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

M.J. Diana, J.J. Parkos III, M.A. Nannini, A.J. Pope, M.M. Vanlandeghem, C.S. Deboom, J.A. Stein, B.P. Olds, L.M. Einfalt, J.E. Claussen, D.P. Philipp, and D.H. Wahl

Submitted to
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Illinois Department of Natural Resources
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David H. Wahl
Principle Investigator

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Michael Douglas,
Director
Division of Ecology and
Conservation Sciences

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David P. Philipp
Co-investigator

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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. 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 fall of 2007 and spring of 2008. 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 remaining in Woods Lake in 2007 or 2008, however there were stocked fish collected in Lake Charleston, Mingo and Homer. We observed very few stocked largemouth bass remaining and will conclude our sampling for long-term survival with this segment.

Data from this segment were combined with previous segments in order to assess differences in growth and survival with varying stocking size. 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 without increasing survival. As a result, we recommend stocking four inch bass because small fingerlings do not survive well and no differences in long-term survival exist between medium, large, and advanced fingerlings.

In this segment we also continued to evaluate long-term survival and growth of intensively and extensively reared stocked fish. Thus far, no differences in survival have been observed between intensively and extensively reared fish in any of the three study reservoirs. However, the relative survival of intensively and extensively reared largemouth bass did vary between lakes. We are no longer collecting significant numbers of stocked fish in any of the three lakes stocked with intensive and extensively reared fish and sampling was concluded in this segment. Scales were collected from adult fish in electrofishing samples and were aged during this segment by two independent readers. These age data will be used to assign a rearing type to each stocked fish that was collected and will be used to evaluate the long-term survival differences of the fish reared from these different techniques in the next segment. Based on our results thus far, the usefulness of supplemental stocking as a management strategy will vary by individual lake.

We initiated a new stocking experiment in this segment to examine the relative advantages of point and dispersed stocking of largemouth bass. We stocked four lakes by both stocking at the boat ramp and stocking into habitat at locations around the lake. We observed very low survival to the first fall for stocked fish regardless of stocking strategy. Future stockings will be needed to assess differences in survival and growth.

In this segment, we also evaluated the long-term contribution of four-inch stocked largemouth bass 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 adults resulting in small contributions to the population. Our results suggest limited contribution of stocked fish to adult largemouth bass populations and the size of stocked fish in the first fall following stocking is related to higher CPUE of adult fish. Substantial mortality exists between the age-1 and adult ages of stocked largemouth bass which differs from wild fish that experience low mortality following the first fall. 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.

The objective of Job 101.3 is to evaluate the survival and reproductive success of stocked largemouth bass to resident populations. 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 reached 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 2007 were collected from each of the six study lakes and their allele frequencies determined for the MDH B2 allele. Although it is still early to fully evaluate the effects of stocking, five of the six lakes do show an increase in the MDH B2 allele. Stocking contribution appears to be high in small lakes, but relatively low in larger ones. 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 which abiotic and biotic factors are associated with variation in recruitment of largemouth bass to age 1. We used the results from previous segments to construct lake-specific regression models of largemouth bass recruitment and then tested their accuracy with data from this segment (2007 year class). In general, differences among lakes in mean recruitment were related to survival of young-of-the-year (YOY) to fall, implying that year class strength differences are set prior to winter. For each individual lake, reproductive output (i.e., spawning stock abundance, peak YOY density) or abundance of larval and juvenile bluegill sunfish were included in models predicting recruitment strength. Lakes where bluegill abundance was not included in recruitment models had very productive bluegill populations; therefore, recruitment in these systems was not limited by prey fish abundance. These models generally overestimated abundance of age 1 recruits in the 2007 year class, but were accurate at predicting if a lake would have either below or above average year class strength. For all year classes examined, YOY largemouth bass exhibited a negative relationship between abundance and growth. Future work involving improvement of habitat availability (i.e., aquatic vegetation) may improve growth rates by increasing the number of YOY individuals that can be sustained by the environment.

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, and 3 without. We observed greater average densities of largemouth bass, bluegill, and all other fish in the vegetated enclosures compared to the non-vegetated enclosures. These differences however were small and we plan to continue this work in Lincoln Trail and expand to additional lakes. We also expanded our analysis of the influence of vegetation and woody debris to largemouth bass recruitment. Lakes were mapped for composition and abundance of vegetation and woody habitat. We observed no direct correlations with vegetation and woody habitat with young-of-year largemouth bass abundance in the fall. In future segments, we will expand these analyses to incorporate additional years of data and evaluate the interaction between vegetation and woody habitat.

In this segment, we also identified 13 lakes to include in a multi lake experiment examining the effects of manipulating vegetation on largemouth bass populations. We have identified two low vegetation lakes where we will increase aquatic vegetation. In spring of 2008, we began planting vegetation in fish enclosures in Lake Paradise. Five species of vegetation were planted in varying size and array of enclosures. We will evaluate the different types of enclosures and vegetation species in order to assess the vegetation planting as well as make management recommendations on planting techniques. In fall of 2006 through spring of 2007, Dolan Lake was drawn down and rotenone was applied to reduce carp and gizzard shad abundance and expose the seed banks in an attempt to increase vegetation and sportsfish production. These lakes are being monitored for changes in the fish community. We also began monitoring three high vegetation lakes where we will decrease vegetation levels (Airport Pond, Kakusha Lake, and Stillwater Lake). An additional 8 lakes will be treated as control lakes where no vegetation management will occur. The control lakes vary in vegetative cover from low to high and will be coupled with experimental lakes. We began monitoring these lakes before vegetation treatments to evaluate the effects on largemouth bass recruitment and the fish community. These studies will allow us to make recommendations on vegetation management in order to increase largemouth bass recruitment in Illinois reservoirs.

We also began monitoring dam escapement of largemouth bass during high water events. We have observed largemouth bass moving over the dam at Forbes and Ridge Lake. This project is in the initial phase and we will continue to evaluate fish passage during high and low flows to evaluate if escapement can effect largemouth bass recruitment.

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.

In Job 101.5, we continued monitoring largemouth bass spawning activities at Lincoln Trail Lake. Largemouth bass appeared to prefer cobble, pebble and gravel nesting substrates. Spawning date for young-of-year largemouth bass surviving to the fall was disproportionately skewed towards nests from later in the spawning season in most years. Nesting frequency was also compared to existing water quality parameters. Frequency of new nests was directly related to water temperature. Spawning activity decreased when temperature decreased and no spawning was observed at temperatures under 50^{o} F. Total number of nests was not related with the number of recruits. However, adult standing stock was related to the total number of recruits indicating a stock recruitment driven system.

We continued to monitor largemouth 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. 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 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 this segment, we also began to monitor largemouth bass tournaments at Bloomington and Evergreen Lakes in order to assess tournament related mortality and stress related physiology at different times of year. Livewell simulation experiments were also initiated to assess the influence of water temperature and dissolved oxygen on fish exposed to tournament conditions. In addition, pond experiments were implemented to evaluate how holding cages can influence mortality and stress response estimates in the tournament experiments. Results from these experiments will be used to assess the potential impacts of tournament fishing on largemouth bass populations and used to make management recommendations regarding tournament procedures.

In Job 101.5, we also conducted a controlled pond experiment at the Aquatic Research Facility in Champaign, IL to assess the effects of angling on largemouth bass recruitment. We tested the effect of brood reduction on young-of-the-year recruitment, and found that predation on largemouth bass nests during catch and release angling events did reduce the number and biomass of YOY surviving later in the first year of life. We will repeat this experiment in 2008 to increase experimental replication so that statistically significant trends may be detected if present. We also conducted a field experiment on Ridge Lake, holding largemouth bass angling tournaments during the spawning season – the first time Ridge has been open to angling during the spawning season since at least 1996. We detected slightly lower than average YOY densities in fall sampling for 2007, indicating that angling during the spawning season and concomitant brood predation may be influencing YOY recruitment later in the first year of life. Data collection and analysis on Ridge Lake will continue in future segments to further explore the relationship between angling and recruitment in a more natural system, while pond experiments will continue to allow for controlled examination of specific, angling-related mechanisms influencing recruitment.

In Job 101.6, a portion of Clinton Lake that was closed to fishing was sampled to determine the effects of a 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. Sampling will continue at Clinton Lake to monitor largemouth bass populations for changes resulting from the refuge. We also began sampling Otter Lake as an additional location to evaluate refuges. Electrofishing and seine samples were initiated in two proposed refuge sites as well as three control sites. We plan to implement the refuge after several years of monitoring pre refuge conditions in the lake. We also began assessing potential study design and lakes for monitoring effects of harvest regulations on largemouth bass populations. Initial lakes were selected to compare the effects of regulations on largemouth bass populations. INHS study lakes have regulations from standard 14and 15-inch length limits to varying slot limits. We will employ FAS data in future segments to supplement the initial study lakes used in this analysis. We will be specifically targeting assessments of how size limit regulations may influence 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 101.1 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 from 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. Field results of growth and survival from stocked large and advanced largemouth bass have shown lower growth rates through time compared to natural largemouth bass, even though these fish are often stocked at a larger size than their natural cohorts. Field sampling of largemouth bass diets also shows stocked fish are eating more invertebrates than fish prey. Prior to stocking, hatchery largemouth bass gain experience feeding on live prey during extensive rearing in ponds, however, they are only exposed to fathead minnows and invertebrates, two prey that are relatively non-evasive. Bluegill are abundant in many reservoirs and an important prey species available to juvenile largemouth bass, but can be evasive and require more experience to capture than fusiform prey. To determine foraging success of naïve hatchery largemouth bass on bluegill and determine its effect on post-stocking success, we designed a laboratory study. We compared foraging behaviors between 6 and 8" hatchery and natural largemouth bass feeding on bluegill, and summarize these findings to explain differences in growth and diets between stocked hatchery and natural largemouth bass.

Differences in rearing and stocking method (e.g., intensive raceway versus extensive ponds and point versus dispersed stocking) 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. In addition, stocking fish into habitat may be preferred to the common practice of point stocking at the boat ramp. Stocked bass have shown increased ability to avoid predation when stocked in a variety of habitats or habituated before stocking (Schlechte et al. 2005). However, these two stocking strategies have not been directly compared in a field setting.

Previous experiments and available theory dealing with trophic interactions and largemouth bass stocking suggest many possible effects on receiving aquatic communities (Nowlin et al. 2006, Drenner et al. 2000). Of primary concern to fisheries managers are the potential impacts of stocked largemouth bass on prey species such as bluegill and potential "biomanipulation" effects that may result in changes in water clarity or macrophyte abundance (Drenner et al 2000, Shapiro et al 1975, Lathrop et al 2002). Case studies addressing community effects of largemouth bass stocking have shown a strong impact on prey populations when introduced into predator free systems (Drenner 2000, Chapleau et al. 1997); however biomanipulation effects are weaker in systems with resident predator populations (Rosenfeld 2000), and systems with high phosphorous loading rates (Benndorf 1991). In addition, prey species that outgrow the gape limitation of predators (e.g. bluegill and gizzard shad) may also limit the extent of community responses to largemouth bass stocking (Nowlin et al 2006). Research in a number of systems has produced a theoretical framework for exploring the effects of predator stocking but these hypotheses have not been rigorously tested in lakes similar to those found in Illinois (McQueen 1986). Many properties of Illinois lakes including depth, trophic state, prey communities and resident predator populations have been shown to weaken community effects of stocking in other systems (Benndorf 2002, Scharf 2007). In addition, the specific outcome of predator stocking is often variable which limits accurate prediction of the impacts stocking may have (Schaus and Vanni 2002, Schulze 2006). We are exploring the community response of continued stocking of largemouth bass in Illinois lakes in comparison to unstocked lakes over time to evaluate the factors determining differences in responses among lakes. These analyses will shed light on the potential impacts of largemouth bass stocking and will help managers to predict the likely community response of stocking this predator.

PROCEDURES:

Size Specific Stocking

We stocked four size groups of largemouth bass in four lakes (Charleston, Homer, Mingo, and Woods) from 1998 through 2004 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. All fish were reared initially in raceways at the Jake Wolf Fish Hatchery and large and advanced fingerlings were finished in rearing ponds. 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.

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 3+ fish from previous stockings in the four study lakes. Each lake was sampled twice in the fall of 2007 and twice in the spring of 2008. 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 2007 and 2008 were 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.

In previous segments, differences in growth were observed between large and advanced fingerlings when compared to wild fish initially following stocking. To determine the cause of these differences, we compared foraging behavior of 6 and 8 inch hatchery reared and natural largemouth bass over a two month period. Natural largemouth bass (large = 126-170 mm TL; advanced = 178-214 mm TL) were collected by electroshocking from Mingo and Homer Lakes in Illinois. Hatchery largemouth bass (large = 135-170 mm TL; advanced = 180-223 mm TL) were obtained at the time of stocking from the Jake Wolf Memorial Fish Hatchery. Each treatment group was held separately in fiberglass tanks at the Kaskaskia Biological Station and fed fathead minnows. After two weeks on a diet of fathead minnows, the behavior of hatchery and natural largemouth bass foraging on bluegill prey were tested in half hour experiments conducted in an open 2.5 m diameter pool. Individual largemouth bass were starved and acclimated in the pool 24 hrs prior to experiments, and 10 bluegill prey (27-33% of largemouth bass TL) were also placed in a covered enclosure within the pool. An experiment began with release of the bluegill from the holding compartment into the pool with the largemouth bass. Predator foraging was recorded by an observer (behind a blind) as the number of follows, strikes, and captures on bluegill prey. Activity, or time(s) spent swimming by the largemouth bass was recorded, as well as how fast the predator moved (m/s). Capture efficiency was calculated as the ratio of captures to strikes. After an experiment, the largemouth bass was allowed to forage for 24 hours and number of bluegill captured after 5 and 24 h was recorded. Largemouth bass were returned to their holding tank after an experiment and maintained on a diet of fathead minnows. Using the same procedures, the same largemouth bass were again tested after four and eight week intervals, which corresponded with field sampling of diets for stocked and natural largemouth bass. Ten experiments using ten individual largemouth bass were completed for each treatment (hatchery, natural largemouth bass) and interval (2, 4, 8 weeks) for a total of 60 experiments.

Stocking Technique: Boat Ramp v. Dispersed

In this segment, we initiated a study evaluating the influence of stocking location on survival of stocked largemouth bass. Three lakes were stocked with 100mm largemouth bass fingerlings in 2007 using two stocking techniques. Half of the fish at each lake were stocked at the boat ramp, directly from the hatchery truck, while the other half were loaded into aerated hauling tanks in boats and distributed throughout the lake. Distributed stockings targeted placing fingerlings into wood and vegetated habitat dispersed throughout the lake. Fish were marked with a pelvic fin clip two weeks prior to stocking while in raceways at the Jake Wolf Memorial Fish hatchery. Fish stocked at the boat ramp were given a right pelvic fin clip and fish to be dispersed were given a left pelvic fin clip. Lakes were sampled two times in the fall and two times in the spring using DC electrofishing. Three 30 minute electrofishing transects were performed on each sampling date and all largemouth bass were collected, measured for total length, examined for clips, and scales were collected from all clipped fish for age determination. CPUE was calculated for stocked and wild fish and contribution of stocked fish to the total bass population was calculated as the proportion of stocked fish CPUE to all largemouth bass CPUE. We will use these data to compare survival and growth of stocked fish from the two stocking techniques.

Rearing Technique: Intensive v. Extensive

The effects of rearing techniques on growth and survival of stocked largemouth bass were evaluated in lakes Shelbyville, Jacksonville and Walton Park in 2007. 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 3+ 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 aged 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.

Factors Affecting Stocking Success

Largemouth bass were stocked in 15 reservoirs in Illinois during three years 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 mid July to mid August and the target stocking size was 100 mm with a density of 60 fish per hectare. 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.

Catch per unit effort (CPUE) of stocked and wild largemouth bass was calculated for age-0 in the fall, age-0 the following spring, age-1 in the second fall, and adult fish in subsequent falls. CPUE of adult largemouth bass was calculated for each stocking at combined ages of 3, 4, and 5 years. Adult ages could not be delineated into individual years due to the lack of age data and the inaccuracy of using length frequency analysis to determine age for these larger largemouth bass. CPUE was averaged across years for each reservoir using reservoir as the experimental unit to evaluate differences among reservoirs and examined for relationships with reservoir characteristics using Pearson correlation analysis. We also calculated the proportional contribution of stocked fish to the total largemouth bass population. CPUE of stocked largemouth bass from electrofishing samples was divided by the CPUE of all largemouth bass sampled for each date of sampling. Using a proportion rather than CPUE alone will allow us to better compare values across lakes because regardless of catch rates, the ratio of stocked to wild fish should be accurately represented.

To further study differences in contribution of stocked fish we examined change in survival between stocked and wild largemouth bass. Survival was estimated as the proportion of change in catch per unit effort from electrofishing at three time steps, from the first fall following stocking to the subsequent spring (age-0 fall to age-0 spring), from the first spring following stocking to the subsequent fall (age-0 spring to age-1), and from the second fall following stocking to the adult age (age-1 to adult). Using these metrics, we could examine differences in declines in CPUE between wild and stocked fish.

To determine the influence of wild largemouth bass populations, we examined differences in contribution of stocked fish and survival of both stocked and wild fish between lakes with varying largemouth bass populations. We examined differences in contribution of stocked fish and survival of both stocked and wild fish using repeated measures ANOVA. Using these analyses, we evaluated changes in survival through time and differences in survival between stocked and wild largemouth bass.

<u>Influence of Stocked Fish on Resident Populations</u>

Lakes for this analysis were stratified into those containing a gizzard shad prey base (N=9) and those without gizzard shad (N=7) to account for the strong community interactions of this prey species (Dettmers and Stein 1996) and to examine differences in response between these lakes. Comparisons before and after stocking were then made between lakes receiving largemouth bass stockings (with shad N=5, without shad N=3) and those without stockings (with shad N=4, without shad N=4) using a replicated before-after control-impact (MBACI) design suited to a repeated measures analysis of variance (Underwood 1994, Kough and Mapstone 1995). Data collection and stocking methodology were as described in the previous section "Mechanisms Influencing Stocking Success". Collected data include larval fish density, benthic macroinvertebrate abundance, relative abundance of prey species, zooplankton density, chlorophyll a, water clarity, and total phosphorous concentration.

In this segment we present preliminary results focused on the response of prey communities (bluegill) to largemouth bass stocking relative to controls (unstocked lakes). Densities of littoral bluegill prey were assessed by fall seining (9.2 m bag seine, 3.2 mm mesh) at four fixed sites within each lake. Effort was calculated as the area of the haul (length x width of the seine to the nearest meter). All fish were counted and at least 50 individuals of each species collected were measured (total length in mm). Density (number per square meter) was calculated for bluegill on each study lake throughout the fall and was averaged for each year from 1998 to 2005. Comparisons were then made between stocked and unstocked lakes before (fall 1999 and earlier) and after (fall 2000 and later) largemouth bass stocking.

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. We examined survival of the different sizes of stocked fingerlings that 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 2-1). No stocked fish were observed in Woods Lake in 2007 or 2008. 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 both fall 2007 and spring 2008. Mingo Lake had no stocked fish sampled in fall 2007 and very few in spring 2008. These lakes were last stocked in 2003 and appear to have few stocked bass surviving past age 4.

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 2007 and 2008 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 2-1). 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 thereafter, 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 2-2), 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.

Cost of producing fish increased with the size of the fish being produced (Table 2-2). 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).

In laboratory experiments, large hatchery fingerling largemouth bass captured fewer bluegill after 24 hours than natural largemouth bass throughout the study (Table 2-3). Foraging behaviors were also more costly for large hatchery largemouth bass, as they engaged in more follows and strikes to capture bluegill than natural fish. As a result, hatchery fish only had a 7% capture efficiency on bluegill compared to 28% for natural largemouth bass. Hatchery largemouth bass were more active and swam around the tank more during the experiment (40% of time) at two and four weeks, but after 8 weeks decreased activity to a level similar to natural fish (24%). Hatchery largemouth bass also swam at a faster rate than natural fish both initially and at 4 weeks, but slowed swimming speed to a rate similar to natural fish after 8 weeks. Advanced hatchery largemouth bass were more active throughout the experiment than natural fish, and initially caught more bluegill at 2 weeks. Natural largemouth bass at two weeks moved little and caught fewer bluegill, perhaps due to lack of acclimation to laboratory conditions. However, number of captures was similar for both groups at 4 and 8 weeks, hatchery fish again had more follows and strikes on bluegill prey than natural fish, and capture efficiencies were also lower for hatchery fish (5%) compared to natural largemouth bass (21%). Similar to 6" largemouth bass, hatchery fish were more active at all intervals than natural fish, and had higher swimming speeds throughout all trials.

Rearing Techniques: Intensive v. Extensive

In this segment, fish from previous stockings were sampled to compare long-term differences in growth and survival. Two of the three lakes had stocked fish observed in electrofishing samples in both spring and fall 2007 and spring of 2008 (Table 2-4). Lake Shelbyville had no stocked fish sampled in 2007 and 2008 and Jacksonville and Walton Park both had very few fish sampled. Due to the low catch rates of wild largemouth bass in Walton Park, stocked fish comprised a mean of 10.4% of total largemouth bass in electrofishing samples in 2007. 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. In this segment, all scales from 1999 – 2006 were read by two independent readers and will be used to distinguish intensive and extensively reared fish. Once the appropriate rearing type can be determined 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.

Stocking Techniques: Boat Ramp v. Dispersed

Three lakes were stocked in 2007 with half the fish being stocked at the boat ramp and half distributed throughout the lake. All lakes had very low survival of both boat ramp and dispersed stocked fish to the first fall following stocking (Table 2-5). No stocked fish were observed in the spring on 2008. This low survival may be due to the warm lake temperatures on the date of stocking. High mortality of dispersed fish may also be affected by the increased handling time associated with loading the fish onto a boat and dispersing them throughout the lake. We did not however observe greater survival of fish stocked at the boat ramp where this handling did not occur. Additional years of stocking are required to evaluate differences in these stocking techniques. We will continue to stock four lakes each year using these strategies in order to make management recommendations regarding stocking locations to maximize survival.

Mechanisms Influencing Stocking Success:

Similar factors appeared to influence initial abundance of stocked and wild largemouth bass, but not older fish. The initial period following stocking can be critical to survival of stocked largemouth bass. Stocked largemouth bass CPUE in the first fall following stocking was significantly correlated with that of CPUE for wild age-0 largemouth bass ($r = 0.55$; $P = 0.03$). Stocked largemouth bass are surviving better in those lakes that have favorable conditions for wild young-of year largemouth bass survival and growth. Unfortunately, lakes with good wild largemouth bass survival and growth are not usually the target of supplemental stocking efforts. However, adult stocked largemouth bass CPUE 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 ($r = 0.26$, $P = 0.34$). Abundance of stocked adult fish was not related to stocked age-0 abundance both before and after the first winter and recruitment may not be set until a later time. Wild fish recruitment, however, did appear to be set at an early age. Age-0 wild fish abundance was correlated with the abundances of all older wild fish age classes. CPUE for age-0 wild fish was positively correlated with age-0 in the spring ($r = 0.63$; $P = 0.01$), age-1 ($r = 0.92$; $P < 0.0001$), and adult ($r = 0.63$; $P = 0.01$) wild fish. Wild fish abundance in the first fall was a good predictor of wild adult fish abundance. Unlike abundance, the mean size of age-0 stocked largemouth bass in the fall was related to abundance of older stocked fish. Mean size of stocked largemouth bass in the first fall after stocking was positively correlated with CPUE of age-1 ($r = 0.74$, $P = 0.002$; Figure 2-3 A.) and adult ($r = 0.68$; $P = 0.006$; Figure 2-3 B.) stocked largemouth bass.

Contribution of stocked fish to the total largemouth bass population varied among lakes. The proportion of stocked largemouth bass in the first fall following stocking ranged from 3 to 50 percent of the total population across lakes. Stocked largemouth bass CPUE was lower than wild fish for all age classes and declined through time (Table

2-6). Percent contribution of stocked fish to adult largemouth bass was the lowest of all age classes, ranging from 0 to 18 percent of the total largemouth bass collected in electrofishing samples. There was a significant difference in contribution of stocked largemouth bass by age group ($F = 11.42$; $df = 3$; $P < 0.0001$; Figure 2-4). Adult contribution of stocked largemouth bass was significantly lower than age-0 in the fall ($t = -4.68$; $P < 0.001$), age-0 in the spring ($t = -5.38$; $P < 0.001$), and age-1 fish ($t = -3.42$; $P = 0.008$). The proportion of stocked largemouth bass in the population decreased significantly between the age-1 and the adult stage. This decrease in survival was also evident through a significantly lower survival of stocked fish to the adult largemouth bass population. Stocked fish had significantly lower survival than wild fish ($F = 29.77$ $df = 1$; $P < 0.001$). The interaction between stocked and wild survival with age was also significant ($F = 6.4$; $df = 2$; $P = 0.0062$) due to survival of adult wild largemouth bass being greater than survival of stocked adult fish ($t = 5.88$; $P < 0.0001$; Figure 2-5). In general, there was low survival of stocked fish from the age-1 to the adult age resulting in a decrease in contribution of stocked fish to the adult age class. There appears to be substantial continued mortality in stocked fish during the second year that affects recruitment to adulthood.

Influence of Stocked Fish on Resident Populations

We found significant differences in bluegill density between stocked and unstocked lakes without gizzard shad (ANOVA, Time x Treatment, $P = 0.03$, Figure 2-6). The effect on bluegill density was not observed in lakes containing gizzard shad (ANOVA, Time x Treatment $P > 0.34$, Figure 2-6) suggesting that the presence of gizzard shad may be a factor limiting the community effects of largemouth bass stocking. There was also considerable variation in the magnitude of response within the stocked lakes without gizzard shad (ANOVA, Year x Location (Treatment), $P = 0.009$). Individual lake characteristics other than prey type also resulted in differing responses to largemouth bass stocking. Supplemental stocking of largemouth bass appears to influence the abundance of small bluegill in the littoral zone. These effects are variable within lakes dominated by bluegill prey and lacking in lakes dominated by gizzard shad.

RECOMMENDATIONS:

We observed few stocked fish remaining in lakes stocked with four sizes of largemouth bass. At this time, we will conclude sampling and conduct final analysis of survival and growth of differing sizes of stocked fish. 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.

Hatchery largemouth bass did not forage as efficiently as natural largemouth bass in laboratory experiments. Hatchery largemouth bass did capture bluegill, but required more time and energy per capture compared to natural fish. Hatchery largemouth bass also spent more energy on swimming or cruising activity that was not related to foraging. Other studies have found hatchery fish of other species to be more active or aggressive than natural fish, behaviors both of which would increase energy demands (Mesa 1991). Bluegill were novel prey for hatchery largemouth bass. On initial capture, hatchery largemouth bass often rejected bluegill because of their spines. Bluegill need to be swallowed head first after capture because of their body depth and spines, whereas fusiform or soft bodied prey such as minnows or gizzard shad can be chased from behind and swallowed tail first (Einfalt and Wahl 1997). Bluegill are also more evasive and harder to capture than other fusiform prey, and naïve largemouth bass may require many exposures with this prey species to gain experience with successful capturing and handling. Additional laboratory experiments will determine the feasibility of improving capture rates on bluegill by hatchery largemouth bass. Using the same methods, hatchery bass will be fed bluegill prey instead of fathead minnows before and during the 2, 4, and 8 week intervals. Results will be compared to these current findings to assess the potential of acclimating largemouth bass to natural bluegill forage prior to stocking to increase post-stocking success. In the next segment, we will conclude the analysis of differences in diet and behavior of large and advanced fingerlings. 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 and field samples will help us understand how stocked bass feed and if these mechanisms account for the observed growth and survival differences from natural bass.

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. Very few stocked fish were observed in electrofishing samples conducted in the three study lakes. As a result, we will conclude field sampling in these lakes this segment and future efforts will focus on analysis of existing data. In future segments, we will incorporate age data to verify the rearing strategy for each stock fish observed in electrofishing transects. Final analysis will be conducted to evaluate differences in growth and survival of the two rearing types and management recommendations will be made from these analyses.

We have initiated studies evaluating stocking location in order to increase initial survival of stocked largemouth bass. In the initial year of stocking, we have observed very low stocking survival of largemouth bass stocked both at the boat ramp and dispersed throughout the lake. This is only the initial year of stocking and survival may have been limited due to the high temperatures on the date of stocking or the increased handling time due to the stocking techniques. We will continue to compare survival of point stocking versus dispersed stocking at multiple locations of optimal habitat throughout the lake. In the next segment we will stock Lake Charleston, Lake Mingo, and Otter Lake using these two strategies (Homer will be stocked in the following segment). We will evaluate growth and survival by conducting spring and fall electrofishing. Ultimately we hope to evaluate if increased survival of stocked largemouth bass can be achieved through these techniques and provide management recommendations on stocking strategies.

Our results suggest the need to evaluate long-term survival of stocked largemouth bass to fully evaluate stocking success. Although stocked fish may exhibit similar survival to wild fish in a lake initially following stocking, significant mortality can occur through the adult age. Stocking success could be evaluated incorrectly if long-term survival is not considered. We have found that recruitment of largemouth bass is not determined in the first year after stocking. Many previous evaluations of stocking success for other species have not examined stocking success beyond the first spring. These studies may omit a critical period for determining survival of stocked fish. For largemouth bass, success of stocked fish in the first year is often not reflected in creel data providing further evidence for variable survival following the first year after stocking (Boxrucker 1986; Neal et al. 2002). Managers should consider survival to age-1 and adult fish when managing a lake or reservoir by stocking. Considering the availability of appropriate prey and habitat for larger stocked fish may reduce mortality and increase recruitment to the fishery. We did observe a large range in stocking success with some lakes exhibiting no survival of stocked fish whereas others had stocked fish collected in substantial numbers (as high as 21% of the adult population) up to 5 years following stocking. Because of the high variation in stocking survival among lakes, there is a need for additional analyses examining factors influencing stocking success. We focused thus far on differences in survival of wild and stocked largemouth bass and the role of predator populations in determining stocking success. In future segments we will examine other factors such as prey abundance and availability, available habitat, thermal regimes, and fishing pressure. We will examine variation among lakes in order to further explore what factors may play a role in determining growth and survival of stocked fish.

Reductions in planktivorous prey fish abundances such as those observed in stocked lakes without gizzard shad have the potential to cause trophic cascades that affect the entire food web and ultimately affect water clarity and primary production. Another possible result of this decline is a reduction in available prey for other predatory species in the system and reduced intraspecific competition within bluegill populations. Changes in the density of bluegill in stocked lakes were not consistent in all cases pointing to other factors that may determine the vulnerability of a particular lake to community change. In future segments we will continue to examine the community effects of largemouth bass stocking by looking at other parameters such as zooplankton density and chlorophyll a concentration. We will also examine changes in the relative abundance of other fish species, as well as adult bluegill populations, which may result from the decline in juvenile bluegill density. In addition, we will investigate lake characteristics responsible for variation in community changes among non-shad systems to identify factors determining the sensitivity of a particular lake to largemouth bass stocking.

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 enhance 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. 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, Sam Parr, Forbes, and Shelbyville in 1999 and continued through 2004.

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 sampling 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 the fingerlings have all had 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 3-1). 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 2003, the earliest stocked fish should have begun reaching maturity. All lakes were sampled for YOY in subsequent years from 2003 to 2007 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 (Figure 3-1). One of the study lakes, Walton Park, showed a major change (51%) in the frequency of the MDH-B2 allele due to the stocking of hatchery fingerlings. Sam Parr Lake showed a moderate change (32%) in allele frequencies. Forbes Lake and Lake Murphysboro had minor influences (at 6% and 11% contribution respectively) while McLeansboro Lake and Shelbyville showed no influence of stocked fish contributing to the reproducing population (Table 3-2). 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:

All of the stocked fish are most likely contributing to the spawning population, in all of the study lakes. Sampling should continue in each of the study lakes for a couple more years during the post-spawning months to determine contributions from stocked fish. Efforts should be made to collect adequate sample sizes, to remove any sampling error when calculating allele frequencies.

Genetic frequencies from YOY spawned from largemouth bass stocked with the MDH B2 allele have increased very little in three of the study lakes (Forbes Lake, McLeansboro Lake, and Lake Shelbyville). Forbes Lake and Lake Shelbyville are much larger than the other lakes, which may influence the effectiveness of stocking programs in these lakes. Stocked fish appear to have made significant contributions to two of the smaller lakes, Sam Parr Lake and Walton Park.

While our data suggests that lake size may be an important factor influencing the success of a stocking program, it also suggests that other factors may be involved as well since similar sized lakes also had different contributions from stocked fish. These other factors may be similar to factors being examined under Job 101.2 that can influence the survival of stocked largemouth bass in different lakes. In addition to factors affecting survival of stocked fish, we will also use existing data collected on these lakes to determine the reproductive contribution of stocked largemouth bass relative to their proportional abundance in the adult population. By determining how the contribution of stocked largemouth bass compares relative to natural largemouth bass, we will be able to determine if stocked bass that make it to maturity are as effective as natural largemouth bass in contributing to later year classes. This information will allow us to make management recommendations regarding when and where stocking largemouth bass in Illinois will be beneficial.

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:

Recruitment in fish populations is a process driven by growth and mortality during the earliest life stages (Hjort 1914; Houde 1987). Most fish species produce many thousands of offspring in a reproductive season and a large majority of these offspring die before they reach the end of their first year of life. Sometimes this early mortality is episodic, involving large numbers of individuals dying simultaneously, and at other times, high mortality rates occur throughout the first growing season of life (Houde 1989). Even slight differences in mortality rates can result in large variation in year class strength between populations and years. Because of the importance of recruitment for the persistence of wild fish populations and the sustainability of fisheries, fish recruitment has been studied for over 100 years. Despite this long research effort, the mechanisms responsible for variation in fish recruitment remain largely unknown (Cowan and Shaw 2002). At this point in time, only a few general patterns of recruitment have been well described: recruitment is highly variable, driven by mortality during the first year of life, and this mortality is often size-specific (Houde 1987; Miller et al. 1988).

Ludsin and DeVries (1997) outlined a conceptual model of recruitment that focused on the linked importance of four events during the early life history of largemouth bass *Micropterus salmoides*. These events were hatching, onset of piscivory, fall lipid accumulation, and first winter. Fish that hatched early had a higher chance of making a transition to a piscivorous diet, resulting in faster growth and higher lipid reserves, and ultimately, improved survival through winter (Ludsin and DeVries 1997). This model was used primarily to explain variation in recruitment probability of early- and late-hatched cohorts within a year class, but the model can also be extended to larger-scale variation in recruitment (i.e., among year classes and populations; Ludsin and DeVries 1997). Hatch time, an important component of individual recruitment success, can be extended to entire populations and cohorts by considering the overall timing of young-of-the-year (YOY) largemouth bass hatching relative to that of important prey species (Adams and DeAngelis 1987). For onset of piscivory, conditions favorable for an early and consistent shift to piscivory may not be found in all populations and year classes (Olson 1996). Conditions favorable for a larger proportion of either a population or a cohort to develop sufficient lipid reserves and survive their first winter will vary as forage, predators, and winter weather varies (Miranda and Hubbard 1994a; Miranda and Hubbard 1994b; Ludsin and DeVries 1997; Fullerton et al. 2000). Though events as early as hatch have an effect on recruitment, the model of Ludsin and DeVries (1997) presents winter survival of juveniles as the main survival bottleneck determining year class strength.

Parkos and Wahl (2002) provided a conceptual model of largemouth bass recruitment that extended the model of Ludsin and DeVries (1997) to include more potential recruitment mechanisms. In particular, this model accounted for the importance of parental care to survival of the earliest life stages (embryo and larva) of largemouth bass. Events that can interfere with parental care of developing offspring, such as extreme weather events and removal of nesting males by angling (Kramer and Smith 1962; Philipp et al. 1997), were hypothesized to have the potential to negatively affect overall year class strength. Parkos and Wahl (2002) concluded that for some populations and cohorts, processes operating during the earliest developmental stages of YOY largemouth bass (i.e., survival of embryos and larvae) have a larger effect on overall recruitment strength than patterns of mortality occurring towards the end of the first year of life (i.e., first summer and winter survival of juveniles). Unfortunately, examples of recruitment studies that consider mechanisms operating at multiple developmental stages during the first year of life are rare. Incorporating all potentially important events during the first year of life across multiple environmental conditions (i.e., multiple year classes and populations) are needed to generalize models of recruitment.

Aquatic vegetation is a habitat feature that can influence the abiotic and biotic conditions that determine largemouth bass recruitment strength. Aquatic vegetation is often an important habitat feature for age-0 fishes and recruitment (Wright 1990; McRae and Diana 2005). Aquatic vegetation can benefit fish by decreasing turbidity, providing substrate for spawning, increasing structure for avoiding predators, and acting as habitat for important prey (Savino and Stein 1982; Carpenter and Lodge 1986; Scheffer et al. 1993). Previous examinations of the effects of aquatic vegetation on largemouth bass growth and recruitment has been mixed. Whether or not aquatic vegetation has a positive or negative effect on YOY largemouth bass is likely to be dependent on the level of vegetation coverage. Too much vegetation will negatively influence YOY largemouth bass foraging efficiency and subsequent growth (Anderson 1984; Caliteux et al. 1996; Sammons et al. 2003), while a moderate amount of coverage could positively affect YOY survival (Miranda and Pugh 1997). Any benefits provided will also vary by the type of structure offered by different vegetation species (Havens et al. 2005). In this job, we are evaluating the role of vegetation by relating densities and types with largemouth bass recruitment.

Woody debris may also provide some of the same benefits offered by aquatic vegetation. Studies have shown a potential for higher overwinter survival of young-of-year largemouth bass with increasing available woody brush habitat when predators are present (Miranda and Hubbard 1994). In reservoirs, higher centrarchid abundance was associated with coarse woody habitat (Barwick 2004) and removal of coarse woody habitat has also been shown to cause reduced growth rates in largemouth bass and a shift to eating more terrestrial prey (Sass et al. 2006). Numerous studies have demonstrated that complex wood substrate provides habitat for macroinvertebrates (O’Connor 1991; France 1996; Smokorowski et al. 2006). These available food resources concentrate prey fish and in turn provides forage for largemouth bass increasing their foraging success (Hickey and Kohler 2004). All these previous data suggest that woody habitat provides an integral component of multiple trophic levels in many aquatic ecosystems. We are conducting management experiments where vegetation and woody habitat are manipulated (e.g. plantings and removals, varying density and presence versus absence) and examine changes in largemouth bass growth and survival at the lake scale.

Another potential factor influencing largemouth bass recruitment is dam escapement. Escapement from reservoirs generally increase by four times in the spring and summer when water levels are high (Paller et al. 2006). The increase in escapement coincides with the time when largemouth bass are reproducing and may impact recruitment. In addition, this potential influence might be greater on smaller lakes where fish have a higher probability of being in close proximity to the discharge over the dam. Therefore, it may 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.

PROCEDURES:

Evaluation of Recruitment Mechanisms

We sampled 12 reservoirs in 2007 to assess the influence of various factors on largemouth bass recruitment. Eight reservoirs were sampled every two weeks, while the remaining four 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 were 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.

Correlation and linear regression analyses were used to determine which variables explained the most recruitment variation within individual lakes and among all lakes. 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 focus prey availability variables onto 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. Models were built using data from the 1999-2006 year classes and then tested with cohorts from 2007 to see how well these models predict relative year class strength.

Vegetation and Woody Habitat

In this segment, we began to expand our analysis of the influence of vegetation on largemouth bass recruitment. Abundance of largemouth bass and other fish species were assessed in relation to presence of vegetation at Lincoln Trail Lake. Several sites were chosen in August of 2006 and 2007, 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 did 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.

Vegetation was also mapped in 13 lakes throughout Illinois. In past segments, vegetation was assessed by mapping areas of homogenous vegetation onto lake maps by hand. Vegetation areas were mapped by sketching areas of homogenous vegetation, noting the density and species of vegetation present. Vegetated areas were drawn to scale as accurately as possible, making notes on the distance vegetation extended from shore and using shoreline features to place on the map. In this segment, we attempted to increase the accuracy of our vegetation mapping procedure using GPS. Rather than sketching vegetated areas onto a map, we used GPS units to trace the vegetated edge and waypoints to identify transitions in types and densities of vegetated areas. GPS data was the converted into GIS layers and digitized in ArcGIS 9.1. Once areas of homogenous vegetation were identified, density and mass of each species was measured. Ten rings of 0.5 m diameter were distributed throughout the different vegetated areas. All vegetation in a ring was removed, separated and identified to species and weighed. The mass of each vegetation type in a ring was used as a representative sample for the vegetated area. These rings will be used to estimate densities and biomass of each vegetation type present. Lake area, lake shoreline, vegetated area, and vegetated shoreline were digitized from hand drawn maps using ImagePro Plus ver. 4.5.1 software. GIS tools were then used to calculate vegetated area and vegetated perimeter of the lake. Vegetation rings were used to assign densities and mass of each vegetation type to polygons of homogenous vegetation. Paired t-tests were performed to compare estimates of vegetated area and perimeter from the hand drawn maps and GPS maps. The GPS data should provide a more accurate depiction of vegetation in our study lakes. Vegetation was then related to measures of largemouth bass recruitment including CPUE of young-of-year largemouth bass in fall electrofishing transects.

Similar to aquatic vegetation, coarse woody habitat (CWH) may influence recruitment by providing habitat and prey resources for young-of-year largemouth bass. We chose 8 lakes with varying amounts of coarse woody habitat for initial examination. Lakes ranged from 0.04 – 1.4 sq. km. in size with perimeters ranging from 1.2 – 10 km. Wood densities ranged from 0 – 30 trees per km and vegetation coverage ranged from 0 – 100 %. In each of the existing study lakes, CWH was documented with GPS to assess number and location of all woody habitats. Quantification of each tree has been done utilizing a complexity scale of 1-5 (1 being a log barren of all branches and 5 being a tree with most of its crown still in tact) (Newbrey et al. 2005). Visual estimated lengths were taken from boat for each lay down. These data were entered into the ArcGIS program and a metric of trees km^{-1} was obtained. Along with other data collected, correlation analysis was done based on tree density.

<u>Vegetation Management Experiment</u>

In this segment, we also developed a multiple lake experiment to evaluate different vegetation management strategies. We identified 13 lakes and divided them into three treatments based on management objectives. Treatments include management to increase vegetation, management to reduce vegetation, and control treatments where vegetation will not be manipulated. Management to increase vegetation has begun on Dolan Lake and Lake Paradise. Dolan Lake was drawn down in winter of 2006-2007 and treated with rotenone in an attempt to remove carp and gizzard shad and expose the seed bank to promote vegetation growth. Successful reduction or removal of carp coupled with establishing new vegetated areas should increase overall vegetated cover in Dolan Lake. In this segment, we began a large vegetation planting effort in Lake Paradise through cooperation with Illinois District Biologist Mike Mounce and the City of Mattoon Water Department. Enclosures were constructed in varying design to eliminate loss of vegetation due to carp and turtles. Enclosures were constructed using varying lengths of PVC coated wire fencing. Fencing was shaped into a cylinder and closed using cable ties. Lengths of rebar were driven into the substrate and attached to the fencing cylinders using heavy duty wire ties to secure the enclosure in place. After attachment to the rebar, the cage was driven into the substrate an additional 2 to 4 inches (depending upon substrate) to seat the enclosure and ensure no fish passage under the fencing. Enclosures were utilized in two plantings in the spring of 2008. The first planting occurred in early June and was designed to test the success of three different enclosure types for planting of wild celery and sago pondweed tubers. One replicate included a large enclosure, four small dispersed enclosures and four small clustered enclosures (Figure 4-1). Large enclosures were constructed of 20 feet of fencing creating an enclosure with a 6.4 foot diameter (area=31.8 ft^2). Small enclosures were constructed from 10 feet of fencing creating an enclosure with a 3.2 ft diameter (area= 7.9 ft^2 approximately ¼ the size of large enclosures). Wild celery were planted using small bags of cheese cloth weighted with pea gravel with 5 tubers in each bag. Large enclosures were planted with 26 bags of wild celery and small enclosures alternated between 6 and 7 bags per enclosure. Sago pondweed tubers were planted in a similar manner with 7 tubers in each bag. Large enclosures were planted with 31 bags of sago pondweed and small enclosures were planted with 8 bags. Ten replicates were planted with wild celery and 9 replicates were planted with sago pondweed. The second planting occurred in late June and was designed to test the success of chara, coontail, and American pondweed. These species were planted three stems in a cluster at 1 foot spacing throughout an enclosure. One replicate consisted of two large enclosures and four small enclosures. Three replicates were planted for each vegetation type. For all treatments, planting location was determined by low sloping shoreline, adequate sunlight, and shorelines protected from southern wind in order to promote successful establishment and growth of aquatic vegetation. We will monitor the success of the different enclosure designs and vegetation types by assessing vegetation in August of 2008 and in June and August in subsequent segments.

We have been monitoring three lakes as part of the vegetation removal treatment. Stillwater Lake, Airport Lake, and Lake Kakusha have high vegetation densities and are in need of treatment to remove vegetation. Monitoring of pre vegetation management began in this segment and will continue for 2 to 3 additional years. At that point we will begin to remove vegetation through treatment methods to be determined depending upon specific lake characteristics and vegetation species to be targeted. We will monitor changes in largemouth bass populations and prey organisms throughout the treatment period. Control treatments are divided into 3 categories based on the percent cover of vegetation (High, Medium, and Low). Control lakes will be used to compare changes in largemouth bass populations to lakes where vegetation is being manipulated to determine the effects of vegetation management.

In this segment, we initiated field sampling of the 13 lakes to be used in this study. Lakes were mapped for vegetation in June and August using GPS mapping techniques. Three AC electrofishing transects were sampled two times in the spring and two in the fall at each lake. All fish were identified to species and measured for total length. Largemouth bass were also weighed and scales were taken for age and growth estimation. Benthic invertebrates were sampled two times annually in June and August at six sites using a stovepipe sampler. Zooplankton, larval fish and seine samples were performed bimonthly on 8 lakes and monthly on the remaining 5 lakes. Larval fish were collected using a 0.5 m diameter plankton push net with a 500um mesh and a 1:5 width to length ratio. Larval pushes were sampled for 5 minutes and total water sampled was measured using a torpedo flow meter mounted in the center of the net. Zooplankton was sampled using vertical tows at 4 inshore and 4 offshore locations at each lake using 0.5 m diameter plankton net with 63 um mesh and a 1:3 width to length ratio. All samples were preserved and brought to the laboratory where they were identified and counted. Seine samples were taken at 4 shoreline locations on each lake using a 4 x 30 ft m seine with a 4 x 4 foot bag. The width length and depth of each transect were recorded to determine the volume of water seined. All fish collected were identified to species and a minimum of 50 individuals were measured for total length and additional fish were counted.

We have also developed an experiment to examine the effects of woody habitat using 10 one-tenth acre ponds at the Sam Parr Biological Station. Within half of the ponds, wood has been added to cover 30% of the shoreline and 25% of total area. Golden shiners (80 between 60-65 mm), bluegill (115 between 35-70mm) and largemouth bass (5 between 200-300mm) were introduced to each pond. Temperature, dissolved oxygen, pH, chlorophyll, phosphorus, zooplankton, macroinvertebrates will each be sampled biweekly. Weight and length of each species of fish will be determined once the ponds are drained to assess growth. Numbers of fish surviving will be used to assess predator prey dynamics.

Dam Escapement

In order to access dam escapement by largemouth bass we sampled the river downstream of the dam on two reservoirs, Ridge Lake and Forbes Lake via backpack electrofishing. We set up three transects in the Skillet Fork River approximately 0.5 miles downstream of the dam on Forbes lake. Each transect was electrofished moving in an upstream fashion towards the dam. All fish collected in each transect were counted and measured to the nearest millimeter (TL). The dorsal caudal fin on all fish was clipped in order to identify fish recaptured in future surveys. The volume of water coming over the dam was also measured, as well as any peak volume that occurred between sampling periods. The stream downstream of the dam on Ridge Lake was sampled in a similar manner.

FINDINGS:

Evaluation of Recruitment Mechanisms

In 2007, YOY largemouth bass densities (Figure 4-2) and growth (Figure 4-3) were highly variable among lakes. YOY largemouth bass appeared as early as May, but were generally most abundant in June. Peak densities ranged from 0.02/m^2 (Clinton, Shelbyville) to 2.08 m^2 (Walnut Point; Table 4-1). Dolan and Paradise could not be sampled in spring due to lowered water levels for either fish removal (Dolan) or dam repairs (Paradise). Abundance of YOY largemouth bass recruited to fall varied from 1.46 fish/hr to 66.8 fish/hr (Figure 4-3A) and was positively related to abundance of juvenile bluegill sunfish during the summer ($r_s = +0.72$, $P = 0.02$). Among lakes, differences in YOY largemouth bass size by the end of the growing season (Figure 4-4B) were negatively density-dependent (abundance of fall YOY LMB and total length of fall YOY LMB; $r = -0.64$, $P = 0.05$). YOY largemouth bass mean total lengths by the end of the growing season varied from 83 to 137 mm (Figure 4-4B).

Components of the physical and biological environment potentially important to YOY largemouth bass growth and survival varied among the study lakes. Aquatic vegetation coverage ranged from 0% to over half of total lake area (Table 4-2). Average vegetated area (%) was not significantly correlated with peak density of YOY largemouth bass or total length of largemouth bass in the fall (Figure 4-5). 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). Chlorophyll a concentrations ranged from 1.53 µg/L to 75 µg/L (Table 4-2). Gizzard shad populations were either absent (Lincoln Trail, Ridge, Walnut Point), at low to moderate abundances (CPUE = 17-86.5/hr; Forbes, Lake of the Woods, Sterling), or highly abundant (CPUE = 119-657/hr; Clinton, Paradise, Pierce, Shelbyville, Woods; Table 4-2). Similar to previous years of the study, densities of larval fish varied a great deal among lakes during (0.11-35.7 fish/m^3; Table 4-2). Our diet studies in Illinois have pinpointed bluegill sunfish as the most important fish prey for YOY largemouth bass. In 2007, larval Lepomis were highly abundant in Dolan, Forbes, Lincoln Trail, and Walnut Point (Figure 4-6A). In Dolan, Lincoln Trail, and Walnut Point, larval Lepomis were highly abundant into late summer. Differences in the densities of juvenile bluegill (TL $\leq$ 60 mm) during the summer were also apparent, with abundances distinctly higher in Dolan, Forbes, Ridge, and Lincoln Trail (Figure 4-6B). Following water level manipulation and rotenone application, abiotic and biotic conditions in Dolan changed considerably, with lower chlorophyll *a* concentration, absence of gizzard shad, and higher than average larval and juvenile bluegill sunfish abundances.

For most lakes, models with either productivity from largemouth bass nests or abundance of bluegill sunfish prey significantly explained within-lake variation in recruitment to age 1 over 1999-2006 (Table 4-3). Spawn stock abundance represented potential and peak density of YOY largemouth bass actual reproductive output in each lake. Lakes where recruitment was not sensitive to prey fish abundance had higher productivity of larval sunfish than other lakes ($t = -3.32$; $P = 0.02$). For Ridge Lake, recruitment was negatively related to spring precipitation and positively related to winter temperatures (Table 4-3). There were no models that significantly explained recruitment variation in Dolan, Shelbyville, and Woods, though recruitment in Dolan was highly correlated with peak density of YOY largemouth bass ($r = +0.90$; $P = 0.04$). For the 2007 year class, largemouth bass recruitment to age 1 varied among the study lakes (Figure 4-7). In general, the recruitment models built from 1999-2006 data overestimated recruitment to age 1, but was fairly accurate in predicting if a given lake would have above or below average year class strength (Figure 4-8). Among lakes, mean recruitment strength was related to differences in fall abundance of YOY largemouth bass (Table 4-4).

<u>Vegetation and Woody Habitat</u>

We also assessed the role of vegetation in Lincoln Trail Lake by simultaneously sampling largemouth bass in enclosures ranging from 40 – 120 square feet (Table 4-5). Dominant vegetation at Lincoln Trail was American pondweed, coontail and chara. Largemouth bass densities ranged from 0 to 0.12 fish per square meter. Mean bluegill density and total fish density was significantly higher in sites with vegetation than those without (Table 4-5). Bluegills dominate the species composition, averaging more than 70% of all fish caught. Vegetation appeared to hold both more largemouth bass as well as prey. These habitats may therefore be critical to maximizing young of year largemouth bass recruitment and growth.

Vegetation varied in our study lakes from 0-100% total cover (Table 4-6). Assessments of vegetation from hand drawn maps were not significantly different from those mapped using GPS for vegetated area (t = 2.16; P = 0.28) or perimeter (t = 2.16: P = 0.27) in fall of 2007 when lakes were mapped using both methods. The GPS mapping is the more accurate method for assessing vegetation, but the previous method should also be accurate for assessing vegetation prior to 2007. Mean annual prey resource data was summarized (Table 4-7) and related to GIS vegetation assessments. Although we observed higher densities of prey fish in vegetated areas than non vegetated areas in our enclosures, we did not observe differences in prey resources at the lake wide scale. No prey resource data was significantly correlated with percent vegetated area or perimeter in 2007. Measures of largemouth bass recruitment were also not correlated with vegetated area or perimeter. Catch per unit effort of young-of-year largemouth bass from fall electrofishing was not correlated with proportion of vegetated lake area (r = 0.06; P = 0.85) or perimeter (r = 0.17: P = 0.61) in fall 2007 (Figure 4-9). Adult largemouth bass catch per unit effort also was not related to percent vegetated area (r = -0.01; P = 0.98) or perimeter (r = 0.05; P = 0.87). Preliminary assessments of vegetation show no relationships between largemouth bass recruitment or prey resources. Vegetation data estimates using GPS data for 2007 was only performed in the fall. Largemouth bass recruitment may be more closely related to the spring vegetation. Vegetation density in June may be critical to providing habitat for newly spawned largemouth bass and differ from vegetation in August. In future analyses, we will begin to examine temporal patterns in vegetation in more detail. In addition we will examine the species of vegetation that are present in a lake and how that may affect fish populations.

For the 8 lakes used to examine woody habitat, the fall CPUE range for young-of-year (YOY) largemouth bass in 2007 was 4.4 – 59.2 fish per hour of electrofishing, whereas adult (> 8”) largemouth bass fall CPUE range was 3 – 52.3 fish per hour of electrofishing. Fall CPUE range for bluegill was 62.5 - 292 fish per hour of electrofishing. The range of wood density in study lakes was 0 – 29.3 trees per km. A positive trend appears to exist between YOY largemouth bass and tree density (Figure 4-10). While not statistically significant, the power is low (<0.80), suggesting that additional lakes need to be included to further examine these relationships.

Vegetation Management Experiment

In this segment, Lake Paradise was successfully planted with the 5 species of vegetation. In July of 2008, plantings of emergent vegetation will be completed that compliment this initial effort. We will continue to monitor and evaluate the success of the varying enclosure sizes and arrangement as well as differences between the vegetation species in order to make management recommendations regarding planting techniques. We will also continue to monitor largemouth bass populations in vegetation addition, removal and control lakes. These data will allow us to better understand the effects of vegetation management practices on largemouth bass populations.

Dam Escapement

In this segment, we performed dam escapement assessments on Forbes and Ridge Lake. Spring of 2008 was particularly wet and thus far all of the sampling has followed a major rainfall event where a larger than normal volume of water has been discharged from the spillways. Therefore, we have yet to establish a baseline by which to compare results however have good data representing extreme high flow events. While results are preliminary at this time, there is evidence for largemouth bass escapement, particularly in the stream below the dam at Ridge Lake (Table 4-8). One of the 300+ mm bass collected at Ridge Lake has been confirmed to have come from the lake because it was marked with a pit tag. Dramatically higher numbers of small largemouth bass were present in the Ridge Lake sample than in the Forbes Lake sample.

RECOMMENDATIONS:

We found that both reproductive output and the abundance of an important prey species, bluegill sunfish, were the primary sources of variation in recruitment of largemouth bass to age 1. In very small systems, such as Ridge Lake (7 ha), annual fluctuations in spring discharge and winter temperatures have a strong effect on recruitment to age-1. Where productivity of prey needed by YOY largemouth bass to complete and sustain a diet switch to piscivory is low, recruitment to age-1 was sensitive to fluctuations in the availability of fish prey. Reproductive potential (i.e., spawning stock and nest success) and productivity of bluegill sunfish also defined inter-system differences in recruitment potential.

To enhance reproductive output, management can focus on options designed to increase nest success and promote the survival of larger, older sexually mature individuals. Largemouth bass anglers target the largest, oldest individuals that are most likely to produce offspring that recruit into the population; therefore, the safest approach would be to allow early spawning, larger males to nest uninhibited by the recreational fishery. Another important management approach for enhancement of nest success is to provide adequate nesting habitat. In this case, habitat also refers to water level, as fluctuating water levels can have negative consequences for largemouth bass nest survival (Kohler et al. 1993). Otherwise, appropriate substrate and complex structure is needed to protect eggs and larvae from waves and silt deposition (Kramer and Smith 1962).

In lakes where recruitment strength is limited by prey fish availability, management can be directed towards community attributes that influence the growth and production of important prey species. For YOY largemouth bass, our study has shown that bluegill sunfish are the most important prey species for the transition of diet from invertebrate to fish prey. Throughout this study, larval and juvenile bluegill abundances were correlated with largemouth bass recruitment success. Adequate nesting habitat, harvest regulations, and reduction of competitors such as gizzard shad are some ways to promote sufficient productivity of bluegill sunfish to support high largemouth bass recruitment.

Another consistent pattern has been a negative relationship between YOY largemouth bass density and growth. Survival of early life stages is highly size-dependent; therefore, factors that would increase the carrying capacity of a lake may allow for higher growth and survival. Many of the study lakes had low abundance of submerged vegetation, potentially limiting the habitat available for YOY largemouth bass. Increased habitat availability and prey abundance should allow for higher growth rates when initial year class size is large.

Differences among lakes in average year class strength were related to mean abundance of YOY largemouth bass in the fall. This pattern suggests that differences among lakes in their recruitment potential are a function of survival during the first growing season. Assessments of the abundance of YOY largemouth bass prior to winter should yield a relatively reliable indicator of a given lake's year class strength. The specific timing of establishment of relative year class strength, however, varied from spring spawning to fall across lakes; therefore, assessments of year class strength will be most useful if conducted in the fall.

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. Additionally, we will include sampling sites with wood but no vegetation to include in the analysis. With these data we can examine relationships between habitat composition, density and largemouth bass density and size structure. Although we did not observe significant relationships between vegetation and woody habitat on largemouth bass population with one year of mapping data, there seems to be evidence to support a habitat effect. We will quantify these relationships over additional years with further data collection to increase the power of the results. Sampling will continue on the lakes where we are measuring vegetation, largemouth bass population response, as well as other biotic and abiotic variables.

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/or nuisance vegetation (e.g. Eurasian milfoil) and habitat restoration to increase vegetation where it is lacking. We have initiated a multi lake experiment examining lakes with a range of vegetation densities and have begun measuring recruitment of largemouth bass in those systems. We need to continue to monitor pre treatment conditions for the next 2 to 3 years before implementing vegetation removal. We will compare control lakes to vegetation removal and addition and relate changes in largemouth bass recruitment, growth, and abundance to the management practices. This will be used to identify critical levels of vegetation to target for management. We will continue to monitor fish exclusion fences and transplanted vegetation at Lake Paradise and assess if increases in vegetation are observed. 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. These studies will allow us to make recommendations on vegetation and woody habitat management in order to increase largemouth bass recruitment in Illinois reservoirs.

Pond experiments initiated in the previous segment will also be completed. Understanding the contribution woody habitat makes to different trophic levels and how it influences predator-prey interactions will be valuable in predicting effects on largemouth bass populations. These studies will allow us to make management recommendations regarding vegetation control and woody habitat enhancement in order to increase largemouth bass recruitment.

The assessment of dam escapement is in the very early stages of implementation and evaluation and much more data is needed to draw conclusions about the effect of escapement on largemouth bass populations and recruitment. Additional data will be collected so that a baseline can be established in order to compare largemouth bass numbers after an increased discharge event to largemouth bass numbers during low flow periods. These samples will provide a better understanding of the number of fish that are new to the population as opposed to fish that are residents of the stream population. We will also supplement these data with historical information from Ridge Lake collected over the last 20 years.

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 the fitness of parental males, 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 more vulnerable to anglers. We would also expect these fish to be targeted by anglers, including fishing 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. One method of reducing this mortality may be holding tournaments when water temperatures are cool (spring and fall) and possibly avoiding tournaments during high water temperatures (summer). Seasonal differences in largemouth bass physiology and response to tournaments may help explain differences in mortality in addition to seasonal water temperature changes.

Impacts of tournaments on largemouth bass populations can be quantified by examining the physiology (stress response) of tournament-caught fish. Physiological measures provide us the ability to pin-point the nature of the stress response and identify stressful tournament practices. Some researchers have suggested that tournament related mortality may result from the cumulative effects of multiple sub-lethal factors (Schramm et al. 1987; Kwak and Henry 1995). Identifying stressful tournament practices by evaluating physiological responses of largemouth bass will provide a better understanding of the factors that underlie tournament related mortality and develop management recommendations to minimize these losses.

Though mortality of largemouth bass in tournaments has been estimated to be as high as 30-70 percent (Allen et al 2004, Edwards et al 2004, Schramm et al 1987, Weathers et al 1987, and Wilde et al 1998), these estimates are made by examining mortality of largemouth bass held in cages after undergoing the tournament process. However, the confined space and relatively shallow nature of these cages may inflict additional mortality and stress, and increase the estimated mortality estimates from tournaments. Our facilities at the Sam Parr Biological Station provide an exceptional opportunity to determine the potential additional stress and mortality inflicted on largemouth bass subjected to tournament conditions.

The popularity of largemouth bass angling may have a greater consequence on population sustainability through disruption or early termination of parental care than through more classical mechanisms such as over harvest. The aggressive nature of parental male black bass during the parental care period (Ongarato and Snucins 1993) increases an individual’s vulnerability to angling (Lindgren and Willis 1990). Angling of the parental male disrupts brood defense and leaves a male's young vulnerable to predation (Philipp et al. 1997; Kubacki et al. 2002). If harvested, parental care is prematurely terminated, resulting in the complete loss of the angled male's reproductive output. Anglers using catch and release strategies when targeting nesting males influence the number of surviving young through their landing technique, handling, and holding time of the parental male.

Successful reproduction is critical to the long-term viability of a population. Understanding how catch and release angling of nesting male largemouth bass impacts recruitment is a prerequisite to developing effective management strategies for maintaining healthy populations of largemouth bass. Such strategies may include closed seasons (Kubacki et al. 2002), fish sanctuaries (Suski et al. 2002), habitat modification (Bozek et al. 2002), or other regulatory mechanisms (Quinn 2002). Research to date has focused almost exclusively on the effects of catch and release angling on individual males and their broods, but no research has been conducted to determine how recruitment might be affected by catch and release angling of nesting male largemouth bass. Reduction in reproductive output is expected to reduce recruitment, but has not been directly examined (Myers et al. 1997; Ridgway and Shuter 1997; Svec 2000).

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. Snorkel surveys commenced on April 16th, 2008 and continued through May 30th, 2008. 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 was 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 quadrant 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. Habitat rankings were established comparing pairwise differences between matching log-ratios of available versus used habitats (Aebischer et al. 1993). Habitat within the 4m x 4m quadrant was identified as available habitat, while nest substrate was identified as used habitat. Positive values within the ranking matrix illustrate substrate preference with greater numbers showing greater preference. Young-of-year largemouth bass were also collected in the months of August and September in 2007 and previous years 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.

Evaluation of 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. In addition, anglers were interviewed at select tournaments to determine the amount of fish released during a tournament. Anglers can release fish either through culling or due to them being smaller than the harvest regulation. Anglers were asked to report the number of sub legal fish caught and released as well as the number of fish released due to culling. We used these data in an attempt to determine the level of culling occurring during an average tournament as well as the extent of catch and release angling of small fish. Culling can influence the sex ratio of fish being weighed in if there is a difference in the size of male and female largemouth bass as well as increase the number of fish subjected to livewell conditions.

In 2008, we will be evaluating post-tournament delayed mortality at Evergreen Lake. Delayed mortality will be assessed following tournaments in four seasons (1 tournament per season): early spring (pre-spawn), late spring/early summer (post-spawn), summer, and fall. Following the conclusion of the tournament, fish will be placed into holding pens (N=10 fish per pen, 4 pens maximum). The holding pens constructed during the past segment have mesh netting attached to a frame made of floating PVC measuring 6’x4’ with a net depth of 9’. Largemouth bass will be electrofished after the tournament and placed into cages to control for cage effects. Pens will be checked 24, 48, and 72 hours following the conclusion of the tournament for deceased bass. After 72 hours, the remaining live fish will be released back into the lake. Delayed mortality will be determined by subtracting the mortality of electrofished control fish from the mortality of the tournament-caught fish. We will also be visiting tournaments at Lake Bloomington on a similar seasonal schedule. Following the conclusion of those tournaments, blood will be drawn from tournament-caught fish and processed for indicators of physiological disturbance (stress) to evaluate seasonal changes in physiological responses of fish to tournaments.

In order to assess whether cages induce additional stress and mortality on tournament caught largemouth bass, we will conduct an experiment at the Sam Parr

Biological Station during summer 2008. The experiment will involve 4, 1-acre ponds, each with a single cage. Largemouth bass will be subjected to a simulated tournament in which bass will be held in a holding tank for 2 hrs (to simulate a live well), then will be weighed, measured and exposed to air for a period of 1 minute. Largemouth bass will then be immediately placed into either a pond or a cage so that there will be 10 bass in each of the ponds as well as each of the cages. The experiment will run for 3 days, after which time we will access both mortality and sub-lethal stress by examining physiological indicators from a blood sample.

We initiated an examination of the impact of brood predation during an angling event on recruitment of nesting largemouth bass through a controlled pond experiment at the INHS Aquatic Research Facility in Champaign, IL. Pond experiments provide the opportunity to test the population level effects of catch and release angling in a controlled setting. We also conducted an experiment at Ridge Lake examining the effects of tournament-style angling of nesting largemouth bass in a population previously unexploited during the spawning season. These experiments allow the examination of specific mechanisms (e.g., brood predation during the angling event, tournament angling of nesting bass) that may impact recruitment. In pond experiments, adult largemouth bass males and females were stocked in similar numbers and sizes across eight one-third acre ponds prior to the onset of spawning. Swimmers made periodic observations in each pond to determine the onset of spawning. Once males had eggs in their nests, nests were marked with a uniquely numbered nest tag, guarding males were identified by approximate length and fin clip, and egg score (Claussen 1991; Kubacki 1992) and stage of egg/larvae development was recorded. Periodic snorkeling surveys were conducted throughout the parental care period to determine the rate of larval development and individual reproductive success of each nest. Ponds were randomly assigned to either a control or treatment group. At the egg or wriggler stage, swimmers removed 50% of each brood from each nest in all four treatment ponds, simulating brood predation during a catch and release angling event and allowing for population-wide comparisons of reproductive output in systems with and without catch and release angling during the parental care period. In August of 2007, all eight ponds were drained and YOY collected and enumerated to determine any effects of brood predation on reproductive output. We measured differences in total number, biomass, and size structure of YOY between control and treatment ponds.

In addition to the pond experiments, we implemented a lake experiment where we conducted largemouth bass tournaments in the spring at Ridge Lake where no prior tournament activity. Standardized electrofishing collections have been executed every spring and fall since the last draining event of Ridge Lake in 1995. These collections provide a 10-year baseline estimate of relative abundance of adult largemouth bass populations. A large number of adult and sub-adult largemouth bass have also been given PIT tags, and recapture data on these individuals has been collected. This data provides an opportunity to determine absolute population size estimates using typical mark-recapture. Young-of-the-year largemouth bass have been sampled every spring and fall using beach seines in shallow areas since 1996, providing a long-term baseline estimate of relative abundance of this age-class as well. Additionally, a complete creel census has been conducted on Ridge Lake during the open angling season of each year.

No angling during the largemouth bass spawning season has been allowed on Ridge Lake prior to 2007.

In the early spring of 2007, seven angling tournaments were conducted during the spawning season (April 22 - May 22), prior to the opening of the regular public angling season. During each tournament, six anglers spent four hours (24 angler hours per tournament) targeting nesting largemouth bass. Angled fish were held in live wells and transferred to holding pens for the duration of the tournament. All angled bass were measured and weighed, scales were collected for determining age, and a PIT tag was injected into the peritoneal cavity of each fish not previously tagged. PIT tags were used to identify recaptures during subsequent tournaments as well as contributing to ongoing mark-recapture studies on Ridge Lake. Standard electrofishing and beach seining was conducted during the late summer and early fall of 2007, providing estimates of adult and young-of-the-year relative abundance estimates.

Livewell Simulations

We evaluated a range of potentially stressful livewell environments to determine conditions which should be avoided during livewell confinement. We subjected largemouth bass to a series of temperature and dissolved oxygen shocks and took blood and muscle samples from individuals and processed them for indicators of physiological disturbance. Individual largemouth bass were held in aerated opaque boxes containing 20ºC water and were then temperature shocked by pumping water of a specified temperature into the chambers. Temperature treatments consisted of a rapid (< 1 min) decrease in temperature from 20ºC to 15ºC and from 20ºC to 8ºC, and a rapid (< 1 min) increase in temperature from 20ºC to 25ºC and from 20ºC to 32ºC. Dissolved oxygen treatments consisted of a rapid (< 1 min) decrease in dissolved oxygen concentration from 8 mg/L to 4mg/L and from 8mg/L to 2 mg/L, and a rapid (< 1 min) increase in dissolved oxygen concentration from 8mg/L to 12mg/L and from 8mg/L to 18mg/L. Hypoxia was created by pumping nitrogen gas into chambers and hyperoxia was created by pumping oxygen gas into chambers. Water temperature was held constant at 20ºC for all dissolved oxygen treatments to control for confounding effects of temperature. Following either temperature or dissolved oxygen shock, fish were held at the specified temperature or dissolved oxygen concentration for either 1 or 6 hours and then sampled in order to determine short-term (1 h) or long-term (6 h) responses to the changing livewell environment.

Long-Term Effects of Harvest

We began to evaluate how long-term harvest and varying tournament pressure has impacted the population size structure of largemouth bass populations through selection-driven changes in life history traits. Electrofishing transects were performed in seven lakes in the spring and fall and all largemouth bass were collected, measured for total length and weighed. Scales were collected from each largemouth bass and were aged by two independent readers to determine mean length at age for fish in each lake. In spring electrofishing samples, sex was determined when possible as well as maturity status (mature or immature) and spawning status (ripe, running, or spent). Subsamples of largemouth bass were collected from each lake for size ranges that were too small to determine sex and maturity status in the field. These fish were brought to the lab, dissected and sex and maturity status was determined. 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 53 nests were observed between 4/23/2008 and 5/28/2008 in Lincoln Trail Lake. Water temperature and spawning was largely affected by the variable weather pattern during spring. The first nests were observed shortly after temperatures reached 17^{o}C, but spawning occurred sporadically with the largest peak occurring after the first cold period (Figure 5-1). Bass spawned preferentially on hard substrates with cobble, pebble, and gravel being ranked highest (Table 5-1). Substrates with the lowest ranking were vegetation, detritus, and leaves. Future use of compositional analysis will be used to identify which habitats used by nesting largemouth bass differ significantly from available habitats.

Survival to fall was back calculated to spring spawn time using otoliths in 2000, 2001, 2003, and 2007. Snorkel surveys were not possible in 2002 and 2004 due to high turbidity and otoliths were not taken in 2006. Numbers of nests during the spawning period generally followed a positively skewed unimodal pattern. The distribution of survivors was bimodal in 2000, 2001, but unimodal in 2003 and 2007. These results suggest the presence of multiple cohorts in some years. The number of new nests on a date was closely related to the number of young-of-year largemouth bass surviving to the fall in two years, but not in two other years (Figure 5-2). In 2003, and 2007, YOY survived disproportionately from later in the spawning season. 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 back-calculating spawning dates. We will evaluate otoliths 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.

Nesting success, calculated by number of nests per year, was not correlated to recruitment to age-1. However, stock, or number of mature adults, was correlated to recruitment (P=.041, Figure 5-3), suggesting that recruitment in Lincoln Trail Lake is driven by a stock-recruitment relationship.

Evaluation of Tournaments

In this segment, sampling of largemouth bass fishing tournaments were conducted in 2007 in Mill Creek , and Lake Mattoon 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. A majority of both male and female bass sampled in spring tournaments had signs of spawning activity (ripe, running, swollen pore, and fin erosion). Similar proportions of males to females were angled during the spawning period when compared to post spawn in all lakes except Shelbyville which had a greater proportion of females during the spawning season than post spawn (Table 5-2). This would imply that there is no sex specific targeting depending upon if the tournament occurs during the spawning period. Male fish are caught in a higher proportion than females during all seasons except during the spawn in Shelbyville. However this difference is small in Lake Shelbyville and sex specific targeting of fish may not occur in this lake. These results are contrary to conventional wisdom that female largemouth bass are targeted because of their larger size. We also did not observe large differences in the size of female largemouth bass weighed in at tournaments compared to male fish during either season.

A total of 45 anglers were interviewed from 2003 to 2008 to examine the prevalence of culling. The number of sub-legal fish that were caught and released varied by lake (Table 5-3). Very few short fish were caught in Lake Mattoon (0.25 per angler) while Mill Creek (3.1 fish per angler) and Shelbyville (5.4 fish per angler) had higher numbers of short fish released. Culling was low on all lakes (0.27 fish per angler) primarily due to few anglers reaching the creel limit for largemouth bass and not needing to release fish when caught. Culling appears to be minimal, except possibly in large tournaments, and should not influence estimates of sex ratios of fish in tournaments.

Pond experiments and tournament mortality experiments will be conducted in summer of 2008 and findings will be reported in future segments. Cages have been built and ponds were prepared in order to conduct this experiment in summer 2008. In this segment, pond experiments were conducted in order to evaluate the effects of removing fry from the nest to simulate increased nest predation or decreased nest survival. Total YOY and YOY biomass measurements were both standardized within pond by pond-wide egg score, to standardize across ponds for differences in female fecundity and male mating success. Treatment ponds showed a 35% reduction in YOY produced, and a 39% reduction in YOY biomass (Figure 5-4). Mean total length of YOY in control ponds was 52mm compared to treatment ponds mean total length of 56mm, and the size distribution in treatment ponds was more variable than in control ponds (Figure 5-5). YOY in treatment and control ponds had identical condition factors (k=1.29).

While none of the results in the first year of this experiment showed statistical significance due to a low number of replicates, the size of the effect of brood reduction on number and biomass of YOY was notable. These reductions demonstrate that from the time of spawn to mid-August, brood predation (resulting from catch and release angling during the nesting period) does reduce the number of YOY recruited to the mid-summer largemouth bass population.

Tournaments were conducted at Ridge Lake throughout the 2007 spawning season. Anglers caught 448 largemouth bass over 168 angler hours for a mean tournament CPUE of 2.67 fish/angler-hour (range 1.00 – 4.42 fish/angler-hour). Fall seine samples taken from 1996-2006 on Ridge Lake averaged 0.09 YOY/m2 (range = 0.02 – 0.15 YOY/m2) compared to 0.06 YOY/m2 for fall 2007 samples, slightly lower than the eleven-year mean. This may reflect the influence of angling during the spawning season, but many other factors need to be considered before a definitive interpretation can be made.

Livewell simulations

Rapid cooling of water from 20ºC to 8ºC resulted in increased activity levels of the enzyme lactate dehydrogenase (LDH; Figure 5-6). LDH is an indicator of tissue damage when found in the plasma. Anglers often add ice to livewells throughout the tournament day to mitigate increasing livewell water temperatures (Gilliland 2002). Our results, however, suggest that although thought to be beneficial, over-additions of ice can result in tissue damage and have potential long-term negative effects. When subjected to hypoxia levels of 2 mg/L and 4 mg/L, largemouth bass showed decreases in potassium ion concentrations ([K+], Figure 5-7). Potassium is an important ion in regulating the overall ionic balance of fish and the observed decreases in potassium concentrations suggest disruption to this important physiological process at 2 mg/L and 4 mg/L.

Long-Term Affects of Harvest

We have begun to accumulate age and maturity data for largemouth bass in seven study lakes to examine the long-term effects of harvest. In this segment, we collected a number of largemouth bass that could be used for determining maturation status. We aged scales taken from the seven lakes from spring electrofishing samples from 2005-2007 and determined mean length-at-age for each population (Table 5-4). Fish collected during spring 2007 were dissected and sex and maturity status were determined as well as age. These data were combined with data from electrofishing samples from 2005-2008 where we could positively identify the sex and determine the age of the fish. Initial assessment of maturity show age of maturity of both male and female to be approximately age 3 on Lake Shelbyville. These are preliminary analyses based on low samples sizes and in future segments we will increase the number of largemouth bass for assessment of both the length-at-age and maturity. We will also incorporate both information on tournament frequency as well as creel data in order to assess different fishing pressures and relate them to largemouth bass size structure and maturation rates.

RECOMMENDATIONS:

Thus far, we have been able to assess spawning activity during four years at Lincoln Trail Lake. Monitoring 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 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 and address their importance in determining recruitment.

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. 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 future 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.

Monitoring of tournaments for spawning condition and sex ratios was concluded in this segment. A large proportion of largemouth bass caught in tournaments during the spawning period were mature fish that were actively engaging in spawning activities. Fish angled off the nest in tournaments have been shown to have extremely high nest abandonment rates. Tournaments during the largemouth bass spawning seasons have the potential to influence spawning success for individual fish and potentially fish populations. Fish targeted in tournaments are generally of mature size and may be more vulnerable during spawning activities. In particular male largemouth bass that are guarding a nest may be overly aggressive and located in shallow areas vulnerable to fishing gears. However we did not observe male fish being captured at higher ratios during the spawning than in post spawning suggesting that they are not targeted in tournaments. We did have some evidence that male fish are caught in greater numbers than females throughout the year, but the ratio is not greatly skewed. 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. Catch and release angling has been shown to have reduced effects on nesting largemouth bass compared to tournament caught fish and leads us to conclude that this angling should not limit spawning success. 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 different types of 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. Pond experiments examining the influence of angling on largemouth bass recruitment will be repeated in 2008 to increase the number of replicates. These experiments should also be expanded to assess late summer and fall recruitment differences between treatment and control groups, allowing for an expansion of the scope of this study to more closely reflect the effects of brood predation throughout the entire first year of life. No experimental angling tournaments will be conducted on Ridge Lake in 2008 to provide control data, but additional tournaments in 2009 will be explored. In future segments, information gathered from these experiments will be combined with long-term creel survey and population assessment data to construct and test mathematical models of largemouth bass recruitment dynamics (Job 101.4). 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.

We will continue to evaluate how varying tournament pressure and angler harvest has impacted the size structure of largemouth bass populations through selection-driven changes in life history traits. We will continue to sample lakes with varying tournament pressure for largemouth bass. This will involve determining sex-specific size-at-age, life span, and age-at-first-maturation profiles. 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 conduct analysis of sex specific characteristics. We will also incorporate creel data in order to estimate the extent of largemouth bass harvest and assess its effect on sex-specific traits. This will allow us to identify the potential impacts of tournaments and harvest to life history characteristics in largemouth bass populations.

We will continue to evaluate mortality in bass tournaments and methods of assessing mortality. Pond experiments will be conducted in the next segment to evaluate the influence of cages in which bass are held after tournaments to assess mortality. This experiment will run during the summer of 2008 and recommendations will be made in subsequent reports. Results from livewell simulations demonstrate the effects of temperature changes and oxygen concentration in livewells. Anglers need to be cognizant of large temperature changes that might occur during livewell confinement. Although thought to be beneficial, over-additions of ice to livewells may cause drastic drops in livewell water temperatures and cause tissue damage in tournament-angled fish. Anglers will often add ice to livewells multiple times throughout the tournament day (Gilliland 2002), which may compound stressors even if the initial temperature drop is not large. Anglers should monitor livewell temperatures and should only use enough ice to maintain livewell temperatures ± 5ºC of the ambient water temperature. Aerators should be run continuously to prevent hypoxia. Although we found some physiological disturbances in fish which were exposed to 18 mg/L (hyperoxia), this level of dissolved oxygen concentration is virtually unobtainable using a standard aerator. We will continue to evaluate the physiological response of largemouth bass to a variety of simulated livewell conditions to further explore tournament-related stressors and make recommendations to minimize stress during tournaments and improve overall post-tournament survival. We will also be evaluating the physiology of tournament-caught fish to help identify stressful tournament practices and further improve the tournament process.

Job 101.6. Evaluating the impact of spawning refuges, habitat manipulations, harvest regulations and other management strategies 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 among 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. Otter Lake is a 310-hectare lake that operates as a water supply and recreational lake. Jeffrey Pontnack (District 14/15 Fisheries Biologist) and Dennis Ross (General Manager of Otter Lake Water Commission) have proposed closing two large bays to fishing and boating, providing a spawning and fishing refuge for largemouth bass and other fish species. The refuges may be beneficial to largemouth bass, by increasing spawning success and decreasing fishing mortality. We are using these lakes to evaluate the success of a fish refuge in increasing numbers and size structure of the largemouth bass population.

There are many potential harvest regulation strategies that can be used to help manage bass populations, including size limits, closed seasons, and spawning refuges. Each of them can have a different impact on the population, either by affecting size structure or numbers. Some regulations have the potential to impact recruitment more than others, but right now, we cannot make accurate predictions. Increasing the quality of angler catch or harvest rates are common rationales for harvest regulations (Paukert et al. 2007). However, compilation of 91 studies using minimum-length limits and slot-length limits concluded that most studies were conducted over too short a period and did not include creel data to document if a regulation increased angler catch rates (Wilde 1997). Many regulation decisions are not influenced by information available on black bass biology (Paukert et al. 2007). There is a need for research examining the effects of angling regulations (Novinger 1984; Wilde 1997; Paukert et al. 2007).

PROCEDURES:

Population abundance and size structure of largemouth bass were assessed in Otter and Clinton Lake using spring and fall electrofishing and seining. Clinton Lake refuge was closed in 2001 and samples were taken both before and after implementation of the refuge. Samples collected on Clinton during 1999 – 2001 represent pre-refuge and

2002 to present represent post-refuge. In this segment, post refuge electrofishing transects and seines hauls were performed in Clinton Lake during the spring and fall of 2007 and the spring of 2008. 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 at approximately 2 and 4 lake kilometers from the refuge. Seining was conducted using a 9.2-m bag seine pulled along the shoreline at fixed transects. Two refuges have been identified in Otter Lake that are planned to be closed beginning in 2010 or 2011. In this segment we began sampling each refuge site and have performed one 30 minute electrofishing transect and one seine haul in each. Three additional control sites were sampled within the lake as reference locations. One reference location is located near each proposed refuge, and the final reference location at the midpoint between the refuge sites. Fish were identified to species and total length was recorded. All fish were counted and up to 50 fish were measured for each species. All largemouth and smallmouth bass collected inside refuge sites were given an upper caudal fin clip in order to determine if fish in the refuge move into adjacent areas of the lake. Catch per unit effort (CPUE) was then calculated as the number of fish per hour of AC electrofishing or number per square meter area seined.

We have begun to collate existing data to examine the effect of harvest regulations on Illinois lakes. In this segment, regulations existing on lakes with largemouth bass population data from Job 4, (including recruitment, abundance and size structure) were identified. The FAS Lakes and Creel databases will be used to obtain data on additional lakes in order to increase the number of lakes included in this analysis. 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. These combined datasets offer nearly twenty years of creel survey and population assessment data collected under project F-69-R. We initiated exploratory analyses of these datasets to identify subsets of lakes appropriate for analyses, specifically targeting assessments of 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

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. In addition, CPUE was greater inside the refuge after closing than 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.

Seine data have shown some increases in the catch of young of year largemouth bass throughout the lake and in the refuge after the refuge was established. In the spring of 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 also 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.

We began the monitoring of future refuge and reference sites in Otter Lake during this segment. In fall of 2007 and spring of 2008, we observed higher catch rates of largemouth bass in the refuge sites than the control in the remainder of the lake. The proposed refuge sites appear to be in areas with good bass abundance and closing these areas to fishing has the potential to increase recruitment. We will assess if limiting disturbance of these fish on the nest may increase spawning success and yield larger year classes.

We have 17 lakes that we are currently sampling as part of job 4 with varying regulations (Table 6-2). The most common regulation for largemouth bass in these lakes and throughout Illinois is a 14-inch length limit and a bag limit of 5. Length limits vary slightly from this standard ranging from 14 to 16 inches. In addition there are two lakes with slot limits imposed. Lincoln trail has a no harvest slot from 14 to 18 inches and a bag limit of 4 with only one fish being larger than 18 inches. Walnut Point Lake has a no harvest slot from 12 to 15 inches with a bag limit of 5. We will need to supplement these lakes in order to perform analyses on the effects of differing regulations, primarily to increase the number of lakes with slot limits or larger than 14 inch length limits. We summarized current regulations used in Illinois. Three types of regulations are currently being employed including minimum size limits, no harvest slot limits, and harvest slot limits (Table 6-3). In future segments we will identify a number of lakes (minimum of 10 from each regulation type) in order to assess differences in fish communities and effects on largemouth bass populations. We will use FAS data collected by IDNR district biologists as well as creel data to determine if regulations are having the desired effect on largemouth bass populations, as well as angler behaviors. In addition, largemouth bass regulations were summarized for 52 lakes that were surveyed from 2003-2007 by both FAS sampling and Creel surveys. This dataset will grow to include the more than 100 inland lakes surveyed under F-69-R since 1987.

RECOMMENDATIONS:

There are many potential harvest regulation strategies 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 and Otter Lakes. We plan to continue our evaluation by conducting seine hauls in the spring and fall at sites within the refuge and 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. Data will be compared after the refuge is initiated to those from the same sites during the years preceding the implementation of the refuges. Bass captured in both seine hauls and electrofishing transects inside the refuges will also be marked with a caudal fin clip on Clinton and Otter Lakes. All bass collected will be examined for existing clips in order to determine if bass in the refuge are moving into the main lake. These studies will provide 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 lakes that we are currently sampling do not vary greatly in regulations for largemouth bass. The FAS Lakes and Creel databases will be used to obtain additional data on current regulations existing on a number of lakes, as well as the largemouth bass abundance and size structure present. We will also 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 10

Job	Proposed Cost	Actual Cost
Job 1	$0	$0
Job 2	$95,198	$95,198
Job 3	$52,359	$52,359
Job 4	$142,798	$142,798
Job 5	$57,119	$57,119
Job 6	$95,198	$95,198
Job 7	$33,320	$33,320

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Table 2-1. Catch per unit effort of stocked and all largemouth bass collected using AC electrofishing in the fall of 2007 and the spring of 2008. Contribution of stocked fish to the total population is calculated as the proportion of stocked fish to total fish.

Lake	Season	CPUE Stocked LMB (#/hr)	CPUE All LMB (#/hr)	Contribution of Stocked fish to total Population (%)
Charleston	Fall 2007	1.1	7.7	14.8
	Spring 2008	2.0	26.9	7.4
Homer	Fall 2007	0.3	46.0	0.7
	Spring 2008	2.7	32.6	8.3
Mingo	Fall 2007	0.0	68.7	0.0
	Spring 2008	0.3	55.4	0.6
Woods	Fall 2007	0.0	34.1	0.0
	Spring 2008	0.0	12.3	0.0

Table 2-2. Cost of production for different sizes of stocked fish. Mean stocking cost is the mean cost for the four lakes in this study.

Stocking Size	Cost per Fish	Mean Stocking Cost (per hectare)
Small	$0.03	$3.51
Medium	$0.15	$8.81
Large	$0.72	$18.65
Advanced	$4.05	$55.91

Table 2-3. Comparison of foraging behaviors for 6 and 8 inch hatchery reared (H) and natural (N) largemouth bass in laboratory experiments. In 30 min experiments, individual largemouth bass foraged on 10 bluegill in 2 m pools. Predators were tested at three intervals corresponding to field sampling that examined growth and survival of stocked largemouth bass.

Size	Interval (week)	Follows		Strikes		Captures (24 hrs)		Capture efficiency (%)		Activity (%)	
		H	N	H	N	H	N	H	N	H	N
Large	2	19.1	8.7	13.2	5.3	3.4	5.1	7.7	21.4	40	25
	4	7.6	4.3	6.6	6.1	3.1	5.1	8.9	31.1	40	21
	8	18.7	8.3	9.6	6.7	3.1	4.2	7.7	30.7	27	26
Advanced	2	25.6	0.2	15.1	0.1	4.3	2.6	3.8	0.0	32	12
	4	19.3	11.0	10.8	5.5	3.6	3.1	8.4	4.8	35	18
	8	29.0	14.9	19.4	4.8	3.8	3.3	3.7	9.6	41	21

Table 2-4. Catch per unit effort from electrofishing samples conducted in the spring and fall of 2007 and spring of 2008.

Lake	Season	CPUE Stocked LMB (#/hr)	CPUE All LMB (#/hr)	Contribution of Stocked Fish to Total Population (%)
Jacksonville	Spring 2007	1.3	31.7	4.2
	Fall 2007	0.7	39.3	1.7
Shelbyville	Spring 2007	0.0	23.7	0.0
	Fall 2007	0.0	16.7	0.0
	Spring 2008	0.0	49.9	0.0
Walton Park	Spring 2007	3.1	23.3	13.1
	Fall 2007	1.4	18.6	7.7

Table 2-5. Stocking information and catch per unit effort from electrofishing sampling in the spring and fall of fish stocked using two different types in 2007. Fish were stocked both at the boat ramp and dispersed in habitat around the lake. Contribution of stocked fish to the total population is the proportion of all sampled largemouth bass that were from a specific stocking.

Lake	Number Stocked	Season	Boat Ramp Stocked LMB (#/hr)	Dispersed Stocked LMB (#/hr)	CPUE All LMB (#/hr)	Contribution of Boat Ramp Stocked LMB to Total Population (%)	Contribution of Dispersed Stocked LMB to Total Population (%)
Homer	2,800	Fall 2007	0.7	0.3	46.0	1.4	0.7
		Spring 2008	0.0	0.0	32.6	0.0	0.0
Mingo	6,800	Fall 2007	0.7	2.0	68.7	1.0	2.9
		Spring 2008	0.0	0.0	55.4	0.0	0.0
Otter	15,300	Fall 2007	0.2	0.0	44.3	0.4	0.0
		Spring 2008	0.0	0.0	16.9	0.0	0.0

Table 2-6. Lake size and stocking densities for 15 Illinois lakes stocked with fingerling largemouth bass. CPUE was determined from fall and spring AC electrofishing transects in each lake for age-0 in fall after stocking and the following spring, age-1 the following fall, and adults (> 250 mm) in subsequent years through age-5.

Lake	Mean Stocked CPUE (#/hr)				Mean Natural CPUE (#/hr)			
	Age-0 Fall	Age-0 Spring	Age-1 Fall	Adult	Age-0 Fall	Age-0 Spring	Age-1 Fall	Adult
Bloomington	5.1	0.7	0.2	0.0	42.9	5.1	10.0	26.7
Charleston	6.0	0.9	0.1	0.1	6.0	8.3	1.1	8.7
Forbes	4.7	5.3	0.7	0.8	19.1	9.2	6.1	15.2
Homer	0.7	0.5	0.1	0.0	22.4	10.2	5.5	17.7
Jacksonville	7.5	12.6	3.2	0.6	10.5	6.1	2.4	17.0
Kakusha	3.8	1.3	0.7	0.5	45.0	7.5	8.3	12.3
LeAquaNa	3.4	2.7	0.1	0.1	10.8	10.7	1.7	12.2
McLeansboro	3.6	4.4	0.9	0.8	11.6	6.4	2.6	7.0
Mingo	2.7	0.8	0.8	0.1	20.0	10.8	6.2	11.2
Murphysboro	3.3	3.9	1.6	0.6	18.6	7.9	2.8	12.3
Pierce	14.3	12.7	2.0	0.4	61.4	24.4	15.8	18.2
Sam Parr	4.2	4.2	3.3	2.0	20.7	14.5	5.3	13.9
Spring South	0.7	1.0	0.0	0.0	15.5	11.9	1.8	25.3
Walton Park	5.2	4.0	1.0	2.3	7.7	5.7	4.3	10.8
Woods	0.3	0.3	0.8	0.0	9.7	3.8	3.1	11.8

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. Fish were stocked into each of the lakes for 6 to 8 years ending in 2004.

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 3-2. The overall contribution of stocked fish to natural reproduction observed in the six study lakes. Influence was based on the average allele frequencies of hatchery fish (2001-2005) and the combined last three years of natural reproduction in the study lakes (2005-2007).

Lake	**Percentage of genes from natural reproduction contributed by stocked hatchery fish**	**Influence**
Forbes Lake	6%	Minor
McCleansboro	0%	None
Lake Murphysboro	11%	Minor
Sam Parr Lake	32%	Moderate
Shelbyville	0%	None
Walton Park	51%	Major

Table 4-1. Mean values for 2007 largemouth bass spawning stock (N/hr), peak density of young-of-the-year (N/m^2), fall abundance of young-of-the-year (N/hr), total length of fall young-of-the-year (mm), and abundance of age-1 recruits (N/hr).

Lake	Spawning Stock	Peak YOY	Fall YOY	Fall TL	Age-1 Recruits
Clinton	12	0.02	5.67	117	6.3
Dolan	-	0.22	7.99	137	0.67
Forbes	4.68	0.54	19.4	112	0.67
Lake of the Woods	8.78	0.24	2.95	102	1.09
Lincoln Trail	10.3	0.58	20.3	104	4.73
Paradise	15.3	0.005	1.46	134	0
Pierce	10.7	0.36	24.2	83	3
Ridge	6.22	0.19	66.8	73	2.56
Shelbyville	12.7	0.02	4.05	132	5.33
Sterling	1	0.15	5.67	86	1.33
Walnut Point	3.34	2.08	20.2	87	14.5
Woods	6.67	0.2	7.57	111	0.67

Table 4-2. Average values for 2007 chlorophyll *a* (µg/L), spring density of crustacean zooplankton (N/L), benthos (N/m^2), total larval fish density (N/m^3), summer density of juvenile bluegill sunfish (N/m^2), and fall abundance of gizzard shad (N/hr) in 12 study lakes in Illinois.

Lake	Chlorophyll *a*	Spring Zooplankton	Benthos	Total Larval Fish	Summer Bluegill	Gizzard shad
Clinton	35.1	20.9	10394	4.03	0.09	518
Dolan	30.2		1284	16.8	11.7	0
Forbes	19.2	86.9	3572	13.2	3.88	34
Lake of the Woods	23.6	48.3	8262	5.69	0.26	86.5
Lincoln Trail	15.3	22.2	3028	17.5	0.62	0
Paradise	75		8743	1.71	0.66	146
Pierce	22.7	48.5	2047	3.09	0.42	657
Ridge	20.6	24.8	4807	1.48	2.7	0
Shelbyville	18.5	57.4	5523	0.92	0.07	140
Sterling	1.53	19.2	4349	0.11	0.11	17
Walnut Point	43.7	30.2	22359	35.7	0.59	0
Woods	48.6	49.6	6795	4.81	0.13	119

Table 4-3. Multiple linear regression models for largemouth bass recruitment to age-1 in 12 study lakes in Illinois. All models were based on 1999-2006 data and were significant at 0.05.

Lake	Adjusted R^2	Variables	Coefficients
Clinton	0.69	August Lepomis larvae	3.24
Dolan		none	
Forbes	0.93	Fall YOY bass	0.28
		log10(Juvenile Bluegill+1)	1.97
Lake of the Woods	0.66	Bass spawn stock	1.15
Lincoln Trail	0.56	Bass spawn stock	1.74
Paradise	0.82	Peak YOY bass	19.9
Pierce	0.82	log10(Fall YOY bass+1)	20.7
		Juvenile Bluegill	4.6
Ridge	0.65	Total spring precipitation	-0.9
		Winter temperature deviation	1.53
Shelbyville		none	
Sterling	0.48	log10(Total Lepomis larvae+1)	10.4
Walnut Point	0.61	log10(Peak YOY bass+1)	16.5
Woods		none	

Table 4-4. Multiple linear regression models of inter-system variation in fall total length, and recruitment to age-1 and fall. All models were based on 1999-2006 data and were significant at 0.05.

Response Variable	Adjusted R^2	Variables	Coefficients
Among all lakes (age-1 recruits)	0.68	log10(Fall YOY bass+1)	12.8
Among all lakes	0.65	Peak YOY bass	1.66
(fall YOY recruits)		log10(August Lepomis larvae+1)	17
Among all lakes	0.71	Peak YOY bass	-1.62
(fall YOY TL)		log10(secchi depth + 0.1)	-65.6

Table 4-5. 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 (#/m2)	BLG Density (#/m2)	Total Fish Density (#/m2)
			2006		
Vegetated	1	120	0.09	1.02	1.21
	2	90	0.03	0.50	0.60
	3	78	0.03	0.40	0.51
	Mean	96	0.05	0.64	0.77
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
			2007		
Vegetated	1	60	0.10	0.55	0.83
	2	50	0.04	0.42	0.58
	3	40	0.03	0.45	0.64
	Mean	50	0.06	0.47	0.68
No Veg.	1	78	0.12	0.24	0.44
	2	90	0.04	0.18	0.30
	3	72	0.08	0.20	0.40
	Mean	80	0.08	0.21	0.38

Table 4-6. Vegetation sampling in the fall of 2007 on 14 Illinois lakes. Vegetated areas on each lake were measured through digitizing hand drawn maps and by using GPS measurements of vegetation estimated using GIS coverages. High treatment lakes will be treated in order to reduce vegetation. Low planted lakes will be planted with vegetation or rehabilitated using drawdown and rotenone. Control lakes will be used to assess the success of treated and planted manipulations.

Type	Lake	Date	Lake Area (m^2)	Lake Perimeter (m^2)	Digitized Vegetated Area (m^2)	Digitized Vegetated Perimeter (m^2)	GIS Vegetated Area (m^2)	GIS Vegetated Perimeter (m^2)	GIS % Vegetated Area	GIS % Vegetated Perimeter
High Treatment	Airport	8/29/07	89246	1171	176008	2323	178486	2342	100	100
	Kakusha	8/20/07	192665	3256	9389	602	4555	494	2	15
	Stillwater	8/21/07	89363	2215	88380	2193	89382	2227	100	100
Low Planted	Dolan	8/23/07	302869	5335	51528	4050	77124	4066	25	76
	Paradise	8/23/07	706098	7287	96316	3845	90497	3727	13	51
High Control	Le-Aqua-Na	8/20/07	175825	2709	55754	1761	49182	1744	28	64
	Ridge	8/27/07	47514	1414	9347	854	7640	766	16	54
Medium Control	Forbes	8/30/07	2056612	29364	NA	NA	306671	26295	15	90
	Lincoln Trail	9/7/07	584546	10033	167322	9154	143055	10034	24	100
	Pierce	8/21/07	647830	6406	167097	8236	152673	5891	24	92
Low Control	LOTW	9/6/07	103090	2259	2685	2160	338	95	0	4
	Walnut Point	8/17/07	215810	9396	1115	163	13	14	0.006	0.146
	Woods	8/10/07	3241	127217	0	0	0	0	0	0

Table 4-7. Mean chlorophyll a concentration, larval fish density, zooplankton density, macro benthos density, and electrofishing catch-per-unity-effort for bluegill, young-of-year and adult largemouth bass for 2007.

Lake	Chl a (ug/L)	Mean Total Larval Fish Density (#/L)	Mean Total Zooplankton Density (#/L)	Mean Benthos >250um Density (#/m^2)	YOY LMB Fall Electrofishing CPUE (#/hr)	BLG CPUE Fall Electrofishing (#/hr)	Adult >8" LMB Fall Electrofishing CPUE (#/hr)
Airport	18	0	235	583	22	132	33
Dolan	30	17	1164	134	26	70	37
Forbes	19	13	406	4210	26	122	25
Kakusha	39	0	1441	1114	39	258	16
Lake of the Woods	24	5	381	267	7	149	29
Lincoln Trail	15	18	165	231	21	103	19
Paradise	75	1	400	131	4	126	16
Pierce	23	2	302	378	26	157	20
Ridge	21	1	399	1039	59	67	52
Stillwater	10	0	260	455	26	75	14
Walnut Point	44	36	494	199	24	63	18
Woods	49	5	319	75	11	292	24

Table 4-8. Numbers of bass from each 100 mm size class found in the streams below the dams of both Forbes Lake and Ridge Lake.

Date	300+ mm	300-200 mm	200-100 mm	100-0 mm
Forbes Lake				
4/24/08	3	2	3	0
5/19/08	3	1	2	3
6/13/08	0	2	0	2
Ridge Lake				
6/10/08	4	1	1	25

Table 5-1. Ranking matrix for largemouth bass nesting substrate. Values are log-ratio comparisons between available and used habitats. Positive values indicate preference of used habitat over available habitat. The greater the deviation from zero, the greater the preference. Data were collected during 2006-2008 in Lincoln Trail Lake.

Habitat Type Used	Available Habitat Type									# of Positive Values
	Vegetation	Wood	Sticks	Leaves	Detritus	Sand	Gravel	Cobble	Pebble	
Vegetation		-1.3	-1.2	-0.7	-0.2	-0.8	-1.5	-2.0	-1.8	0
Wood	1.3		0.1	0.6	1.1	0.5	-0.2	-0.7	-0.5	5
Sticks	1.2	-0.1		0.5	1.1	0.4	-0.3	-0.8	-0.5	4
Leaves	0.7	-0.6	-0.5		0.5	-0.1	-0.8	-1.3	-1.1	2
Detritus	0.2	-1.1	-1.1	-0.5		-0.7	-1.3	-1.9	-1.6	1
Sand	0.8	-0.5	-0.4	0.1	0.7		-0.7	-1.2	-0.9	3
Gravel	1.5	0.2	0.3	0.8	1.3	0.7		-0.5	-0.3	6
Cobble	2.0	0.7	0.8	1.3	1.9	1.2	0.5		0.2	8
Pebble	1.8	0.5	0.5	1.1	1.6	0.9	0.3	-0.2		7

Table 5-2. Number of fish surveyed, sex ratios, average total length, and percent spawning male largemouth bass from tournament catches on Mill Creek, Lake Mattoon, Lake Shelbyville, and Steven Forbes Lake during spawn and post-spawn periods from 1999 to 2007. TL refers to the total length of the fish.

Lake	Season	# of Tournaments	Total # of Fish	% Male	TL of Females	TL of Males
Forbes	Spawn	10	61	57	453	407
	Post Spawn	5	32	63	399	439
Mattoon	Spawn	7	70	59	454	409
	Post Spawn	6	51	59	414	387
Mill Creek	Spawn	6	128	66	428	369
	Post Spawn	4	84	49	406	401
Shelbyville	Spawn	5	101	35	431	382
	Post Spawn	5	280	51	424	408

Table 5-3. Angler interview responses regarding the number of released fish during tournaments. Fish were released due to culling for large fish or because they were below the legal limit (short fish).

Lake	Date	# of Anglers Interviewed	Mean # Culled	Mean # of Short Fish
Mattoon	8/11/04	10	0.0	0.5
Mattoon	8/9/06	3	0.0	0.0
Mill Creek	8/8/04	11	0.0	0.0
Mill Creek	7/26/06	5	0.0	3.2
Mill Creek	8/9/06	7	0.1	3.4
Mill Creek	5/16/07	4	1.8	5.8
Shelbyville	5/11/03	5	0.0	5.4
Total		45	0.3	2.6

Table 5-4. Mean length for each age of largemouth bass in selected Illinois lakes. Ages were determined from scale samples read from spring electrofishing transects from 2005-2008. Tournament pressure was ranked as none, low, or high based on the total number of tournaments per year.

Lake	Tournament Pressure	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6
Lake of the Woods	None	223	247	302	289	355	418
Lincoln Trail	Med	-	238	271	324	375	429
Paradise	None	113	235	309	359	408	-
Ridge	Low	142	198	276	325	336	-
Shelbyville	High	186	290	339	338	363	394
Walnut Point	None	-	233	272	293	363	380
Woods	None	-	255	280	341	391	457

Table 6-1. Catch per unit effort (#/hr) for largemouth bass in A. Clinton Lake and B. Otter Lake captured through AC electrofishing. The refuge in Clinton Lake was closed in 2001 and sampling on the closed portion began in fall of 2003. All sampling on Otter Lake has been pre refuge which will be closed at a future date.

A. CLINTON LAKE

Year	Control		Refuge	
	Spring	Fall	Spring	Fall
1999	19.8	24.4	56.0	24.0
2000	32.4	5.5	18.0	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	18.3	32.7	23.0	44.0
2008	37.0	-	38.0	-

B. OTTER LAKE

Year	Control		Refuge	
	Spring	Fall	Spring	Fall
2007	-	37.4	-	55.2
2008	23.6	-	31.4	-

Table 6-2. Largemouth bass regulations in existence for a number of currently being sampled by the Illinois Natural History Survey. CPUE of LMB over 14 inches is catch per unit effort for largemouth bass from electrofishing transects performed in fall 2007.

Lake	**Length Limit (inches)**	**Creel Limit**	**CPUE of LMB >14**
Airport Lake	14	5	15.3
Charleston Lake	14	5	4.2
Clinton Lake	16	3	9.6
Dolan Lake	14	5	2.7
Forbes Lake	14	5	3.0
Lake Kakusha	14	3	12.8
Lake Le-Aqua-Na	14	1	Not Sampled
Lake Mingo	15	5	4.0
Lake Paradise	14	5	10.3
Lake Shelbyville	14	5	4.5
Stillwater Lake	No Fishing	0	6.1
Lake-of-the-Woods	15	1	8.6
Lincoln Trail Lake	<14 or >18	4 total, only 1>18	3.3
Otter Lake	15	3	9.8
Pierce Lake	14	1	6.0
Ridge Lake	14	5	6.4
Walnut Point Lake	<12 or >15	5	2.8
Woods Lake	14	5	9.6

Table 6-3. Summary of harvest regulations for largemouth bass currently being enforced on lakes in Illinois.

Regulation Type	**N**	**Length Limit (inches)**	**Creel Limit (# of Fish)**	**Number of Lakes**
Length Limits	13	12	1	1
		12	5	4
		14	1	20
		14	3	10
		14	5	214
		15	1	27
		15	3	44
		15	5	43
		15	6	1
		16	3	3
		18	1	8
		18	3	1
		18	5	2
No Harvest Slot Limits	7			
		<14, >18	4	1
		<14, >18	5, 1	2
		<15, >15	1, 2	1
		<12, >18	2, 1	2
		<12, >12	2, 1	1
		<12, >15	2, 1	1
		<12, >15	5, 1	2
Harvest Slot Limits	5	12 to 15	3	4
		12 to 15	5	8
		12 to 18	3	1
		12 to 18	5	1
		14 to 18	5	2

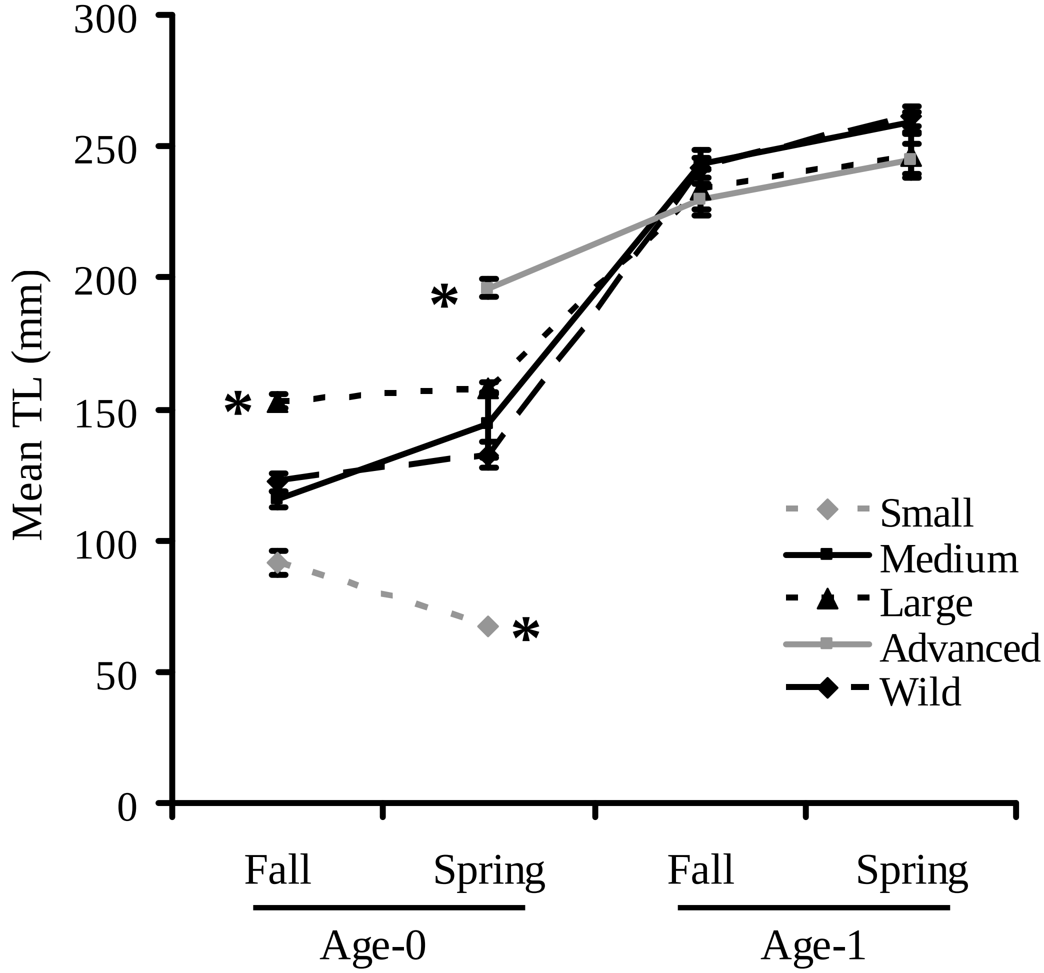

Figure 2-1. Mean total length of four sizes of stocked largemouth bass over the first two years of growth. Bass were collected by 3 phase AC electrofishing transects in the spring and fall. The asterisks represent a mean that is significantly different than the other means within a season.

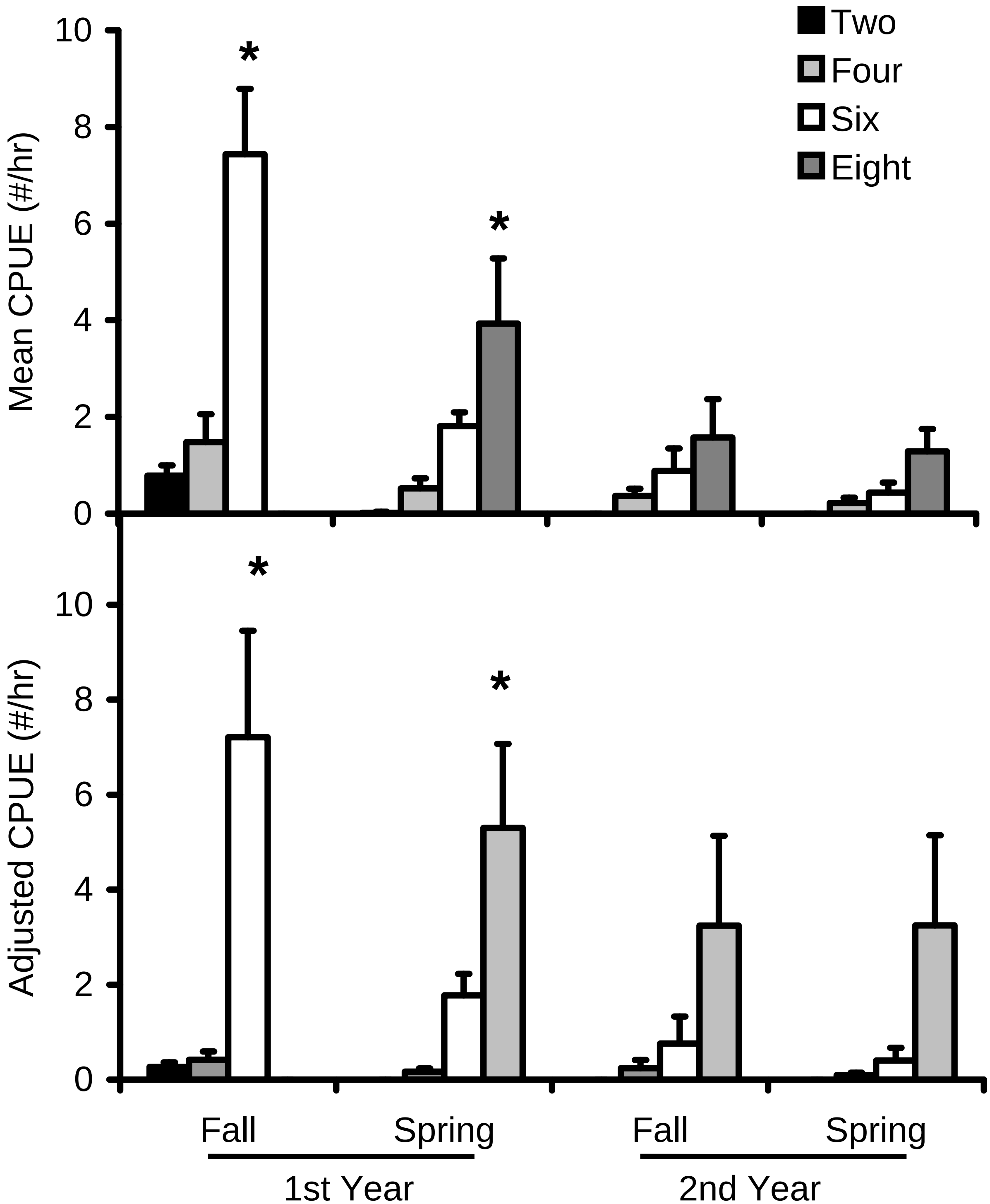

Figure 2-2. Mean catch per unit effort for lakes stocked with four sizes of largemouth bass. Adjusted CPUE is calculated as the CPUE from electrofishing divided by the total number stocked. Error bars represent standard error. An Asterisk represents a significant difference within a season.

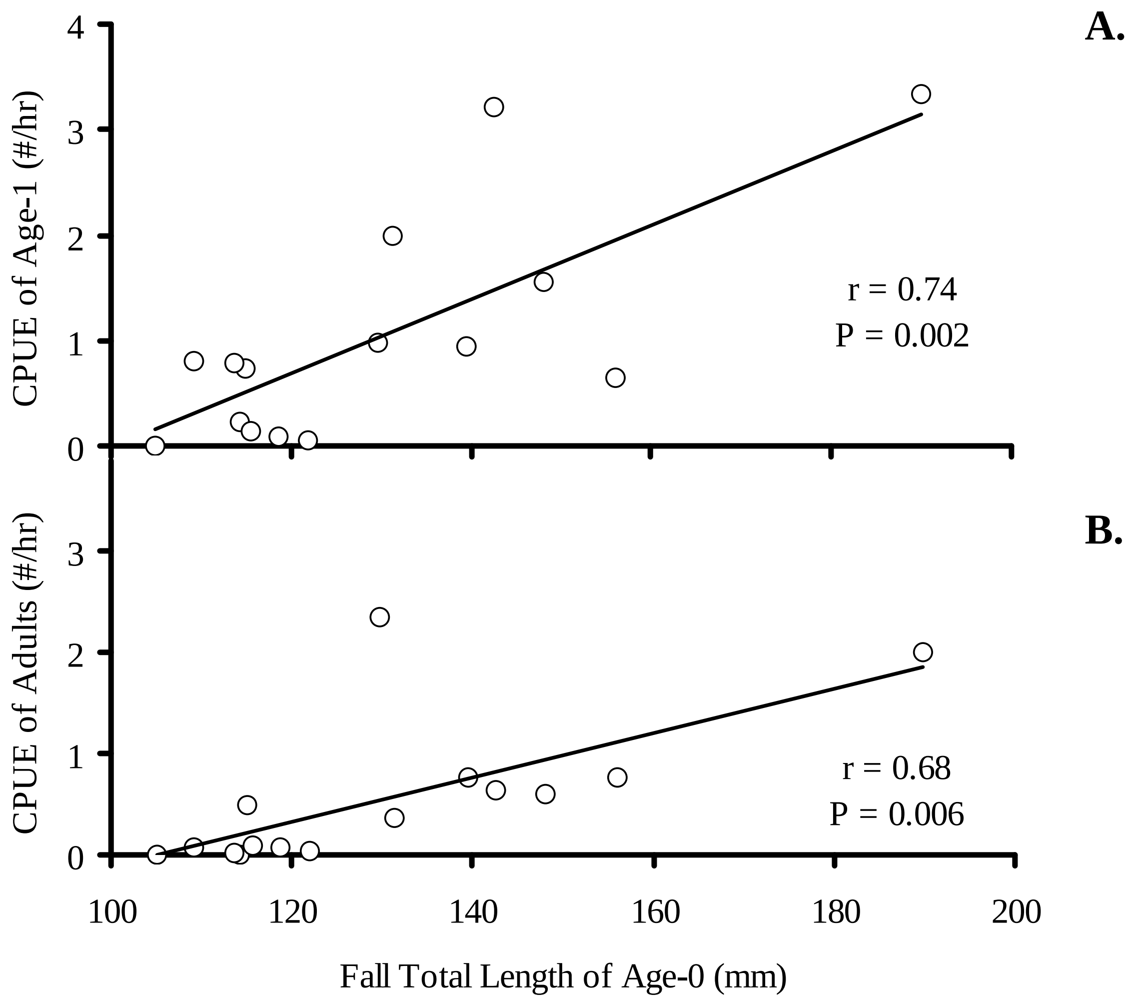

Figure 2-3. Relationship between and mean total length of age-0 stocked largemouth bass in electrofishing samples in the fall following stocking and CPUE of age-1 (age 1; A.) and adult (age 2-5; B.) stocked largemouth bass in fall electrofishing samples in 15 lakes in Illinois. Values are means from three annual stockings.

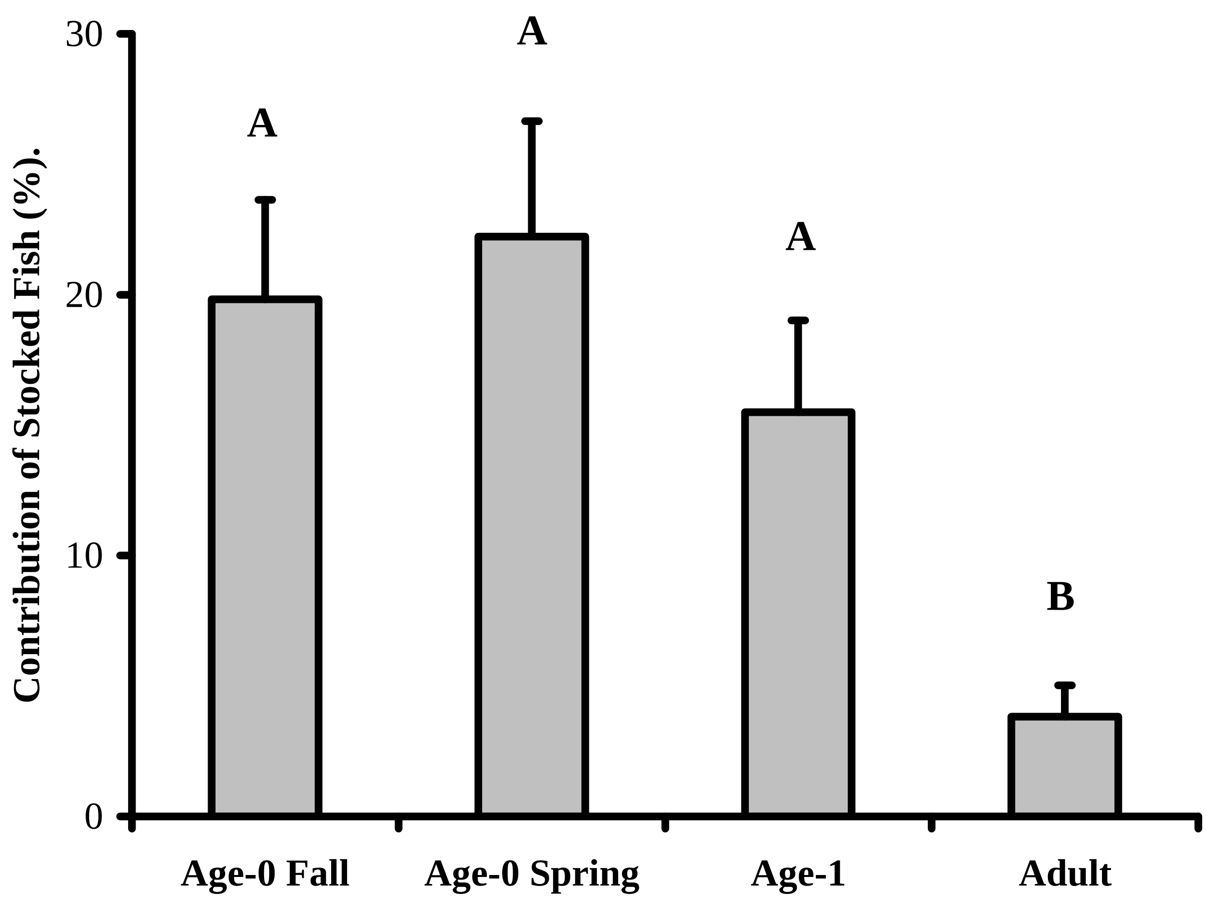

Figure 2-4. Contribution of stocked largemouth bass to the total population through time. Age-0 Fall is the first fall after stocking. Age-0 Spring is the following spring. Age-1 refers to the second fall following stocking and Adult is the mean of fall contribution from the third, forth and fifth fall following stocking. Different letters represent bars that are significantly different ($P < 0.05$) and error bars represent the standard error.

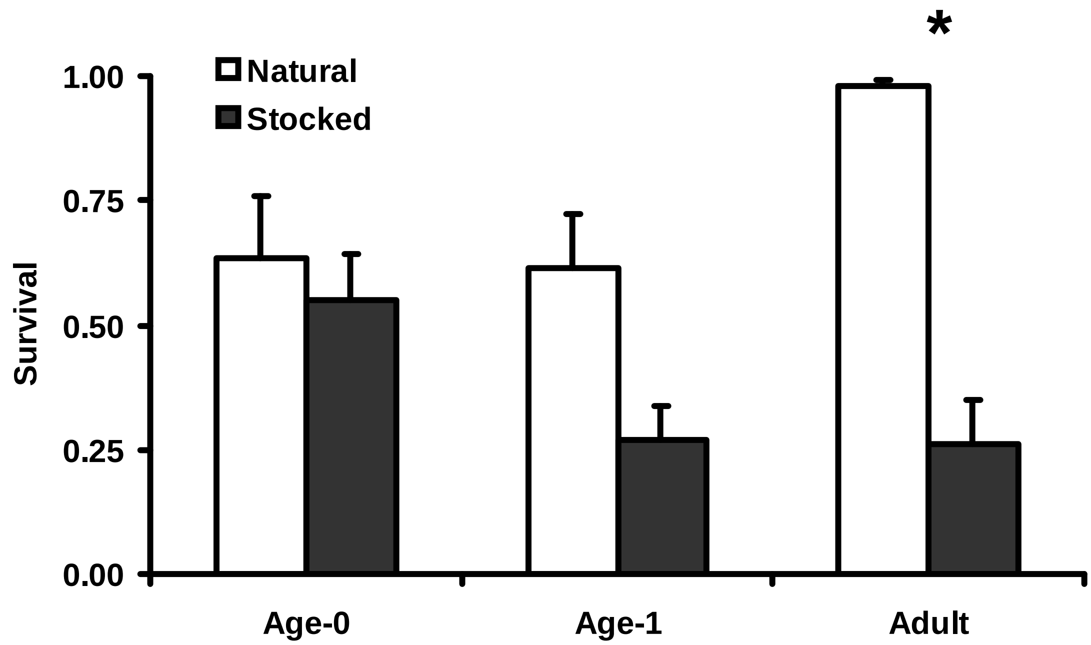

Figure 2-5. Mean proportion of fish surviving to a specific age class based on decreases in CPUE from electrofishing. Age-0 represents survival from the first fall following spawn/stocking to the first spring. Age-1 represents survival from the first spring through the second fall following spawn/stocking. Adult represents the survival from the second fall to adult age. The asterisk represents a significant difference ($P < 0.05$) between stocked and wild fish. Error bars represent the standard error.

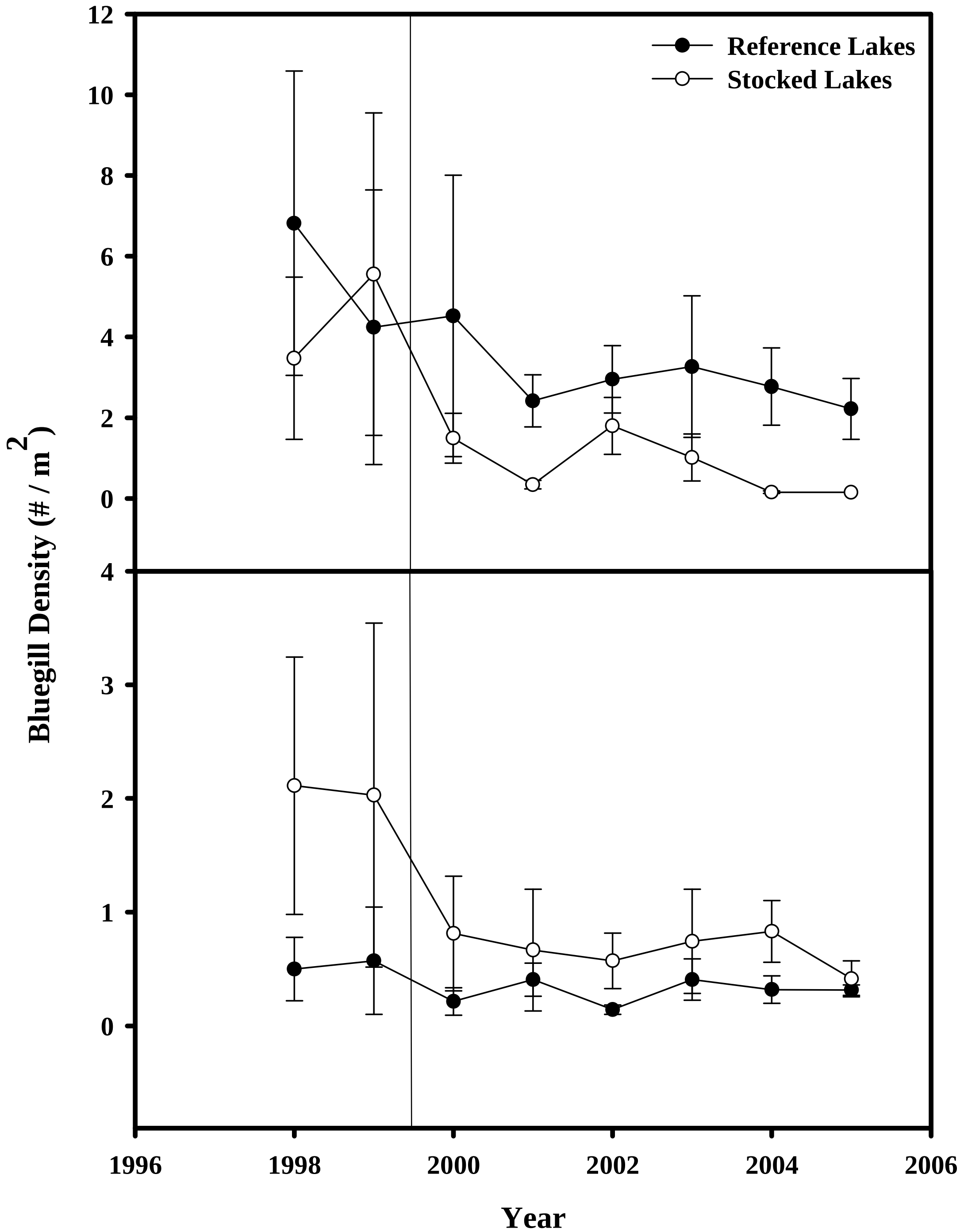

Figure 2-6. Littoral bluegill density (number per m^2) in Illinois lakes without gizzard shad (top) and lakes containing gizzard shad (bottom) stocked with largemouth bass 1998-2005. Vertical line represents date of initial largemouth bass stocking.

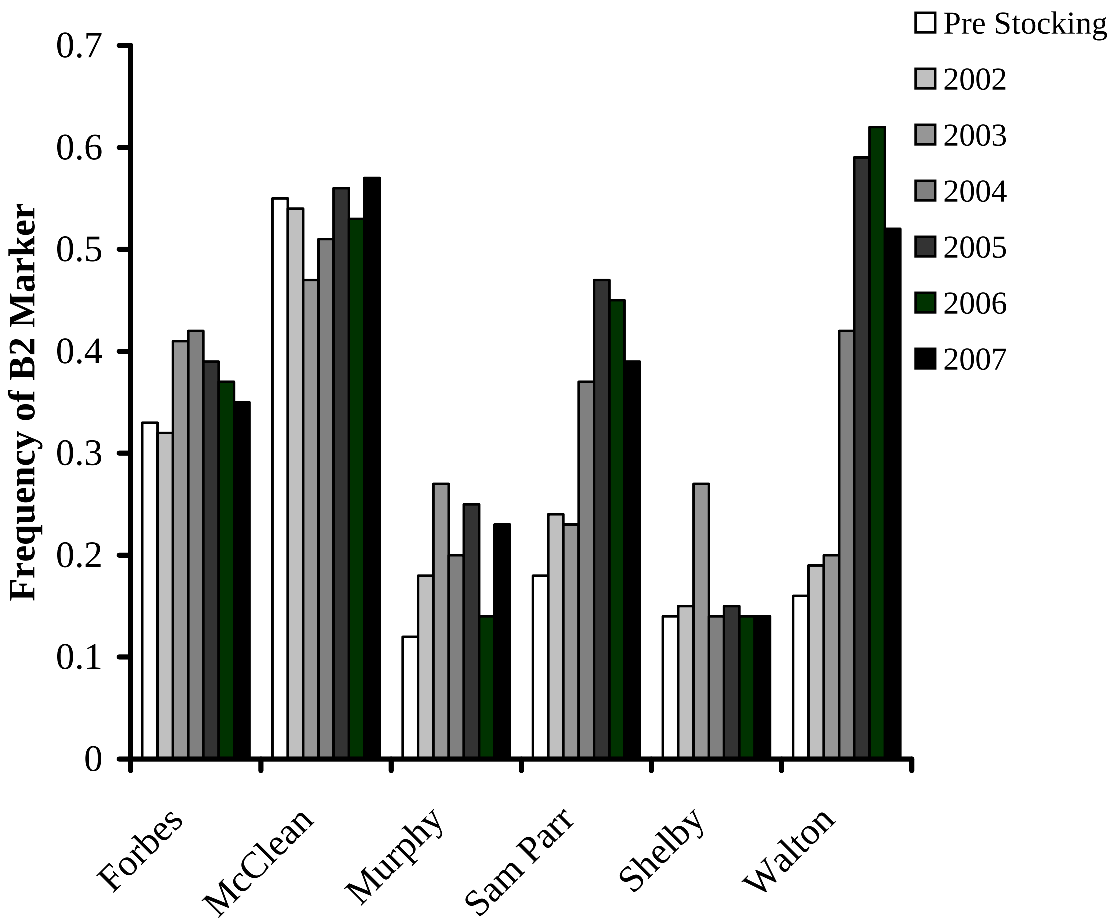

Figure 3-1. Frequency of the B2 allele in the six study lakes previous to stocking and in 2002-2007 during which stocked bass were expected to be contributing to reproductive population.

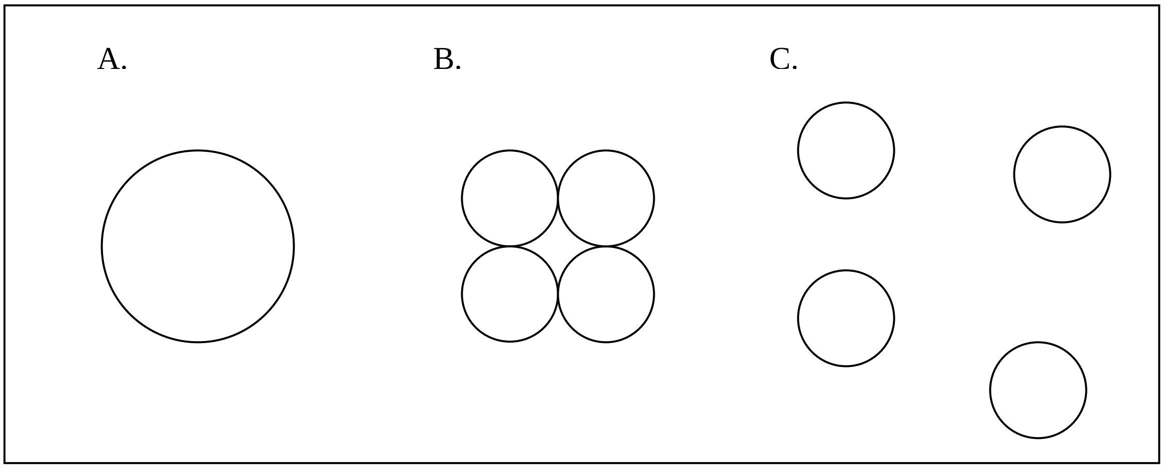

Figure 4-1. Experimental enclosure design used for the testing of planting success for sago pondweed and wild celery tubers. One replicate included (A.) one large enclosure (area = 31.8ft^2), (B.) four small clustered enclosures (area = 7.9 ft^2), and (C.) four small dispersed enclosures.

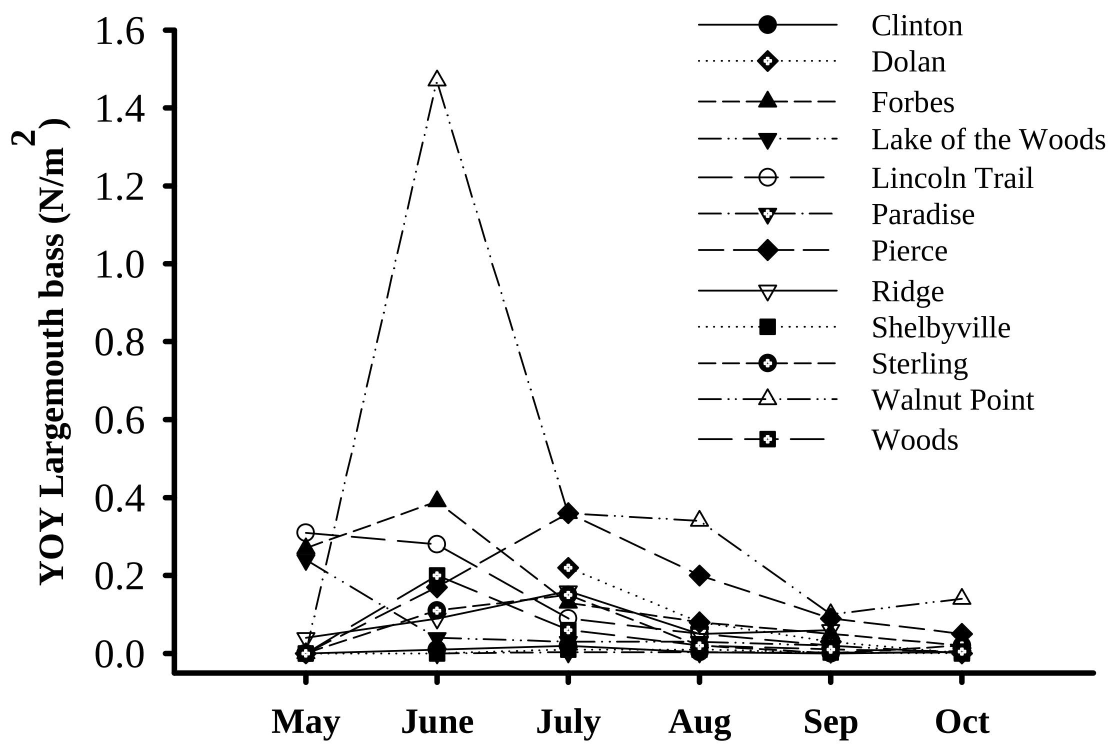

Figure 4-2. Average monthly young-of-the-year (YOY) largemouth bass densities (N/m2) from seine collections in 12 study lakes during 2007. Closed symbols represent lakes with gizzard shad and open symbols represent lakes without gizzard shad.

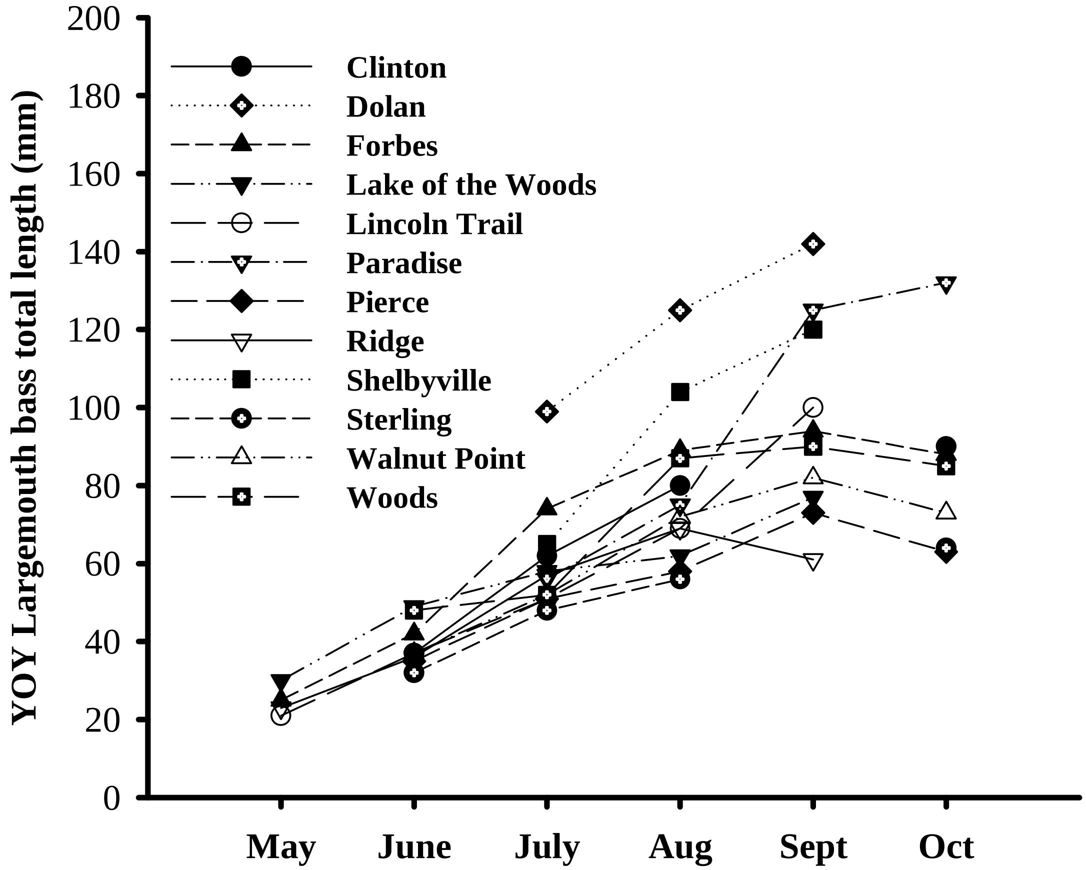

Figure 4-3. Monthly averages of young-of-the-year (YOY) largemouth bass total lengths (mm) from seine collections in 12 study lakes in 2007. Closed symbols are lakes with gizzard shad and open symbols are lakes without gizzard shad.

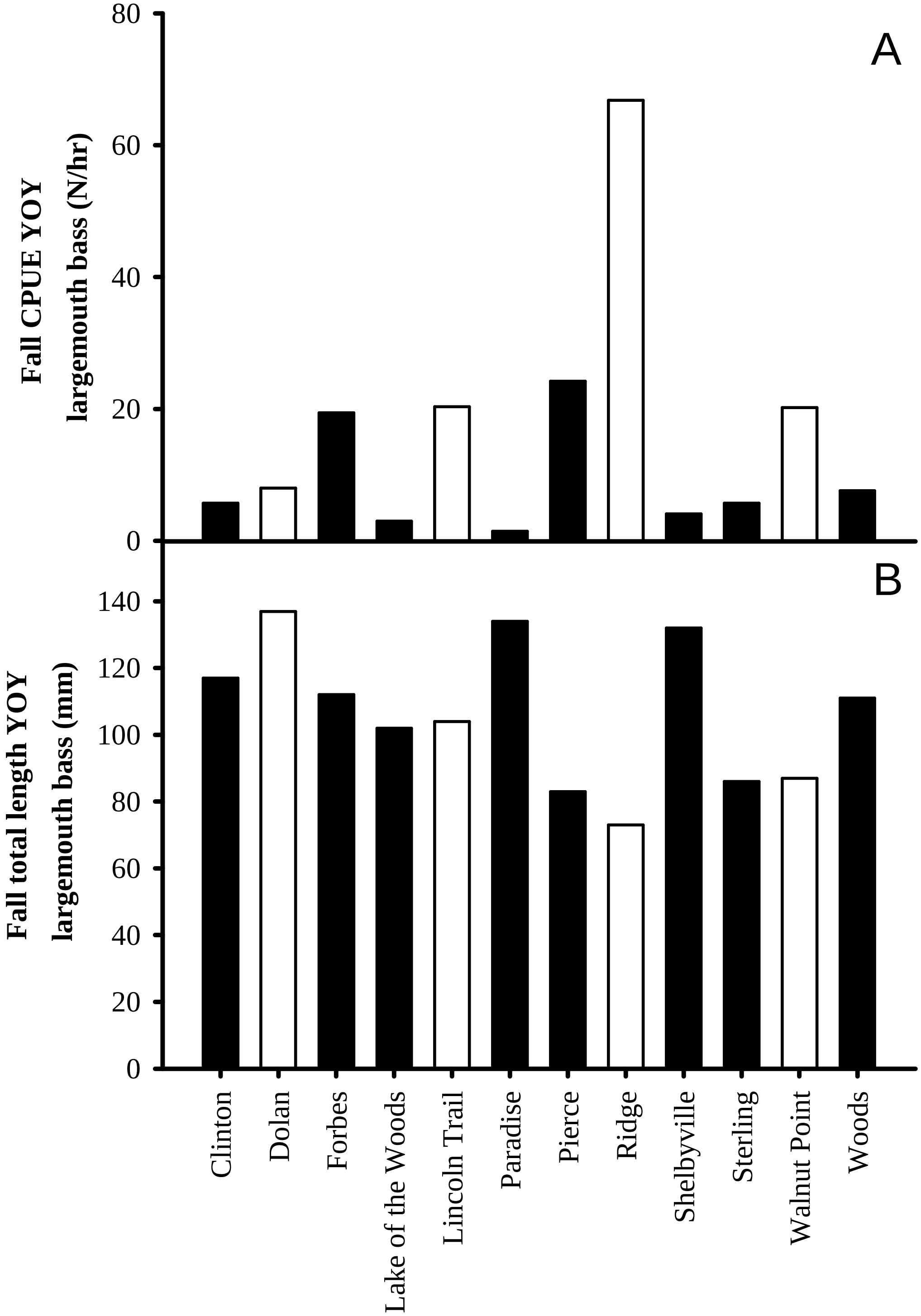

Figure 4-4. Fall (A) catch per unit effort (N/hr) and (B) total length of young-of-the-year largemouth bass in 12 study lakes. Closed bars are lakes with gizzard shad and open bars are lakes without shad.

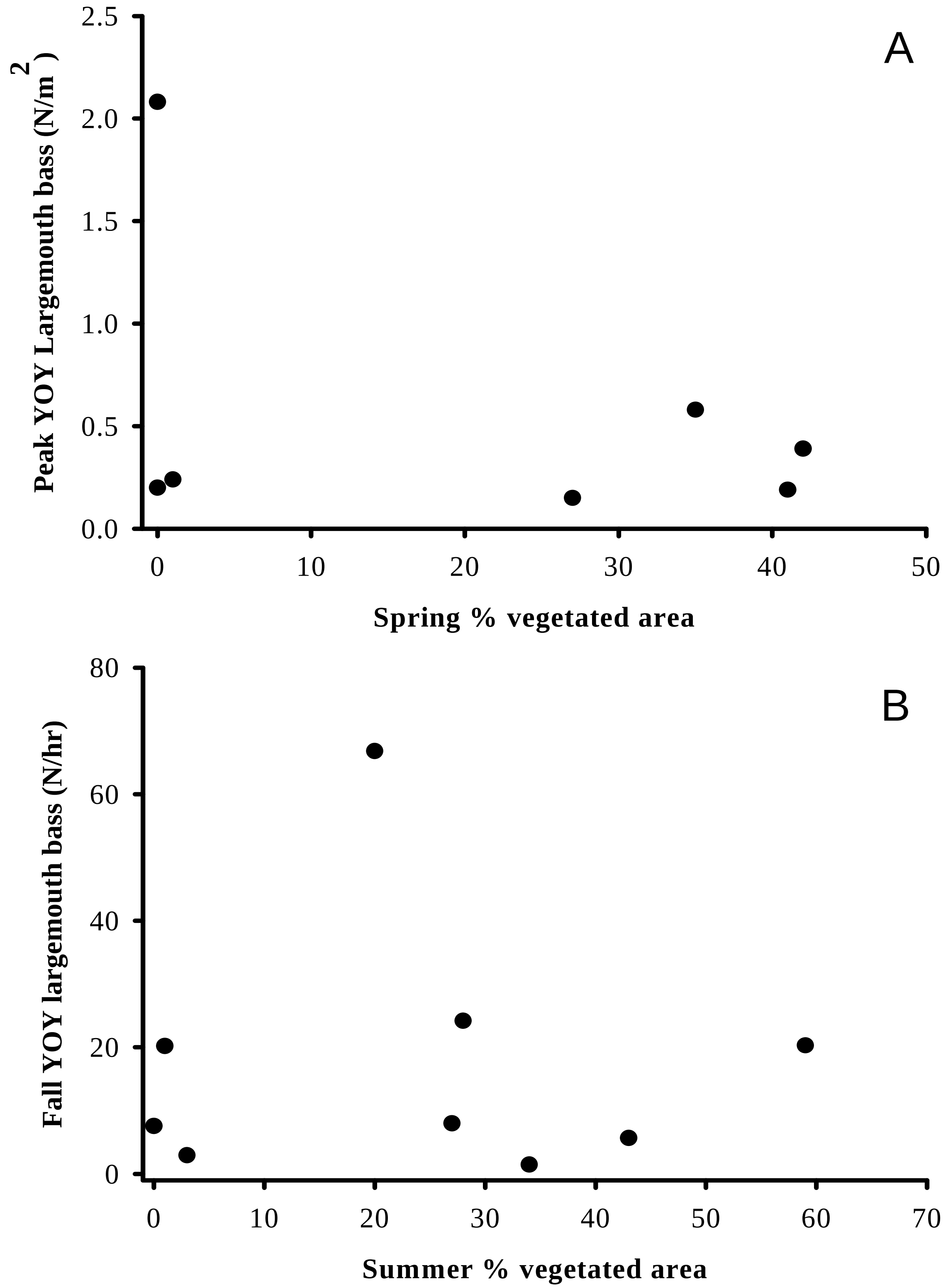

Figure 4-5. (A) Average % vegetated area in the spring and peak YOY largemouth bass density and (B) mean % vegetated area in the summer and fall total length of YOY largemouth bass.

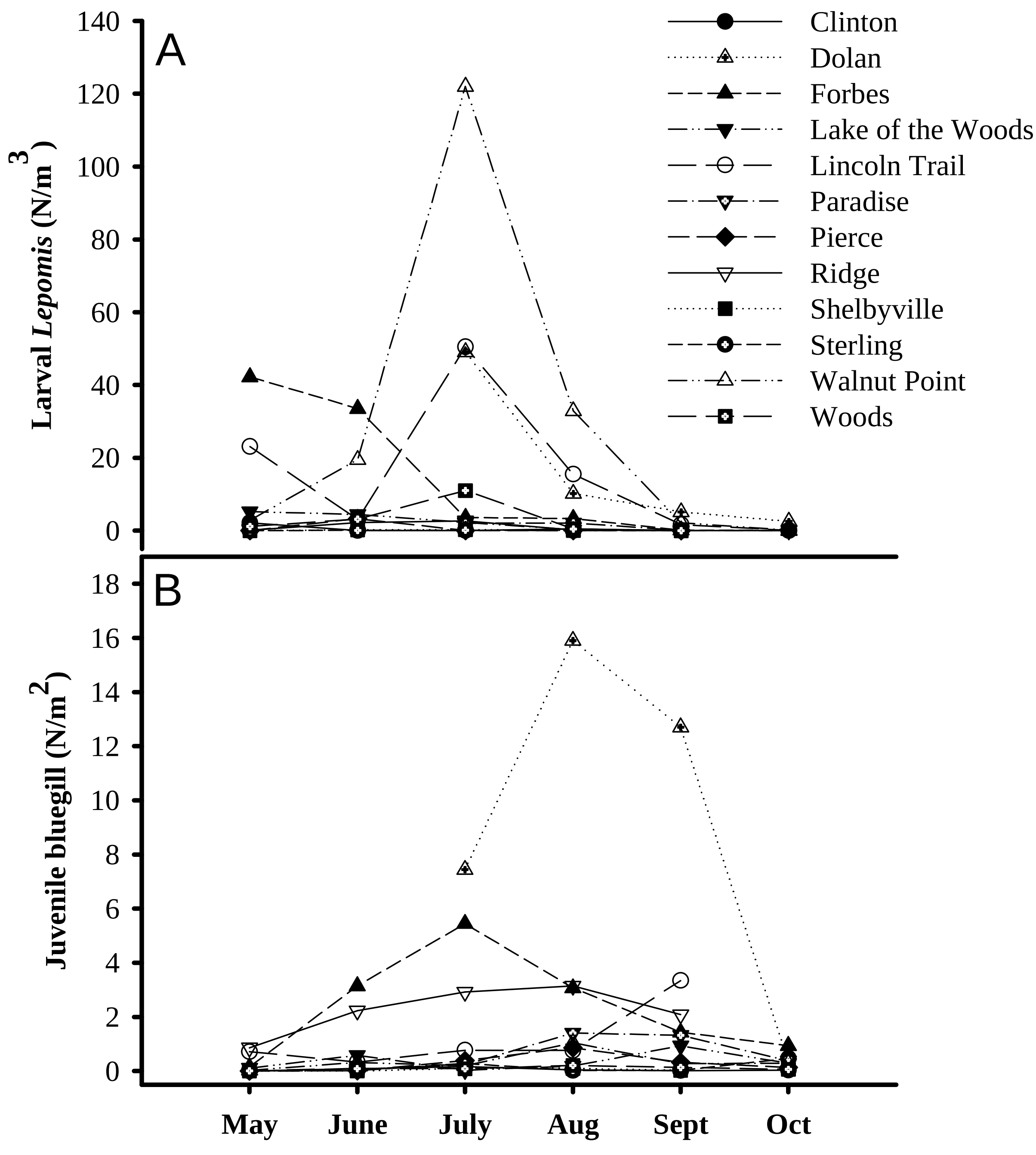

Figure 4-6. Mean monthly densities of (A) larval Lepomis and (B) juvenile bluegill sunfish (TL < 60 mm). Lakes with open symbols do not contain gizzard shad.

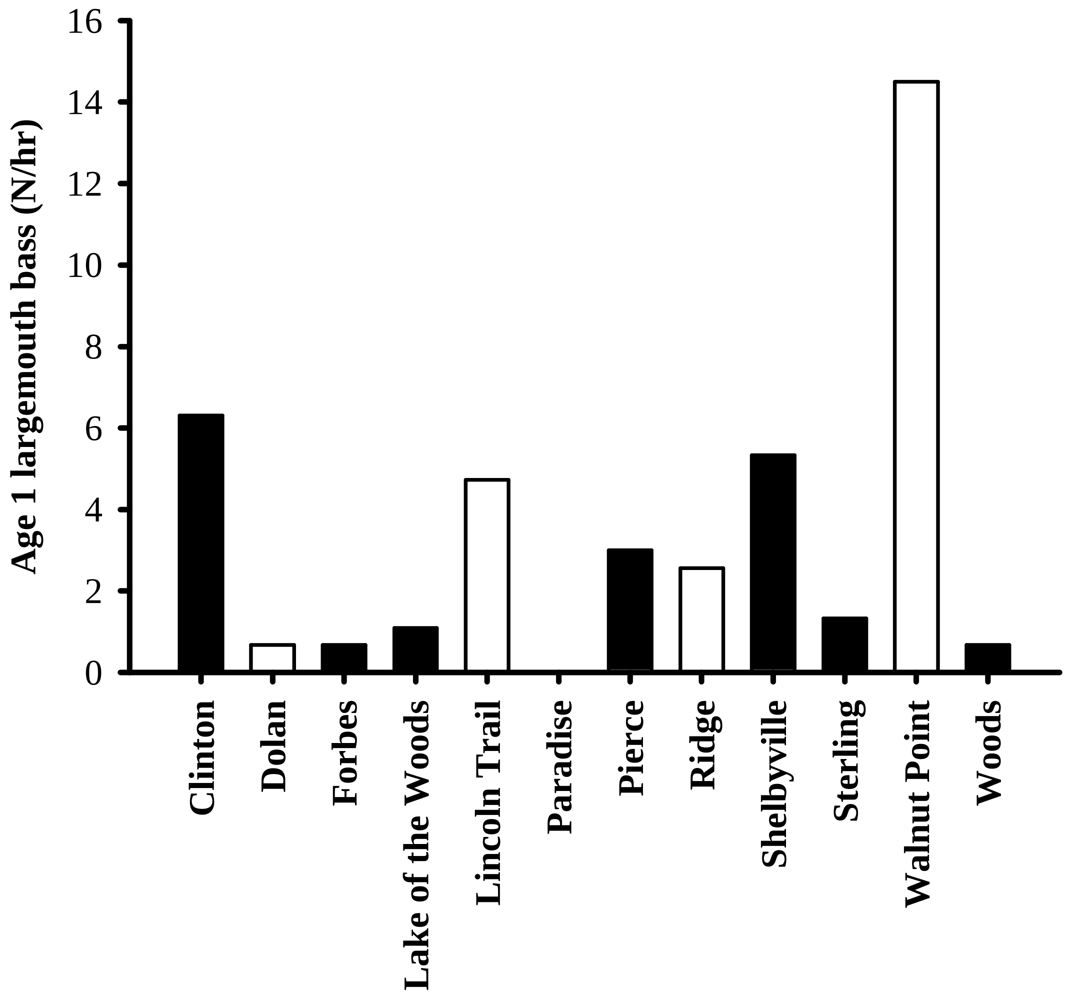

Figure 4-7. Spring 2008 catch per unit effort (N/hr) of largemouth bass recruited to age 1 in 12 study lakes.

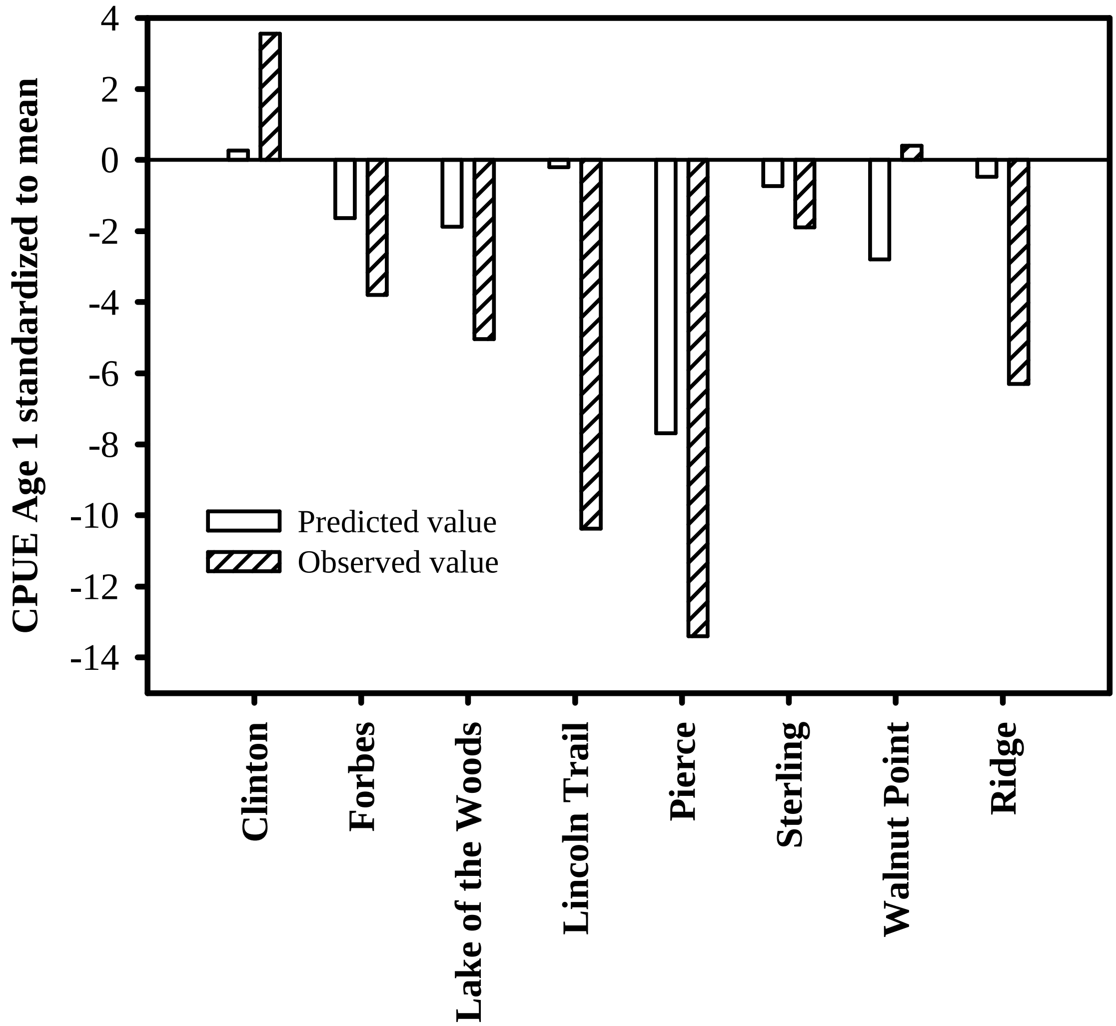

Figure 4-8. Predicted and observed recruitment to age 1 for eight study populations of largemouth bass. Recruitment predictions are from regression models applied to 2007 environmental data. Recruitment measures are standardized relative to an eight-year (1999-2006) mean.

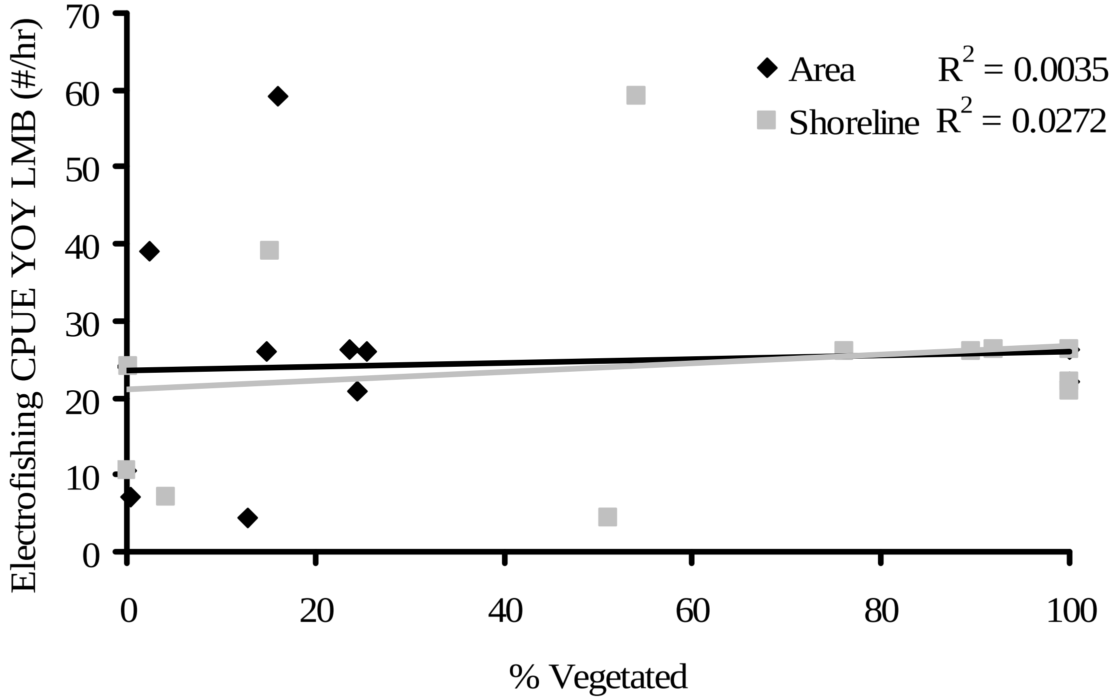

Figure 4-9. Catch-per-unit-effort of young-of-year (< 150 mm) largemouth bass from fall electrofishing samples in 2007 as a function of percent vegetated lake area and shoreline for each lake

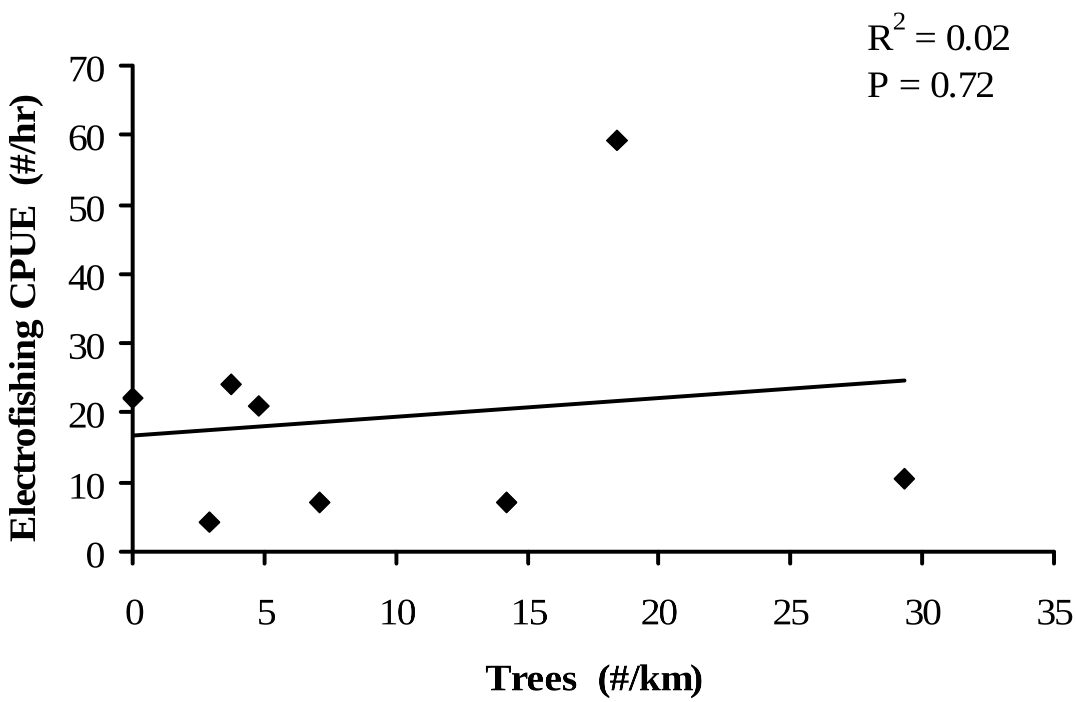

Figure 4-10. Electrofishing catch per unit effort (CPUE) of young-of-year largemouth bass conducted in the fall of 2007 compared to tree density (#/km) within 8 Illinois lakes.

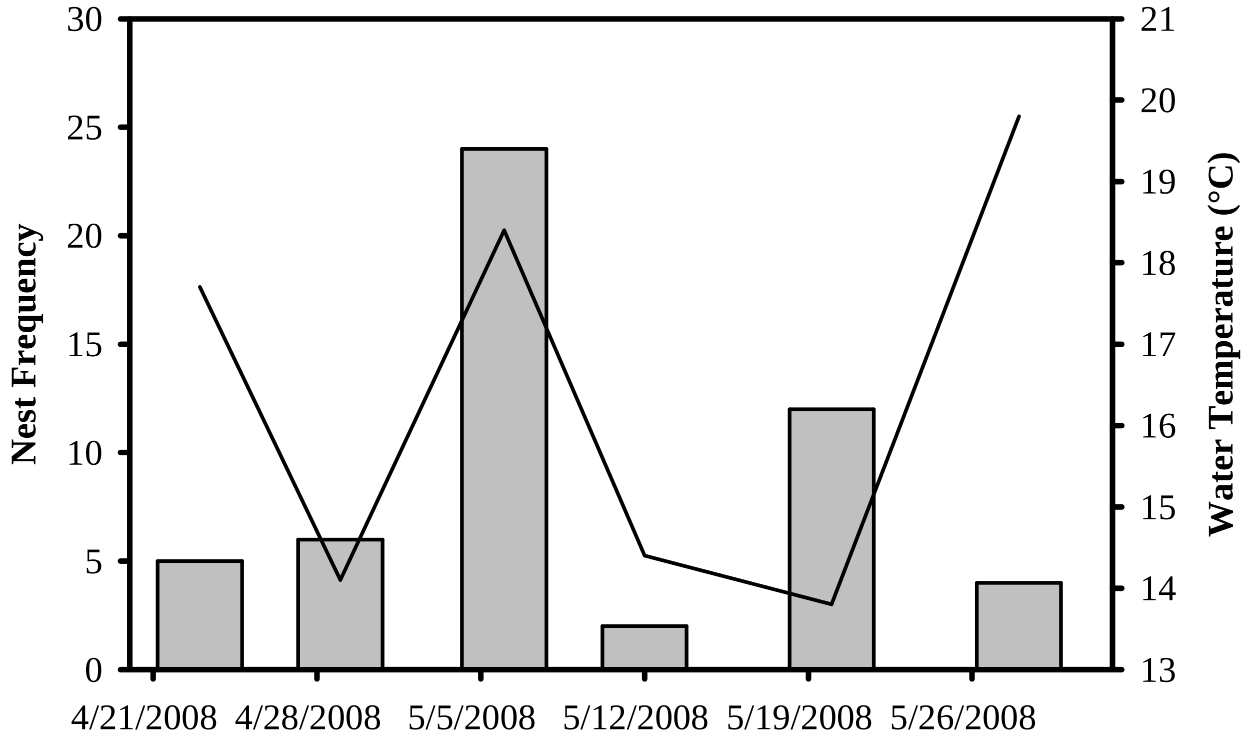

Figure 5-1. Nest frequency (bars) and water temperature (°C, line) through time during spring 2008 in Lincoln Trail Lake.

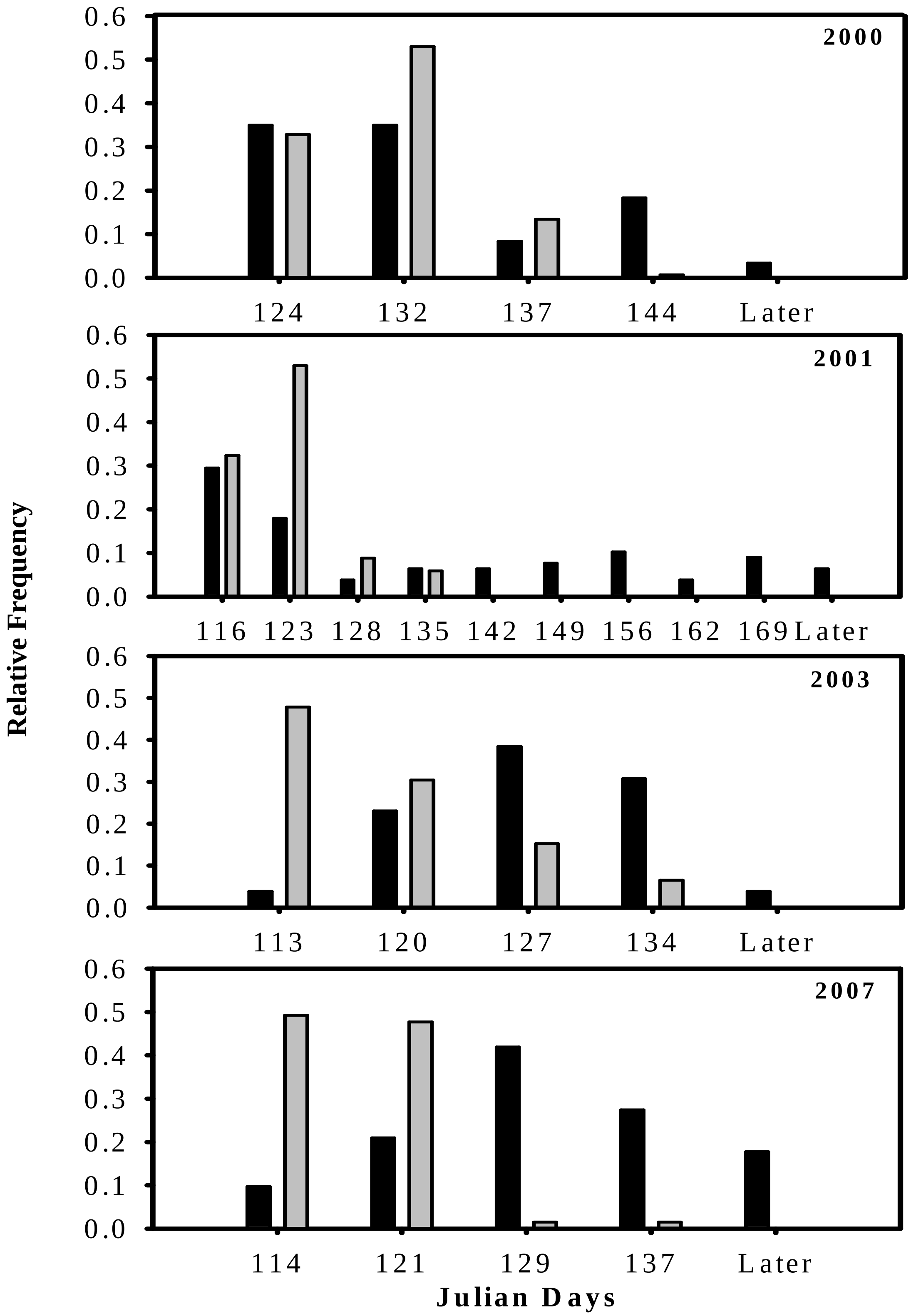

Figure 5-2. Relative frequency of largemouth bass nests (light bars) and relative abundance of YOY in fall (dark bars) through time in Lincoln Trail Lake. YOY spawn date was back-calculated using daily otolith rings.

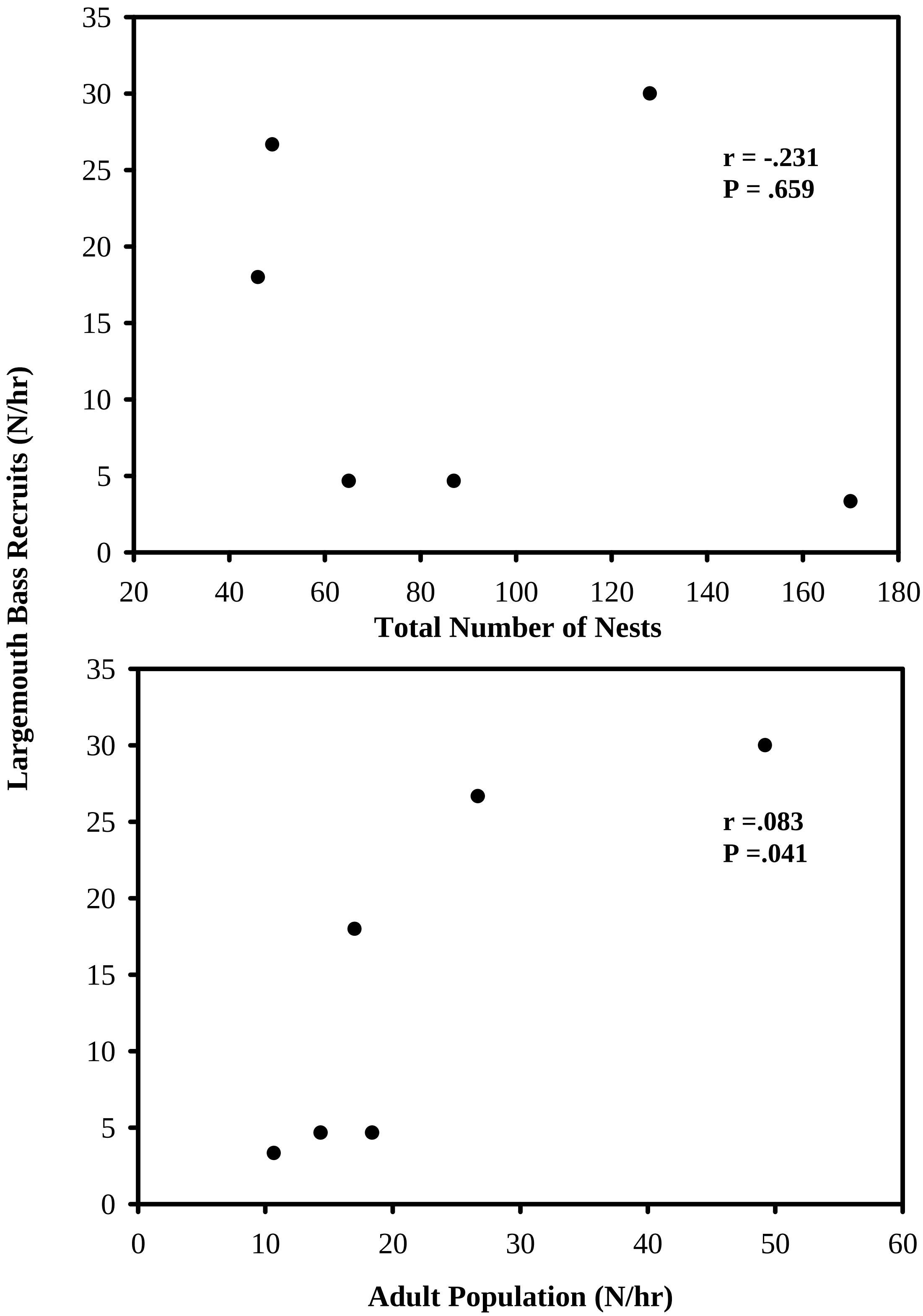

Figure 5-3. CPUE of Largemouth Bass recruited to age-1 (<150mm) versus Total Number of Nests and CPUE of breeding adult population (>250mm).

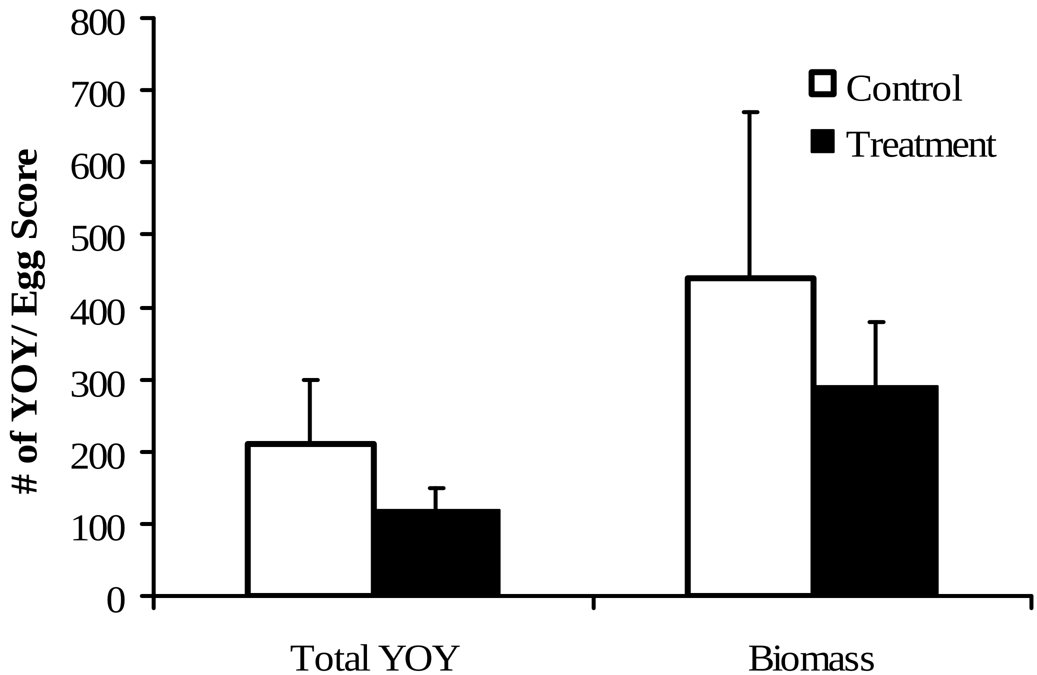

Figure 5-4. Total YOY produced and YOY biomass in control (no manipulation) and treatment (50% brood reduction) ponds in 2007.

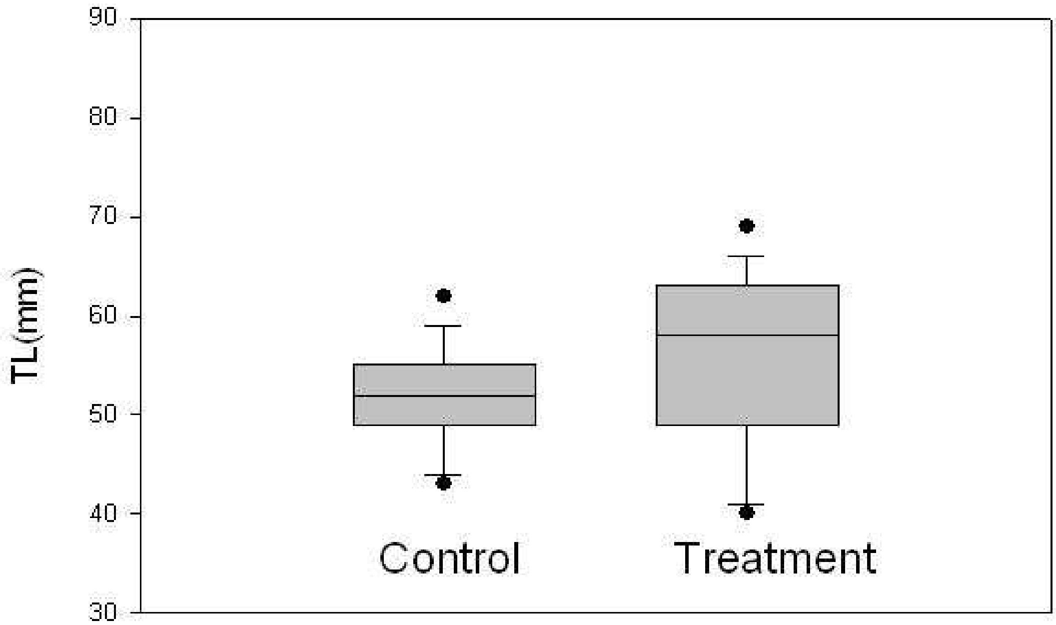

Figure 5-5. Mean total length of YOY largemouth bass in control (above) and treatment (above) ponds in 2007.

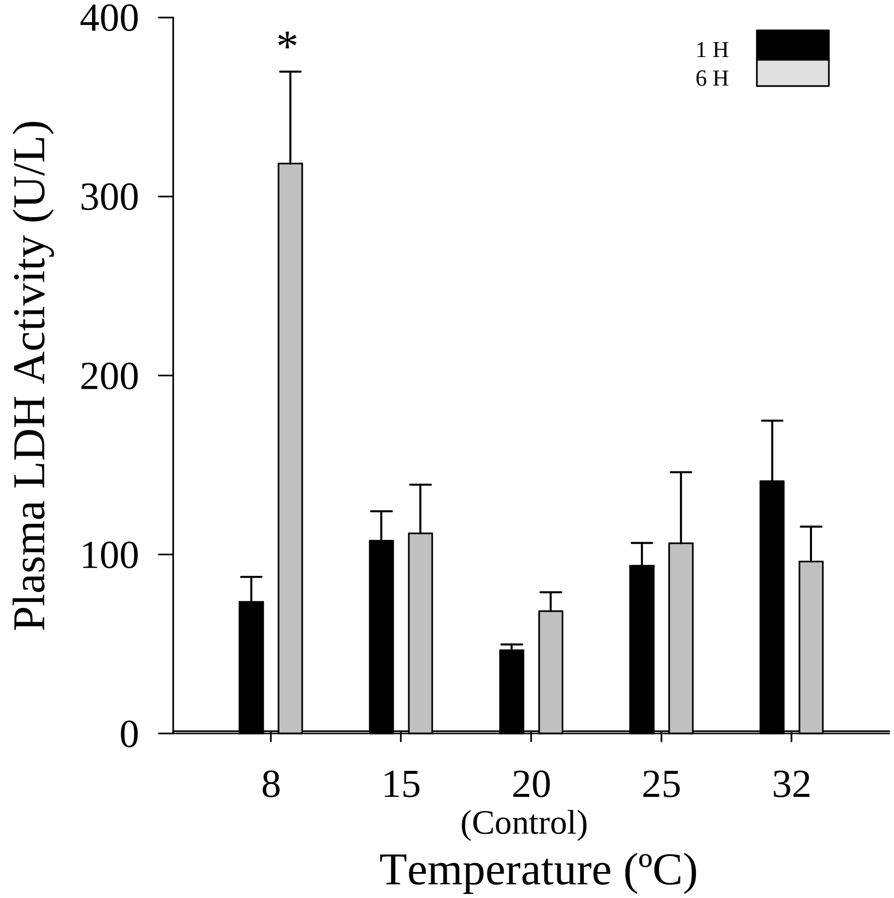

Figure 5-6. Activity of the enzyme lactate dehydrogenase (LDH) in largemouth bass plasma following a rapid change in water temperature. An asterisk indicates a significant ($P < 0.05$) difference from the control (no temperature change) value. When exposed to a temperature change from 20ºC to 8ºC, LDH values nearly quadruple, indicating tissue damage in largemouth bass for this temperature treatment. Anglers should avoid over-additions of ice to livewells during tournaments as this can cause tissue damage of tournament-angled fish.

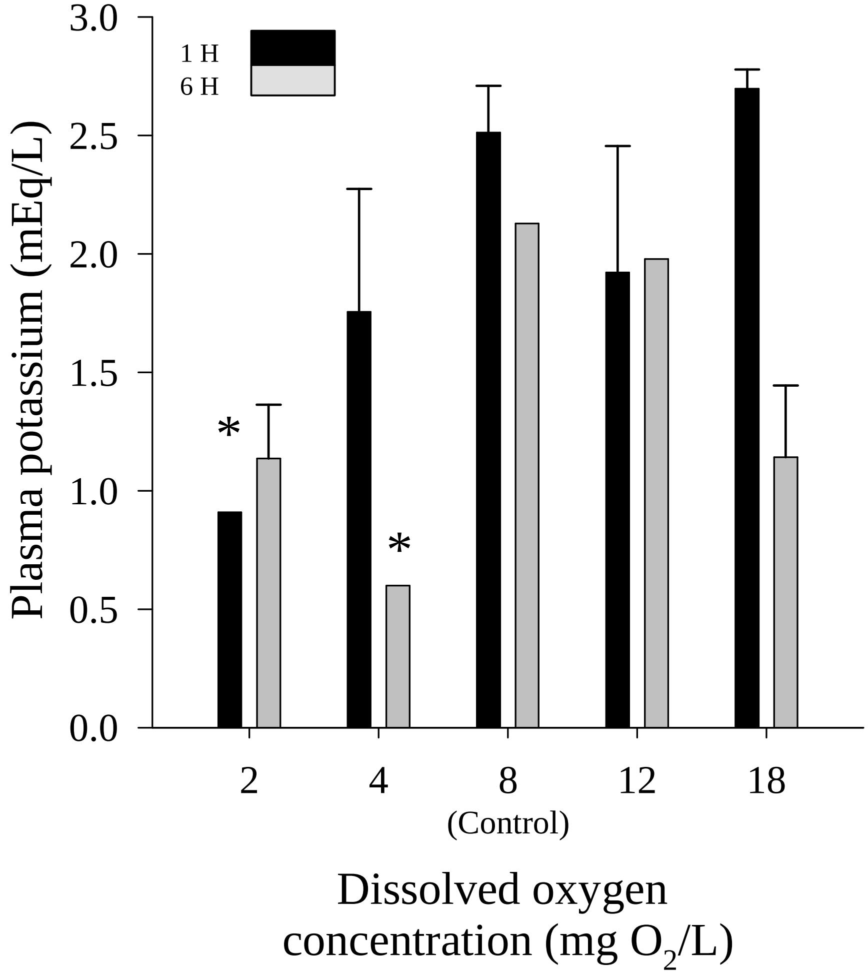

Figure 5-7. Concentrations of potassium ions in largemouth bass plasma following a rapid change in dissolved oxygen concentration. An asterisk indicates a significant ($P<0.05$) difference from control (no dissolved oxygen change) values. During short-term (1 h) and long-term (6 h) exposure to 2 mg/L and long-term exposure to 4 mg/L, potassium ion concentrations are less than half of control values. This indicates a disruption in the ion-regulatory processes at these dissolved oxygen concentrations that should be avoided during livewell confinement.