus salmoides is a commonly used management tool to enhance largemouth bass populations. Supplemental stocking efforts are directed at either increasing harvest rates and reproductive potential, or restoring a fish community's predator/prey balance. However, for these positive benefits to occur, stocked fish must contribute to the natural population. Numerous studies have examined either the introductions of different genetic stocks of largemouth bass (Rieger and Summerfelt 1978; Maceina et al. 1988; Mitchell et al. 1991; Gilliland 1992; Terre et al. 1993) or the introductions of largemouth bass into ponds (Dillard and Novinger 1975; Modde 1980; Stone and Modde 1982). Surprisingly, few studies have examined the factors thought to influence supplemental stocking of largemouth bass. The few studies that have examined the contribution of stocked largemouth bass to a natural population, examined only one (Lawson and Davies 1979; Buynak and Mitchell 1999) or two lakes (Boxrucker 1986; Ryan et al. 1996). Given that lakes are highly variable, examining stocking evaluations in only one or two lakes limits our ability to make generalizations.

Factors influencing stocking success may include predation, prey availability, and abiotic variables (Wahl et al. 1995). Predation from older age classes of largemouth bass may be especially important given that they have been shown to prey heavily on other species of stocked fish (Wahl and Stein 1989; Santucci and Wahl 1993) and are highly cannibalistic (Post et al. 1998). The availability of appropriate sized prey has also been shown to be important to survival of stocked fish for other species (Fielder 1992; Stahl and Stein 1993). Finally, abiotic factors such as water temperature at time of stocking may contribute to stocking success. High water temperatures at time of stocking may increase stocking stress and subsequent mortality (Clapp et al. 1997). Determining which of these factors is most important to stocking success has important implications for deciding the appropriate locations and times to stock.

Previous stocking evaluations conducted in the Midwest have often examined species that do not naturally reproduce in the recipient water body (e.g. muskellunge Esox masquinongy, Szendrey and Wahl 1996; walleye Stizostedion vitreum, Santucci and Wahl 1993). Largemouth bass, however, reproduce naturally in most Midwestern impoundments, and therefore supplemental stocking programs are directed at enhancing existing populations. The number of natural fish produced during the year of stocking may influence stocking success through competitive interactions for food and habitat. Because native largemouth bass may out compete stocked largemouth bass, a large natural year class may decrease stocking success in an individual lake. Conversely, stocked largemouth bass may do well in years where the population exhibits high natural recruitment because they are potentially influenced by the same variables.

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 the ability to stock the 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.

Differences in rearing method (e.g., intensive raceway versus extensive ponds) of the largemouth bass fingerlings may also 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 have not yet been assessed.

PROCEDURES:

Size Specific Stocking:

We stocked four size groups of largemouth bass in four lakes (Charleston, Homer, Mingo, and Woods) from 1998 through 2004 (Figure 2-1) and are evaluating their long-term success. Largemouth bass were stocked as small fingerlings (50 mm) in July, medium fingerlings (100 mm) in August, large fingerlings (150 mm) in September and advanced fingerlings (200 mm) in October for 3 years in Mingo and Woods and 4 years in Charleston and Homer. 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 pelvic 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. We estimated initial stocking mortality by placing 30 fish into each of three floating mesh cages. Largemouth bass were taken directly from the hatchery truck and placed immediately into the cages. Cages were 3 m deep and 1 m in diameter and were placed in at least 3 m of water. The cages were checked after 24 hours and removed after 48 hours and the number of live and dead fish was counted. Predation on stocked bass was estimated by sampling predator diets. Potential predators were collected by electrofishing and diets were collected using a tubing method (Van Den Avyle 1979) and the number of stocked bass as well as size and type of prey were recorded. Predator diets were examined daily the first week and weekly thereafter until they were found to contain no stocked bass on two consecutive sample dates.

Diets were also collected on large and advanced fingerlings, as well as natural fish after stocking to evaluate differences in feeding following stocking. Stocked and natural largemouth bass were collected by AC electrofishing 3 shoreline transects (½ hour each) at set intervals following stocking (two weeks, one month, and two months). Both stocked and natural largemouth bass diets were examined by tubing unless the fish was too small, in which case it was collected and dissected in the laboratory.

In this segment, we continued to sample adult largemouth bass and examine them for clips to determine the long term survival of the stocked largemouth bass and if there were any differences associated with their stocking size. Sampling efforts were made to collect age 2+ fish from previous stockings in the four study lakes. Each lake was sampled twice in the spring of 2006, and twice in the fall of 2006. Three transects were AC electrofished for 30 minutes each on all study lakes each sampling date. All largemouth bass were collected, measured for total length, and examined for clips. Scales were removed from all clipped fish and were read for age by two independent readers. The year a fish was stocked and stocking size was determined using the scale age and the observed clip. Catch per unit effort was calculated for each size of stocked bass and natural bass and used to compare survival of the different stocks. Mean total length was calculated for each stock and used to compare growth differences. The growth and survival data from 2006 was combined with data from previous segments to evaluate overall differences in growth and survival. Differences in survival and growth among the various sizes of stocked fish were examined using repeated measures ANOVA to test for differences in CPUE and mean total length through time.

Rearing Technique:

The effects of rearing techniques on growth and survival of stocked largemouth bass were evaluated in lakes Shelbyville, Jacksonville and Walton Park in 2006. Extensively reared bass were produced at the Little Grassy Fish Hatchery where they were held in ponds and fed on minnows until stocking. Intensively reared bass were produced at the Jake Wolf Fish Hatchery where they were held in 265 L concrete tanks and fed commercially produced pellets until stocking. Each fish was given a distinct pelvic fin clip for future identification of rearing technique. Fish were transported from the hatchery in oxygenated hauling tanks to the recipient lakes. Hauling time ranged between 0.5 to 3 hours. Fifty largemouth bass were measured (nearest mm) and weighed (nearest g) before stocking on each date. Fish were released near shore at a single location at each lake. Attempts were made to stock largemouth bass at a rate of 60 fish per hectare, however rates varied by individual lake due to varying success of rearing ponds and hatchery production.

In this segment, we examined growth and survival of age 2+ fish stocked in previous segments. Growth and survival of stocked largemouth bass was determined in the fall and spring by sampling during the day with a 3-phase AC electrofishing boat. Three shoreline transects on each lake were electrofished for 0.5 h each on a sampling date and all largemouth bass were collected, measured, weighed, and examined for clips. Scales were removed from all clipped fish and were read for age by two independent readers. The year a fish was stocked and stocking size was determined using the scale age and the observed clip. Catch per unit of effort (CPUE) was calculated as the number of stocked fish collected per hour and was used as a relative measure of survival across lakes. Growth was estimated using the mean size of bass at the time of sampling.

Mechanisms Influencing Stocking Success:

Largemouth bass were stocked in 15 reservoirs in Illinois (Figure 2-2) during three years (1999 – 2001) and we analyzed long-term growth and survival to assess mechanisms influencing success. Largemouth bass were the main predator in all of the reservoirs and the primary forage fish were bluegill *Lepomis macrochirus* and gizzard shad *Dorosoma cepedianum*. Stockings occurred in late mid July to mid August and the target stocking size was 100 mm with a density of 60 fish per hectare (Table 2-2). Each fish was marked with a pelvic fin clip in order to identify stocked fish in future samples. Clips had high retention rates for the duration of the study (see Job 1, previous reports). Pelvic fin clips were left or right in alternating years in order to aid in determining which year each fish was stocked when it was recaptured.

Relative abundance of stocked and natural largemouth bass were determined through 3 phase AC electrofishing performed in each lake following stocking for a minimum of 5 years and continued until no clipped fish were observed in electrofishing samples. Each lake was electrofished a minimum of two dates in both the spring and fall. Three transects on each lake were electrofished for 0.5 h each on a sampling date. All largemouth bass collected were measured for total length and examined for clips and assigned a year class based on clip, length frequency, and aging from scales. Catch per unit effort (CPUE) of stocked and natural largemouth bass was calculated for young-of year (age-0) in the fall, young-of-year the following spring, juvenile (age-1) in the fall, and adult fish in subsequent falls. CPUE of adult largemouth bass was calculated for each stocking at three, four, and five years of age. CPUE was averaged across years within each lake and examined for relationships with lake characteristics using correlation analysis.

Abundance and size of prey fish in each lake were assessed by electrofishing and seining. Bluegill and gizzard shad were collected by electrofishing and measured in total length (mm). Inshore bluegill density (primarily young-of-year) was also assessed by fall shoreline seining (9.2 x 1.2 m bag seine, 3.2 mm mesh) at four fixed sites within each lake on the same sampling dates as the electrofishing samples. Effort was calculated as the area of the haul (length x width of seine to the nearest meter). All fish were counted and a minimum of 50 individuals of each species collected were measured (total length in mm). Density (number per square meter) was calculated for bluegill throughout the fall. Density of prey-sized bluegill was calculated for both seine and electrofishing samples as the proportion of the catch that were vulnerable to bass predation (33% body length). Bluegill with total length less than 35 mm were used to calculate bluegill prey abundance for young-of-year bass in the fall and bluegill with total length less than 82 mm was used for juvenile bass.

Invertebrate prey resources were also assessed in each lake. Macroinvertebrates were collected on nine of the fifteen lakes during the month of August. Inshore macroinvertebrates were collected using a stovepipe sampler (20 cm diameter; McPeek 1990; Turner and Trexler 1997) at 6 sites (one sample per site) within each lake. Stovepipe samples collected benthic invertebrates as well as those on vegetation and in the water column. Samples were cleaned in a 250 µm mesh bottomed bucket and preserved in an ethanol/rose bengal solution (70%) for processing. Individual organisms were separated into major taxonomic groups (Chaoborus, Nematoda, Annelidia, Hirundinea, Isopoda, Amphipoda, Hydracarina, Ephemeroptera, Anisoptera, Zygoptera, Hemiptera, Trichoptera, Coleoptera, Chironomidae, Ceratopogonidae, Tabanidae, Gastropoda, Pelycopoda, and Megaloptera), counted and measured. Densities were calculated as the total number of organisms per meter squared for each stovepipe sample. To quantify zooplankton abundance, collections were taken using vertical tows with a 0.5

m diameter, 64 μm mesh zooplankton net at four inshore and four offshore sites (one tow per site). Zooplankton tows were performed every two weeks or monthly during May – October on nine of the fifteen lakes. Zooplankton were preserved in a Lugols solution (4%) for later processing. Individual organisms were separated into major taxonomic groups (Daphnia, Cyclopoid copepod, Calanoid copepod, nauplii copepod, rotifer, *Daphnia lumholtzi*, Bosminidae, Sididae, Ostracoda, Leptodora, Chydoridae, Ceriodaphnia, Simocephalus, and Scaphloberis), counted and measured. Densities were calculated as the number of individuals per liter of water averaged across all sampling dates. Abundance of prey resources were examined for relationships with stocked and natural largemouth bass abundance using correlation analysis.

FINDINGS:

<u>Size Specific Stockings:</u>

In this segment, we continued to examined growth, survival and mortality of adults of different sizes of largemouth bass stocked in previous segments. Unmarked largemouth bass were collected to examine for OTC marks for evidence of small fingerlings surviving to adulthood. However, no OTC marks were observed in any study reservoir in adult bass otoliths. The lack of OTC marks in adult bass supports the estimates of low survival in the first year after stocking and the conclusion that small fingerlings are not surviving past the first year following stocking.

In this segment, we examined survival of the different sizes of stocked fingerlings that were stocked in previous segments and are now adults. The contribution of stocked fish to the adult bass population varied among lakes, but in general was a relatively low proportion of the total bass population (Table 2-2). Charleston had the lowest catch per unit effort of natural largemouth bass and also appeared to have the highest survival of stocked bass. We also found evidence of stocked bass surviving in Homer Lake in spring 2006. Woods and Mingo lakes did not have any stocked bass sampled in spring 2006. These lakes were last stocked in 2003 and appear not have any stocked bass surviving to age 3. In contrast, some of the fish stocked in Homer and Charleston in 2004 have survived to age 2.

There is a good deal of year-to-year variation in survival and growth of stocked largemouth bass. This variation makes it important to examine patterns that occurred across all stockings and lakes that were stocked with different sizes of bass. Data from 2006 were combined with data from previous segments to examine differences throughout the experiment. Large fingerlings were significantly larger in size than the small and medium fingerlings as well as natural bass in the lakes at the time of their stocking and remained larger until the onset of winter (Figure 2-3). This suggests there is a potential for size specific mortality over winter. The following spring however, there was very little difference in size between all of the size groups of stocked and natural bass. Similarly, advanced fingerlings stocked in the spring (May) were significantly larger than their cohorts but by the summer all were similar in size. All sizes of stocked bass as well as the natural bass were of similar length going into the second winter and no long-term growth differences were evident. Although there are initial size differences at stocking for large and advanced fingerlings, lags in growth occur shortly after, perhaps as a result of the transition from foraging in hatchery conditions to the wild.

Survival also differed among the size groups of stocked fish. CPUE of large fingerlings was significantly greater than the small and medium stocked fingerlings in the first fall after stocking (Figure 2-4), probably because little time had passed since they were stocked. As a result, large fingerling abundance was higher going into the first winter than small and medium size groups, whereas, over winter survival was extremely low for large fingerlings. Advanced fingerlings were stocked in the spring and as a result spring electrofishing samples yielded higher numbers than other sizes of stocked fish. However, a short time after stocking, CPUE during the summer months for advanced fingerlings had declined to similar levels as medium and large fingerlings. Overall survival was low for all stocking sizes as the majority of fish in electrofishing samples of older age groups were naturally produced fish. This pattern is consistent over the following 2-3 years and mean CPUE of lakes over time for the medium, large and advanced fingerlings remained low at around 2 to 3 bass per hour of electrofishing compared to the wild fish CPUE of 28 fish per hour. In future analysis, population estimates will be calculated to determine the total number of stocked bass of each size that we observe in the adult population.

Cost of producing fish increased with the size of the fish being produced. Small fingerlings were the cheapest to produce, even though they were stocked in the largest quantity. Advanced fingerlings were the most expensive to produce due to overwintering them in the hatchery ponds. Medium fingerlings were the most cost effective size to stock based on (1) better survival when compared to small fingerlings and (2) similar survival and low cost when compared to large and advanced fingerlings (see previous reports).

Rearing techniques:

In this segment, fish stocked in previous stockings were sampled to compare long-term differences in growth and survival. All three lakes had stocked fish observed in electrofishing samples in both spring and fall 2006 (Table 2-3). Because these fish were stocked over three years ago, scales were collected from all clipped largemouth bass and are in the process of being read by two readers. Once the age is determined for each fish, the appropriate rearing strategy can be determined and a comparison of long-term differences in survival and growth can be made. In previous segments, we observed a high level of variability in survival of intensively and extensively reared bass. No consistent pattern in survival was observed and which rearing technique yielded the highest survival varied by year and lake. Due to the variability between lakes and years, and the low level of survival for both intensively and extensively stocked bass, it is difficult at this point to determine which rearing strategy performs the best. Age determination and assigning a verified stocking strategy to each fish will aid in evaluating the stocking strategies and must be completed before any recommendations are made.

Mechanisms Influencing Stocking Success:

Contribution of stocked fish to the total largemouth bass population was variable among lakes. Mean contribution of stocked largemouth bass in the first fall following stocking ranged from 3 to 50 percent across lakes. Natural largemouth bass CPUE was high in the fall for young-of-year fish, declined for juveniles and then increased moderately for adult fish. Stocked largemouth bass CPUE was lower than natural fish for all age classes and declined through time (Figure 2-5A). The contribution of stocked largemouth bass to the population also decreased with fish age through time (Figure 2-5B). Percent contribution of adult bass was the lowest of all age classes ranging from 0 to 18 percent of the total largemouth bass collected in electrofishing samples. In contrast, mean total length of stocked largemouth bass continued to increase through time (Figure 2-6). There was little change in growth for each age class with mean total length from age 0 to 5 increasing consistently.

Similar factors appear to influence initial abundance of stocked and natural largemouth bass. Stocked largemouth bass CPUE in the first fall following stocking was significantly correlated with that of natural young of year largemouth bass CPUE ($r = 0.55$, $P = 0.03$). However, by the following spring, there was no longer any relationship between stocked and natural young-of-year largemouth bass abundance ($r = 0.46$, $P = 0.08$). Stocked fish abundance and mean length were similar in the first fall after stocking and the following spring. Both CPUE ($r = 0.80$, $P < 0.001$) and mean total length ($r = 0.62$, $P = 0.02$) from electrofishing samples were significantly correlated between the first fall following stocking and the following spring (Figure 2-7). CPUE in the first fall following stocking was not correlated with mean total length in the fall ($r = 0.22$, $P = 0.43$), however the following spring CPUE was related to the mean size of the stocked fish in the spring (Figure 2-8). Abundance of juvenile stocked bass was related to both the size and abundance of young-of-year bass in the spring following stocking (Figure 2-9).

Adult abundance of stocked largemouth bass was related to the abundance of juveniles but not abundance of younger fish. It appears that catch rates were more closely related when less time exists between them. However, some changes in CPUE are occurring through time and CPUE of younger fish was no longer related to adult CPUE. Adult stocked largemouth bass CPUE was correlated with CPUE of juvenile stocked largemouth bass ($r = 0.54$, $P = 0.04$), but was not correlated with CPUE of stocked largemouth bass in the first fall after stocking ($r = 0.17$, $P = 0.55$) or the first spring ($r = 0.26$, $P = 0.34$). The mean size of young-of-year stocked largemouth bass in the fall was related to abundance of older fish. Mean size of stocked largemouth bass in the first fall after stocking was positively correlated with CPUE of juvenile ($r = 0.74$, $P = 0.002$) and adult ($r = 0.68$, $P = 0.006$) stocked largemouth bass (Figure 2-10). Lakes with faster growth rates immediately after stocking have greater adult stocked bass abundances. Lakes with faster growth rates also had greater abundances of young-of-year stocked and natural fish in the fall again suggesting that similar factors are influencing both growth and survival.

The 15 lakes varied in abundance of prey organisms for largemouth bass. Macroinvertebrate density ranged from 426 to 18399 individuals per square meter but was not significantly correlated with young-of-year abundance of stocked ($r = -0.06$, $P = 0.89$) or natural ($r = 0.42$, $P = 0.64$) largemouth bass. Macroinvertebrate density was also not correlated with mean size of stocked largemouth bass for either young-of-year ($r = -0.49$, $P = 0.19$) or juvenile ($r = -0.20$, $P = 0.62$) size classes. For individual taxonomic groups of macroinvertebrates, no significant correlations existed for either stocked or natural CPUE or mean total length for any age. Zooplankton densities exhibited similar lack of correlation with growth and abundance of stocked largemouth bass. Zooplankton density also ranged widely from 36 to 629 individuals per liter, but was not significantly correlated with young-of-year CPUE (r = -0.08, P = 0.84) or mean total length (r = -0.25, P = 0.51) of stocked largemouth bass in the fall. Separating zooplankton into major taxonomic groups, there were still no significant correlations with stocked largemouth bass mean size and CPUE for any age class.

Prey fish abundance from electrofishing and seine hauls did not appear to influence abundance or size of stocked largemouth bass. CPUE of available bluegill prey from electrofishing was not correlated with CPUE of young-of-year (bluegill size <35 mm; r = 0.25, P = 0.38) or juvenile (bluegill size <82 mm; r = -0.2, P = 09.4) stocked largemouth bass. Abundance of available bluegill prey was also not correlated with mean size in the fall of young-of-year (r = 0.22, P = 0.43) or juvenile (r = -0.30, P = 0.30) stocked largemouth bass. In contrast, bluegill densities from fall seine samples were significantly correlated with mean total length of young-of-year (r = 0.74, P = 0.002) and CPUE of juvenile (r = 0.77, P = 0.001) stocked largemouth bass. These relationships were heavily influenced by one lake with high bluegill densities (Sam Parr; 12.9 bluegill per m^2) and when this lake was removed, the correlations were no longer significant. Gizzard shad abundances were also not related to stocking success, mean total length, or CPUE for any age class. Prey fish densities from seine and CPUE from electrofishing samples also exhibited no significant correlations with stocked largemouth bass at either the juvenile or adult age for abundance or size and does not appear to be a major factor influencing stocking success.

Abundance of predators was not related to stocked largemouth bass abundance. The CPUE of natural largemouth bass predators (> 250 mm) was not correlated with the CPUE of young-of-year stocked fish in the first fall following stocking (r = 0.13, P = 0.65) or the following spring (r = 0.10, P = 0.73). CPUE of natural adult bass was also not related to stocked adult bass numbers (r = -0.35, P = 0.20). There appears to be little influence of largemouth bass predator abundance on young-of-year stocked bass. In addition, abundances of natural and stocked fish were not related after the first fall following stocking.

RECOMMENDATIONS:

Survival of the different sizes of stocked fish varied initially, but was similar after the second spring following stocking. Similarly, there were some differences in sizes of bass through the first fall and winter, but after the first spring, no size differences were evident between the different sizes of stocked fish. In particular, a lag in growth occurred for the 6 and 8-inch fish after stocking and despite being larger initially, they were soon similar in size to the natural population. This may be due to an acclimation period where hatchery bass adjust to feeding on natural prey resources. The study lakes primarily have bluegill forage and it may take some time for minnow fed hatchery bass to become efficient at feeding on different prey fish. Laboratory feeding experiments will be continued in 2006 and will be presented in subsequent reports. We also need to continue analysis of diets from large and advanced fingerlings to better understand differences from natural fish. In future segments we will use bioenergetics models to estimate if the differences in diet can account for the growth lag observed in stocked fish. These analyses combined with the feeding experiments will help us understand how stocked bass feed and if these mechanisms account for the observed growth and survival differences from natural bass.

Stockings for this job were concluded in 2005 and future efforts will focus on assessing the survival and growth of the previously stocked bass through time. We have continued to observe adult stocked bass in the lake populations and plan to continue to monitor these fish. Stocked bass CPUE has continued to decrease as the fish become older. We will continue to monitor the lakes until we no longer observe stocked largemouth bass in electrofishing samples. In previous segments, we collected scales from all stocked fish and these scales will be aged and used to determine growth rates and long-term survival.

Results from comparisons between intensive and extensive stocked fish were not consistent across lakes, suggesting the need for further exploration of the effectiveness of the two techniques. In future segments, we will continue to follow the fish stocked in previous years to observe any differences in long-term survival and growth. Attempts will also be made to supplement electrofishing sampling efforts to increase sample size and recapture a larger numbers of stocked bass to better represent growth of fish from the two rearing techniques. Sampling will also be conducted in future segments to follow the long-term survival of the largemouth bass reared using different techniques. Because clips were alternated for each stocking technique between years, age must be determined to assign a stocking technique to each fish. Scales that were collected in previous segments must be aged in order to assign the appropriate rearing techniques to each fish to verify if one rearing technique is beneficial over the other.

Initial survival of stocked young-of year and natural abundance of largemouth bass followed similar patterns in our study lakes. Both CPUE and mean total length of young-of-year of stocked and natural largemouth bass were correlated the first fall after stocking and the following spring. Similar factors may influence first year survival and growth of stocked and natural largemouth bass. Also, factors that cause low recruitment of natural fish may also be limiting stocked largemouth bass survival. It appears stocked largemouth bass will perform better in those lakes that have favorable conditions for natural young-of year largemouth bass survival and growth. Unfortunately, lakes with good natural largemouth bass survival and growth are not the target of supplemental stocking efforts. We will continue to evaluate which conditions are favorable to increasing stocking success by correlating it to environmental conditions. This will allow us to make management recommendations on when and where to stock largemouth bass.

We attempted to identify when the recruitment of stocked largemouth bass to the adult population was determined. Abundance of young-of-year stocked largemouth bass in the first fall was related to abundance in the spring. Mean total length of young-of-year fish was also correlated in the fall and the following spring suggesting that overwinter mortality was not important and no size specific mortality occurred. We did not observe any relationship between abundance of young-of-year stocked fish (both fall and spring) and abundance of stocked fish as adults. Not until fish reached juvenile life stages was abundance correlated with the abundance of adults. There appears to be substantial continued mortality during the second year that affects recruitment to adulthood. Combined our results provide evidence that the abundance of adult stocked fish is not determined until the second fall following stocking. Abundance of both juvenile and adult stocked largemouth bass was also related to the mean size of the stocked fish during the first fall following stocking. Although there was no evidence for size specific survival over the first winter, there does appear to be some long term differences in survival that are related to size of the fish in the first fall. There may be either size selective survival of larger fish during later life stages or lakes with higher growth rates may also yield higher abundance and contribution of stocked largemouth bass. Growth of stocked fish immediately following stocking may influence the long-term survival of stocked largemouth bass. We believe it is important to evaluate stocked fish past the first year in order to fully determine stocking success.

We evaluated if lake conditions and available prey could predict potential survival of stocked largemouth bass to adult ages. However, we did not find any significant relationships between a number of prey resources and mean size or abundance of stocked largemouth bass through age 5. Predator abundance also did not influence the survival of stocked largemouth bass through age-5. Predator abundance was not related to abundance of either young-of-year or juvenile fish in the current study. We found that abundance of predators (largemouth bass and other predators) does not have a strong influence on survival of stocked largemouth bass. Thus far we have focused on the role of prey and predator populations in determining stocking success. Other factors such as available habitat, thermal regimes, and fishing pressure may also be important. Future analysis will examine variation among lakes in order to further explore what factors may play a role in determining growth and survival of stocked fish.

Finally, we will initiate studies to evaluate stocking strategies in order to increase initial survival of stocked largemouth bass. We will compare survival of point stocking versus dispersed stocking at multiple locations of optimal habitat throughout the lake. In the next segment we will stock Otter Lake, Lake Mingo, and Homer Lake using these two strategies (Lake Charleston will be stocked in the following segment). We will evaluate growth and survival by conducting spring and fall electrofishing. Ultimately we hope to increase survival of stocked largemouth bass through these techniques and provide management recommendations on stocking strategies.

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 reproducing and harvestable 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, 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 (Philipp, 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 stocked directly into a target lake, while others 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 beginning in 1998, and these in addition to Walton Park, Murphysboro, McLeansboro, and Sam Parr in 1999 and continued through 2005.

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 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 MDH-B locus. In this segment, young-of-year from the six lakes were sampled by boat electroshocking to determine if the frequency of the MDH B2 allele has increased through reproduction of the stocked fish. These sample efforts will document the contribution of stocked fish to the reproductive population.

FINDINGS: The original largemouth bass fingerlings stocked into each lake were analyzed to determine if they all have the MDH B2B2 genotype. All samples analyzed from each stocking were 100% MDH B2B2 genotype with the exception of fingerlings stocked into Lake Shelbyville in the summer of 2001. In that case, five of the fifty fingerlings that were analyzed had the MDH B1B2 genotype and not the MDH B2B2 genotype; therefore a correction factor will have to be used to analyze future samples from Lake Shelbyville.

The background frequencies of largemouth bass from four of the six study lakes have less than 20% of the individuals with the MDH B2B2 genotype. The exceptions were Forbes and McLeansboro (Table 3-1a). The higher frequency of the MDH B2 allele from McLeansboro is potentially problematic and may make this lake difficult to use in determining the contribution of stocked fish to recruitment.

Preliminary sampling of largemouth bass began in 2002. By 2003, the earliest stocked fish should have begun reaching maturity and all lakes were sampled for YOY in 2003, 2004, 2005 and 2006 to determine if the frequency of the MDH B allele has changed as a result of the stocked fish spawning and passing on the MDH B2 allele. During 2006, we collected young-of-year largemouth bass from each of the study lakes (Table 3-1b). At the time of this report, the frequency of the MDH B2 allele for the 2006 samples have not yet been determined. Therefore, findings reported here represent the frequencies of the MDH B2 allele for each of the lakes through 2005. In three of the lakes (Murphysboro, Sam Parr, and Walton Park) the MDH B2 allele frequencies have increased (18% to 43%; Figure 3-1). In the other lakes (Forbes, McLeansboro, and Shelbyville), frequencies have remained the same, or fluctuated slightly. McLeansboro Lake had a higher frequency MDH B2 allele from the pre-stocking sample, and therefore the effects of stocking are not clear. Because of its large size, assessing the contribution of stocked fish in Lake Shelbyville may take a longer period before a change in allele frequencies can be determined and may be why the change is so small compared to the other lakes.

RECOMMENDATIONS: Genetic frequencies from YOY spawned from largemouth bass stocked with the MDH B2 allele have increased in three of the study lakes. Values have not increased dramatically in Forbes, McLeansboro, and Lake Shelbyville. It is too early to evaluate the affects of stocking in McLeansboro Lake and Lake Shelbyville. During the next segment, we will complete genetic analysis of fish collected during 2006. Sampling should continue in each of the study lakes for several years during the post-spawning months. Lakes will also need to be monitored for several years now that fish from the later stockings have all matured and should be contributing to the potential spawning population in the lakes. Efforts should be made to collect adequate sample sizes, to remove any sampling error when calculating allele frequencies.

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, similar to other fish species, experience variable recruitment among populations and years (Jackson and Noble 2000). In general, reproductive capacity of the adult population (Ricker 1954; Rutherford 2002), food availability during the larval life stage, and predation on early life stages (Houde 1987) are general mechanisms of fish recruitment. With slight modifications, these three hypotheses could apply to the specific case of largemouth bass recruitment.

The reproductive behavior of largemouth bass potentially complicates any relationship between spawning stock and recruitment. Besides spawning, largemouth bass reproductive behavior includes nest construction, courtship, and brood defense. Typically, spawning stock is the abundance of all fish of a specific age or size range that have reached sexual maturity. However, for a species with courtship, territoriality, and parental care, a much smaller fraction of mature fish may be responsible for the majority of surviving young of the year (YOY), therefore, typical estimates of spawning stock may inadequately assess or overestimate the reproductive capacity of the adult population (Raffeto et al. 1990). Furthermore, conditions (e.g., temperature) and human behaviors (e.g., angling) that affect nest success influence reproductive output and, potentially, recruitment (Philipp et al. 1997; see also Job 101.5).

An important factor in the environment of any developing YOY fish is the availability of food. Ultimately, food availability within a given system is driven by its productivity. The reliance of larval fish on zooplankton is often the critical relationship influencing recruitment strength (Miller et al. 1988; Goodgame and Miranda 1993; Olson 1996). With fish species that are primarily piscivorous as adults, such as largemouth bass, a successful transition from invertebrate to fish prey during the first year of life could be critical for future survival and success (Mittelbach and Persson 1998). The availability of both invertebrate prey during the earliest life stages and vulnerable fish prey are likely to be important for the consistent and timely development of piscivory (Olson 1996). The growth advantage gained by a switch to piscivory should be important to recruitment due to the size-dependent nature of YOY mortality.

Size-dependent mortality of YOY may be especially important for largemouth bass recruitment due to either selective predation on smaller bass or size-specific winter mortality. Predation often exacts a heavy toll on YOY fishes, potentially influencing recruitment strength (Houde 1987). Typically, the most important form of predation on YOY largemouth bass is cannibalism by earlier hatched individuals and largemouth bass from previous year classes (Post et al. 1998; Parkos and Wahl 2002). Predation pressure may also influence mortality of YOY largemouth bass during their first winter, when they are dependent on their lipid reserves for survival (Miranda and Hubbard 1994; Ludsin and DeVries 1997). Winter mortality may be the most important recruitment bottleneck for YOY largemouth bass, but no evidence for this relationship has been previously found for Illinois populations (Fuhr et al. 2002).

Despite the importance of identifying the processes operating during the early life stages of largemouth bass that influence recruitment to age-1, these mechanisms remain largely unknown. The current study addresses this critical gap in knowledge by monitoring multiple largemouth bass populations and their associated aquatic communities across multiple years. By monitoring over several years, our study encompasses variable environmental conditions and recruitment levels. Identification of important mechanisms and indexes of largemouth bass recruitment will guide management of sustainable largemouth bass populations and aid in prioritization of stocking efforts for lakes less likely to produce strong year classes.

PROCEDURES:

We sampled 11 reservoirs in 2006 to assess the influence of various factors on largemouth bass recruitment. Eight reservoirs were sampled every two weeks, while the remaining three impoundments 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.

Shoreline seining and electrofishing was used to assess largemouth bass YOY abundance and recruitment. Seining was conducted using a 9.2-m bag seine pulled along the shoreline at fixed transects. All fish species were counted and up to 50 fish from each species were measured to total length (mm). Electrofishing was used to collect YOY largemouth bass in the fall after they were too large to be effectively sampled by seining. Electrofishing the following spring was used to estimate recruitment to age-1. Based on otolith-derived ages, all largemouth bass from fall to the following spring that were less than or equal to 150 mm total length were considered to belong to the same year class.

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 either taken from the thermocline or from the bottom (if the lake was not stratified) to the surface. Zooplankton samples were preserved in 4% Lugol's solution and returned to the lab for processing. Zooplankton subsamples were counted until at least 200 organisms from the two most abundant taxonomic groups were counted. Organisms from all other taxanomic groups were also counted in those subsamples. Body size was measured on 30 individuals from each species from two of the inshore and two of the offshore sites. Larval fish were sampled at six sites on each lake by pushing a 0.5-m diameter push net with 500-µm mesh. The larval net was mounted to the front of the boat and pushed for 5 minutes along the shoreline and 5 minutes offshore. Larval fish were preserved in ETOH for later sorting and identification. Forage fish were collected by shoreline seining as described for YOY largemouth bass.

Physical and chemical variables potentially important to largemouth bass recruitment were sampled in each of the study lakes. 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 four lakes to record water temperature at 2-hour intervals throughout the year. In June and August, aquatic vegetation was identified and mapped in each lake to estimate the amount of vegetation cover. Water samples for chlorophyll-*a* and total phosphorus were collected during regular sampling dates, using an integrated tube sampler lowered to twice the secchi depth. Chlorophyll-*a* was estimated fluorometrically with an acetone extraction, and total phosphorus was determined by measuring sample absorbance with a spectrophotometer after an acid molybdate extraction.

A stepwise selection procedure was used to construct a multiple linear regression model from those variables that were significantly correlated with largemouth bass recruitment at the $\alpha = 0.10$ level. Correlation analyses consisted of either Pearson correlations, or if the data was non-normally distributed, Spearman correlations. All variables were transformed with a natural logarithm, except total length, benthos density, and chlorophyll *a* concentration. The significance level necessary for entry into the multiple linear regression model was $P = 0.15$. Diets from YOY largemouth bass in four lakes (Forbes, Lake of the Woods, Lincoln Trail, and Walnut Point) were used to identify prey items most important to young-of-year largemouth bass. Variables in recruitment models included spring zooplankton density (excluding nauplii copepods and rotifers), Lepomis larvae, post-spring density of juvenile bluegill ($TL \leq 60$ mm), and benthos (combined density of amphipods, chironomidae, hemiptera, zygoptera, and ephemeroptera). The amount of recruitment variation explained by the model was estimated with an adjusted R^2.

Abundance of largemouth bass and other fish species were assessed in relation to differing vegetation densities at Lincoln Trail Lake. Several sites were chosen in August of 2006, 3 along a shoreline with aquatic vegetation and 3 that did not have vegetation. Each site was blocked off using a 100 feet long by 10 feet deep seine that would not allow the movement of fish into or out of the enclosed area. Vegetation was assessed within the enclosed sampling area using three 0.5 meter diameter rings. Vegetation was removed from each ring, identified to species and weighed to assess vegetation diversity and abundance. The vegetation area and the location of the three rings were mapped for each enclosure. Fish were sampled from each enclosure using 3-pass depletion with a backpack DC electrofishing unit. All fish were identified to species and measured for total length.

FINDINGS:

In 2006, YOY largemouth bass densities (Figure 4-1) and growth (Figure 4-2) were highly variable among lakes. YOY largemouth bass appeared as early as May, but were generally most abundant in June. Peak densities ranged from 0.042/m^2 (Clinton, Shelbyville) to 5.12 m^2 (Walnut Point). Among lakes, differences in YOY largemouth bass density by the end of the growing season (Figure 4-3A) were already apparent by June (June YOY LMB density and fall YOY LMB CPUE; $r_s = +0.60$, $P = 0.05$). Differences in YOY largemouth bass growth were also noticeable by June and were quite distinct by September. YOY largemouth bass mean total lengths by the end of the growing season varied from 86 to 133 mm (Figure 4-3B). The study lakes exhibited strong density dependence in YOY largemouth bass growth (peak YOY LMB and fall YOY LMB TL; $r_s = -0.83$, $P = 0.002$).

Components of the physical and biological environment potentially important to YOY largemouth bass growth and survival varied among the study lakes. Water clarity ranged from less than 1 meter to more than 2 meters secchi depth (Table 4-1). Aquatic vegetation coverage ranged from 0% to almost half of total lake area; however, by late summer, among lake differences in vegetation abundance were not as pronounced (Table 4-1). Peak density of YOY largemouth bass was negatively related to average coverage of aquatic vegetation (r_s = -0.81; P = 0.01; Figure 4-4A). There was a positive but nonsignifcant correlation between fall total length of YOY bass and vegetation cover (r = +0.54; P = 0.17; Figure 4-4B). A great deal of variation was present in abundances of prey items typically utilized by YOY largemouth bass (crustacean zooplankton, benthos, larval, and juvenile bluegill). This variation will be valuable in assessing the factors most important in influencing largemouth bass recruitment. Chlorophyll-*a* concentrations were generally lower than in previous years, and ranged from 3.53 2 µg/L to 59.2 µg/L (Table 4-2). Gizzard shad populations were either absent (Lincoln Trail, Ridge, Walnut Point), at low to moderate abundances (Forbes, Lake of the Woods, Pierce, Sterling), or highly abundant (Clinton, Paradise, Shelbyville, Woods; Table 4-2). Densities of larval fish varied a great deal among lakes during 2006 (Table 4-2). Our diet studies in Illinois have pinpointed bluegill as the most important fish prey for YOY largemouth bass. In 2006, larval Lepomis were highly abundant in Forbes, Lake of the Woods, Lincoln Trail, and Walnut Point (Figure 4-5A). In Lincoln Trail and Walnut Point, larval Lepomis were highly abundant into late summer. Peak density of YOY largemouth bass was positively correlated with total production of larval Lepomis (r_s = +0.65; P = 0.03). Differences in the densities of juvenile bluegill during the summer were also apparent, with abundances distinctly higher in Ridge and Lincoln Trail (Figure 4-5B). Juvenile bluegill density was negatively correlated with gizzard shad abundance (r_s = -0.69; P = 0.02).

Largemouth bass recruitment to age-1 varied among the study lakes (Figure 4-6). Differences in recruitment strength among lakes were detectable by the end of the growing season (fall YOY LMB CPUE and age-1 recruits; r = + 0.56, P = 0.07). However, these differences in recruitment to age-1 were not significantly correlated with any of the other measured abiotic and biotic variables ($P \geq 0.21$). Abundance of YOY largemouth bass at the end of the growing season was positively correlated with June YOY largemouth bass density (r_s = +0.60; P = 0.05), spring zooplankton density (r = +0.60; P = 0.05), and secchi depth transparency (r = +0.51; P = 0.11), and negatively correlated with gizzard shad density (r = -0.64; P = 0.04). After stepwise selection, variation in fall YOY largemouth bass abundance was linearly related to June YOY largemouth bass density, spring zooplankton, and secchi depth transparency (adjusted R^2 = 0.89; P = 0.003).

We also assessed the role of vegetation in Lincoln Trail Lake by simultaneously sampling largemouth bass. Dominant vegetation at Lincoln Trail was American pondweed, coontail and chara. Largemouth bass densities ranged from 0 to 0.09 fish per square meter. Mean largemouth bass density was higher in sites with vegetation than those without (Table 4-3). Mean bluegill density was also greater in the vegetated sites. Vegetation appeared to both attract largemouth bass as well as prey. These habitats may therefore be critical to maximizing young of year largemouth bass recruitment and growth.

RECOMMENDATIONS:

After measuring the dynamics of largemouth bass early life stages across multiple lakes and years, we have found that largemouth bass recruitment can be affected by a variety of relatively complex mechanisms. Despite high among-lake and –year variability, some consistent patterns have emerged. One consistent pattern has been a positive association between densities of larval Lepomis and peak YOY largemouth bass. Both measures reflect reproductive output from the nests of bass, bluegill, and other sunfish. This pattern may be evidence that certain conditions, such as habitat availability, favor high reproductive success for fish species that nest and provide parental care. Lepomis YOY, especially bluegill, are an important forage species for YOY largemouth bass; therefore, factors affecting bluegill success are also important for largemouth bass recruitment.

Another consistent pattern has been a negative correlation between gizzard shad abundance and density of juvenile bluegill. Gizzard shad are found in a majority of Illinois reservoirs and can reach very high abundances. Gizzard shad and bluegill larvae compete for zooplankton, an interaction that can result in fewer bluegills surviving to the juvenile life stage where they become an important prey item for YOY bass. Gizzard shad may also indirectly influence largemouth bass recruitment by affecting water quality. Older gizzard shad forage on detritus, resulting in increased suspension of sediments and nutrients. In support of this interaction, we have found that lakes with abundant gizzard shad typically have reduced water clarity and increased lake productivity.

Survival of early life stages of fish is strongly size-dependent; therefore, factors that affect first-year growth can be crucial for successful recruitment. We have found that a consistent annual pattern has been a negative correlation between YOY bass growth and abundance. This strong density-dependence of YOY bass growth highlights the importance of providing sufficient food resources to support increased bass recruitment. All of the above patterns that have been relatively consistent from year to year point to recruitment strength as an outcome of several interacting factors, including successful reproduction, habitat quality, and food availability. We found that this pattern was also evident in factors associated with variation among lakes in the size of the 2006 year class of largemouth bass by the end of the first growing season, in that the model that significantly explained this variation consisted of variables associated with reproductive output (June density YOY bass), habitat quality (water clarity), and prey availability (spring density of zooplankton). A final consistent pattern has been that differences among lakes in largemouth bass recruitment strength can typically be detected before the first winter. The timing of this early index of recruitment strength has varied from year to year, but usually an early correlation of year class strength has been present. The high among-lake and –year variability has made the collection of several years of data critical to the identification of consistent patterns of bass recruitment. We are currently collecting the final year of multiple-lake data on largemouth bass recruitment. This data will be added to our previous years of data in order to construct our final models of the mechanisms behind variation among lakes and years in largemouth bass recruitment. In addition, the identification of habitat quality and reproductive success as important recruitment mechanisms in Illinois bass populations has led to the expansion of our efforts to examine habitat features such as aquatic vegetation in more detail.

Additional information on the role of aquatic vegetation to largemouth bass recruitment has been identified as an important goal for management in Illinois. Data from vegetation enclosures provided evidence that vegetation is important to young-of-year largemouth bass in Lincoln Trail. In the next segment, we will continue to expand the work we have completed with vegetation enclosures to include an additional lake (Walnut Point) and identify additional potential lakes that may be included. With these data we can examine relationships between vegetation composition, density and largemouth bass density and size structure.

There are a number of potential management strategies for manipulating vegetation that are of interest to managers in Illinois, including chemical treatment to reduce overabundant vegetation and habitat restoration to increase vegetation where it is lacking. We will initiate a multi lake experiment examining lakes with a range of vegetation densities and measure recruitment of largemouth bass in those systems. This will be used to identify critical levels of vegetation to target for management. Once adequate background data is obtained, we will develop a management experiment including control lakes, as well as treatment lakes in order to increase density of vegetation where it is low (Dolan and Paradise), and decrease vegetation density where it is high (Kakusha, Stillwater, and Airport).

We will install fish exclusion fences and transplant vegetation into the enclosed areas at Lake Paradise to increase vegetation. In Dolan Lake, the water level was drawn down in an attempt to eliminate carp and gizzard shad. We expect through the removal of these fish and the exposing of the seed bank, that vegetation will increase in this lake. Vegetation removal in other lakes will be accomplished primarily through chemical treatments appropriate to reduce the dominant problem vegetation. We will continue to monitor largemouth bass populations throughout the implementation of the experimental treatments as well as other biotic and abiotic factors we have related to largemouth bass recruitment success. This will allow us to make management recommendations regarding the implications of vegetation management on largemouth bass recruitment as well as other components of the food web.

Similar to aquatic vegetation, woody debris may influence recruitment by providing habitat and prey resources for young-of-year largemouth bass. We will develop pond experiments that vary the amount and complexity of woody debris to examine changes in largemouth bass recruitment. These pond experiments will be coupled with controlled laboratory experiments that will allow us to further examine the influence of woody debris on largemouth bass behavior. We will also examine woody debris in the existing study lakes and relate them to largemouth bass recruitment. These studies will allow us to make recommendations on vegetation and woody habitat management in order to increase largemouth bass recruitment in Illinois reservoirs.

Two additional factors that we have not yet assessed that could potentially influence largemouth bass recruitment are the effects of introduced muskellunge and dam escapement. Lake sampling conducted as part of the current study will be used for as reference conditions for experiments assessing the community level effects of muskellunge stockings in conjunction with Project F-151-R (Evaluation of growth, survival, and food habits of different genetic stocks of muskellunge: implications for stocking programs in Illinois and the Midwest). Dam escapement could also potentially limit recruitment of young of year largemouth bass. We will evaluate this using existing data from Ridge Lake. It may also be possible to develop an index of watershed to lake acreage that could be used to predict potential lakes where escapement could be a concern. Based on these initial analyses, we may examine these questions on a few selected study lakes.

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 have unknown effects on largemouth bass reproductive success. In the spring, male largemouth bass (*Micropterus salmoides*) build solitary, highly visible (depending on water clarity) 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 male remains to provide all parental care of the developing offspring, a period that may last four or more weeks (Ridgway 1988; Cooke et al. 2002). While male bass are providing parental care for their broods, they are extremely aggressive (Ridgway 1988; Cooke et al. 2002) 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 limit scenarios in an effort to enhance or promote bass reproduction and recruitment (see Schramm et al. 1995). We are assessing the relationship between nesting success and recruitment in Lincoln Trail Lake. In addition we are determining which cohort (based on spawning date) contributed the most to largemouth bass recruitment. The strategy of maximizing reproductive success by protecting successful spawning bass from angling assumes that there is a positive relationship between reproductive success and recruitment. One of our objectives here is to quantify the effects of angling on the reproductive success of largemouth bass.

Male largemouth bass experience reduced levels of food consumption while providing parental care (Kramer and Smith 1962; Pflieger 1966; Coble 1975). Therefore, the spawning season has negative effects on parental males fitness, characterized by a decrease in energy store 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; Cooke et al. 2002). As a result, an energetically costly activity, such as being captured by angling, could result in a decreased ability of that male to provide continued parental care (Kieffer et al. 1995) and negatively impact offspring survival. Furthermore, Phillip et al. (1997) have confirmed that angling of nesting bass, even on a catch-and-release basis, results in increased brood predation and nest abandonment rates. Therefore, substantial catch-and-release angling for nesting bass could have negative effects on reproductive success. Because female largemouth bass preferentially spawn with the largest males, those males will have the largest broods. Also, those males with the largest broods will defend their nest more aggressively, making them susceptible to anglers. We would also expect these fish to be targeted by anglers, including during tournaments. During competitive angling events, fish are held in livewells, for several hours in some instances, and then transported to a central location where they are subjected to the weigh-in procedure. All these practices could contribute to increased abandonment by nesting males. One objective of our study is to better assess the impact that competitive angling and catch-and-release angling have on the reproductive success of largemouth bass. We have also performed nest observations in order to quantify varying levels of nest predation as well as mapped largemouth bass nests in order to better understand habitat suitable for nesting.

Competitive tournament fishing for black bass in the United States has grown rapidly over the past several years. Most of these angling events, although catch and release, require the fish be held in live wells for extended periods of time and subjected to a rather involved weigh-in procedure. The weigh-in process, using the best current techniques, usually involves extended air exposure of a bass that has been shown to contribute to mortality associated with tournaments. The delayed mortality of bass involved in tournaments can be substantial and may be as high as 30 – 70 percent (Allen et al 2004, Edwards et al 2004, Schram et al 1987, Weathers et al 1987, and Wilde et al 1998). We are continuing to examine ways to reduce this mortality of bass during tournaments. One method of reducing this mortality may be paper tournaments where anglers record data on captured fish and release them at the time of capture. This would eliminate stress associated with both holding the bass in a livewell and the weigh-in.

PROCEDURES:

Nest observations: Snorkeling surveys were used to assess bass spawning activity, nest site selection by males, aggressiveness of males guarding a nest, and the level of nest predation in Lincoln Trail Lake. Snorkeling began on April 16, 2007 and continued through May 30, 2007. Six transects have been monitored each of several years. Each nest we locate was given a nest tag and an egg score (1-5). The water depth of the nest was recorded as well as the developmental stage of the offspring. A visual length estimate of the guarding male was noted as well as the presence or absence of a hook wound. For a subsample of nests, the male was chased off the nest for a five-minute interval where we could observe nest predation while the male was absent. The number of predators in the nest were recorded, as well as their size and amount of time spent in the nest. Also, the number of times the male had to be chased off the nest during the five-minute interval was recorded as a measure of aggression. Habitat within a 4m x 4m area around the nest was mapped, making note of substrate, cover and potential nest predators. We also assessed the available habitat within each transect to determine if largemouth bass were exhibiting any substrate selectivity for specific nesting sites. Transects were snorkeled perpendicular to the shoreline. Substrate was quantified at 5-meter intervals. At each interval, 5 point estimates were visually assessed for dominant substrate along each transect from 2m of depth to the shore. These data were used to estimate the proportion of each substrate type available within each snorkeling transect and compared to the substrate at each nesting site. In previous segments, young-of-year largemouth bass were collected in the months of August and September fall by AC electrofishing (three transects on two dates) and seine hauls (four seines every other week). Otoliths were removed from these bass, mounted on microscope slides and sanded to increase the clarity of the growth rings. Two readers examined each otolith and the daily growth rings were counted. The number of rings was then used to back calculate swim up date for each fish collected. Disagreement between readers made it difficult to determine swim-up date for otoliths collected in September, so only August dates were used in this analysis. Spawning date was determined by correcting swim up date; total of 11 days (mean number of days from spawn date to swim up) were added to the swim up date for each otolith (Miller and Stock 1984; Allen and Romero 1975). The relative number of young of year spawned for each week was compared to the frequency of new nests observed for that week in order to determine differential survival.

Tournaments: Throughout the spawn and post-spawn period, we monitored bass tournaments at Mill Creek, Lake Mattoon, Forbes Lake, and Lake Shelbyville 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. We also began interviewing anglers at weigh-ins to determine if anglers were culling fish and influencing sex ratios observed at the conclusion of the tournaments. Previous data collected from tournaments showed that females angled were on average larger than males. This may produce skewed sex ratios at tournaments towards larger females as anglers culled out smaller males. Angler interview questions included the number of fish that were culled and the number of sub-legal fish that were caught and released. We used these data in an attempt to determine if culling was influencing sex ratios of bass weighed in during the spawning season.

Tournament simulations were performed on Ridge Lake in the spring of 2007. Ridge Lake is typically closed to fishing during the spawning season. Six anglers competed in largemouth tournaments twice a week throughout the spawning period. The lake was divided into 6 sections and each section was fished by an angler for 45 minutes. Anglers were rotated through sections randomly and each angler fished in each section of the lake once. Tournaments will continue in alternating years. Largemouth bass recruitment will be assessed using bi-monthly seine samples and spring and fall electrofishing. These experiments will allow us to evaluate the affects of angling largemouth bass off the nest.

Long-Term Affects of Harvest: We began to evaluate how long-term harvest of Illinois bass has impacted the population size structure of those populations through selection-driven changes in life history traits. We have been collecting scales from largemouth bass from four lakes sampled in spring electrofishing that can be positively identified as male or female. This data will be used to determine sex-specific size-at-age, life span, and age-at-first-maturation profiles for these populations and others in Illinois with various levels of exploitation.

FINDINGS:

Nest Observations: A total of 65 nests were observed between 4/16/2007 and 5/30/2007 in Lincoln Trail Lake. The appearance of new nests was related to the water temperature on the date of sampling (Figure 5-1). Water temperature increased at a relatively constant rate and most new nests were observed shortly after temperatures reached 17 ^{o}C. These patterns are similar to those observed in previous years. Bass spawned on a variety of substrates and did not seem to strongly prefer any particular nesting habitat. However, largemouth bass nests appeared to contain greater proportions of gravel and detritus than was available in the littoral habitat or the 4 by 4 meter area surrounding the nest (Figure 5-2). Largemouth bass also chose nests in areas with low proportions of vegetation (6%) and sand (10%). Largemouth bass may avoid nesting in these habitat types because they are available in high proportions in the littoral habitat. Largemouth bass in Lincoln Trail may prefer to nest on substrate with larger particle size and less vegetation.

We did not observe high levels of egg predation when the bass were chased away from the nest. Only two bass nests had predators feeding on eggs during the five-minute interval. Largemouth bass with nest predation were less aggressive (mean times chased off the nest = 1.1) when compared to other males guarding nests (mean times chased off nest = 1.7). Only 12 of the 63 nests had potential egg predators surrounding the nest at the time of observation. Our sample size of nests with predators will need to be increased in the future.

The number of new nests on a date was related to the number of largemouth bass surviving to the fall in the two years we have examined this far. Survival was back calculated using otoliths in 2000 and 2001 (Figure 5-3) with patterns of relative contribution being similar between the two years. Numbers of nests during the spawning period generally followed a unimodal pattern in both years, with more spawning occurring early rather than later during the spawning period (Figure 5-3). The distribution of survivors was generally similar to spawning being skewed slightly toward the earlier spawned individuals. Combined, results from these two years suggest survivors were disproportionately coming from earlier in the spawning period. Some estimated survival came from later in the season than we observed nesting to have occurred. These discrepancies could be the result of either missing later spawning activity during snorkeling or errors in backcalculating spawning dates. We will evaluate olotiths collected earlier in the summer to reduce aging error and assess the potential for each of these alternatives. We will also continue to add additional years using otoliths to assess spawning date contribution to young-of year largemouth bass recruitment.

<u>*Tournaments*</u>: In this segment, sampling of largemouth bass fishing tournaments were conducted in 2007 in Mill Creek (N=1), and Lake Mattoon (N=1) and were combined with data collected in previous years. Tournament anglers in the spring do appear to target spawning bass. The percentage of bass that were reproductively active ranged from 66% to 100% of all fish captured (Table 5-1). A majority of both male and female bass sampled in spring tournaments had signs of spawning activity (ripe, running, swollen pore, and fin erosion). A higher proportion of males than females were angled in all lakes during the spawning period except Shelbyville (Table 5-1). This would imply that spawning males might be targeted greater than females. However, the proportion of males to females captured in post spawn tournaments is similar to tournaments during the spawning period.

<u>*Long-Term Affects of Harvest*</u>: We have begun to accumulate sex specific data for largemouth bass in the four study lakes. In this segment, we collected a number of largemouth bass that could be used for determining maturation status. This data was combined with data from electrofishing samples from 2005-2007 where we could positively identify the sex and determine the age of the fish to determine the total number

of fish we can include in this analysis (Table 5-2). In future segments we will determine the age of these fish using scale samples and present them in future reports.

RECOMMENDATIONS:

Monitoring largemouth bass spawning activity in Lincoln Trail has allowed us to determine the duration of spawning as well as the relative number of nests formed each week. In future segments we will continue to monitor nesting activity and collect otoliths from young of year bass in the fall. The otoliths from additional years will be removed and the daily rings will be read (as time permits) in order to back calculate spawning date. The relative number of bass collected in the fall from each spawning date will continue to be compared to the number of new bass nests to determine differences in relative survival. A number of factors related to spawning date could influence survival. Earlier spawned fish may have a size and growth advantage over later spawned fish. Alternatively, the timing of nesting and hatch may be related to a number of variables such as available prey and the presence of nest and other predators. We will continue to evaluate these factors in future segments.

Monitoring largemouth bass nesting in Lincoln Trail has also allowed us to determine where nesting is occurring and the types of habitat bass prefer for spawning. Continuing to evaluate preferences in spawning habitat and available habitat for bass spawning is important in order to understand what factors may influence nesting success. Management strategies such as improving nesting habitat may be important in lakes where spawning success is low due to lack of appropriate habitat. We have also observed varying levels of nest predation and aggressiveness of bass guarding the nest. In future segments, we will incorporate additional nest mapping data. This data will continue to be utilized to evaluate spawning substrate and habitat preferences and to examine factors that may influence the aggressiveness and success of nesting bass. In addition, habitat adjacent to the nest may be important for YOY bass for feeding and avoiding predation. We will continue to read daily otoliths from largemouth bass collected in other years from Lincoln Trail to add additional data to the analysis of contribution of fish by spawning date. Additional data will aid in the understanding of the importance of spawning date to survival and help develop management strategies to protect spawning fish.

We will continue to monitor bass tournaments in order to assess if reproductively active males are being preferentially caught. Data from three of the four lakes examined suggests that this may be the case during both spring tournaments and the post-spawning period. Preliminary information provided by tournament angler surveys suggests that the culling and release of smaller males for larger females is minimal and not skewing sex ratio estimates. Sample sizes are very small thus far for these surveys and future segments will focus on increasing sample number of angler surveys to determine the effects of culling. Additional research to determine the implications of angling bass from the nest on the overall bass population and year class strength are needed. With these data, we will be able to make predictions about how angling will affect recruitment of largemouth bass.

To assess the effects of angling practices and tournaments on largemouth bass reproduction we will continue experiments initiated at Ridge Lake. Changes in largemouth bass recruitment and adult populations will be monitored to determine the potential population level affects of largemouth bass tournament angling during the spawning season. We will also assess how much spring-time angling over nesting bass is occurring in Illinois by analyzing past and current creel data as well as directly comparing the results from Illinois lakes with our historical Canadian databases.

In response to concerns about the mortality of competitively angled largemouth bass, we propose a series of controlled experiments to examine methods for reducing this mortality. Experiments will be conducted at the Sam Parr Biological Station and during several Illinois tournaments on Lake Shelbyville, Evergreen Lake as well as other potential study lakes. First, we will assess mortality of tournament caught fish during hot weather. We will examine these issues by holding fish in cages following tournaments. Paper tournaments eliminate the need for the stressful weigh-in associated with tournaments. We will continue to evaluate the potential value of paper tournaments through comparing results with those of weigh-ins and evaluating their accuracy. Lastly, we will evaluate how long-term harvest of Illinois bass has impacted the population size structure of those populations through selection-driven changes in life history traits. This will involve determining sex-specific size-at-age, life span, and age-at-first-maturation profiles for a variety of populations in Illinois with various levels of exploitation. We will continue to collect largemouth bass scales from individuals with known sexes in future segments. At this time our sample size is low and additional samples are required to perform the analysis of sex specific characteristics. We will also incorporate creel data in order to estimate the extent of largemouth bass harvest and compare to differences in sex-specific traits. This will allow us to identify the potential impacts of harvest to life history characteristics in largemouth bass populations.

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. To evaluate the effects of fish refuges on Illinois bass recruitment and size structure.

INTRODUCTION: Largemouth bass can be vulnerable to anglers while spawning and reproductive success may depend on the level of angling stress the fish undergoes during this period. This has sparked a recent controversy amoung anglers as to whether or not bed fishing (angling fish off the nest) is detrimental to bass populations. Our recent research (Job 101.5) suggests that angling largemouth bass off nests can cause nest abandonment, which results in the failure of the nest to produce offspring. Many states have implemented closed seasons or spawning refuges, which are closed to fishing in an attempt to alleviate this problem. It is unclear if these management techniques are appropriate for Illinois reservoirs.

Clinton Lake is an approximately 2000-hectare lake that is operated as both a power plant cooling lake and a recreational lake. In the fall of 2001, a portion of the lake adjacent to the Clinton Lake Power Plant was permanently closed to boaters and anglers. This closed area provides a refuge for largemouth bass from angling. The refuge may be beneficial to largemouth bass, by increasing spawning success and decreasing fishing mortality. We are using this opportunity to begin to evaluate the success of a fish refuge in increasing numbers and size structure of the largemouth bass population.

PROCEDURES: Population abundance and size structure of largemouth bass were assessed in Clinton Lake using spring and fall electrofishing and seining both before and after implementation of the refuge. Samples collected during 1999 – 2001 represent pre-refuge. In this segment, post refuge electrofishing transects and seines hauls were performed in the spring and fall of 2006 and the spring of 2007. Two, thirty minute electrofishing transects and two seine hauls were performed inside the refuge on each sampling date. Three transects were also electrofished and seined outside of the refuge. Sites outside of the refuge were located adjacent to and approximately 2 and 4 lake miles from the refuge. Fish were identified to species and total length was recorded. Catch per unit effort (CPUE) was then calculated as the number of fish per hour of AC 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. All largemouth and smallmouth bass collected inside the refuge were given an upper caudal fin clip in order to determine if fish in the refuge move into adjacent areas of the lake.

We have begun to collate existing data to examine the success of harvest regulations on Illinois lakes. The FAS Lakes and Creel databases will be used to obtain data on current regulations existing on a number of lakes, as well as the largemouth bass abundance and size structure present. In this segment we have been working to identify the regulations that have historically been in place on multiple lakes and to obtain FAS data for these lakes. Some of the regulations currently existing that will be examined include 14”, 15,” a few 16”,18” and 21” minimum length limits, as well as 12-15” and 14-18” slots.

FINDINGS: Mean CPUE for largemouth bass in Clinton Lake from 1999 through 2001 was 25.5 fish per hour of electrofishing. This is lower than most of our study lakes, which have a range of CPUE from 20.9 to 67.3 fish per hour. As a result, there is the potential for an increase in abundance of largemouth bass in Clinton Lake from the establishment of the refuge. Sampling at sites inside the refuge in 2003 through 2007 yielded a much higher CPUE than sites outside the refuge as well as samples taken before the refuge was closed (Table 6-1). This suggests that bass numbers are increasing in the refuge due to the elimination of fishing pressure. This data however is based on few sample dates in a limited number of years. More data is required to verify that CPUE is consistently higher inside the refuge or if the refuge is contributing to increased numbers of bass throughout the lake.

Seine data from previous segments have shown some increases in the catch of young of year largemouth bass throughout the lake and refuge after the refuge was established. In the spring of 2006 and 2007, we observed a large number of young of year bass in the main lake, however no young of year were collected inside the refuge. The total number of fish captured in seine samples also appears to have increased after the refuge was closed. The refuge may be positively influencing young-of-year largemouth bass recruitment outside of the refuge. With the increased number of adult bass in the refuge, we would expect to see an increase in young of year production inside the refuge, however this is not being observed consistently in our seine and electrofishing samples. Continued assessment of young-of-year bass is required in order to assess if the refuge is enhancing natural recruitment in Clinton Lake.

No clipped fish were observed in electrofishing or seine samples taken outside of the refuge. This implies that there is little or no movement of fish from the refuge to the open portion of the lake. However, these results are also based on a low sample size and must be supplemented in future segments in order to fully assess the potential lake-wide effects the refuge may have as a tool for managing bass populations.

RECOMMENDATIONS:

There are many potential harvest regulations that can be used to manage bass populations, including size and creel limits, closed seasons, and spawning refuges. Each of them, either singly or collectively, can have a different impact on the population, either by affecting size structure and/or abundance. Some regulations have the potential to impact recruitment more than others, but right now, we cannot make accurate predictions. Other management options include habitat, prey, and predator manipulations. Thus far we have been evaluating a spawning /fishing refuge on Clinton Lake. We plan to continue our evaluation by conducting seine hauls in the spring and fall at two sites within the refuge and four sites on the main lake to estimate the abundance of young-of-year largemouth bass. We will also conduct electrofishing transects in the spring and fall within the refuge and on the main lake to monitor adult largemouth bass populations. These data will be compared to those from the same sites during the five years preceding the implementation of the refuge. Bass captured in both seine hauls and electrofishing transects inside the refuge will also be marked with a caudal fin clip. All bass collected will be examined for existing clips in order to determine if bass in the refuge are moving into the main lake. We have also identified Otter Lake as an additional lake to evaluate the effects of fishing refuges on largemouth bass recruitment and survival. We have visited Otter Lake with Jeffrey Pontnack (District 14/15 Fisheries Biologist) and Dennis Ross (General Manager of Otter Lake Water Commission) and identified two potential refuge sites. We will monitor largemouth bass populations for three years prior to closing of the refuges to develop pre refuge data, and a minimum of three years following the closing of the refuges. This additional lake will provide further information regarding the value of fishing refuges for increasing largemouth bass recruitment.

Adaptive management experiments to evaluate habitat manipulations, including vegetation and the role of woody debris (described in Job 4) will also be evaluated as part of this job. Management experiments will manipulate vegetation (e.g. plantings and removals) to examine changes in largemouth bass growth and survival. The experiment will include control lakes, as well as treatment lakes to either increase or decrease the density of aquatic vegetation. These experiments will be used to make management recommendations regarding vegetation and woody habitat in order to increase largemouth bass recruitment.

We will also continue to identify lakes for analysis using existing data to examine the success of harvest regulations on Illinois lakes. The FAS Lakes and Creel databases will be used to obtain data on current regulations existing on a number of lakes, as well as the largemouth bass abundance and size structure present. We will continue to identify past regulations for each potential lake and use nearly twenty years of creel survey data to assess how size limit regulations may influence an angler decisions to choose between harvest and release, and how those cumulative decisions may alter population size structure over time. These data can then be used to guide future discussions about various management experiments that might be implemented.

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.

Segment 9

Job	Proposed Cost	Actual Cost
Job 1	$0	$0
Job 2	$106,815	$106,815
Job 3	$47,840	$47,840
Job 4	$110,224	$110,224
Job 5	$53,820	$53,820
Job 6	$83,734	$83,734
Job 7	$29,900	$29,900

REFERENCES:

Allan, M.S., M.W. Rogers, R.A. Myers, and W.M. Bivin. 2004. Simulated impacts of tournament-associated mortality on largemouth bass fisheries. North American Journal of Fisheries Management 24(4) 1252-1261.

Allen, R.C., and J. Romero. 1975. Underwater observations of largemouth bass spawning and survival in Lake Mead. Pages 104-122 in R.H. Stroud and H. Clepper, editors. Black bass biology and management. Sport Fishing Institute, Washington, District of Colombia, USA.

Boxrucker, J. C. 1982. First year growth and survival of stocked largemouth bass in a small Oklahoma impoundment. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 36:369-376.

Boxrucker, J. C. 1984. Evaluation of supplemental stocking as a black bass management procedure in large impoundments. Oklahoma Department of Wildlife Conservation, Federal Aid in Fish Restoration, F-39-R, Job 4, Final Report, Oklahoma City.

Boxrucker, J. C. 1986. Evaluation of supplemental stocking of largemouth bass as a management tool in small impoundments. North American Journal of Fisheries Management 6:391-396.

Burkett, D. P., P. C. Mankin, G. W. Lewis, W. F. Childers, and D. P. Philipp. 1986. Hook-and-line vulnerability and multiple recapture of largemouth bass under a minimum total-length limit of 457 mm. North American Journal of Fisheries Management 6:109-112.

Buynak, G. L., and B. Mitchell. 1999. Contribution of stocked advanced-fingerling largemouth bass to the population and fishery at Taylorsville Lake, Kentucky. North American Journal of Fisheries Management 19:494-503.

Clapp, D. F. and R. D. Clark. 1989. Hooking mortality of smallmouth bass caught on live minnows and artificial spinners. North American Journal of Fisheries Management 9:81-85.

Clapp, D. F., Y. Bhagwat, and D. H. Wahl. 1997. The effect of thermal stress on walleye fry and fingerling mortality. North American Journal of Fisheries Management 17:429-437.

Coble, D.W. 1975. Smallmouth bass. pp. 21-33 in H.E. Clepper and R.H. Stroud (eds) Black Bass Biology and Management. Sport Fishing Institute, Washington, D.C.

Cooke, S. J., J. F. Schreer, D. H. Wahl, and D. P. Philipp. 2002. Physiological impacts of catch-and-release angling practices on largemouth bass and smallmouth bass. Black bass 2000: ecology, conservation, and management. American Fisheries Society Symposium 31:489-512.

Cooke, S.J.; Philipp, D.P.; Weatherhead, P.J. 2002. Parental care patterns and energetics of smallmouth bass (Micropterus salmoides) monitored with activity transmitters. Canadian Journal of Zoology 80 (4): 756-770

Coutant, C. C. 1972. Successful cold branding of nonsalmonids. The Progressive Fish Culturist 34:131-132.

Dillard, J. G., and G. D. Novinger. 1975. Stocking largemouth bass in small impoundments. Pages 459-474 in H. Clepper, editor. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Edwards, G.R. Jr., R.M. Newmann, R.P. Jacobs, E.B. O'Donnell. 2004. Impacts of small club tournaments on black bass populations in Connecticut and the effects of regulation exemptions. North American Journal of Fisheries Management 24(3) 811-821.

Fielder, D.G. 1992. Evaluation of stocking walleye fry and fingerlings and factors affecting their success in lower Lake Oahe, South Dakota. North American Journal of Fisheries Management 12: 336-345

Fuhr, M.A., D. H. Wahl, and D. P. Philipp. 2002. Fall abundance of age-0 largemouth bass is more important than size in determining age-1 year class strength in Illinois. Black bass 2000: ecology, conservation, and management. American Fisheries Society Symposium 31:91-100.

Garvey, J. E., K. G. Ostrand, and D. H. Wahl. In Press. Interactions among allometric scaling, predation, and ration affect size-dependent growth and mortality of fish during winter. Ecology.

Goodgame, L. S., and L. E. Miranda. 1993. Early growth and survival of age-0 largemouth bass in relation to parental size and swim-up time. *Transactions of the American Fisheries Society* 122: 131–138.

Gilliland, E. R. 1992. Experimental stocking of Florida largemouth bass into small Oklahoma reservoirs. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 46:487-494.

Gustaveson, A. W., R. S. Wydowski, and G. A. Wedemeyer. 1991. Physiological response of largemouth bass to angling stress. Transactions of the American Fisheries Society 120:629-636.

Hanson, P. C., T. B. Johnson, D. E. Schindler, and J. F. Kitchell. 1997. Fish bioenergetics 3.0. WISC-T-97-001. University of Wisconsin Sea Grant Institute, Madison, Wisconsin.

Hearn, M. C. 1977. Post-stocking survival of largemouth bass reared in raceways on an artificial diet. The Progressive Fish-Culturist 39:126-127.

Houde, E. D. 1987. Fish early life dynamics and recruitment variability. American Fisheries Society Symposium 2:17-29.

Holbrook, J. A., II. 1975. Bass fishing tournaments. Pages 104-112 *in* R. H. Stroud and H. Clepper, editors. Black Bass Biology and Management. Sport Fishing Institute. Washington D. C.

Jackson, J. R. and R. L. Noble. 2000. Relationships between annual variations in reservoir conditions and age-0 largemouth bass year class strength. Transactions of the American Fisheries Society 129:716-726.

Kieffer, J.D., M. R. Kubacki, F.J.S. Phelan, D.P. Philipp, and B.L. Tufts. 1995. Effects of catch-and-release angling on nesting male smallmouth bass. Transactions of the American Fisheries Society 124:70-76.

Kieffer, J. D. 2000. Limits to exhaustive exercise in fish. Comparative Biochemistry and Physiology 126:161-179.

Kramer, R. H. and L. L. Smith. 1962. Formation of year class in largemouth bass. Transactions of the American Fisheries Society 91:29-41.

Lawson, C. S., and W. D. Davies. 1979. Effects of bass stocking and rates of fishing on a largemouth bass population. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 31:493-497.

Ludsin, S. A., and D. R. DeVries. 1997. First-year recruitment of largemouth bass: the interdependency of early life stages. Ecological Applications 7: 1024-1038.

Maceina, M. J., B. R. Murphy, and J. J. Isely. 1988. Factors regulating Florida largemouth bass stocking success and hybridization with northern largemouth bass in Aquilla Lake, Texas. Transactions of the American Fisheries Society 117:221-231.

McPeek, M.A. 1990. Determination of species composition in the Enallagma damselfly assemblages of permanent lakes. Ecology 71:83-98.

Mighell, J. L. 1969. Rapid cold-branding of salmon and trout with liquid nitrogen. Journal of the Fisheries Research Board of Canada 26:2765-2769.

Miller, T. J., L. B. Crowder, J. A. Rice, and E. A. Marschall. 1988. Larval size and recruitment mechanisms in fishes: toward a conceptual framework. *Canadian Journal of Fisheries and Aquatic Sciences* 45: 1657–1670.

Miller, S.J., T. Storck. 1984. Temporal spawning distribution of largemouth bass and young-of-year growth, determined from daily growth rings. Transactions of the American Fisheries Society. 113: 571-578.

Miranda, L. E. and W. Hubbard. 1994. Winter survival of age-0 largemouth bass relative to size, predators, and shelter. North American Journal of Fisheries Management 14:790-796.

Mitchell, J. M., K. K. Sellers, W. D. Harvey, and L. T. Fries. 1991. Effects of stocking regime and harvest regulation on Florida largemouth bass stocking success. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 45:477-483.

Mittelbach, G. G. and L. Persson. 1998. The ontogeny of piscivory and its ecological consequences. Canadian Journal of Fisheries and Aquatic Sciences 55:1454-1465.

Modde, T. 1980. State stocking policies for small warmwater impoundments. Fisheries 5:13-17.

Neter, J., M. H. Kutner, C. J. Nachtsheim, and W. Wasserman. 1996. Applied linear regression models, 3rd Edition. Donnelley and Sons, Chicago.

Olson, M. H. 1996. Ontogenetic niche shifts in largemouth bass: variability and consequences for first-year growth. Ecology 77:179-190.

Ostrand, K. G., S. J. Cooke, and D. H. Wahl. In Press. Effects of stress on largemouth bass reproduction. North American Journal of Fisheries Management.

Parkos, J. J. and D. H. Wahl. 2002. Towards an understanding of recruitment mechanisms in largemouth bass. Black bass 2000: ecology, conservation, and management. American Fisheries Society Symposium 31:25-46.

Perry, W. B., W. A. Janowsky, and F. J. Margraf. 1995. A bioenergetics simulation of the potential effects of angler harvest on growth of largemouth bass in a catch-and-release fishery. North American Journal of Fisheries Management 15:705-712.

Pflieger, W.L. 1966. Reproduction of the smallmouth bass (Micropterus dolomieu) in a small Ozark stream. American Midland Naturalist 76:410-418.

Philipp, D. P., W. F. Childers, and G. S. Whitt. 1979. Evolution of patterns of differential gene expression: a comparison of the temporal and spatial patterns of isozyme locus expression in two closely related fish species (northern largemouth bass, Micropterus salmoides, and smallmouth bass, M. dolomieu.) Journal of Experimental Zoology 210:473-487.

Philipp, D. P., C. A. Toline, M. F. Kubacki, D. B. F. Philipp, and F. J. Phelan. 1997. The impact of catch-and-release angling on the reproductive success of smallmouth and largemouth bass. North American Journal of Fisheries Management 17: 557-567.

Post, D., J. Kitchell, and J. Hodgson. 1998. Interactions among adult demography, spawning date, growth rate, predation, overwinter mortality, and the recruitment of largemouth bass in a northern lake. Canadian Journal of Fisheries and Aquatic Science 55:2588-2600.

Quinn, S. 1996. Trends in regulatory and voluntary catch-and-release fishing. Pages 152-162 in L. E. Miranda and D. R. DeVries, editors. Multidimensional approaches to reservoir fisheries management. American Fisheries Society, Symposium 16, Bethesda, Maryland.

Raffeto, N. S., J. R. Baylis, and S. L. Serns. 1990. Complete estimates of reproductive success in a closed population of smallmouth bass (*Micropterus dolomieu*). Ecology 71:1523-1535.

Rice, J. A., J. E. Breck, S. M. Bartell, and J. F. Kitchell. 1983. Evaluating the constraints of temperature, activity, and consumption on growth of largemouth bass. Environmental Biology of Fishes 9:263-275.

Ricker, W. E. 1954. Stock and recruitment. Journal of the Fisheries Research Board of Canada 11:559-623.

Ridgway, M.S. and T.G. Friesen. 1992. Annual variation in parental care in smallmouth bass, Micropterus dolomieu. Environmental Biology of Fishes 35:243-255.

Ridgway, M.S. 1988. Developmental stage of offspring and brood defense in smallmouth bass Micropterus dolomieu. Canadian Journal of Zoology 66 (8) : 1722-1728.

Rieger, P. W., and R. C. Summerfelt. 1978. An evaluation of the introduction of Florida largemouth bass into an Oklahoma reservoir receiving a heated effluent. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 30:48-57.

Rutherford, E. S. 2002. Fishery management. Pages 206-221 in L. A. Fuiman and R. G. Werner, editors. Fishery Science: the unique contributions of early life stages. Blackwell Publishing, Oxford, UK.

Ryan, M. J., M. A. Webb, and L. T. Fries. 1996. Contribution of largemouth bass reared in nursery ponds to year classes in two Texas reservoirs. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 50:131-138.

Santucci, V.J.Jr., and D.H. Wahl. 1993. Factors influencing survival and growth of stocked walleye in a centrarchid-dominated impoundment. Canadian Journal of Fisheries and Aquatic Sciences 50:1548-1558.

Schramm, H. L. and nine coauthors. 1991a. The status of competitive sport fishing in North America. Fisheries 16(3):4-12.

Schramm, H. L.and nine coauthors. 1991b. Sociological, economic, and biological aspects of competitve fishing. Fisheries 16(3):13-21.
Schramm, H.L. Jr., P.J. Haydt, and K.M. Portier. 1987. Evaluation of prerelease, postrelease, and total mortality of largemouth bass caught during tournaments in two Florida lakes. North American Journal of Fisheries Management 7(3) 394-402.
Shupp, B. D. 1979. 1978 status of bass fishing tournaments in the United States. Fisheries 4(6):11-19.
Stahl, T. P., and R. A. Stein. 1994. Influence of larval gizzard shad (Dorosoma cepedianum) density on piscivory and growth of young-of-the-year saugeye (Stizostedion vitreum x S. canadense). Canadian Journal of Fisheries and Aquatic Sciences 51:1993-2002.
Stockwell, J. D., P. J. Diodati, and M. P. Armstrong. 2002. A bioenergetics evaluation of the chronic stress hypothesis: can catch-and-release fishing constrain striped bass growth? American Fisheries Society Symposium 30:144-147.
Stone, C. C. and T. Modde. 1982. Growth and survival of largemouth bass in newly stocked South Dakota ponds. North America Journal of Fisheries Management 4:326-333.
Suski, C. D., S. S. Killen, M. B. Morrissey, S. D. Lund, and B. L. Tufts. 2003. Physiological changes in largemouth bass caused by live-release angling tournaments in southeastern Ontario. North American Journal of Fisheries Management 23:760-769.
Szendrey, T. A., and D. H. Wahl. 1996. Size-specific survival and growth of stocked muskellunge: effects of predation and prey availability. North American Journal of Fisheries Management 16:395-402.
Terre, D. R., S. J. Magnelia, and M. J. Ryan. 1993. Year class contribution of genetically-marked Florida x northern largemouth bass stocked into three Texas reservoirs. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 47:622-632.
Turner, A.M., and J.C. Trexler. 1997. Sampling aquatic invertebrates from marshes: evaluating the options. Journal of the North American Benthological Society 16:694-709.
Van Den Avyle, M. J., and J. E. Roussel. 1979. Evaluation of a simple method for removing food items from live black bass. Progressive Fish-Culturist 42: 222–223.
Wahl, D.H. and R.A. Stein. 1989. Comparative vulnerability for three esocids to largemouth bass predation. Canadian Journal of Fisheries and Aquatic Sciences. 46:2095-2103.
Wahl, D.H., R.A. Stein, and D.R. Devries. 1995. An ecological framework for evaluating the success and effects of stocked fishes. American Fisheries Society Symposium 15:176-189.
Weathers, K.C., and M.J. Newman. 1997. Effects of organizational procedures on mortality of largemouth bass during summer months. North American Journal of Fisheries Management 17(1) 131-135.
Wilde, G. R. 1998. Tournament-associated mortality in black bass. Fisheries 23(10):12-22.

Wilde, G. R., D. W. Strickland, K. G. Ostrand, and M. I. Muoneke. 1998. Characteristics of Texas black bass fishing tournaments. North American Journal of Fisheries Management 18:972-977

Wydoski, R. and L. Emery. 1983. Tagging and marking. Pages 215-238, in L.A. Nielsen and D. L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Table 2-1. Lake size and stocking densities for 15 Illinois lakes stocked annually in July and August with fingerling largemouth bass from 1999 - 2001. Information is based on the mean of stockings in each reservoir. CPUE was determined from fall and spring AC electrofishing transects in each lake for young-of-year (YOY) in fall after stocking and the following spring, juvenile (age-1) the following fall and adults (> 250 mm) in subsequent years through age-5.

Lake	Size (ha)	Stocking Density #/ha	# Stocked	Stocked Mean CPUE (#/hr)				Natural Mean CPUE (#/hr)		
				YOY Fall	YOY Spring	Juvenile Fall	Adult	YOY Fall	YOY Spring	Adult
Bloomington	250	60	15000	5.1	0.7	0.2	0.0	42.9	5.1	26.7
Charleston	113	60	6780	6.0	0.9	0.1	0.1	6.0	8.3	8.7
Forbes	212	60	12720	4.7	5.3	0.7	0.8	19.1	9.2	15.2
Homer	32	60	1920	0.7	0.5	0.1	0.0	22.4	10.2	17.7
Jacksonville	198	59	11682	7.5	12.6	3.2	0.6	10.5	6.1	17.0
Kakusha	21	73	1533	3.8	1.3	0.7	0.5	45.0	7.5	12.3
LeAquaNa	16	71	1136	3.4	2.7	0.1	0.1	10.8	10.7	12.2
McLeansboro	30	60	1800	3.6	4.4	0.9	0.8	11.6	6.4	7.0
Mingo	69	60	4140	2.7	0.8	0.8	0.1	20.0	10.8	11.2
Murphysboro	58	60	3480	3.3	3.9	1.6	0.6	18.6	7.9	12.3
Pierce	66	60	3960	14.3	12.7	2.0	0.4	61.4	24.4	18.2
Sam Parr	73	60	4380	4.2	4.2	3.3	2.0	20.7	14.5	13.9
Spring South	247	60	14820	0.7	1.0	0.0	0.0	15.5	11.9	25.3
Walton Park	12	107	1284	5.2	4.0	1.0	2.3	7.7	5.7	10.8
Woods	11	60	660	0.3	0.3	0.8	0.0	9.7	3.8	11.8

Table 2-2. Mean catch per unit effort of stocked and natural largemouth bass in the four stocked reservoirs in 2006.

Lake	LMB Type	Spring CPUE	Fall CPUE
Charleston	Small Fingerlings	0.0	NA
	Medium Fingerlings	0.0	NA
	Large fingerlings	0.7	NA
	Advanced Fingerlings	2.7	NA
	Unknown	1.0	NA
	Natural	2.0	NA
Homer	Small Fingerlings	0.0	0.0
	Medium Fingerlings	0.4	0.3
	Large fingerlings	1.6	0.3
	Advanced Fingerlings	1.6	0.0
	Unknown	1.2	1.3
	Natural	36.0	50.3
Mingo	Small Fingerlings	0.0	0.0
	Medium Fingerlings	0.3	0.0
	Large fingerlings	0.0	0.0
	Advanced Fingerlings	0.0	0.0
	Unknown	0.0	0.0
	Natural	33.7	40.0
Woods	Small Fingerlings	0.0	0.0
	Medium Fingerlings	0.0	0.0
	Large fingerlings	0.0	0.0
	Advanced Fingerlings	0.3	0.0
	Unknown	0.7	1.3
	Natural	17.5	34.7

Table 2-3. Catch per unit effort (#/hr of electrofishing) for age 2+ fish combined for intensive and extensive largemouth bass from three lakes stocked in previous segments.

Lake	Clipped Largemouth Bass CPUE	
	Spring 2006	Fall 2006
Jacksonville	2.33	3.33
Shelbyville	1.33	0.66
Walton Park	11.33	2.4

Table 3.1. Background frequencies (pre-stocking) of largemouth bass MDH B2:B2 genotype determined from Little Grassy Fish Hatchery and six lakes in Illinois prior to stocking from 1998 to 2001 (Table 3.1a). Fish were stocked into each of the lakes for 6 to 8 years ending in 2004. Post-stocking collections are the number of individuals taken from each of the six lakes in Illinois during 2003 through 2006. Post Stocking allele frequencies are calculated for the MDH B2 allele for each of the six lakes from 2003 to 2005 (Table 3.1b).

Table 3.2a

Lake	N			Allele Frequency	
	1:1	1:2	2:2	1	2
Forbes	81	49	28	0.67	0.33
McClean	23	34	32	0.45	0.55
Murphy	80	12	6	0.88	0.12
Sam Parr	75	16	10	0.82	0.18
Shelby	158	45	8	0.86	0.14
Walton	66	11	8	0.84	0.16

Table 3.1b

Lake	2003			2004			2005			2006
	N	1	2	N	1	2	N	1	2	N
Forbes	94	0.59	0.41	125	0.58	0.42	85	0.61	0.39	100
McClean	87	0.53	0.47	100	0.49	0.51	100	0.44	0.56	61
Murphy	112	0.73	0.27	87	0.80	0.20	66	0.70	0.30	84
Sam Parr	100	0.77	0.23	101	0.63	0.37	67	0.53	0.47	57
Shelby	66	0.73	0.27	209	0.86	0.14	153	0.82	0.18	100
Walton	101	0.8	0.2	31	0.58	0.42	52	0.41	0.59	97

Table 4-1. Average values of secchi depth (m) and aquatic vegetation cover in spring and summer (% of lake area) in 11 study lakes in Illinois during 2006. Dashes refer to data not available when this report was written.

Lake	Secchi	Spring Veg	Summer Veg
Clinton	0.77	-	-
Forbes	0.74	-	-
Lake of the Woods	0.76	0%	1%
Lincoln Trail	2.25	12%	24%
Paradise	0.47	7%	
Pierce	0.94	25%	25%
Ridge	0.84	41%	3%
Shelbyville	1.31	-	-
Sterling	1.85	14%	17%
Walnut	0.83	2%	< 1%
Woods	0.47	0%	0%

Table 4-2. Average values of chlorophyll *a* (µg/L), spring density of crustacean zooplankton (N/L), benthos (N/m^2), total larval fish density (N/m^3), juvenile bluegill density (N/m^2), and fall abundance of gizzard shad (N/hr) in 11 study lakes in Illinois during 2006.

Lake	Chlorophyll	Zooplankton	Benthos	Larval	Juvenile Bluegill	Gizzard Shad
Clinton	23.4	15.5	4920	3.26	0.03	157
Forbes	18.4	41.3	895	7.9	0.65	14
Lake of the Woods	16.1	66.4	6008	7.74	0.25	22
Lincoln Trail	12.3	42	5991	8.81	4.86	0
Paradise	59.2	14.5	3738	2.01	0.57	276
Pierce	19.3	60.9	3249	0.5	0.38	86
Ridge	16.8	84.7	3070	0.56	4.5	0
Shelbyville	12.9	97.3	7899	0.34	0.01	920
Sterling	3.53	34	6217	0.29	0.14	1.33
Walnut	35.5	63.5	7963	18.6	0.73	0
Woods	52	31.5	5478	3.37	0.42	367

Table 4-3: Density of largemouth bass (LMB), bluegill (BLG), and total fish in each of six enclosures (3 vegetated and 3 non-vegetated) in Lincoln Trail Lake. Fish were sampled using 3-pass depletion with a backpack electrofisher.

Type	Site	Area (m^2)	LMB Density (#/m^2)	BLG Density (#/m2)	Total Fish Density (#/m2)
Vegetated	1	120	0.09	1.02	1.21
	2	90	0.03	0.50	0.06
	3	78	0.03	0.40	0.51
	Mean	96	0.05	0.64	0.59
No Veg.	1	78	0.03	0.38	0.54
	2	90	0.00	0.42	0.52
	3	72	0.01	0.15	0.27
	Mean	80	0.01	0.32	0.44

Table 5-1. Number of fish surveyed, sex ratios, average total length, and percent spawning bass from tournament catches on Mill Creek, Lake Mattoon, Lake Shelbyville, and Steven Forbes Lake during spawn and post-spawn periods from 1999 to 2005. Percent spawning are reported for males, females, and all fish caught. TL refers to the total length of the fish.

Lake	Season	N	% Male	Female TL (mm)	Male TL (mm)	Male Running (%)	Female Running (%)	Total Running (%)
Forbes	Spawn	61	57.4	453	407	54.3	80.8	65.6
	Post	32	62.5	399	439			
Mattoon	Spawn	70	58.6	454	409	73.2	100.0	84.3
	Post	45	60.0	411	385			
Mill Creek	Spawn	118	66.1	422	364	100.0	100.0	100.0
	Post	63	42.9	407	386			
Shelbyville	Spawn	145	42.1	431	382	91.8	91.7	93.0
	Post	236	49.6	424	408			

Table 5-2. The number of largemouth bass collected by spring electrofishing with verified sex identification that will be used in the analysis of life history changes due to angling exploitation of largemouth bass populations.

Lake	Number of Fish Collected
Lincoln Trail	29
Shelbyville	37
Paradise	18
Woods	19

Table 6-1. Catch per unit effort (#/hr) for largemouth bass in Clinton Lake captured through AC electrofishing. The refuge was closed in 2001 and sampling on the closed portion began in fall of 2003.

Year	Control		Refuge	
	Spring	Fall	Spring	Fall
1999	19.8	24.4	56.0	24.0
2000	32.4	5.5	18.0	0.0
2001	26.0	48.7	10.0	22.0
Refuge Closed 9-11-01				
2003	21.5	23.8	-	87.5
2004	20.7	28.3	42.0	146.0
2005	27.5	18.3	33.0	25.0
2006	14.1	18.5	24.0	50.0
2007	15.2	-	22.5	-

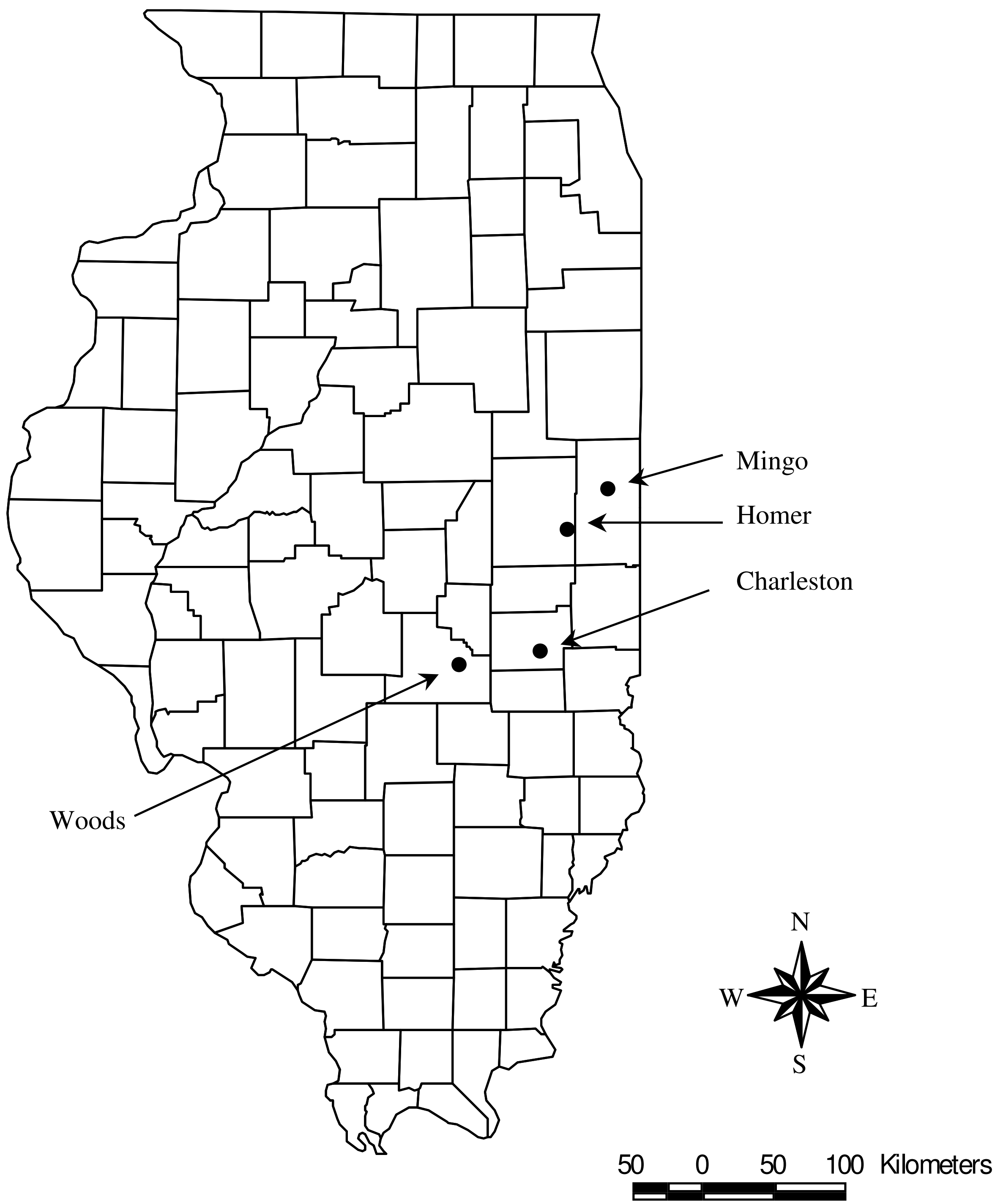


Figure 2-1. Location of 4 lakes in Illinois stocked with four sizes of fingerling largemouth bass in 1999 – 2005.

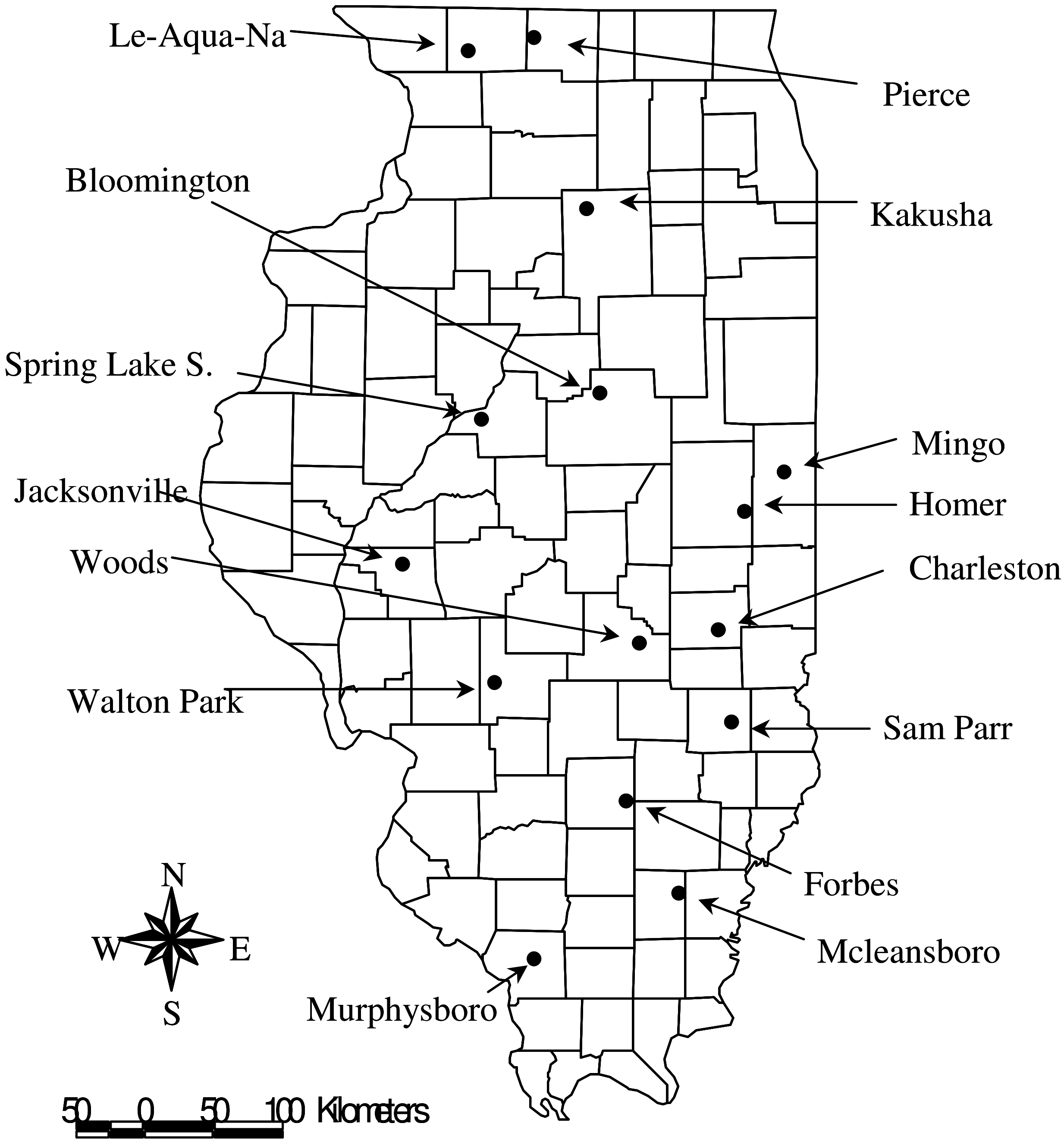


Figure 2-2. Location of 15 lakes in Illinois stocked with fingerling largemouth bass in 1999, 2000, and 2001.

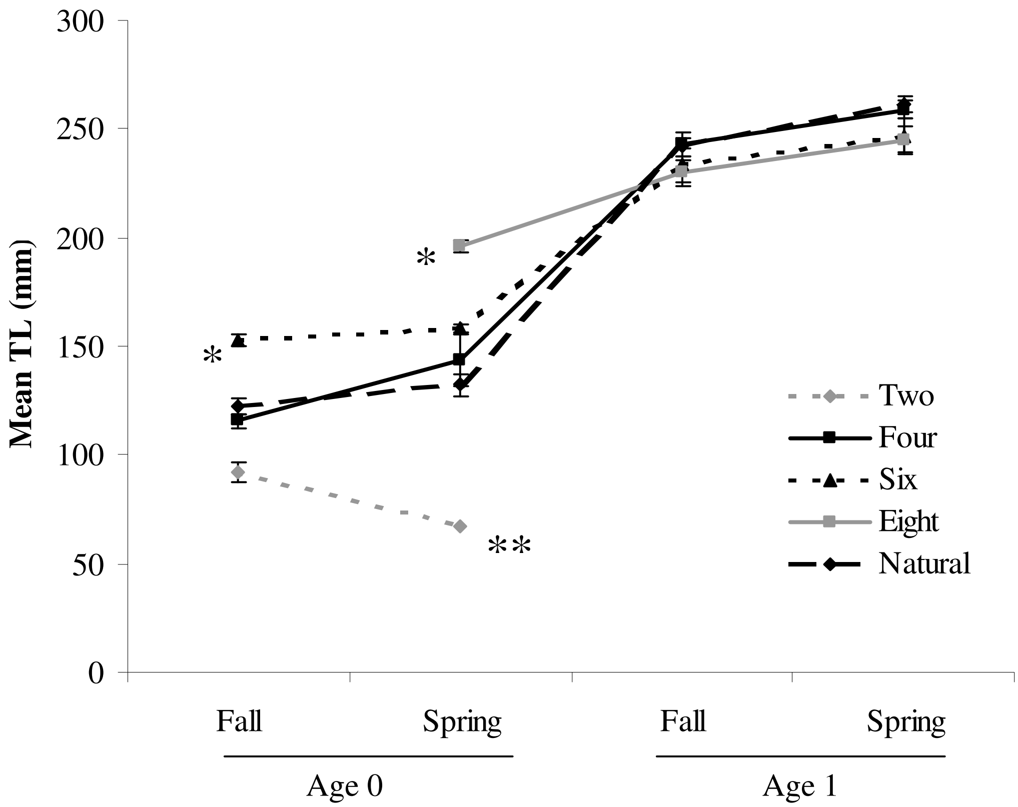


Figure 2-3. Mean total length of four sizes of stocked largemouth bass over the first two years of growth after stocking in 4 reservoirs during 1998-2006. Values are mean total length (mm) +/- 1SE in each season following stocking. Bass were collected by 3 phase AC electrofishing transects in the spring and fall. The asterisks represent a mean that is significantly different than the other means within a season.

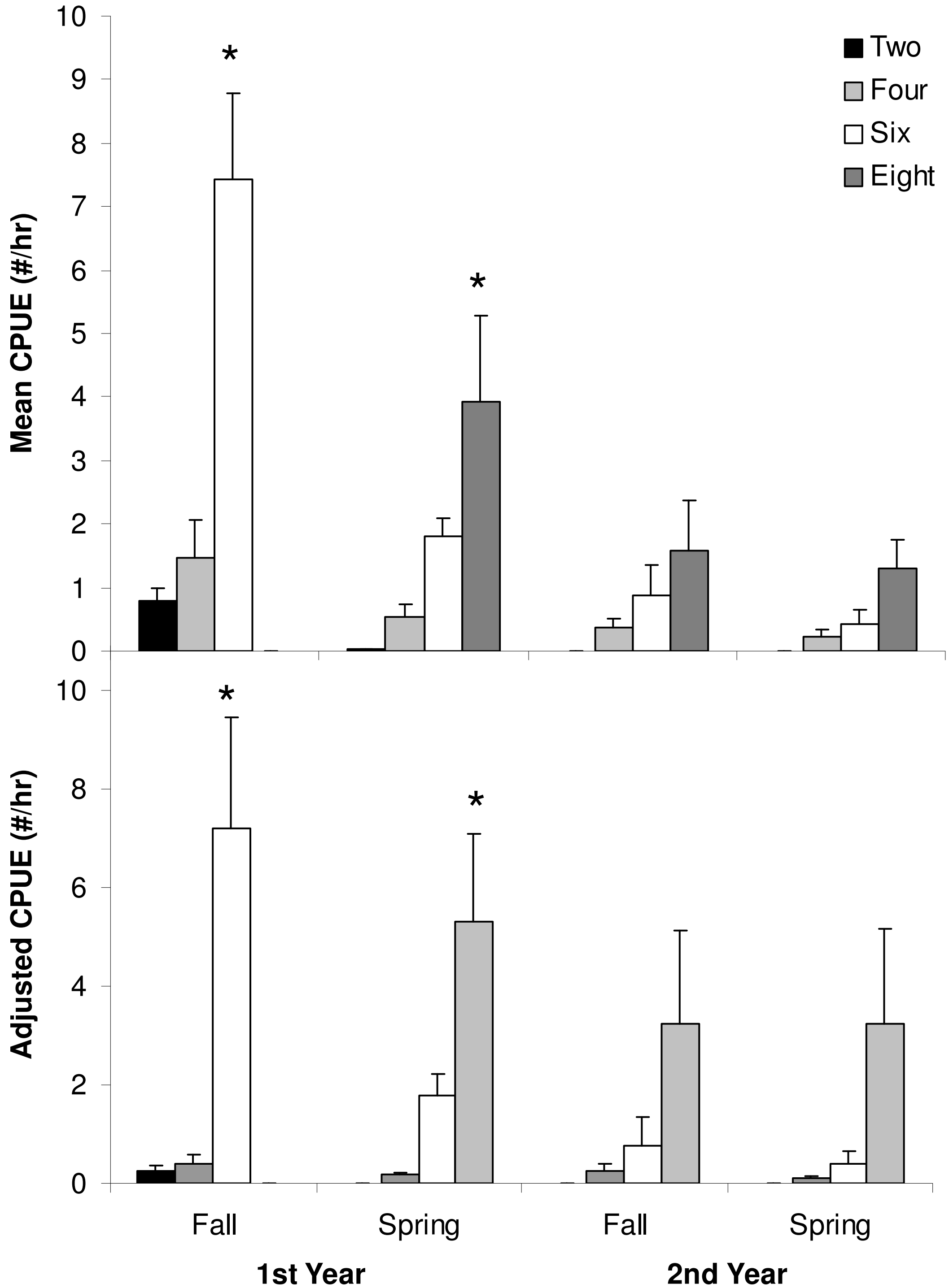


Figure 2-4. Mean catch per unit effort for lakes stocked with four sizes of largemouth bass in 1998-2006. Adjusted CPUE is calculated as the CPUE from electrofishing divided by the total number stocked multiplied by 1000. Error bars represent standard error. An Asterisk represents a significant difference within a season.

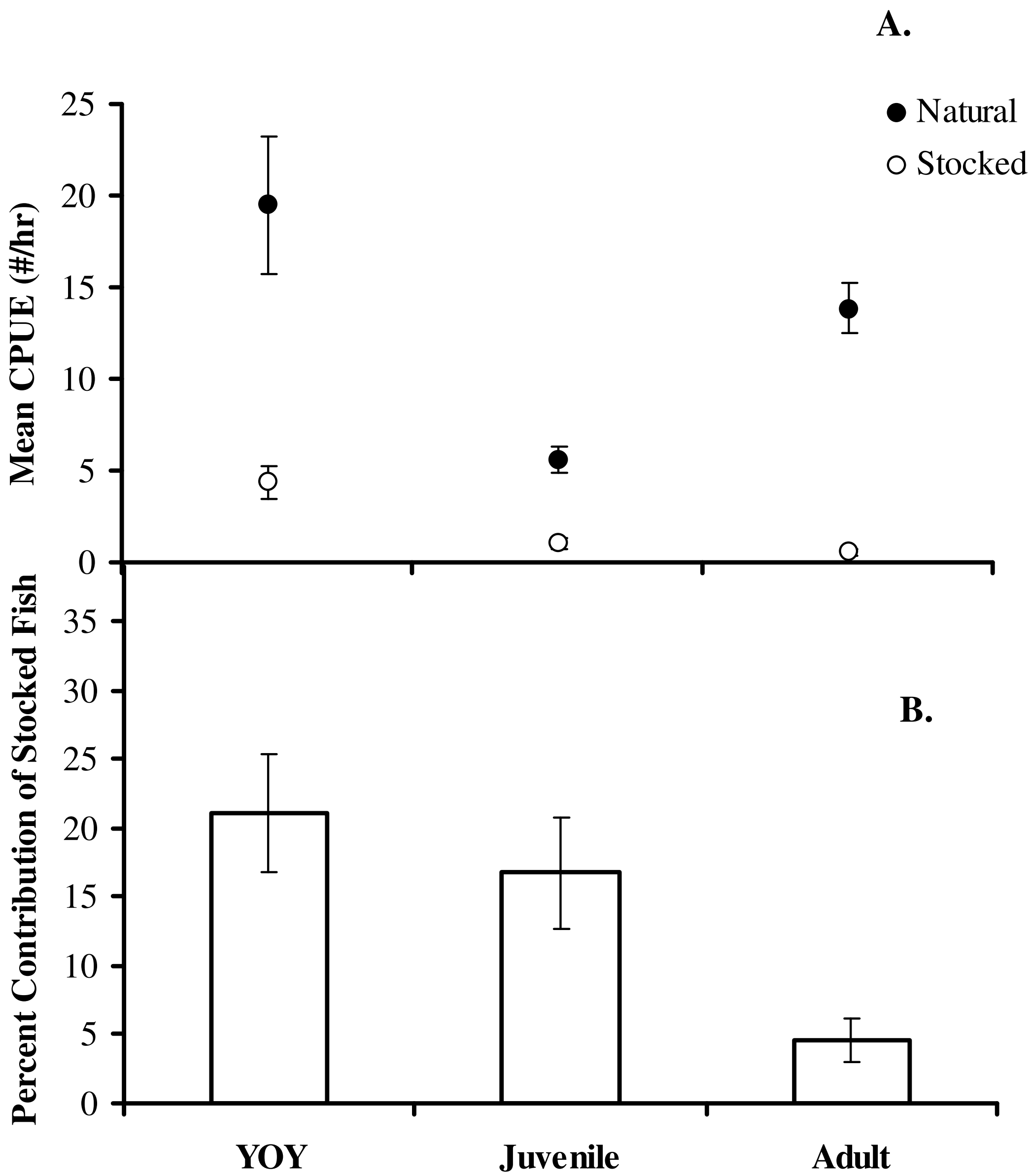


Figure 2-5. Mean CPUE (A) and percent contribution (B) of stocked and natural largemouth bass from fall electrofishing samples in 15 Illinois lakes. Lakes were stocked with 100 mm largemouth bass in July and August. Percent contribution is the CPUE of stocked bass divided by the CPUE of stocked and natural bass in the population. Error bars represent the +/- 1 SE.

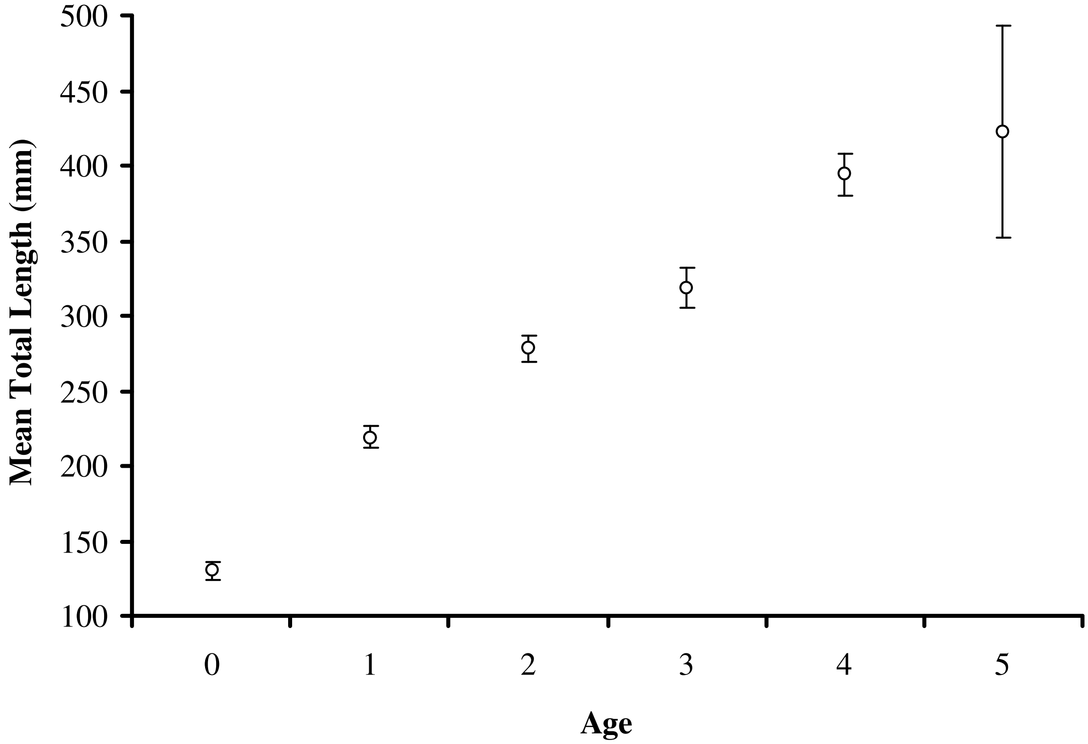
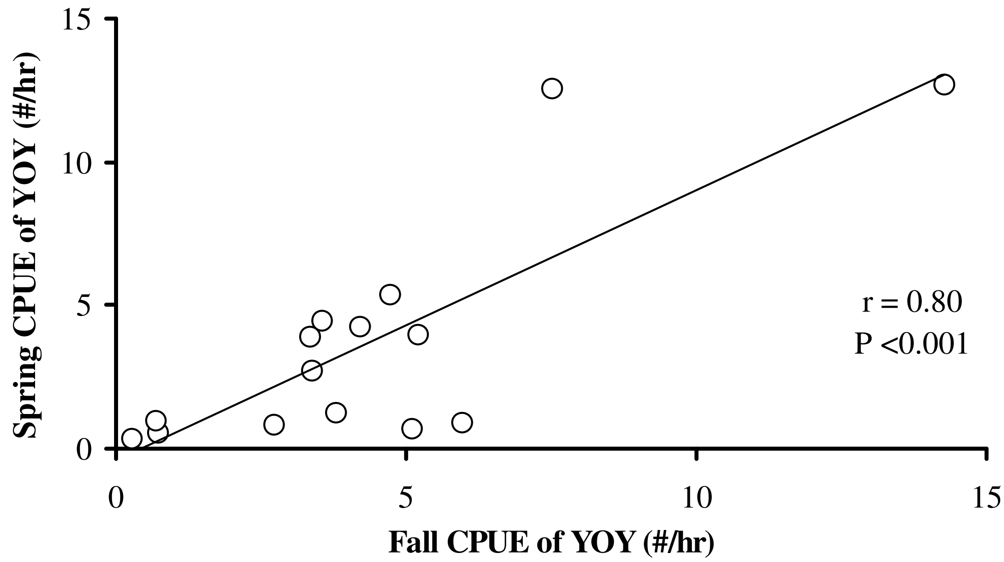


Figure 2-6. Mean total length of stocked fingerling largemouth bass from fall electrofishing from the 15 lakes in Illinois. Error bars are +/- 1 SE.



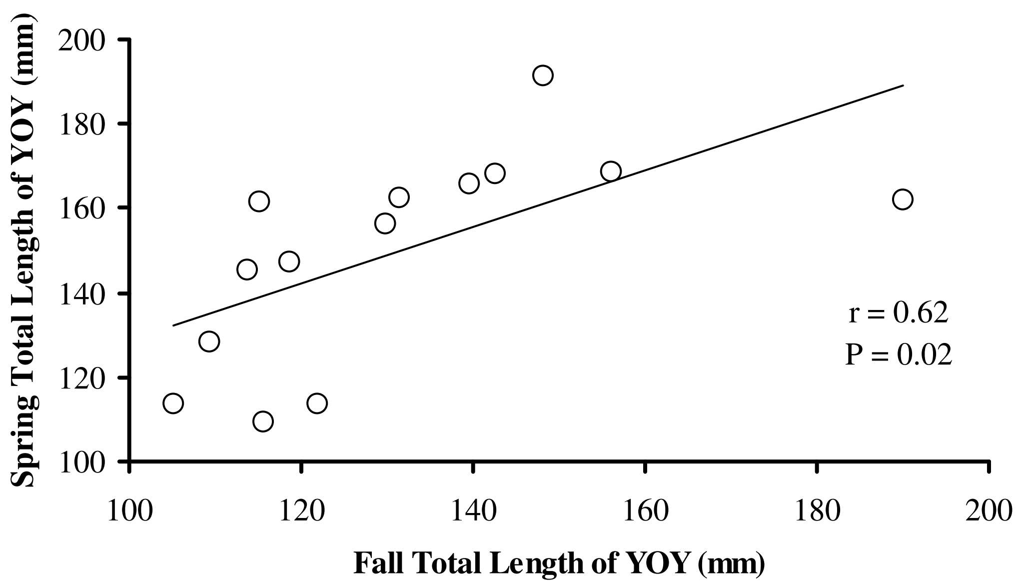


Figure 2-7. Relationship between CPUE (#/hr) and total length (mm) in the fall after stocking and the following spring of stocked largemouth bass from electrofishing samples for 15 lakes in Illinois. Values are means from three annual stockings.

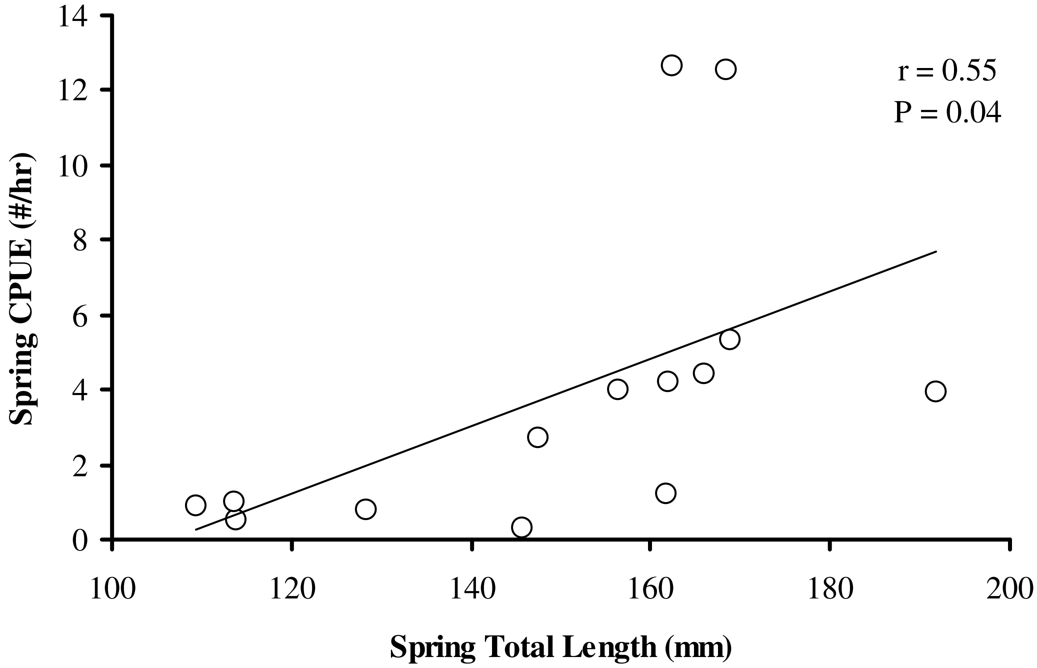


Figure 2-8. Relationship between total length and CPUE in the spring following stocking for stocked largemouth bass from electrofishing samples in 15 lakes in Illinois. Values are means from three annual stockings.

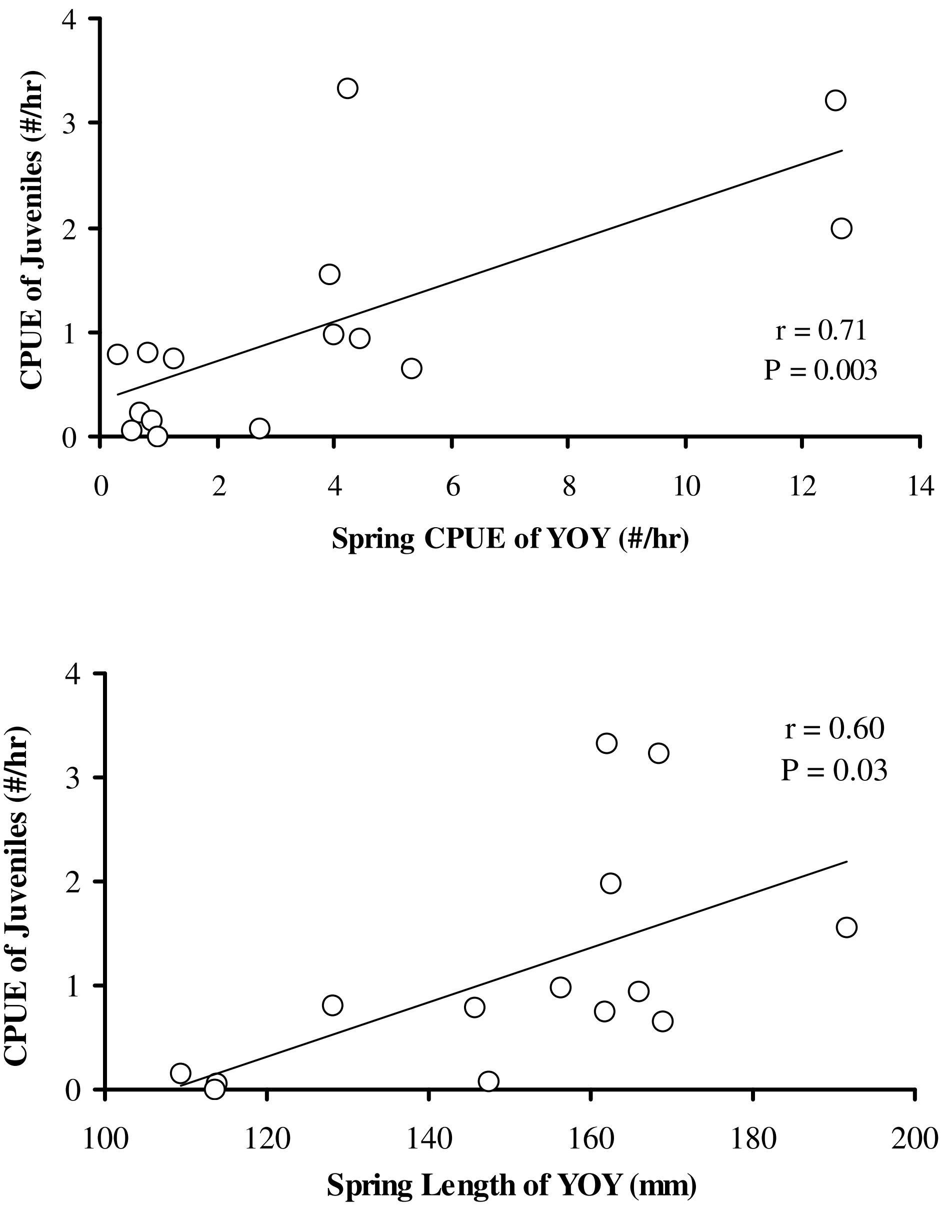


Figure 2-9. Relationship between length and CPUE (#/hr) of young-of-year (YOY) in the spring following stocking and juvenile (age-1) stocked largemouth bass collected in fall electrofishing samples in 15 lakes in Illinois. Values are means from three annual stockings.

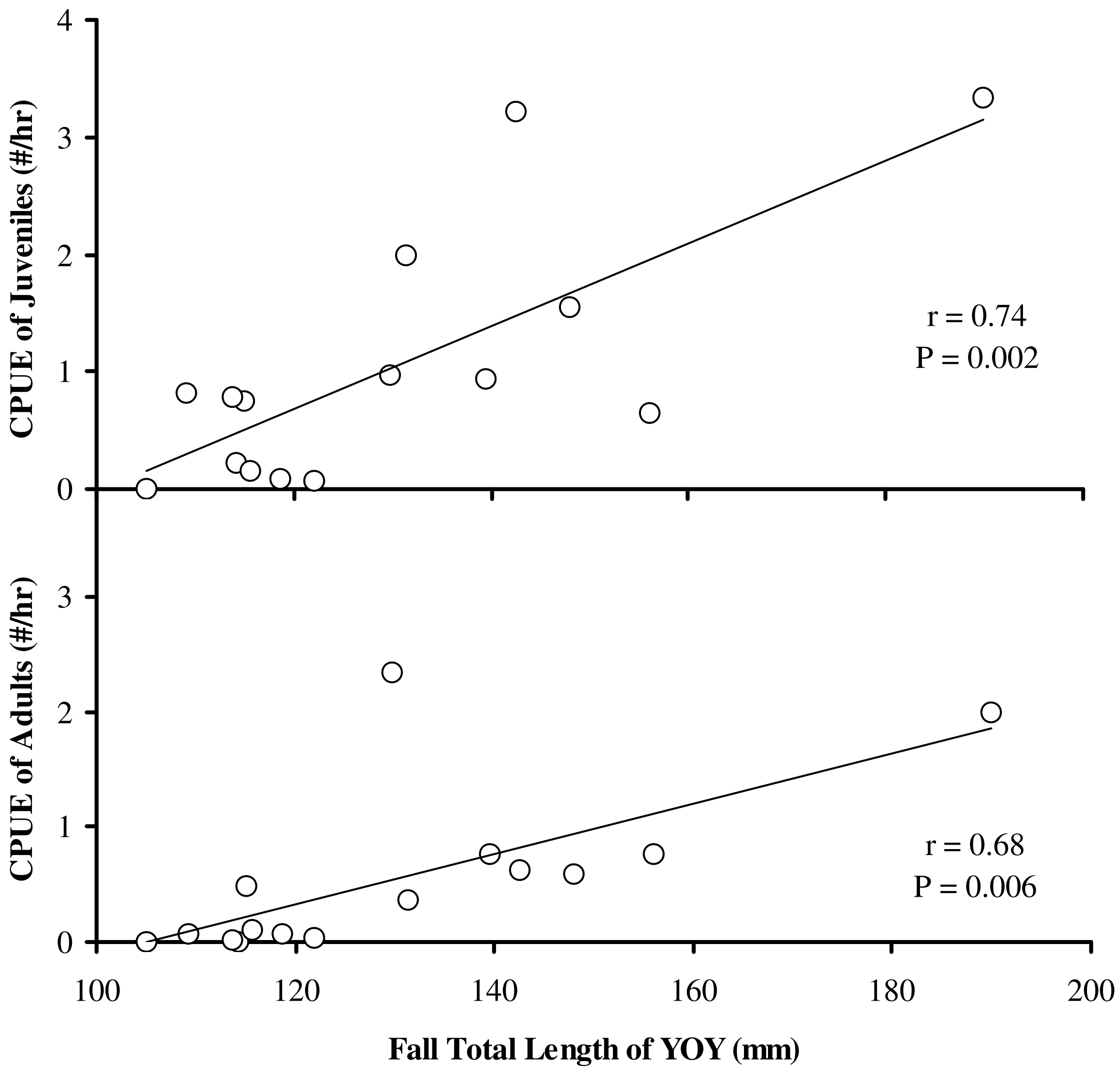


Figure 2-10. Relationship between and mean total length of young of year stocked largemouth bass in electrofishing samples in the fall following stocking and CPUE of juvenile (age 1) and adult (age 2-5) stocked largemouth bass in fall electrofishing samples in 15 lakes in Illinois. Values are means from three annual stockings.

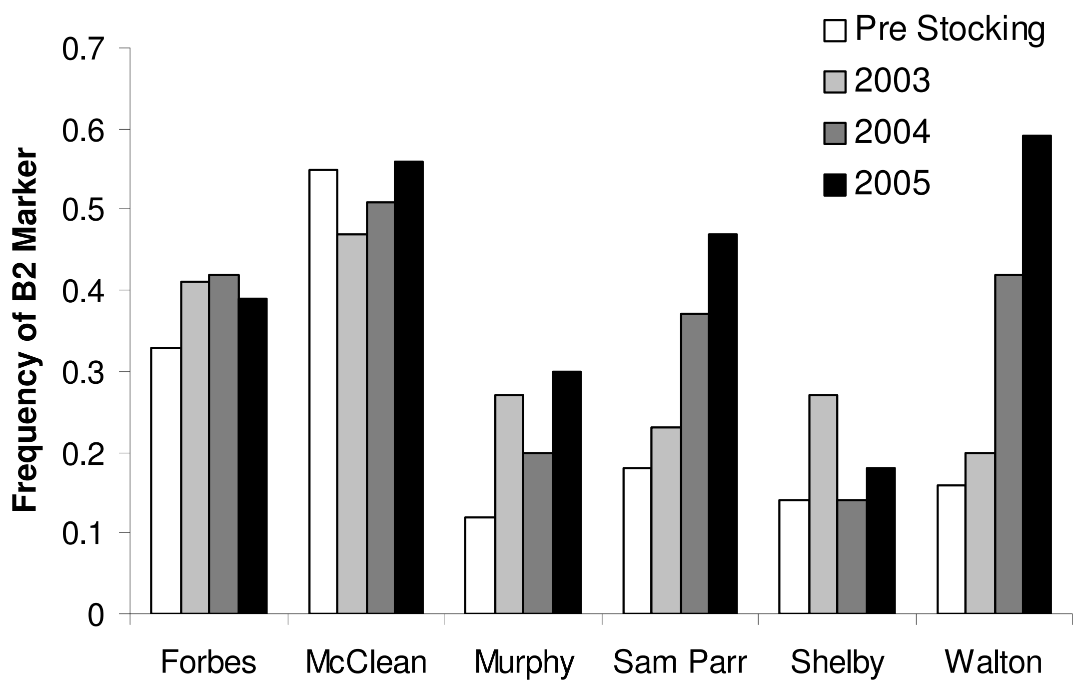


Figure 3-1: Frequency of the B2 allele in the six study lakes previous to stocking and in 2003-2005 during which stocked bass were expected to begin reaching reproductive age.

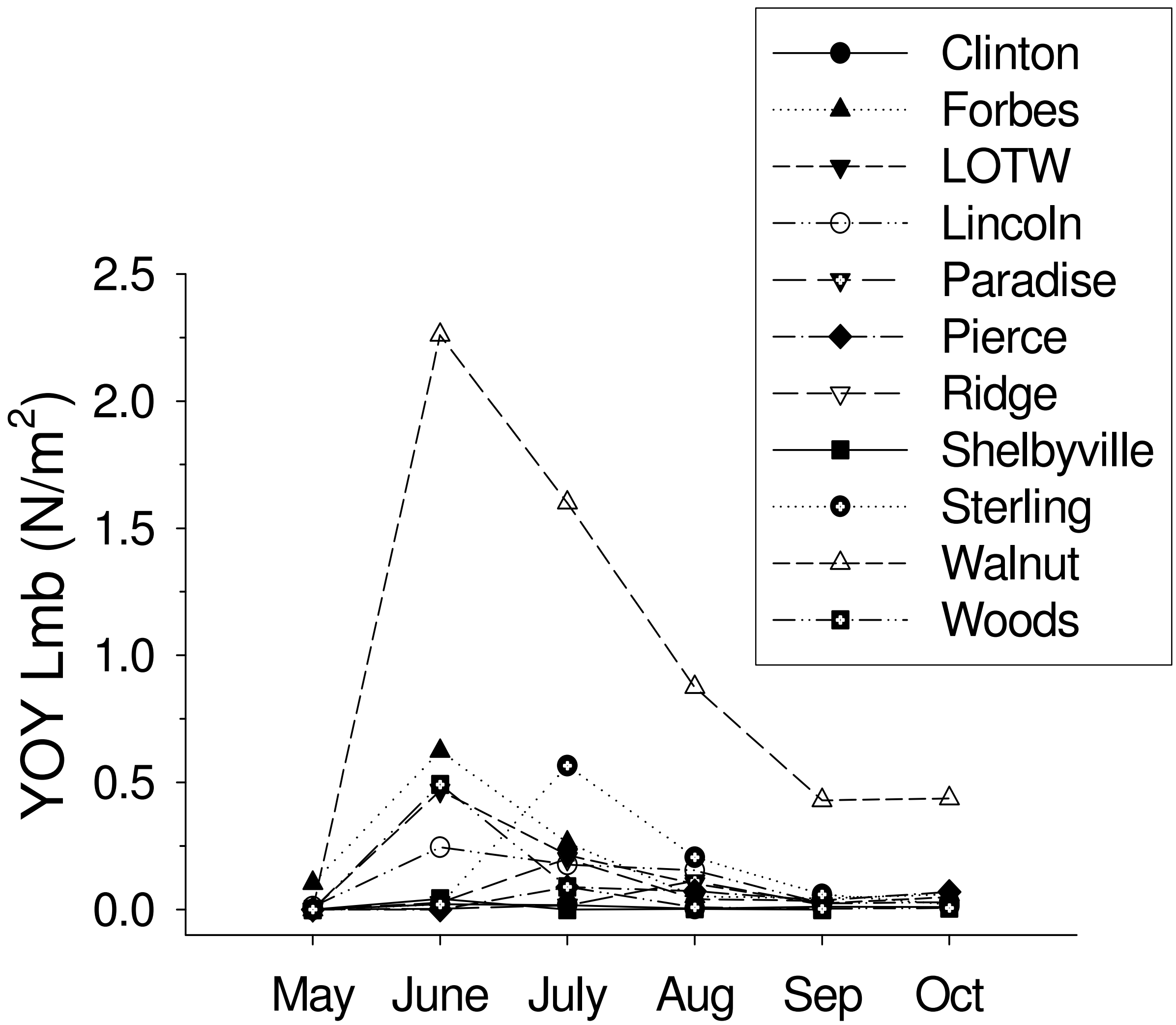


Figure 4-1. Average monthly young of the year (YOY) largemouth bass densities (N/m2) for 11 study lakes in 2006. YOY largemouth bass were collected with a 9.2-m bag seine at 4 fixed stations in each reservoir. Closed symbols represent lakes with gizzard shad and open symbols represent reservoirs without gizzard shad.

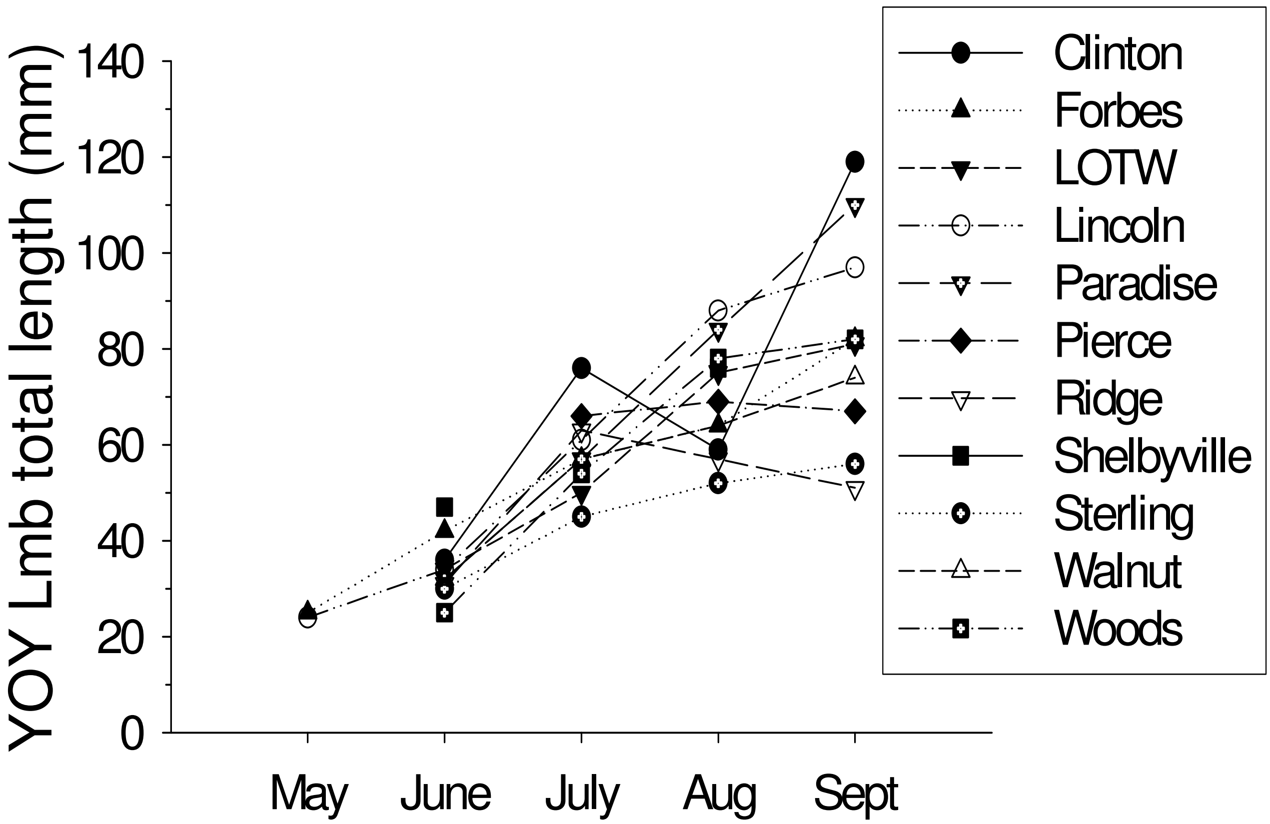


Figure 4-2. Monthly averages of YOY largemouth bass total lengths (mm) in 11 reservoirs in 2006. Fish were collected with a 9.2-m bag seine from 4 fixed stations in each lake. Open symbols represent lakes without gizzard shad.

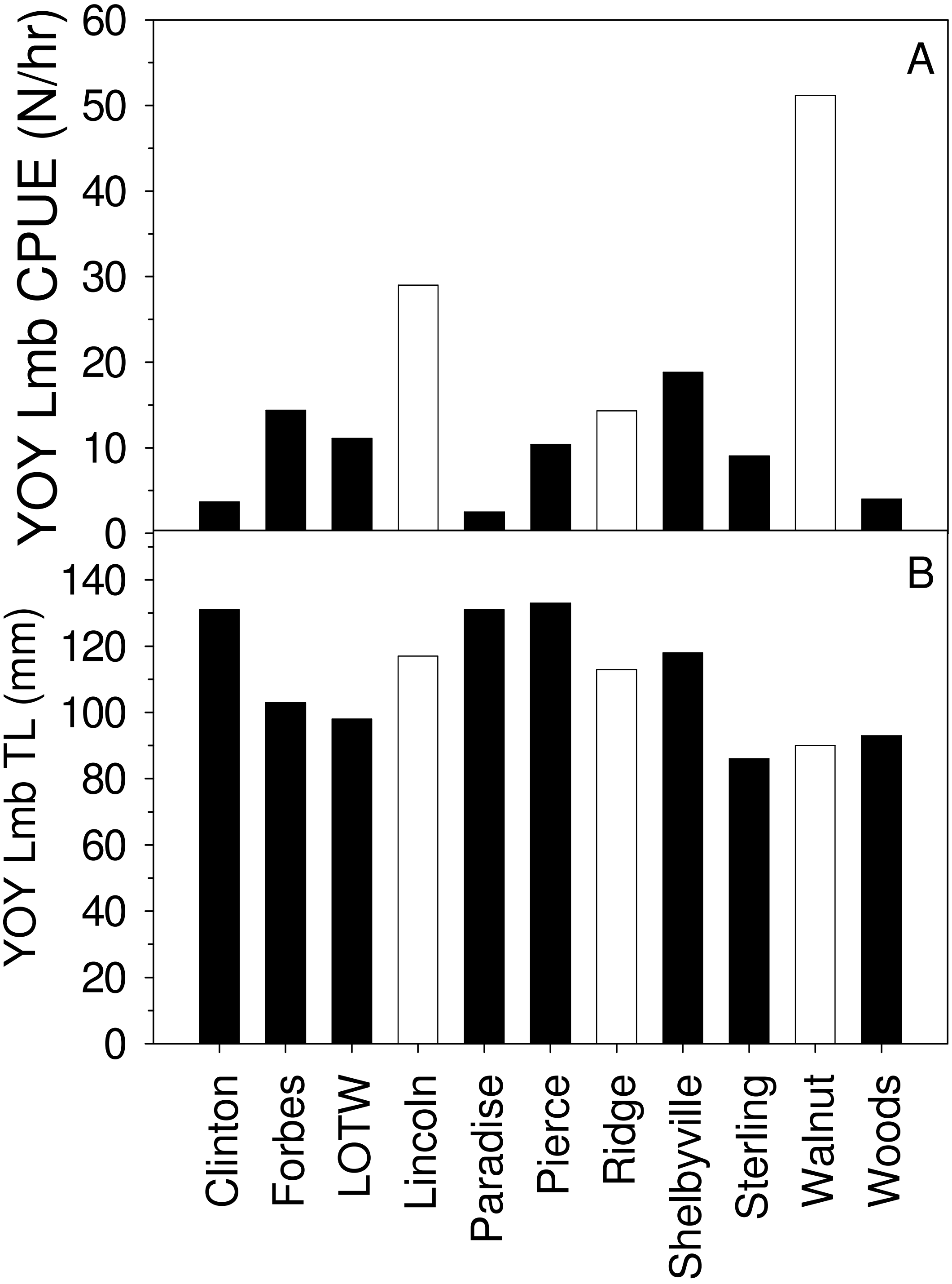


Figure 4-3. (A) Catch per unit effort (N/hr) and (B) total length of YOY largemouth bass at the end of the growing season in 11 reservoirs. Fish were collected by use of A.C. electrofishing along three shoreline transects. Open bars are lakes without gizzard shad.

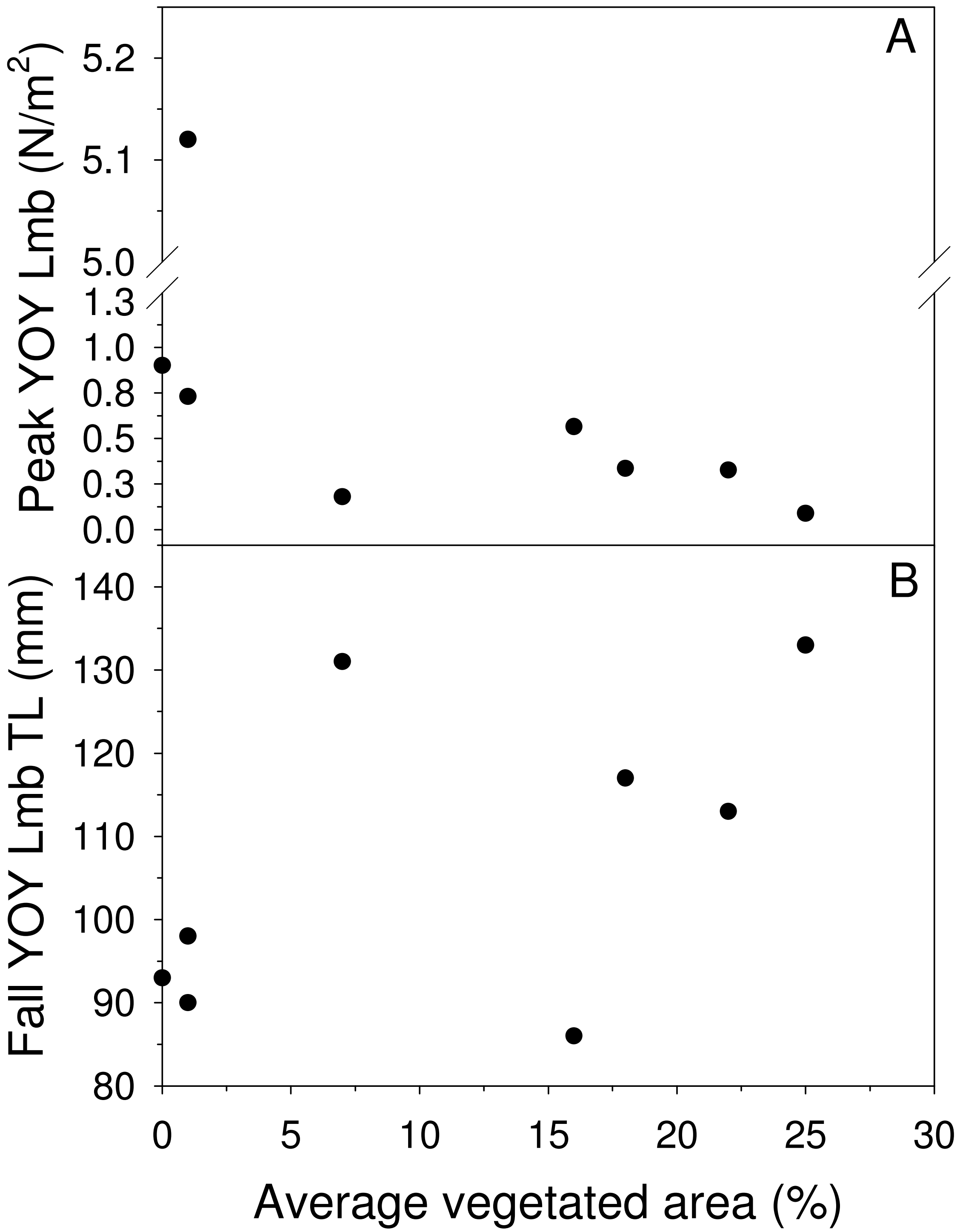


Figure 4-4. Average % vegetated area and (A) peak density of YOY largemouth bass and (B) fall total length (mm) of YOY largemouth bass.

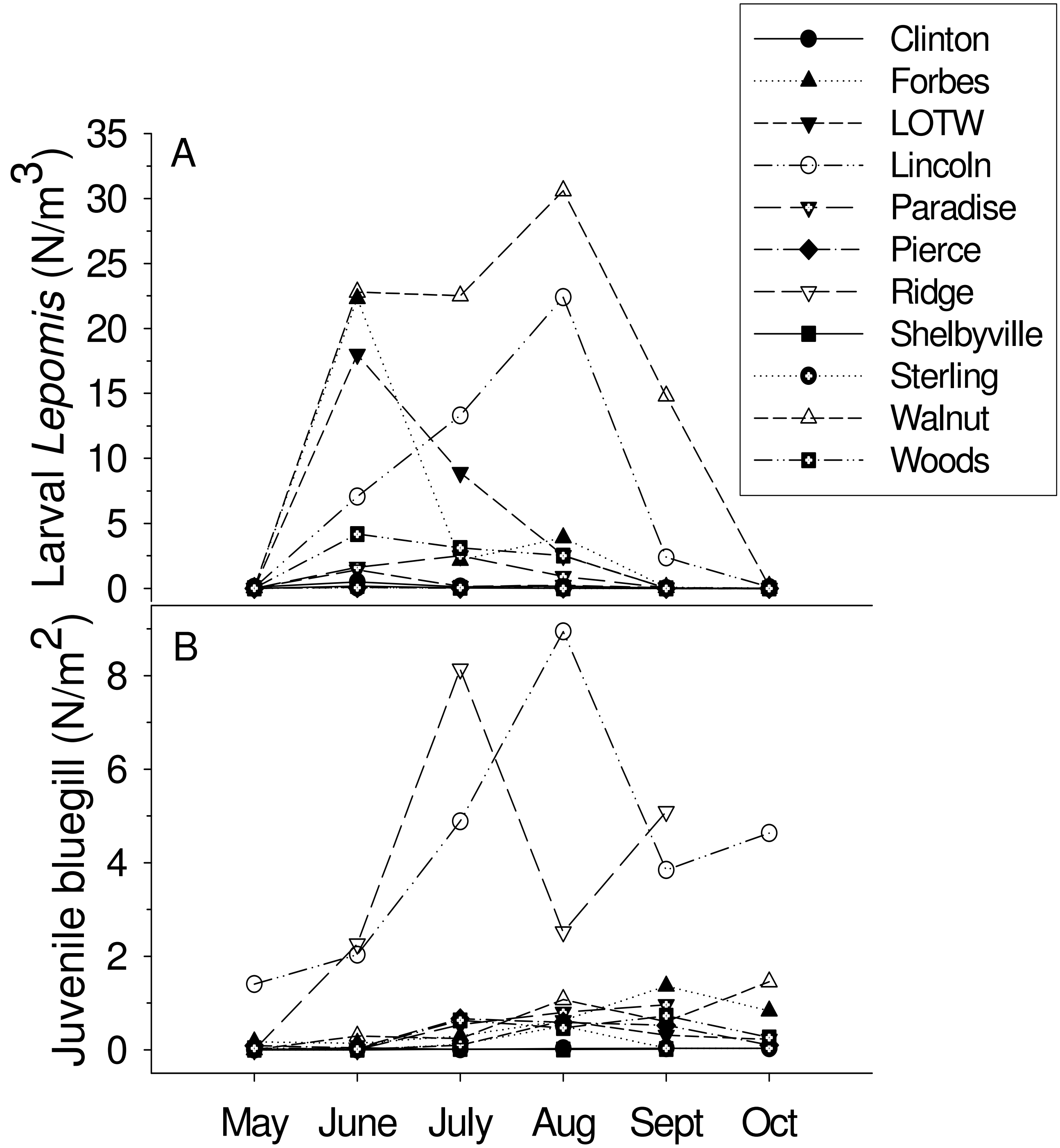


Figure 4-5. Average monthly densities of (A) larval Lepomis (N/m3) and (B) juvenile bluegill (TL ≤ 60 mm TL; N/m2). Larval fish were collected with a 0.5-m diameter push net with 500-mm mesh at six fixed stations and juvenile bluegill were collected with a 9.2-m bag seine pulled at four fixed stations. Lakes with open symbols do not contain gizzard shad.

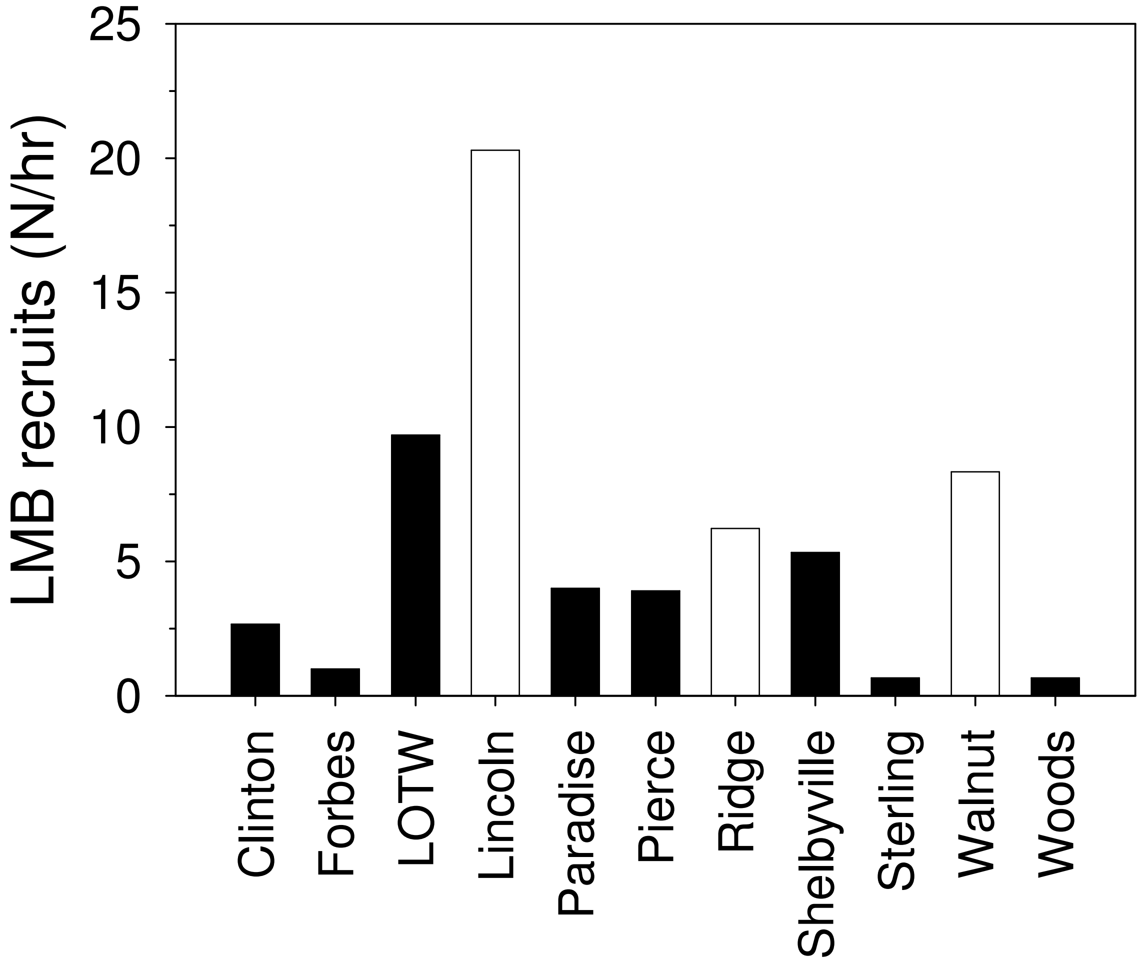


Figure 4-6. Catch per unit effort (N/hr) of largemouth bass recruited to age-1 in 11 reervoirs in spring of 2007. Fish were collected by A.C. electrofishing along three shoreline transects for a 0.5-hr each. Open bars represent lakes without gizzard shad.

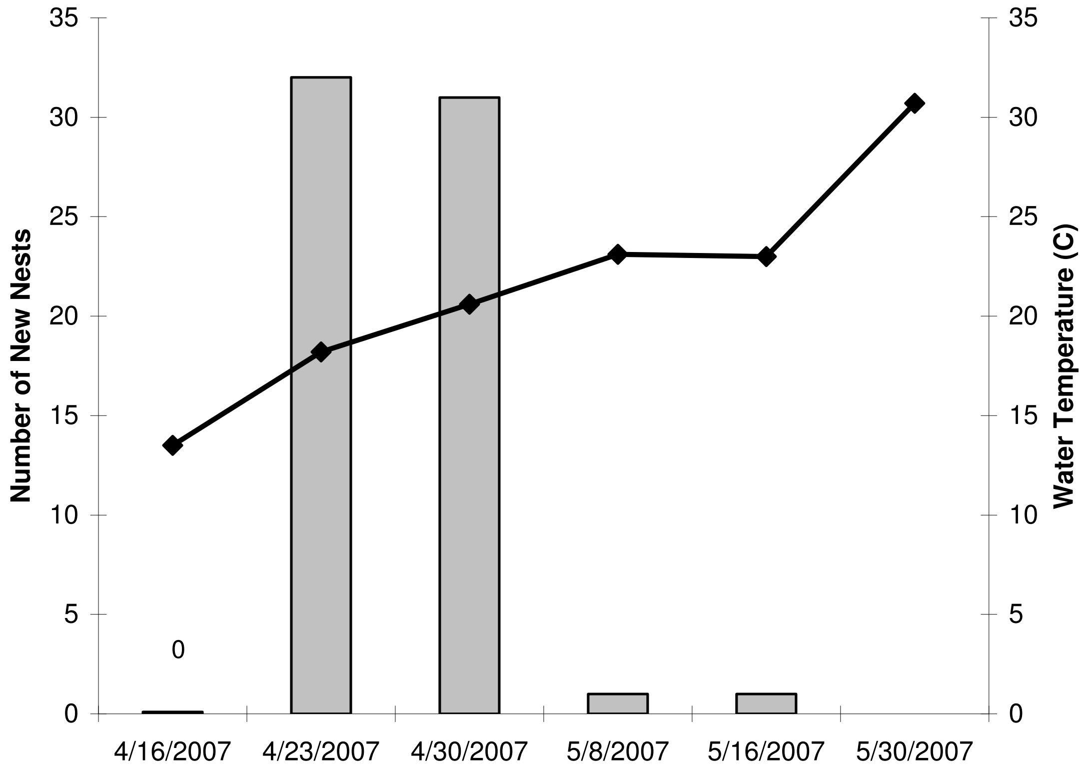


Figure 5-1. Number of new largemouth bass nests (bars) and water temperature (line, ^{o}C) over time in Lincoln Trail reservoir during spring 2007.

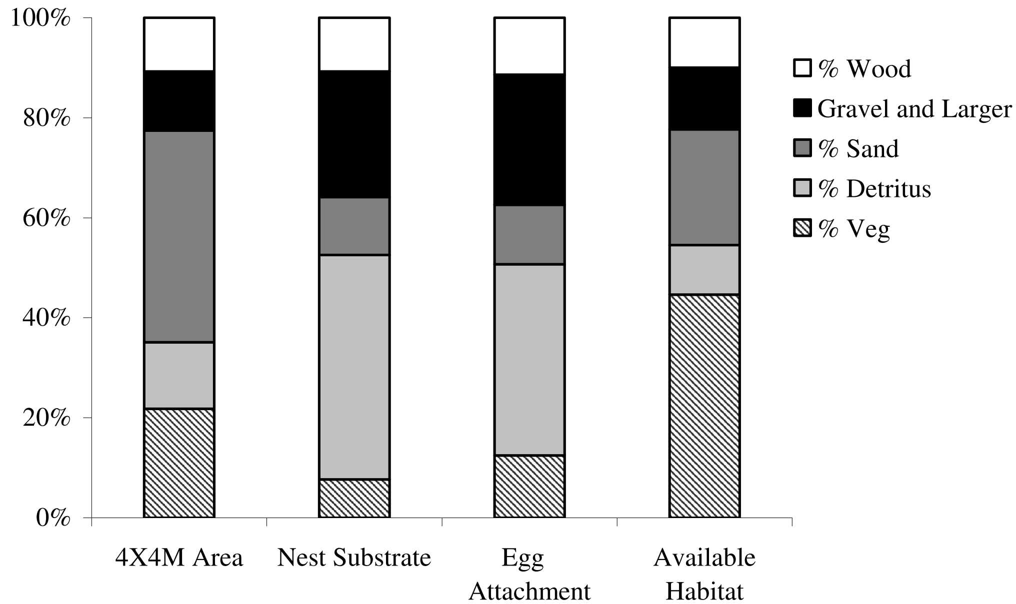


Figure 5-2. Proportion of cover in the 4 by 4 meter area surrounding a nest, the nest (Nest Substrate), the substrate the eggs were attached to in a nest (Egg Attachment) and the habitat available throughout the littoral zone of snorkeling transects (Available Habitat). Gravel and larger is the sum of gravel, cobble and pebble and Detritus is the sum of leaves, sticks, and detritus.

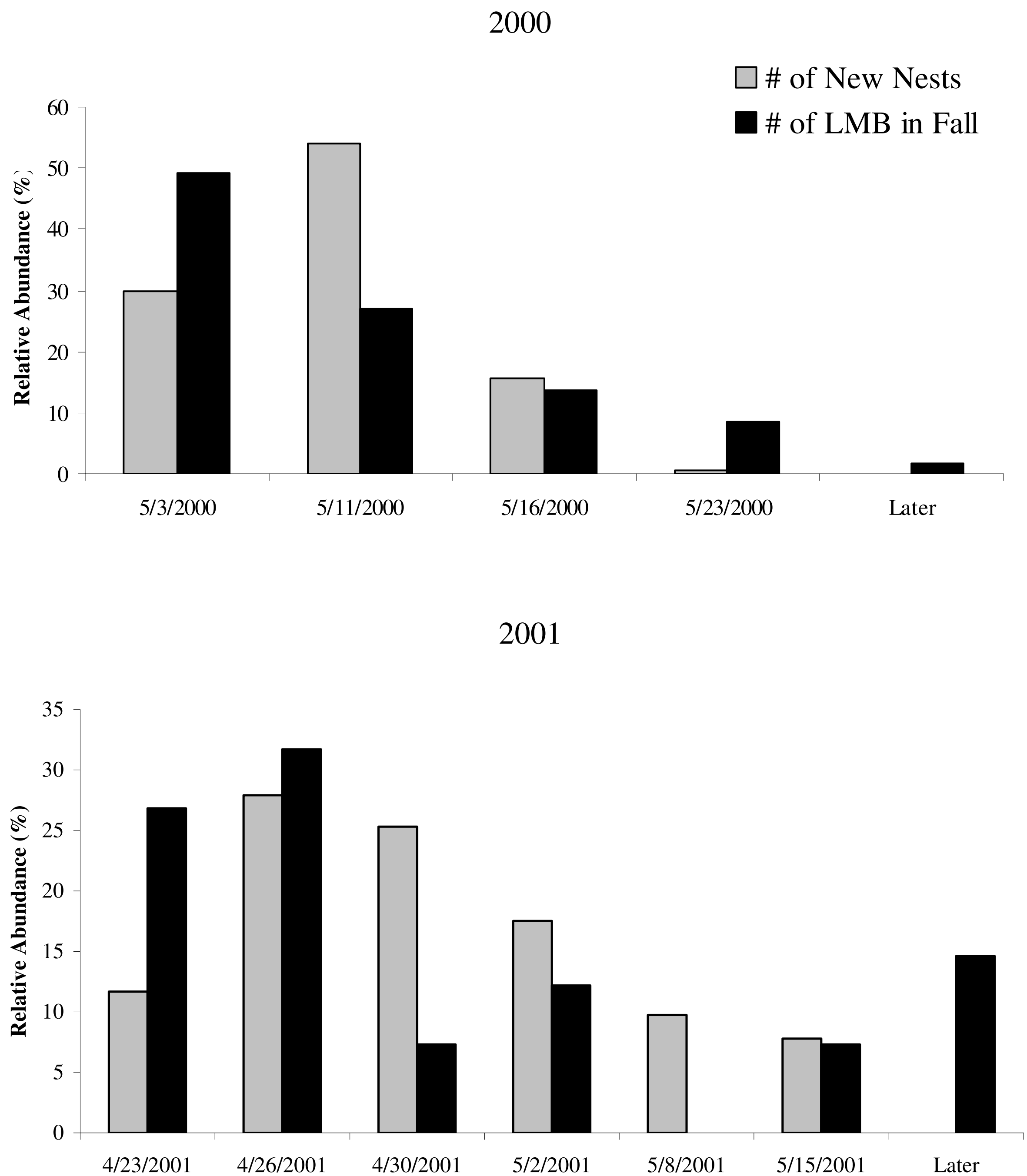


Figure 5-3. Number of new nests on each date from snorkeling samples in spring and the number of fish back calculated to that spawning date. Back calculating was done through reading daily rings from otoliths of young-of year largemouth bass collected in fall seine samples.