ILLINOIS NATURAL HISTORY SURVEY

INSTITUTE OF NATURAL RESOURCE SUSTAINABILITY
UNIVERSITY OF ILLINOIS

ANNUAL PROGRESS REPORT

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

M.J. Diana, M.A. Nannini, A.J. Pope, M.M. Vanlandeghem, C.S. Deboom, J.A. Stein, L.M. Einfalt, D.P. Philipp, J.M. Epifanio, and D.H. Wahl

Submitted to
Division of Fisheries
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July 1, 2008 to June 30, 2009

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Institute of Natural Resource Sustainability
University of Illinois
Illinois Natural History Survey

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Disclaimer:
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EXECUTIVE SUMMARY:

During the past segment, all activities outlined in the annual work plan were accomplished and within the specified budget. The goal of this study is to develop management strategies that maximize growth, recruitment, and harvest of largemouth bass *Micropterus salmoides* in Illinois impoundments. Largemouth bass are frequently stocked in many Illinois impoundments to compensate for variable recruitment. Even so, the long-term contribution of stocked fish to recruitment and harvest of natural bass populations is unknown and we are addressing these questions. Because stocking is only one of several management options for this species, it is critical that additional information on factors limiting recruitment processes be identified. In addition, information on the importance of rearing technique, size of stocked fish, forage base, cover, resident predators, physical-chemical conditions, and stocking stress in determining largemouth bass stocking success is needed to optimize use of hatchery produced fish.

There was no new activity in Job 101.1 as final recommendations were presented in previous reports. In Job 101.2 we are assessing stocking strategies for largemouth bass. Supplemental stocking is a widely used management tool for increasing the standing stock of an existing population. In this segment we continued to evaluate long-term survival and growth of intensively and extensively reared stocked fish. Scales were collected from adult fish in electrofishing samples and were aged during this segment by two independent readers. These age data were used to assign a rearing type to each stocked fish that was collected and was used to evaluate the long-term survival differences of the fish reared from these different techniques. Extensively reared largemouth bass are more abundant than intensively reared fish in fall following stocking and the next spring. However they are no longer more abundant by the second fall after stocking. Thus far, no differences in survival have been observed between intensively and extensively reared fish in any of the three study reservoirs. Based on our results thus far, the usefulness of supplemental stocking as a management strategy will vary by individual lake.

We continued an 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 of stocked fish regardless of stocking strategy. There is some evidence that fish stocked using the dispersed method are experiencing higher survival, but future stockings will be needed to assess differences in survival and growth.

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 fingerlings 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 each year were collected from each of the six study lakes and their allele frequencies were determined for the MDH B2 allele. Five of the six lakes showed an increase in the MDH B2 allele. Stocking contribution was high in small lakes, but relatively low in larger ones. However, in the five study lakes

that showed an increase, reproductive contribution of stocked largemouth bass as adults was similar to contribution of naturally produced largemouth bass. Abundance of young-of-year fish was variable throughout the study, but did not appear to increase as a result of stocking. Factors that contribute to a high proportion of stocked largemouth bass in the adult population can therefore increase the reproductive contribution of stocking programs to lake populations of largemouth bass.

In Job 101.4, we continued to evaluate the role of vegetation and woody habitat on largemouth bass communities. We have developed a management experiment in Illinois lakes examining vegetation management techniques. We have identified 3 lakes that will have vegetation rehabilitation efforts, 3 lakes with the need for vegetation removal and 7 control lakes with varying vegetative cover. Dolan Lake was drawn down and treated with rotenone in fall of 2006 to remove fish. CPUE of gizzard shad from electrofishing dropped from 35.3 fish/hr in 2005 to 2.0 fish/hr in 2008 and carp CPUE dropped from 0.8 in 2005 to 0.0 in 2008. In 2008, we constructed three sizes of fish exclosures on Lake Paradise and planted them with various types of vegetation. Large exclosures produced the highest density of plants and created the largest vegetated area using fewer building materials. American Pondweed survived better than all other species planted and were the most dense in the fall mainly due to the ability to survive a drawdown which occurred late in the summer. We will conduct additional plantings in the existing exclosures in 2009 to aid in the rehabilitation effort in Lake Paradise. Woods Lake will be drained and treated with rotenone in fall 2009 and vegetation and fish communities compared before and after treatment. Stillwater and Airport Lakes will be chemically treated to remove vegetation in spring of 2010. In this segment, we continued to monitor these lakes for pre treatment conditions. We will continue to monitor vegetation density, largemouth bass populations, prey resources, and lake characteristics through each of these treatments and compare them to control lakes to determine the influence of vegetation management on largemouth bass recruitment.

In this segment we also continued to conduct enclosure sampling on Lake Paradise to compare natural fish abundance in open, wood, and vegetated habitats. We enclosed 3 areas in each of 3 habitat types (woody habitat, vegetation, no wood and no vegetation). Young-of year largemouth bass and bluegill densities in wooded enclosures were similar to the open enclosures and lower than the vegetation enclosures. In previous segments, we also observed higher largemouth bass and bluegill densities in vegetated enclosures in Lincoln Trail when compared to non vegetated enclosures. We will continue to conduct similar sampling in multiple habitats in several lakes to determine the importance of habitat and potential nursery areas for largemouth bass as well as examine densities of adult largemouth bass.

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 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 evaluated the effects of largemouth bass tournaments in a variety of experiments. Mortality at small, club-style tournaments at Evergreen Lake was low, and never exceeded 5%. No seasonal differences in mortality were observed although temperatures were as high as 27.6 ºC in summer. Blood samples taken from fish at tournaments at Lake Bloomington indicated that the physiological impact of these events was relatively similar across seasons. In all seasons, largemouth bass incurred a large metabolic disturbance that was likely due to air-exposure during the weigh-in. Largemouth bass would likely benefit from adaptation or closer enforcement of current recommendations such as adequate aeration of livewells and minimization of air exposure during the weigh-in, regardless of water temperature and season. The low mortality and relatively mild physiological disturbances incurred by largemouth bass during club events suggests that these types of tournaments can have minimal impacts on fish compared to larger tournaments if proper care is taken.

We examined the potential of paper tournaments to reduce mortality by examining angler rank from paper and weigh-in results. Paper tournaments ranked anglers similar to weigh-in results when only legal fish are considered, but when all fish caught were included, paper tournaments ranked anglers differently. Paper tournaments can be used to eliminate weigh-in related mortality and stress, and allow inclusion of sub-legal fish in ranking results.

In this segment, we initiated a multiple lake experiment examining largemouth bass populations in lakes with varying tournament pressure. We have begun to compile data on catch rates on lakes where all tournament information can be obtained and have also identified a set of lakes with no tournament activities. We are continuing to collect fish and scales from these populations to determine age-of-maturity and length at age. Preliminary analysis has identified age 3 as mean age of maturation among lakes and fish of age 3 were larger on tournament lakes than non-tournament lakes. Similarly, CPUE of fish over 14 inches was greater on lakes with tournaments than lakes with no tournaments. We will 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 and adult populations.

We also continued 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.

In Job 101.5, we completed 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 also conducted a field experiment on Ridge Lake that was closed to angling during the largemouth bass spawning season prior to 2007. Largemouth bass angling tournaments were conducted during the spawning season in 2007. In 2008, no tournaments were conducted, but will be in the future in alternating years. We observed higher young-of-year densities from seine and electrofishing samples in fall 2007 than in fall 2008. Similarly, CPUE of adult largemouth bass from fall electrofishing was higher in 2007 than 2008. More data will be required to make recommendations on the relationship between angling and recruitment. Data collection and analysis on Ridge Lake will continue in future segments to further explore these relationships in a natural system.

We continued monitoring largemouth bass spawning activities at Lincoln Trail Lake. Largemouth bass appeared to prefer cobble, pebble and gravel nesting substrates, while avoiding vegetation and detritus. Nest predators were relatively more abundant near the preferred nest substrates and relatively less abundant near avoided 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 activity was also compared to existing water quality parameters and frequency of new nests was directly related to water temperature.

In Job 101.6, a portion of Clinton Lake that was closed to fishing was sampled to continue assessment of 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 next year after monitoring pre refuge conditions in the lake. We also began assessing effects of harvest regulations on largemouth bass populations. Initial lakes were selected to compare the effects of regulations on largemouth bass populations. Current study lakes have a number of different regulations (length and slot limits) and were used to conduct initial analysis. Lakes with different regulations exhibited differences in angler catch and harvest rates as well as size structure of largemouth bass populations among regulation types. Increased size limits do seem to decrease harvest and are associated with higher abundance of larger fish. Total angler catch rates were not related to harvest rates demonstrating there are additional factors influencing the decision to harvest. We will employ FAS data from additional lakes in future segments to supplement the initial study lakes used in this analysis. We will specifically target 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 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. Field results of growth and survival from stocked 6 and 8" 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 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, prey that are relatively non-evasive and have low abundances in the wild. 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. We previously compared foraging efficiency of hatchery and natural largemouth bass feeding on bluegill. Bluegill were novel prey for hatchery largemouth bass, and fish did not forage as efficiently as natural largemouth bass and showed no improvement through time. Largemouth bass with continual exposure to bluegill in tanks may show better growth and survival compared to hatchery largemouth bass feeding only on fathead minnow. We designed a laboratory study examining foraging behaviors of 6 and 8" hatchery largemouth bass acclimated to feeding on bluegill. Results are compared to previous experiments examining foraging success 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 rearing 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. 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 prey availability, density dependent interactions, water clarity or macrophyte abundance (Shapiro et al 1975, Drenner et al 2000, 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 (Chapleau et al. 1997, Drenner 2000, Albright 2004); however biomanipulation effects have been shown to be 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). For example Albright (2004) found that in a pond dominated by fusiform prey (golden shiner *Notemigonus crysoleucas)*, largemouth bass introductions caused dramatic declines in planktivore abundance and strong biomanipulation effects, while similar experiments in ponds dominated by the deep bodied pumpkinseed sunfish *Lepomus gibbosus* showed much weaker effects on lower trophic levels (Hambright 1994).

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). 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). In this segment we continue exploring the community response of stocking of largemouth bass in Illinois lakes in comparison to unstocked lakes over time. 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:

<u>Rearing Technique: Intensive v. Extensive</u>

The effects of rearing techniques on growth and survival of stocked largemouth bass were evaluated in lakes Shelbyville, Jacksonville and Walton Park. Extensively reared bass were produced at the Little Grassy Fish Hatchery where they were held in ponds and fed on minnows until stocking. Walton Park was stocked directly from Little Grassy Fish Hatchery, while Jacksonville and Shelbyville utilized lake side rearing ponds. Fish were delivered to the rearing pond in June along with minnows for feed and were allowed to grow until fall when the ponds were drained and fish were stocked into the lake. 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 adult fish stocked in previous segments. Growth and survival of stocked largemouth bass was determined in each 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.

Stocking Technique: Boat Ramp v. Dispersed

In this segment, we continued to evaluate the influence of stocking location on survival of stocked largemouth bass. Four lakes were stocked with 100mm largemouth bass fingerlings in 2008 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 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.

Prey Acclimation

We compared foraging behavior of 6 and 8 inch hatchery reared largemouth bass acclimated to a diet of bluegill over a two month period hatchery and wild fish of similar sizes fed fathead minnows. Hatchery largemouth bass (6”=135-170 mm TL; 8”= 180-223 mm TL) were obtained at the time of stocking from the Jake Wolf Memorial Fish Hatchery in Manito IL. Wild fish were collected using AC 3 phase electrofishing. Bluegill acclimated fish were held in fiberglass tanks at the Kaskaskia Biological Station and fed bluegill of optimal size. Hatchery and wild fish that were not bluegill acclimated were held in similar tanks and fed fathead minnows.

After the two week acclimation period, foraging behavior was tested for the three treatment groups in half hour experiments conducted in an open 2.5 m 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) when not pursuing prey. Capture efficiency was calculated as the ratio of captures to strikes. We also recorded the number of dead bluegill after 24 hours, as largemouth bass often killed bluegill without consuming them, indicating aggressive behavior. 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 continued to be fed the same diet they were fed during the acclimation period. Using the same procedures, the same largemouth bass were again tested after four and eight week intervals, similar to previous experiments presented in earlier reports comparing hatchery reared and natural largemouth bass. Ten experiments using ten individual largemouth bass from each treatment were completed for each interval (2,4, 8 weeks) for a total of 90 trials.

Influence of Stocked Fish on Resident Populations

Lakes for this analysis were stratified into those containing a gizzard shad forage base (N=9) and those without gizzard shad (N=6) 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=3) using a replicated before-after control-impact (MBACI) design suited to a repeated measures analysis of variance (Underwood 1994, Kough and Mapstone 1995). This analysis was conducted by fitting a linear mixed model with main factors of treatment (Trt; stocked or unstocked), and before-after (Period), with lakes (L) nested in Trt and years (Y) nested in Period followed by interactions. The three nested terms were considered random (because lakes were considered a random effect in the model) and the remaining terms were considered fixed. The Trt*Period interaction measures any change associated with the onset of the largemouth bass stocking. These analyses are suited to the detection of abrupt changes in the mean of the parameter being investigated but have limited ability to detect gradual changes through time (Keough and Quinn 2000). To detect gradual changes in stocked lakes we tested for a linear trend in the difference between means (Stocked vs. Unstocked) through time using Pearson correlations. Data collection and stocking methodology were as described in the previous section "Mechanisms Influencing Stocking Success" and are not described here. Collected data include larval fish density, benthic macroinvertebrate abundance, relative abundance of prey species, zooplankton density and size structure, chlorophyll a, water clarity, and total phosphorous concentration. In this segment we report on responses of prey species abundance, zooplankton density and size structure, algal biomass (chlorophyll a), nutrient concentrations (total phosphorous) and water clarity to supplemental largemouth bass stocking.

FINDINGS:

Rearing Techniques: Intensive v. Extensive

In this segment, we concluded electrofishing sampling in the three stocked reservoirs. Few stocked fish were recaptured in fall 2007 and none were collected in fall 2008. We began final analysis on catch rates and mean size in order to evaluate the two rearing techniques. In this segment, all scales from 1999 – 2008 were read by two independent readers and were used to distinguish intensive and extensively reared fish using age and existing clip information. Fish were identified to stocking strategy and mean size-at-age and CPUE from electrofishing were calculated and differences between stockings were examined using repeated measures ANOVA and Tukey-Kramer (T-K) adjusted P value were used to determine significance in post hoc tests.

Significant differences existed between stocking strategies through time. There was also a significant interaction between stocking strategy and time after stocking (RMANOVA, F = 2.21, P = 0.007). Extensively reared largemouth bass were recaptured at a significantly higher rate than intensively reared fish the first fall following stocking (Figure 2-1, T-K, t = 4.11, adj. P = 0.02) and the following spring (T-K, t = 4.33, adj. P = 0.007). After the first spring, catch rates for both intensive and extensive fish drop to below 1 fish per hour of electrofishing and there was no longer a significant difference between the two rearing strategies (adj. P > 0.05). Despite better survival of extensively reared fish, we saw low long term survival of stocked fish from either rearing strategy and no long-term differences in relative abundance.

Significant differences also existed in mean size among intensive extensive, and wild fish. Again there was a significant interaction between stocking strategy and time following stocking (RMANOVA, F = 8.97, P < 0.0001). Extensively reared fish were larger than wild fish (T-K, t = 4.18, adj. P = 0.02) but not significantly larger than intensively reared fish (T-K, t = 3.06, adj. P = 0.50) the first fall following stocking (Figure 2-2). Wild and intensively reared fish were also not different in size in the first fall following stocking (t = 0.58, adj. P = 1.00). Differences in size were no longer significant in the spring following stocking. Extensive fish were similar in size to both wild (T-K, t = 2.64, adj. P = 0.82) and intensive fish (T-K, t = 0.38, adj. P = 1.00) and no difference existed between intensive and wild fish (T-K, t = 1.60, adj. P = 1.00). Wild, intensive and extensive fish remained similar in size throughout the remaining months they were collected in electrofishing samples. Extensively reared fish were larger than intensively reared fish and wild fish when they were stocked and they remain larger through the first fall. However this size differences is short lived and by the following spring there are no differences in size among these fish.

Stocking Techniques: Boat Ramp v. Dispersed

Three lakes were stocked in 2007 and 2008 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 2-1). No stocked fish were observed in the spring of 2008 and very few fish were observed in spring 2009. 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.

Prey Acclimation

Both 6 and 8” largemouth bass acclimated to bluegill showed responses intermediate between hatchery and natural largemouth bass reared on fathead minnows

(Table 2-2). Follows and strikes for 6 and 8" bluegill acclimated hatchery fish were intermediate between natural and hatchery largemouth bass reared on minnows. Capture efficiency increased throughout the experiment for 6 and 8" bluegill acclimated hatchery largemouth bass (ANOVA; $P<0.05$), and equaled natural largemouth bass at 8 weeks ($P>0.14$). Hatchery largemouth bass fed fathead minnows did not increase capture efficiency through time for either 6 or 8" fish ($P>0.38$).

Bluegill acclimated fish also lowered activity levels compared to minnow fed hatchery largemouth bass, and lower activity occurred immediately when tested at 2 weeks and continued through 8 weeks. Bluegill acclimated hatchery largemouth bass also had swimming speeds (m/s) intermediate between minnow fed hatchery and natural largemouth bass, with minnow fed hatchery largemouth bass swimming the fastest when not foraging for prey ($P<0.001$). The number of dead, unconsumed bluegill after 24 hrs was higher for 8" compared to 6" largemouth bass overall ($P<0.001$). For 8" fish, minnow fed hatchery largemouth bass killed, but did not consume an average of 3.6 bluegill per experiment, bluegill acclimated killed 2.5 bluegill, and natural largemouth bass killed 0.6 bluegill.

Influence of Stocked Fish on Resident Populations

We previously reported finding declines in average bluegill density in non-shad lakes in response to supplemental stocking of largemouth bass while this effect was not observed in lakes containing gizzard shad. In this segment we expanded the analysis of prey populations to include all potential prey fish sampled. Analysis of the number of potential prey fish per square meter of seine sampling in non-shad lakes indicated a marginally significant reduction in relative abundance of fish prey (ANOVA, Trt x Period; $P = 0.08$; Table 2-3). A decline in average density of littoral prey fish was not evident in lakes containing gizzard shad (ANOVA, Trt x Period; $P = 0.34$) however a significant negative trend was observed in both sets of stocked lakes (non-shad $r = -0.72$; $P = 0.04$; shad $r = -0.74$; $P = 0.04$; Table 2-3). A weaker but sustained effect of largemouth bass stocking on relative prey fish abundance is evident in lakes containing gizzard shad. While we found evidence of an effect of supplemental stocking of largemouth bass on prey fish abundance, these effects did not carry to other parts of the food web. There was no significant change after largemouth bass stocking in the density or average length of cladoceran zooplankton, total phosphorous concentration, or water clarity in either set of lakes relative to controls (Table 2-3). There was a significant increase in chlorophyll concentration in stocked lakes without gizzard shad (ANOVA Trt x Period; $P = 0.01$) but this effect was small (~ 7 ug/ L) and is not consistent with any known effect of piscivore stocking previously reported in the literature. In future segments we will examine additional long-term responses to bass stocking including the abundance of adult bluegill and gizzard shad, larval fish densities and benthic macroinvertebrate abundances. Analysis of these parameters will complete our investigation into the effects of supplemental largemouth bass stockings on the recipient community.

RECOMMENDATIONS:

Comparisons between intensive and extensive stocked fish showed differences in growth and survival initially following stocking. Extensively reared largemouth bass had higher survival than intensively reared fish and were larger than wild fish in the fall following stocking. They remained more abundant than intensively reared fish the following spring, but were no longer larger than wild fish. Despite higher initial stocking success with extensively reared fish, there were no differences in growth or survival by the second fall following stocking and survival was low for both stocking strategies (< 1 fish per hour of electrofishing). In future segments, we will incorporate the cost of production in order to evaluate how cost benefit analysis can influence which stocking strategy may be more effective. 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 to assess the potential to increase survival of stocked largemouth bass. In the first two years of stocking, we have observed very low stocking survival of largemouth bass stocked both at the boat ramp and dispersed throughout the lake. Survival of these stocked fish has been lower than survival observed from previous stockings we have evaluated. Survival may have been limited due to the high temperatures on the dates of stocking or the increased handling time due to the stocking techniques. Future efforts will be made to stock the fish during the lowest possible temperatures and fish will be handled with extreme care to facilitate survival. We will continue to compare survival of point stocking versus dispersed stocking at multiple locations of optimal habitat throughout the study lakes. In 2009 we will stock Lake Charleston, Homer Lake, Lake Mingo, and Otter Lake using these two strategies. 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 continue to 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 have continued to evaluate different stocking methods which may increase long term survival of stocked largemouth bass. As of now, we have not been able to find benefits of stocking extensively reared fish or larger fish. Future efforts are required to address if stocking fish into habitat can increase stocking success. In future segments we will examine other lake specific factors that may influence stocking success 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.

To improve capture success, we acclimated hatchery largemouth bass to bluegill prey to increase experience for capturing this prey species. Results indicate foraging behavior and capture efficiency can be improved by feeding bluegill to largemouth bass prior to stocking. Since results were intermediate between largemouth bass feeding on fatheads and natural largemouth bass, a longer time period (> 2 mo) than we examined may be necessary to improve foraging ability for bluegill to a level similar to natural largemouth bass.

Largemouth bass reared with bluegill in tanks also used less energy by moving less and at a slower rate compared to hatchery largemouth bass, suggesting largemouth bass may have modified foraging strategies for bluegill prey. Similarly, less movement can result in lower energy demands for fish after stocking. Overall, 8" hatchery largemouth bass used more energy to capture prey than 6" hatchery fish, leading to lower capture efficiencies. Similarly, these fish engaged in more swimming activity and aggressive behavior unrelated to foraging. Hatchery reared fish of other species have been shown to be more active or aggressive than natural fish, behaviors both of which would increase energy demands (Mesa 1991). Laboratory studies suggest foraging ability can be improved by feeding largemouth bass on natural bluegill forage. Results of these studies should be tested in lakes with largemouth bass reared on bluegill in hatcheries or rearing ponds.

Strong reductions in 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. Thus far however we have found little evidence of cascading responses in stocked lakes beyond prey fish abundance. Several possible reasons exist for this lack of cascading responses including the ability of bluegill and gizzard shad to outgrow the gape limitation of predators. If sufficient numbers of juvenile prey fish are able to survive each year to maintain predation on lower trophic levels and the increased predation on juveniles is not affecting adult abundances we might expect little effects of stocked largemouth bass on lower trophic levels. Other possible limiting mechanisms may be the diversity of fish diets, which may weaken links in the food web, compensatory reproductive output by adult prey species or other complex nutrient-planktonic interactions. Aquatic food webs of Illinois lakes appear to be more resilient to perturbations of top predator biomass than the northern lakes where the trophic cascade hypothesis was initially developed and tested. The resilience of Illinois lake communities however does not mean that managers should ignore the potential impacts of supplemental largemouth bass stockings on lake communities. Reductions in littoral prey fish abundances are not trivial effects considering that the abundance of juvenile bluegill sunfish is a primary driver of recruitment in many Illinois lakes. Our results suggest that an unintended consequence of supplemental largemouth bass stocking may be increased intraspecific competition for limited prey resources. Littoral prey fish are likely a limited resource in Illinois lakes and their abundance should be a primary consideration when making decisions regarding supplemental stocking of largemouth bass populations.

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 populations. 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 and were stocked into target lakes. 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-B2 locus. Six study lakes were stocked and sampled; Lake Shelbyville and Forbes Lake beginning in 1998, and Walton Park, Murphysboro, McLeansboro, Sam Parr in 1999. Samples of fish from the hatchery rearing ponds were sampled, and protein electrophoretic analysis (Philipp et al., 1979) was used to confirm that these fish had the MDH B2B2 genotype. Stocking continued in all lakes through 2005. Young-of-year from the six lakes were sampled by boat electrofishing in each year to determine if the frequency of the MDH B2 allele had increased through reproduction of the stocked fish. These sampling efforts were used to document the contribution of stocked fish to the reproductive population.

Correlation analysis was used to determine what factors were important in influencing the change in MDH B2 allele frequency across years in the study lakes.

McCleansboro Lake was excluded from the analysis due to high initial MDH B2 allele frequencies that made detection of changes in the frequency difficult. Among the factors examined were catch per unit effort of adult bass, proportion of B2B2 adults in the population, and proportion of B2B2 YOY when they were stocked (see Job 101.4 for electrofishing sampling methodology).

Finally, to determine if B2B2 adults and YOY were contributing to reproduction proportional to their representation in the population, a regression analysis of actual MDH B2 allele frequency to predicted MDH B2 allele frequency was conducted. To estimate the predicted MDH B2 allele frequency of naturally spawned YOY from adult fish, we calculated the total frequency of the MDH B2 allele in the adult population. This was estimated using the proportion of natural adult largemouth bass multiplied by the background MDH B2 allele frequency for those fish and was added to the proportion of B2B2 adults in the population. If B2B2 fish are contributing to reproduction equal to their proportion in the population, the slope of the regression of actual and predicted MDH B2 allele frequencies in YOY fish should be equal to 1. Deviations from 1 indicate lower or greater contribution then expected. The predicted contribution of MDH B2 allele frequency was estimated similarly from YOY (lag three years) and compared to actual MDH B2 allele frequencies, to evaluate if reproductive contribution of stocked fish was related to the abundance of young-of-year stocked fish .

FINDINGS:

The original largemouth bass fingerlings stocked into each lake were analyzed to determine if the fingerlings 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; therefore a correction factor was used to analyze samples from Lake Shelbyville.

The background frequencies of largemouth bass from four of the six study lakes had less than 20% of the individuals with the MDH B2B2 genotype. The exceptions were Forbes (33%) and McLeansboro (55%) (Table 3-1). The higher frequency of the MDH B2 allele from McLeansboro is problematic and this lake was eliminated from assessments of the contribution of stocked fish to recruitment.

All lakes were sampled for YOY from 2002 to 2007 to determine if the frequency of the MDH B2 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 whereas Forbes Lake and Lake Murphysboro had minor influences (at 6% and 11% contribution respectively). Shelbyville showed no influence of stocked fish contributing to the reproducing population (Table 3-2). The change in allele frequency generally increased with decreasing lake size (Table 3-2).

Correlation analysis found that the proportion of the adult largemouth bass that were from stocked fish was strongly related to the frequency of the MDH B2 allele for that year class of YOY (Pearson $r = 0.65$, $P = 0.0006$, Figure 3-2). As proportion of B2B2 adults in the population increased so did the frequency in the B2 allele in that year class of YOY. The frequency of the MDH B2 allele was also correlated with the proportion of fish stocked as YOY (Pearson r = 0.80, P = 0.0003, Figure 3-3). Thus it appears that stocked largemouth bass do contribute to reproduction when they reach reproductive sizes.

Stocked B2B2 adult largemouth bass appear to reproduce as effectively as natural largemouth bass if they survive to maturity. The slope of the regression of predicted vs. actual MDH B2 allele frequency based on the proportion of B2B2 adults was 0.72 and was not significantly different from 1 ($F_{1,28}$=3.54, P=0.07; Figure 3-4). However, factors occurring prior to reaching adulthood reduce the contribution to reproduction of stocked fish. The regression of actual vs. predicted MDH B2 allele frequency based on the proportion of YOY B2B2 fish at the time of stocking had a slope of 0.55 and was significantly less than 1 ($F_{1,13}$=4.71, P=0.05, Figure 3-5). This is most likely the result of poorer survival of B2B2 YOY compared to natural YOY largemouth bass. Therefore, it appears that the most important factor affecting the contribution of stocked fish to a population is the number of individuals surviving to become reproductive adults.

RECOMMENDATIONS:

Stocked fish contributed to the spawning population in some of the study lakes. Genetic frequencies from YOY spawned from largemouth bass stocked with the MDH B2 allele 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 data suggests that lake size may be an important factor influencing the success of a stocking program, other factors may be involved as well. 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 particular factors that affect the early survival and proportion of stocked largemouth bass that reach sexual maturity are very important. Though it appears that stocked bass survival to adulthood is roughly half the survival of natural bass, the proportion of stocked bass to natural bass in the first fall after stocking does predict reproductive contribution. If natural bass YOY numbers are low, stocked bass can more easily represent a higher proportion of YOY fish and thus have a higher contribution to reproduction when that year class reaches adulthood. Once stocked largemouth bass do reach sexual maturity, they appear to make similar contributions to reproduction as natural adult largemouth bass. From these data it appears that stocking largemouth bass will make the greatest contribution in small lakes when natural reproduction by resident largemouth bass is low.

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. Parkos and Wahl (2002) provided a conceptual model of largemouth bass recruitment that 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).

Aquatic vegetation is a habitat feature that influences 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 have 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) to 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:

Vegetation Management Experiment

In this segment, we continued 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 continued 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. Similar lake rehabilitation is planned for Woods Lake beginning in fall of 2009. The lake will be drawn down and rotenone will be applied to remove all fish. Fish will be restocked in spring of 2010 and the rehabilitation will begin. In this segment, we continued pre-drawdown assessment of fish, vegetation, and prey populations. Again, the goal is to remove carp and gizzard shad and allow vegetation to reestablish, providing habitat for fish.

In this segment, we continued to evaluate a large vegetation planting effort in Lake Paradise through cooperation with Illinois District Biologist Mike Mounce and the City of Mattoon Water Department. Exclosures were constructed in 2008 using varying designs to reduce loss of vegetation from carp and turtles. Exclosures 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 exclosure in place. After attachment to the rebar, the cage was driven into the substrate an additional 50 to 100 mm (depending upon substrate) to seat the exclosure and ensure no fish passage under the fencing. Exclosures 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 exclosure types for planting of wild celery and sago pondweed tubers. One replicate included a large exclosure, four small dispersed exclosures and four small clustered exclosures (Figure 4-1). Large exclosures were constructed of 6.1 m of fencing creating an exclosure with a 2.0 m diameter (area = 3.0 m^2). Small exclosures were constructed from 3.0 m of fencing creating an exclosure with a 1.0 m diameter (area = 0.7 m^2 approximately ¼ the size of large exclosures). Wild celery were planted using small bags of cheese cloth weighted with pea gravel with 5 tubers in each bag. Large exclosures were planted with 26 bags of wild celery and small exclosures with 6.5 bags per exclosure. Sago pondweed tubers were planted in a similar manner with 7 tubers in each bag. Large exclosures were planted with 31 bags of sago pondweed and small exclosures 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 exclosure. One replicate consisted of two large exclosures and four small exclosures. 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. Exclosures were visited in August of 2008 and June of 2009 to evaluate planting success. Each exclosure was divided into 4 quadrates. Each quadrate was visually assessed for percent cover of planted vegetation. In addition, a subsample of exclosures were sampled for fish, macroinvertebrates and biomass of vegetation. Fish were collected using a backpack electrofisher (250 V DC, 6 Amps). A 1 meter circle was electrofished around each exclosure and then the interior of the exclosure was sampled. All fish were identified to species, measured for total length and released. Benthic invertebrates were collected 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. Vegetation was collected if it was sampled in the modified stovepipe sampler. All vegetation was identified to species and weighed. We will monitor the success of the different exclosure designs and vegetation types by assessing vegetation in June and August in future 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 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. Control lakes include 3 levels of vegetation (high, medium, and low) based on percent cover.

In this segment, we continued field sampling of the 13 lakes in order to monitor largemouth bass populations, vegetation, prey resources, and fish communities. 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 1.2 x 9.1 m seine with a 1.2 x 1.2 m 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.

Lakes were mapped for vegetation in June and August using GPS mapping techniques. In this segment, GPS was used to trace the vegetated edge and waypoints to identify transitions in types and densities of vegetated areas. GPS data was then 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. Coarse woody habitat was also documented with GPS to assess number and location of all woody habitats. Quantification of each tree was 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 tree. 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 conducted based on tree density.

Vegetation and Woody Habitat Enclosures

In this segment, we continued to examine habitat use of young-of-year largemouth bass. Abundance of largemouth bass and other fish species were assessed in relation to presence of vegetation and wood at Lincoln Trail Lake, and Lake Paradise. In previous segments we sampled 3 sites along a shoreline with aquatic vegetation and 3 that did not have vegetation in Lincoln Trail. In August 2008, 9 sites were sampled, 3 with woody habitat, 3 with vegetation, and 3 with no wood or vegetation (open) in

Paradise. 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.

Woody Habitat Pond Experiments

Two trials of an experiment designed to examine the importance of woody habitat to fish communities were conducted in one-tenth acre ponds at the Sam Parr Biological Station. The first was conducted from May 2008 through August 2008 and the second was conducted overwinter from fall of 2008 through the spring of 2009 to examine the role of woody habitat on largemouth bass and bluegill growth and survival. Five ponds contained four clusters of tree limbs covering approximately 30% of the shoreline. The remaining five ponds contained no wood. Ponds were treated with an herbicide to prevent the growth of any vegetation during the course of the experiment.

In the first experiment golden shiners (80 between 60-65 mm), bluegill (115 between 35-70mm) and largemouth bass (5 between 200-300mm) were introduced to each of 10 ponds in May 2008. Temperature, dissolved oxygen, pH, chlorophyll a, phosphorus, zooplankton, and macroinvertebrates were sampled biweekly. The experiment ended in August 2008 when the ponds were drained and all remaining fish were measured. Weight, length and number of survivors of each species of fish were determined to assess growth as well as survival between the wood and no wood treatments. In this segment we present results of growth and survival effects of wood and no wood treatments on largemouth bass and bluegill.

In the second trial, 150 small bluegill (size range 20-50 mm) and 40 large bluegill (size range 70-130 mm) were stocked into each of 8 ponds. Small bluegills were vulnerable to predation whereas large fish were not. Five largemouth bass (size range 140-210 mm) were also stocked into each pond. Temperature, dissolved oxygen, pH, chlorophyll, phosphorus, zooplankton and macroinvertebrates were sampled both at the beginning of the experiment and again at the end of the experiment in late March. The ponds were drained and all of the remaining fish were counted, measured (TL, mm) and weighed (g). The percent survival of each bluegill size category as well as largemouth bass survival was calculated and analyzed to determine if there were differences in mortality between the wood and no wood treatments.

Dam Escapement

In order to access dam escapement by largemouth bass we sampled 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 direction 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. Downstream area of the Ridge Lake dam was sampled in a similar manner. A 200 m stretch of the stream was sampled via electrofishing in an upstream direction and in one transect.

FINDINGS:

Vegetation Management Experiment

In this segment, Lake Paradise was successfully planted with the 5 species of vegetation (see Figure 4-2 for planting locations). In June, sago pondweed and wild celery tubers were successfully planted in 356 exclosures (Table 4-1). In July of 2008, plantings of American pondweed, coontail, and chara were completed in 134 exclosures (Table 4-1). However in early August, Lake Paradise experienced a drawdown leaving a majority of the cages out of the water and dry. All exclosures were revisited in August of 2008 and June of 2009 to evaluate differences in survival among vegetation species. Differences in survival were observed depending upon species planted and the size and clustering of the cages (Table 4-2). American Pondweed survived the best and had the highest fall survival with a mean cover of 70% (Table 4-2). The other species of vegetation had lower survival (mean cover = 11%) and by the fall, very few plants survived. Plant cover was the highest in the large exclosures (mean cover = 24%) followed by the small dispersed cages (mean cover = 16%) and small clustered cages (mean cover = 9%). Large cages appear to be most effective at establishing plants as well as use less material to build. In the June of 2009, densities of all species of plants had decreased (mean cover = 1.5%) and very little overwinter survival was observed. On subsequent trips to Lake Paradise in 2009, we did observe some regrowth of vegetation and evidence of plants surviving and growing, but the densities have not yet been evaluated. We evaluated the rehabilitation effort at Dolan Lake by examining the catch rates of gizzard shad and common carp, the fish targeted in rotenone treatments. CPUE of gizzard shad from electrofishing dropped from 35.3 fish/hr in 2005 to 2.0 fish/hr in 2008 and carp CPUE dropped from 0.8 in 2005 to 0.0 in 2008. Gizzard shad populations have dropped, but were not eradicated and may rebound in the future. Although carp numbers were not high in electrofishing samples prior to the drawdown, we have not observed carp in our samples since the rehabilitation effort.

In this segment we continued to monitor 13 lakes to examine the role of vegetation in determining largemouth bass recruitment. Vegetative cover ranged from 0-100% in the study lakes (Table 4-3). Percent of the lake area that was vegetated was significantly correlated with the perimeter of the shore that is vegetated (Spring: $r = 0.65$; $P = 0.02$; Fall: $r = 0.64$; $P = 0.02$). Both vegetated area and perimeter were also significantly correlated from the spring to the fall in both percent vegetated area ($r = 0.99$; $P < 0.0001$) and vegetated perimeter ($r = 0.95$; $P < 0.0001$). Percent vegetated area in the spring was not related to the size of the lake ($r = -0.19$; $P = 0.53$). We also continued to monitor larval fish, juvenile, and adult fish communities as well as zooplankton and benthic macroinvertebrates to assess the effect of aquatic vegetation. CPUE was calculated from electrofishing samples for young-of-year largemouth bass (< 200 mm), adult largemouth bass (> 200 mm), and all bluegill (Table 4-4). Mean annual density was also calculated for total zooplankton, total benthos, and total larval fish as well as larval bluegill and gizzard shad. These variables were then examined for correlation with the vegetated area and perimeter of each lake. Vegetation was not significantly correlated with young-of year largemouth bass electrofishing CPUE, adult largemouth bass electrofishing CPUE, or any of the measurements of prey resources (all $P > 0.10$). Thus far in this study, there is no evidence of simple relationships between vegetation and largemouth bass recruitment, however, this is based on a low number of samples and simple correlation analysis. We will continue to monitor vegetation densities, largemouth bass populations, fish assemblages, prey resources and lake characteristics in vegetation addition, removal and control lakes. Woody habitat was not assessed in 2008 since it is not expected to vary on an annual basis, but we plan to do so in 2009. We will include woody habitat measurements in analyses for next segment to attempt to further understand its role in largemouth bass recruitment.

Vegetation and Woody Habitat Enclosures

We also assessed the role of vegetation and woody habitat in Lincoln Trail Lake and Lake Paradise by enclosing areas in different habitat types and sampling largemouth bass in each enclosure. Dominant vegetation at Lincoln Trail was American pondweed, coontail and chara. Areas sampled in Lake Paradise were dominated by spatterdock and water willow. In this segment we sampled 9 enclosures in Lake Paradise, 3 with woody habitat, 3 with vegetation, and 3 open (Table 4-5). Densities of largemouth bass captured in each enclosure was low in Paradise (mean LMB density = 0.007) compared to Lincoln Trail (mean LMB density = 0.05 fish/m^2). Paradise has been identified as a low largemouth bass recruitment lake in previous reports. Within Lake Paradise, the enclosures in woody habitat had the lowest largemouth bass density (0.002 fish/m^2) which was similar to the open enclosures (0.007 fish/m^2). Largemouth bass densities were the highest in sites with vegetation (0.013 fish/m^2). Similarly, mean bluegill density and total fish density was significantly higher in sites with vegetation than those without, however total fish density was greatest in the open enclosures (Table 4-5). Other fish in the open water included species such as gizzard shad. Vegetation appeared to hold both more largemouth bass as well as potential prey species. These habitats may therefore be critical to maximizing young of year largemouth bass recruitment and growth. Although we do not know how density of young-of-year fish in these habitats is related to recruitment, vegetated habitat may be important to recruitment success. We plan to continue to sample multiple lakes with this enclosure design in order to incorporate different habitat types and supplement these samples in order to evaluate the importance of each habitat type as potential largemouth bass nurseries.

Woody Habitat Pond Experiments

In the summer pond experiment, ponds containing coarse woody habitat had significantly higher growth (change in mean weight) for juvenile bluegill ($F_{1,8} = 4.99$, $P = 0.05$; Figure 4-3) whereas survival of this species was similar between treatments ($F_{1,8} = 1.41$, $P = 0.27$). There were no differences in largemouth bass growth ($F_{1,8} = 0.01$, $P = 0.90$) or survival ($F_{1,8} = 0.89$, $P = 0.40$).

In the overwinter experiment there were no differences in percent survival between the wood and no wood treatments for small bluegill ($F_{1,6}$=0.81, P=0.4), large bluegill ($F_{1,6}$=0.0, P=1.0) or for largemouth bass ($F_{1,6}$=0.0, P=1.0). While woody structure did not affect the survival of any of these groups, other factors such as growth may have been affected and will be analyzed in the future.

Dam Escapement

In this segment, one additional sample was collected from Forbes Lake following a high water event. Only two large largemouth bass were collected at this time and neither one of them had been captured in previous sampling (Table 4-8). We have not yet established a baseline by which to compare high water results. However we 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 4-6). 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 below Ridge Lake compared to Forbes Lake.

RECOMMENDATIONS:

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 and Paradise. In the next segment, we will continue to expand the work we have completed with vegetation and woody habitat enclosures and identify additional potential lakes that may be included. With these data we can examine relationships between habitat composition and largemouth bass density and size structure.

There are a number of potential management strategies for manipulating vegetation that are of interest to managers in Illinois, including chemical treatment to reduce overabundant vegetation and/or nuisance vegetation (e.g. Eurasian milfoil) and habitat restoration to increase vegetation where it is lacking. We have continued a multi lake experiment examining lakes with a range of vegetation densities and have begun measuring recruitment of largemouth bass in those systems. We will continue to monitor pre treatment conditions in 2009 and plan to initiate vegetation treatments to reduce vegetation in Stillwater, Airport, and Kakusha Lakes in 2010. Vegetation removal in these lakes will be accomplished primarily through chemical treatments appropriate to reduce the dominant problem vegetation. 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. We will supplement the plantings from 2008 with spring and summer plantings in 2009 of American pondweed and wild celery. These two species of plants did well in 2008 prior to the drawdown and should provide vegetation cover within enclosures. 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. 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. A similar drawdown and fish removal in Woods Lake is planned for fall 2009 and we will evaluate the post drawdown fish communities and vegetation density. 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 and woody habitat management on largemouth bass recruitment as well as other components of the food web.

While the addition of complex structures has been utilized as a lake restoration technique for many years (see reviews by Smokorowski et al. 1998 and Bolding et al. 2004) controlled manipulative experiments designed to examine the importance of such structure to fish populations in lentic systems is surprisingly rare (Smokorowski and Pratt 2007). In our pond experiments we have thus far focused on coarse woody habitat, which is hypothesized to be an important to aquatic food webs because it supports a high biomass of aquatic invertebrates (Bowen et al. 1998) and offers a temporally stable structure (Guyette and Cole 1999). In summer pond experiment we found evidence that the presence of coarse woody habitat can increase growth of bluegill in a simple aquatic community. Previous research in this study has identified the production of bluegill as an important driver of largemouth bass recruitment in Illinois lakes (see Job 101.4) and (combined with our results) may provide a mechanism by which littoral habitat may influence largemouth bass populations. In future segments we will examine potential differences in abiotic and food web components that may explain the observed differences in bluegill growth between treatments.

Though we found no effect of woody debris on the survival of either size class of bluegill in the overwinter experiment, results of the summer experiment highlight that many of the effects of woody habitat may be indirect. Small vulnerable size classes of bluegill might be especially likely to change behavior when woody cover is available. We will continue to look for differences in growth rates between the treatments and examine other trophic levels to determine if woody habitat has the potential to affect the community dynamics of freshwater systems, which may affect growth and survival of largemouth bass.

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. Additional techniques to establish this baseline during low flow times will be employed at the Ridge Lake site where a new screened catch basin can be used to collect fish. 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:

The growth in the popularity of competitive angling events targeting black bass has been substantial in the United States over the last 40 years with exceptional growth occurring in the past decade. Highlighting this recent growth, about 18,000 events were estimated to occur in North America in 2000 whereas over 32,000 were estimated to occur in 2005 in the United States alone (Kerr and Kamke 2003; Schramm and Hunt 2007). Although tournament rules require the release of captured bass following the conclusion of the "weigh-in," high mortality (>50%) has been reported during tournaments within the last 10 years (Neal and Lopez-Clayton 2001; Gilliland 2002; Wilde et al. 2002a), necessitating investigations into strategies to minimize mortality during these events. Mortality can be capture-related (i.e. hooking mortality) but can also be due to the collective impact of several sub-lethal stressors incurred by bass throughout the tournament process (Kwak and Henry 1995) such as the disturbances sustained during livewell confinement or the weighing procedure. In addition, the sub-lethal physiological disturbances incurred by bass that ultimately survive the tournament process can negatively impact growth (Wendelaar Bonga 1997) and fitness (Schreck et al. 2001; Ostrand et al. 2004) and increase susceptibility to disease (Pickering and Pottinger 1989). Clearly, identifying factors that influence the sub-lethal and lethal consequences of tournaments on largemouth bass and potential avenues to mitigate these impacts is important for the sustainable use of bass fisheries.

One factor that may influence the impact of tournaments on largemouth bass is the size or organization of these events. Tournaments administered by local clubs typically have fewer than 50 anglers whereas events sanctioned by professional organizations can have upwards of 500 anglers. These "club-style" tournaments however, are more numerous and are often less organized than professional "tour-style" events yet previous studies have focused almost exclusively on large tournaments. In addition, the few studies that examine the effects of small tournaments have conflicting results regarding the impacts of such events. For example, Ostrand et al. (1999) reported that small tournaments (< 50 anglers) had higher initial mortality (4.1%) than large tournaments (1.8%; > 50 anglers) presumably due to lower levels of organization in the smaller events. Conversely, mortality has been suggested to increase with increasing number of tournament participants (Schramm et al. 1987; Hartley and Moring 1995) and mortality was reported to be low (about 2%) in club-style tournaments in Connecticut (Edwards et al. 2004). Air-exposure during the weigh-in has been shown to instigate a large metabolic disturbance in largemouth bass that may contribute to mortality (Suski et al. 2004) yet no studies have quantified the sub-lethal physiological impacts of small tournaments even though air exposure of fish during the weigh-in may be longer (due to poor organization) or shorter (due to few anglers) during these events relative to tour-style events. Currently, the information regarding small tournaments does not provide a clear picture of the status of tournaments in Illinois as the number of tour-style events is relatively low (possibly as they are only held on our largest water bodies, e.g. Lake Shelbyville, Rend Lake, Carlyle Lake) whereas club-style competitions are frequent and are often held on smaller water bodies.

Another factor that may influence the impact of tournaments on largemouth bass is the timing of events. Tournaments are held throughout the year and seasonal fluctuations in water temperatures may affect the impacts of tournaments as mortality has been shown to correlate with water temperature (Wilde 1998). In addition, largemouth bass exhibit seasonal changes in several indices of physiological condition (Brown and Murphy 2004) and may display season-specific physiological responses to tournaments which may ultimately influence mortality rates. Mortality of largemouth bass during tournaments held in the spring spawning season has been reported to be higher than those held during summer, possibly due to stressors associated with spawning behavior (Kwak and Henry 1995). Currently, little is known about seasonal responses of largemouth bass to tournaments, especially sub-lethal physiological disturbances, and this information would be particularly relevant as tournaments are held on Illinois waters 12 months out of the year. A comprehensive evaluation of sub-lethal and lethal consequences of club-style tournaments across multiple seasons would be useful as the majority of tournaments held in Illinois are club-style events, the current information regarding small tournaments is conflicting, and it is unknown whether season-specific tournament guidelines can have benefits for largemouth bass.

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).

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. All these practices could contribute to increased abandonment by nesting males.

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). 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.

PROCEDURES:

Tournament Mortality

In 2008, we evaluated delayed mortality following tournaments at Evergreen Lake during early-spring, early-summer, mid-summer, and fall. Water temperatures varied across seasons and were 14.0 ºC at the early-spring tournament, 25.2 ºC in early-summer, 27.6 ºC in mid-summer, and 19.6 ºC in fall. Following the conclusion of each tournament, fish were placed into holding pens (N=10 fish per pen, 3 pens per tournament). The holding pens had mesh netting attached to a frame made of floating PVC measuring 6'x4' with a net depth of 9'. Additional largemouth bass were collected via electrofishing after the tournament and placed into similar cages to account for cage effects. Pens were checked 24 and 72 hours following the conclusion of the tournament for deceased bass and all remaining bass after 72 hours were released. Initial mortality (number of fish deceased prior to weigh-in) was also recorded. Delayed mortality was calculated by subtracting the mortality of electrofished control fish from the mortality of the tournament-caught fish when applicable.

Also in 2008, we blood sampled largemouth bass at Lake Bloomington during tournaments in early-spring, late-spring, mid-summer, and fall. To determine whether changes in physiological parameters were season-specific responses to tournaments or seasonal changes in baseline parameters, we collected largemouth bass via electrofishing immediately following each tournament. Fish were returned to the laboratory at the Kaskaskia Biological Station, allowed to recuperate, and were then blood sampled to generate resting values for all parameters in each season (termed the 'Seasonal control group'). Blood and plasma samples were processed for indicators of physiological disturbances.

Tournaments at both Evergreen Lake and Lake Bloomington were part of the same tournament organization and weigh-ins were officiated by the same individual at each event. Each tournament was 8 hours in length and consisted of 25 2-person teams allowed to weigh-in a maximum of 5 fish meeting or exceeding the 15" minimum length limit. Teams were penalized 1 pound for each deceased fish brought to the weigh-in. This penalty is 2-4 times greater than the typical penalty assessed by many nationally-run organizations.

Paper Tournaments

In previous segments we conducted paper a paper tournament on Lake Shelbyville to determine their potential for reducing largemouth bass mortality through the elimination of the weigh-in. In this segment we have compiled the data from 6 additional tournaments. Anglers were asked to record the total length of each fish caught to the nearest quarter inch. Anglers were then ranked under a variety of scoring criteria, including the tournament official results (total weight of fish > legal limit), total paper length (sum of total length of all fish caught), total paper weight (sum of weight estimated from paper lengths of all fish caught), paper length from legal fish (sum of lengths from fish over the legal limit), and paper weight from legal fish (sum of weight estimated from paper lengths). Paper lengths were converted to paper weights using a length weight regression developed from largemouth bass collected on Lake Shelbyville from electrofishing samples. Once anglers were ranked under each scenario, the difference of each ranking from the official weigh-in ranking was calculated as the absolute deviation from the weigh-in rank. We compared the differences in ranking among the tournament scenarios in order to evaluate each technique.

Influence of Spring Tournaments on Reproduction

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 and 2008, 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 2008, this controlled experiment was expanded to assess late summer and fall recruitment differences between treatment and control groups, allowing this study to more closely reflect the effects of brood predation throughout the entire first year of life. YOY collected from experimental ponds were stocked in six ponds at two densities (n=4200 in 3 high density ponds and n=2100 in 3 low density ponds). Ponds were drained in late October and all surviving YOY were enumerated.

In addition to the pond experiments, we implemented a lake experiment where we conducted largemouth bass tournaments in the spring of 2007 at Ridge Lake where no prior tournament activity had taken place. No tournaments were held during 2008 and will be compared to years with tournaments. Presence of tournaments will continue in future years in alternating fashion. Prior to 2007 a large number of largemouth bass were PIT tagged (>2000 fish) and new fish are tagged each year at a rate of 200 fish per year. PIT tag data can be used to estimate population sizes to determine changes in largemouth bass populations throughout this study. Largemouth bass recruitment was assessed using seine hauls and electrofishing. Seine hauls were conducted bimonthly at three pre determined transects in Ridge Lake. In addition, the entire lake was electrofished twice in the spring and twice in the fall of each year. All largemouth bass collected were, measured for length, examined for PIT tags and released. Recruitment was assessed as the relative CPUE from fall electrofishing samples and mean density of young-of-year largemouth bass collected in seines in late August and early September. Additionally, a complete creel census has been conducted on Ridge Lake during the open angling season of each year.

In the early spring of 2007, seven angling tournaments were conducted during the spawning season (April 22 - May 22) on Ridge Lake, 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. In 2008 no tournaments were conducted and the lake was closed to angling until May 22, 2008.

Long-Term Effects of Tournaments

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 eleven lakes in the spring and fall and all largemouth bass were collected, measured for total length and weighed. Of the lakes sampled, 5 were lakes with tournament activity and 6 were lakes with no tournament activity. All lakes had similar regulations with minimum length limits ranging from 14-18 inches and 6 fish bag limits. 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). 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. Tournament data will be collected for each lake and the total number of tournaments, total number of anglers, total fishing hours, and total number of fish caught will be determined for each lake. We will examine the intensity of tournament activity at each lake and evaluate the abundance and size structure of the associated largemouth bass population.

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 23rd, 2009 and continued through May 11th, 2009. Each of six transects have been monitored for several years. Each located nest 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. The species and number of predators in the nest was recorded, as well as their size and amount of time spent in the nest. 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 and 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. A Chi-squared test was used to determine significant variation of used habitat from available habitat in 2006, 2007, and 2008. The absolute value of residuals (greater than 1.96) determined which substrate type was used significantly greater than (+) or less than (-) expected. To determine if different nest substrates pose greater risks of predation, percent composition of nests with potential nest predators were separated from nests with no potential predators. A random distribution of selected nest sites would yield equal numbers of nests with and without nest predators. Young-of-year largemouth bass were also collected in the months of July and August in each year 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. 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.

FINDINGS:

Tournament Mortality

Overall, tournament-related mortality at Evergreen Lake was quite low and never exceeded 5%. No delayed mortality was observed in early-spring, early-summer, or mid-summer tournaments. During fall, 1 of the 20 largemouth bass weighed-in was found deceased within 72 h following the conclusion of the tournament, resulting in 5% delayed mortality for that season. One deceased fish was brought to the weigh-in (initial mortality) in both the early-summer tournament and mid-summer tournament, however, these mortalities were reported to be hooking-related and one of the two fish had visible hooking-related injuries. When initial and delayed mortalities are combined, mortality was 0 % for early-spring, 4 % for early-summer, 3.8% for mid-summer, and 5 % for fall (Table 5-1). No discernable seasonal trends in mortality were observed.

In general, the physiological responses of largemouth bass to tournaments were relatively similar over seasons. Cortisol, a hormone that is released during the stress response and is a sensitive indicator of stress, was elevated in plasma during tournaments in all seasons relative to controls but was only statistically significantly elevated in early-spring (Figure 5-1 A). Similarly, plasma glucose, which is released during the stress response as aerobic fuel to overcome stressors, was also elevated relative to controls in early-spring and late-spring tournaments, but was not different across seasons except that mid-summer levels were greater than fall concentrations (Figure 5-1 B). Largemouth bass incurred a large metabolic disturbance in all seasons, characterized by an increase in plasma lactate concentrations during each season (Figure 5-1 C). Because water temperatures ranged from as low as 15.7 ºC at the early-spring tournament to as high as 27.6 ºC during the mid-summer tournament, this disturbance was likely independent of temperature and was instead related to air-exposure during the weigh-in, which has been shown to cause physiological disturbances in largemouth bass (Suski et al. 2004). Overall, the sub-lethal physiological disturbances observed in this study were similar to those experienced during catch-and-release angling, from which largemouth bass can fully recover (Suski et al. 2006).

Paper Tournaments

In this segment we assessed data from 7 paper tournaments that ranged from 14 to 33 participating anglers (Table 5-2). Results from the paper tournaments were similar to the official weigh-in results when only fish greater than the legal limit are included. Mean deviation in rank for each angler was slightly greater than 1 for both total paper length and converted paper weight of legal sized fish (Figure 5-2). Less than one angler that were ranked in the top five in the official weigh-in were no longer in the top 5 due to the use of paper tournament results for legal fish (Table 5-3). These results suggest that paper tournaments can rank anglers similarly to official weigh-in results and may be used to replace the weigh-in and still identify the tournament winners. When paper tournaments considered all fish caught in angler rankings, rank deviation for each angler increased to around 4. Similarly the number of top 5 anglers that dropped out of the top five increased to 2 anglers. Paper tournaments would allow organizers to consider fish that were caught that are too small to keep in a traditional weigh-in. This method of evaluating who is the best angler will dramatically change the ranking of angler and may be a better or alternative measure of fishing skill rather than only considering legal sized fish. Paper tournaments can also evaluate traditional measures of winners based on anglers with the largest fish. Paper lengths for both tournament scenarios were similar to the weight results and converting paper lengths to weights is not necessary to rank anglers.

Influence of Spring Tournaments on Reproduction

In the controlled pond experiments conducted in 2007 and 2008, recruitment was clearly affected in ponds where 50% brood predation was simulated. Young-of-the-year (YOY) were 37% less abundant (see Figure 5-3), and 34% less YOY biomass (see Figure 5-4) was produced in treatment ponds. Size distribution of YOY was not remarkably different between control and treatment ponds during the two study years (see Figure 5-5). These results show that brood predation reduces the abundance of YOY surviving until the fall, and that YOY biomass is equally affected, indicating that neither compensatory growth nor compensatory survival operate to mitigate brood loss.

In the expanded experiment conducted from August to October of 2008, mean survival in high-density ponds was 53%, while mean survival in low-density ponds was 63%. The percentage of YOY recovered was not significantly different between high and low density ponds ($p = 0.312$), indicating that differences in YOY abundance caused by brood predation persist through the fall of the first year of life, supporting the hypothesis that brood predation can impact recruitment dynamics.

Tournaments were conducted at Ridge Lake during the 2007 spawning season and compared to a non-tournament year in 2008. 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). Both fall seine and electrofishing yielded lower largemouth bass numbers in 2008 than in 2007 (Table 5-4). Mean density of young of year largemouth bass in 2007 seine hauls was 0.11 fish/m^2 compared to 0.06 fish/m^2 in 2008. Similar differences were observed in electrofishing samples for young-of-year largemouth bass with 2007 CPUE being higher than 2008 (Table 5-4). Not only were young-of year largemouth bass more abundant in 2007, but they were larger in size. Similar differences also existed in adult catch rates with 2007 being higher than 2008 (Table 5-4). These results are based on one year of tournament fishing and one year of closed fishing and any interpretation is limited. These preliminary results suggest that tournaments may not adversely impact reproduction or lakes with higher reproduction are chosen for tournaments locations identifying which of these scenarios is operating will need to be assessed in future analyses. We will continue to conduct spring tournaments at Ridge Lake during the bass spawn in alternating years to evaluate changes in recruitment that may be attributed to tournament activity.

Long-Term Affects of Harvest

We have begun to accumulate age and maturity data for largemouth bass in eleven study lakes to examine the long-term effects of tournament pressure. 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 2005-2008 which will be used to determined mean length-at-age for each population. Fish collected during spring 2008 and previous years were aged and sex and maturity status were determined. Initial assessment of maturity show age of maturity of both male and female to be approximately age 3 on lakes that were sampled. We do not have enough fish from each lake to precisely determine age of maturity at this time. Of the lakes sampled, a majority of fish collected were immature at age 2 and mature at age 4 with 75% being mature at age 3 (55% of females; 90% of males). We used length at age 3 to explore potential differences in size among tournament and non tournament lakes (Figure 5-6). Tournament lakes had a higher mean size at age 3 than non tournament lakes, however there is a good deal of variation and these differences are not significant. We also examined CPUE from electrofishing for tournament and non tournament lakes and found higher CPUE of largemouth bass greater than 14 inches in tournament lakes than non tournament lakes (Figure 5-7). These are preliminary examinations of the largemouth bass populations in tournament lakes. We need to expand our database by including additional lakes in order to test for significance in the differences observed. In this segment we also compiled tournament data on Lake Shelbyville from 2002 through 2008 (Table 5-5). We are currently contacting tournament supervisors from our study lakes in order to obtain data on all tournaments that occurred on each lake. Only lakes where data from all tournaments can be obtained will be retained in the analysis. This will allow us to quantify tournament pressure and relate it to largemouth bass adult populations, recruitment, and other metrics such as PSDs, and RSDs.

Nest Observations

A total of 16 nests were observed between 4/23/2009 and 5/11/2009 in Lincoln Trail Lake. In May, turbidity from heavy spring rains greatly decreased ability of snorkelers to identify nests and subsequent snorkeling dates were cancelled. The first nests were observed shortly after temperatures reached 13^{o}C, and more nests were identified the following week as the water temperature increased (Figure 5-8). Nest substrate use was significantly different than available habitat in all three years ($P<0.001$). In 2006, wood, sticks, cobble and pebble were used more than expected, while vegetation, leaves, and detritus were used less than expected (Table 5-6). In 2007, gravel, cobble and pebble were used more than expected, while vegetation was used less than expected. In 2008, gravel and cobble were used more than expected while vegetation, was used less than expected. There was a greater likelihood of nest predation when bass spawned on gravel, pebbles, and cobble and a lesser likelihood when bass spawned on vegetation, wood, and detritus (Figure 5-9).

Survival to fall was back calculated to spring spawn time using otoliths in 2000, 2001, 2003, 2007, and 2008. 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 followed a positively skewed unimodal pattern, with the exception of 2008 when spawning was bimodal. The distribution of survivors was bimodal in 2001, but unimodal in 2000, 2003 2007, and 2008. 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 2000 and 2001, but not in other years (Figure 5-10). In 2003, 2007, and 2008 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.

RECOMMENDATIONS:

Minimizing air-exposure throughout the tournament process, especially during the weigh-in, can reduce metabolic disturbances such as those incurred by largemouth bass during this study. In addition, oxygen can be quickly depleted in weigh-in bags so aeration of these bags may also reduce metabolic disturbances. Although fish experienced a large metabolic disturbance but mortality was low, recovery from this disturbance may be energetically costly for fish. Apart from this metabolic disturbance, results from this study suggest that club-style tournaments can have minimal lethal and sub-lethal effects on largemouth bass during all seasons. The low mortality and sub-lethal disturbances could have been due to several factors. Most anglers weighed-in fewer fish than the 5 fish limit resulting in low livewell oxygen demand. Next, although smaller tournaments have been suggested to be poorly organized (Ostrand et al. 1999), tournaments at Evergreen Lake and Lake Bloomington appeared to be well organized. The handling time of tournament-caught fish was low, possibly due to the well-organized group, which may have minimized mortality as handling time has been previously shown to positively correlate with mortality (Edwards et al. 2004a). Lastly, conservation ethics of tournament participants may have also reduced the impacts on fish as they attempted to avoid a large, 1-pound dead fish penalty, likely by ensuring proper aeration of livewells. A combination of several of these factors reduced the lethal and sub-lethal impacts on largemouth bass during the monitored tournaments.

Results from the current study suggest that season-specific regulations or guidelines specific to club-style tournaments would not have additional benefits for largemouth bass. Organization of club-style tournaments, however, is likely highly variable and not all clubs follow the procedures described above. Largemouth bass would likely benefit from adaptation or closer enforcement of current recommendations such as adequate aeration of livewells and minimization of air exposure during the weigh-in. Quantification of individual parts of the tournament procedure (e.g. handling time, use of large dead-fish penalty) may be helpful recommendations to tournament organizers who do not follow or only loosely follow current guidelines. Our results demonstrate that if proper care is taken, small club-style tournaments can have minimal impacts on the fishery regardless of water temperatures.

Paper tournaments have the potential to remove the stress associated with livewell confinement of fish, weigh-ins, and removal from nesting sites during the spawn. We have demonstrated that paper tournaments can accurately rank anglers as well as allow tournaments to include smaller fish in the rankings and should be considered as an alternative to traditional weigh-ins especially during high temperature times of year and the spawning season. In addition paper tournaments allow the inclusion of fish that are caught, but shorter than the legal limit. These fish are ignored in a traditional weigh-in, but provide an alternative way to evaluate who is the best angler. We have shown the potential of paper tournaments and encourage organizers to consider their use in future tournaments.

The pond experiments conducted in 2007 and 2008 provide evidence of how angling largemouth bass during the spawning season can impact recruitment dynamics and reduce the size of the year class. Brood reduction during an angling event results in lower survival of YOY, and surviving YOY are similarly sized compared to YOY in populations that did not experience brood predation. We found no evidence of compensatory survival or growth in YOY in response to brood reductions, indicating that angling largemouth bass during the spawning season must be considered when discussing management alternatives that target problems in recruitment. To assess the effects of angling practices and tournaments on largemouth bass reproduction we will continue experiments initiated at Ridge Lake. No experimental angling tournaments will be conducted on Ridge Lake in 2008 to provide control data, but additional tournaments in 2009 will be conducted. 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.

We will continue to evaluate how varying tournament pressure and angler harvest has impacted the size structure and abundance 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. At this time our sample size is low and additional samples are required to conduct analysis of sex specific characteristics. 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 differences in fishing pressure and relate them to largemouth bass size structure and maturation rates. This will allow us to identify the potential impacts of tournaments and harvest to life history characteristics in largemouth bass populations.

Thus far, we have been able to assess spawning activity during five 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.

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 during 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 serves as 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 refuges in increasing the density and size structure of the largemouth bass populations.

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 density. 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 further research examining the effects of angling regulations (Novinger 1984; Wilde 1997; Paukert et al. 2007).

In this job, we are examining the use of closed seasons and refuges in two lakes and comparing largemouth bass recruitment and densities before and after implementation of the refuge. We will also evaluate current regulations used in Illinois largemouth bass management in order to determine the effects on population size structure and density as well as angler catch rates.

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 2008 and the spring of 2009. 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. In addition to Clinton Lake, two potential refuges sites were identified in Otter Lake and will be closed to fishing beginning the spring of 2010 or 2011. In this segment we continued sampling Otter Lake to monitor pre refuge largemouth bass populations. One 30 minute electrofishing transect and one seine haul were conducted in each proposed refuge location. In addition, three control sites were sampled (1 electrofish transect and 1 seine haul in each) 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 electrofishing and 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 used for initial analyses. Lakes were categorized by their existing regulations into six categories, Standard (14” length limit, 6 fish creel, n = 8), Lowered Bag (14” length limit, <6 fish bag limit, n = 3), Raised Length (>14” length limit, 6 fish bag limit, n = 2), Raised Length/Low Bag (>14” length limit, <6 fish bag limit, n = 4), Slot (no fish harvest slot, n = 3), and No Fishing (no fishing permitted, n = 1). Creel data was collected from the Illinois Statewide Creel Survey. We compared angler effort, harvest rate, and catch rate (sum of harvest and released fish) among the six regulation types. We also examined largemouth bass population size structure using spring electrofishing samples. Each lake was sampled on two dates in the spring of 2008 and two dates in the spring of 2009. Three transects were sampled using an AC electrofishing boat on each date. All largemouth bass were collected, measured for total length, weighed, sexed and scales were collected for aging. Electrofishing data were summarized as mean CPUE of largemouth bass larger than 14 inches and CPUE of fish shorter than 14 inches.

FINDINGS:

Mean CPUE for largemouth bass in Clinton Lake from 1999 through 2001 was 25.5 fish per hour of electrofishing. This is in the lower range 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 2009 yielded a much higher CPUE than sites outside the refuge (Table 6-1). In addition, CPUE was greater inside the refuge after closing than samples taken before the refuge was closed. This suggests that bass numbers are increasing in the refuge potentially due to the elimination of fishing pressure. 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 will be used 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. We will continue to assess the potential lake-wide effects the refuge may have as a tool for managing bass populations in future segments.

We continued monitoring future refuge and reference sites in Otter Lake during this segment. In fall of 2008 and spring of 2009, we observed slightly higher catch rates of largemouth bass in the refuge sites than the control sites in the remainder of the lake (Table 6-1). 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 during nesting may increase spawning success and yield larger year classes. Effects of a refuge may be easier to detect on Otter Lake as well due to its smaller size.

We have identified 21 lakes that we are currently sampling as part of Jobs 4 and 5 that have 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 6. Length limits vary slightly from this standard ranging from 14 to 18 inches. In addition there are three lakes in this initial group 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 and Mill Creek have a no harvest slot from 12 to 15 inches with a bag limit of 6. Angler effort varied among lakes and regulation type (Figure 6-1). The standard regulation lakes experienced the lowest mean fishing effort (other than the no fishing regulation); however there is a large amount of variation among groups. In addition, angler effort was significantly correlated with size of the lake ($r = 0.66$; $P = 0.0036$) and number of largemouth bass caught ($r = 0.97$; $P < 0.0001$).

Catch and harvest rates of largemouth bass varied among regulation categories. The number of largemouth bass harvested followed a similar pattern to fish that were caught (Figure 6-2). The highest number of fish caught or harvested were observed in lakes with a lowered bag limit as well as lakes with a slot limit. This is counterintuitive for reduced bag limits that are usually implemented to reduce the number of fish harvested and are commonly utilized on lakes with low numbers of largemouth bass. Catch rates (#/hr) of anglers differed from the pattern observed based on numbers of fish caught or harvested (Figure 6-3). The highest angler CPUE for largemouth bass caught was observed in lakes with raised length limit, followed by slot and standard regulations. Angler harvest per hour seems to be most influenced by length limits. Lakes with raised length limits and lowered bag limits had the lowest harvest rates followed by lakes with raised length limits. These regulations appear to limit harvest despite high catch rates. Densities and size distribution of largemouth bass also varied across regulations (Figure 6-4). Lakes with raised length limits had the highest CPUE from electrofishing samples of fish over 14 inches, followed closely by lowered bag and raised length/lowered bag lakes. Lakes with slot limits had the lowest CPUE of fish over 14 inches and the highest CPUE of fish under 14 inches in electrofishing samples. It is difficult to determine if the size structure observed is a result of the regulation or the reason for implementing the regulation. A time series of size structure data is required and will be used in future analyses with densities prior to implementing a regulation to determine how populations change after implementation and the length of time required for changes to occur.

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 refuges were 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) are also being evaluated as part of this job. Management experiments are manipulating vegetation (e.g. plantings and removals) to examine changes in largemouth bass growth and survival. The experiment includes 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 need to supplement existing study lakes in order to analyze effects of differing regulations, primarily to increase the number of lakes with slot limits and larger than 14 inch length limits. In future segments we will identify a number of additional lakes 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. These combined datasets offer nearly twenty years of creel survey and population assessment data collected under project F-69-R. In addition, largemouth bass regulations were summarized in previous reports for 52 lakes that were surveyed from 2003-2007 by both FAS sampling and creel surveys. We will make recommendations regarding the effectiveness of different regulations and how they have influenced size structure of largemouth bass populations through 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.

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Table 2-1: Stocking information for four lakes stocked with fish at the boat ramp and dispersed into habitat. CPUE is catch per hour from electrofishing transects performed in the fall after stocking and the subsequent spring.

Lake	Stocking Date	Boat Ramp Stocking			Dispersed Stocking		
		# Stocked	Fall CPUE	Spring CPUE	# Stocked	Fall CPUE	Spring CPUE
Charleston	8/15/2008	3500	2.0	0	3500	2.0	0.4
Homer	8/16/2007	1400	0	0	1400	0.3	0
Mingo	8/16/2007	3400	0.7	0	3400	2.0	0
	8/14/2008	2150	5.7	0	2150	3.7	0.7
Otter	8/15/2007	7650	0	0	7650	0	0
	8/13/2008	11400	0.8	0	11400	0.2	0

Table 2-2: Comparison of foraging behaviors for 6 and 8 inch hatchery reared (H), bluegill acclimated (BG), and natural (N) largemouth bass in laboratory experiments. In 30 min experiments, individual largemouth bass foraged on 10 bluegill in 2.5 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 (%)			Swimming speed (m/s)		
		H	BG	N	H	BG	N	H	BG	N	H	BG	N	H	BG	N	H	BG	N
6 "	2	19	3	9	13	2	5	3.4	3.0	5.1	7.7	1.0	21.4	40	25	25	0.25	0.22	0.16
	4	8	8	4	7	5	6	3.1	3.4	5.1	8.9	12.4	31.1	40	28	21	0.25	0.20	0.15
	8	19	10	8	10	7	7	3.1	4.2	4.2	7.7	19.5	30.7	27	28	26	0.23	0.20	0.18
8 "	2	26	14	0.2	15	9	0.1	4.3	3.5	2.6	3.8	9.6	0	32	25	12	0.23	0.20	0.16
	4	19	13	11	11	7	5	3.6	4.5	3.1	8.4	10.0	4.8	35	30	18	0.22	0.20	0.17
	8	29	22	15	19	9	5	3.8	4.0	3.3	3.7	17.6	9.6	41	32	21	0.24	0.20	0.16

Table 2-3: Multiple Before-After, Control-Impact (MBACI) analysis to test for changes in food web components through time following supplemental stocking of largemouth bass. Mean difference for each parameter between stocked and unstocked (control) lakes are shown before and after stocking. P-values indicate significance (Trt x Period term) from the repeated measures ANOVA. Correlations (r-values) and associated p-values indicate significance of linear trends in mean differences through time.

Parameter	Difference Before	Difference After		Test for Linear Trend	
			P	r	*P*
			Non-Shad Lakes		
Planktivore Density (#/m^2)	3.03(±27.61)	-1.29(±1.45)	0.03	-0.72	0.04
Cladoceran Density (#/L)	6.59(±34.30)	20.38(±12.18)	0.16	0.16	0.71
Cladoceran Length (mm)	0.007(±0.23)	-0.12(±0.05)	0.06	-0.33	0.46
Chlorophyll a (ug/L)	8.36(±3.74)	15.56(±2.77)	0.01	0.55	0.19
Total P (ug/L)	69.40(±175.42)	172.52(±119.23)	0.26	0.23	0.63
Secchi Depth (m)	-1.08(±2.15)	-0.93(±0.19)	0.85	0.12	0.77
			Shad Lakes		
Planktivore Density (#/m^2)	1.33(±4.00)	0.25(±0.39)	0.34	-0.74	0.04
Cladoceran Density (#/L)	1.11(±19.33)	-0.03(±4.86)	0.72	-0.29	0.48
Cladoceran Length (mm)	-0.02(±4.00)	0.00(±0.04)	0.72	-0.23	0.62
Chlorophyll a (ug/L)	-14.74(±127.27)	-4.90(±9.04)	0.56	0.51	0.20
Total P (ug/L)	-32.69(±187.71)	-9.78(±22.35)	0.69	0.07	0.87
Secchi Depth (m)	0.03(±1.51)	0.08(±0.23)	0.82	0.16	0.70

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 for 6-7 years from 1998 to 2005.

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 as a percentage of genes. 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	Lake size (hectares)	Percentage of genes from natural reproduction contributed by stocked hatchery fish	Influence
Shelbyville	4494	0%	None
Forbes Lake	226	6%	Minor
Lake Murphysboro	58	11%	Minor
Sam Parr Lake	58	32%	Moderate
McCleansboro	30	0%	None
Walton Park	12	51%	Major

Table 4-1: The number of each type of enclosure (large, small dispersed, and small clustered) that were planted in Lake Paradise in June and July of 2008.

Vegetation Planted	Large	Small Dispersed	Small Clustered	Total
American Pondweed	12	24	NA	36
Chara	12	24	8	44
Coontail	14	32	8	54
Sago	5	28	24	57
Wild Celery	26	116	105	247
Mixed	4	40	8	52
Grand Total	73	264	153	490

Table 4-2: Mean percent cover for each species of vegetation planted in Lake Paradise in June and July of 2008. Percent cover was visually assessed in August of 2008 and June of 2009.

Vegetation Species	August 2008			June 2009		
	Large	Small Dispersed	Small Clustered	Large	Small Dispersed	Small Clustered
American Pondweed	78.3	61.3	NA	5.0	2.1	NA
Chara	1.2	0.0	0.0	0.0	0.9	0.0
Coontail	12.8	1.7	0.0	0.0	0.0	0.0
Sago	30.0	8.0	12.4	0.0	0.0	0.0
Wild Celery	22.1	14.6	15.5	0.9	0.7	0.8
Mixed	11.25	12.45	0.0	3.5	3.9	0

Table 4-3: Data from spring and fall vegetation assessments on 13 Illinois lakes in 2008. Vegetation on each lake was mapped using GPS to estimate the area and perimeter of the vegetated area of the lake. Percent vegetated area and perimeter are the proportion of the entire lake.

Lake	Type	Lake Area (m2)	Lake Perimeter (m)	Vegetated				Percent Vegetated			
				Area (m2)		Perimeter (m)		Area		Perimeter	
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Airport	Treatment	89246	1171	89246	89247	1171	1171	100	100	100	100
Kakusha	Treatment	192665	3256	1334	0	131	0	1	0	4	0
Stillwater	Treatment	89363	2215	74023	89363	2215	2215	83	100	100	100
Paradise	Planted	706098	7287	78091	5806	4182	903	11	1	57	12
Dolan	Drawdown	302869	5335	45371	59411	4711	5174	15	20	88	97
Woods	Drawdown	127217	3241	0	91	0	39	0	0	0	1
Forbes	Control	2056612	29364	270560	308225	29097	29832	13	15	99	100
Le-Aqua-Na	Control	145825	2709	29173	35949	1362	1424	20	25	50	53
Lincoln Trail	Control	584546	10033	124267	112233	9661	9841	21	19	96	98
LOTW	Control	103090	2259	900	904	186	197	1	1	8	9
Pierce	Control	647830	6406	137274	131357	4751	5008	21	20	74	78
Ridge	Control	44013	1132	9416	9411	752	830	21	21	66	73
Walnut Point	Control	215810	9396	0	3854	0	485	0	2	0	5

Table 4-4: CPUE for young-of-year and adult largemouth bass in 13 lakes with varying vegetation densities (see Table 4-3). In addition, densities of potential prey species (larval fish, zooplankton, and macroinvertebrates) are presented.

Lake	Type	Mean Fall Electrofishing CPUE (#/hr)			Larval Fish Density (#/m3)			Mean Total Zooplankton Density (#/L)	Mean Total Benthos Density (#/m2)
		YOY LMB (<200mm)	BLG	LMB >200mm	Shad	Lepomis	Total		
Airport	Treatment	68.2	32.4	13.0	0.00	0.63	0.63	484	2932
Kakusha	Treatment	49.3	148.0	51.6	0.00	0.01	0.02	981	4915
Stillwater	Treatment	5.1	51.5	14.8	0.00	0.01	0.04	585	2899
Paradise	Planted	10.0	98.0	13.0	4.89	9.24	14.18	506	3251
Dolan	Drawdown	19.7	62.7	48.7	0.19	89.28	89.73	712	6399
Woods	Drawdown	3.3	55.7	9.3	4.33	1.23	5.56	579	3614
Forbes	Control	16.2	105.3	29.0	1.60	5.06	6.96	711	3827
Le-Aqua-Na	Control	15.9	189.6	33.8	0.00	0.00	0.01	351	6559
Lincoln Trail	Control	23.7	77.3	38.3	0.00	2.06	2.07	218	3364
LOTW	Control	17.4	101.4	18.1	0.64	6.25	6.91	555	8498
Pierce	Control	27.9	93.7	26.1	0.07	0.84	0.97	737	7901
Ridge	Control	39.2	96.8	49.9	0.00	0.11	0.11	459	3212
Walnut Point	Control	37.3	71.0	22.0	0.00	12.70	12.86	1072	910

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 (2006 and 2007) and nine enclosures (3 wood, 3 vegetated and 3 open) in Lake Paradise. Fish were sampled using 3-pass depletion with a DC 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 Vegetation	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 Vegetation	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
			2008		
Wood	1	147	0.007	0.10	0.22
	2	85	0	0.04	0.24
	3	110	0	0.03	0.15
	Mean	114	0.002	0.06	0.20
Vegetated	1	110	0	0.01	0.15
	2	42	0.02	0.40	0.62
	3	55	0.02	0	0.02
	Mean	69	0.01	0.14	0.26
Open	1	80	0	0.04	0.19
	2	78	0	0.09	0.36
	3	60	0.02	0.10	0.38
	Mean	73	0.007	0.08	0.93

Table 4-6: 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
4/28/09	0	2	0	0
Ridge Lake				
6/10/08	4	1	1	25

Table 5-1: Summary of largemouth bass monitored at tournaments at Evergreen Lake during four seasons. Mortality is expressed as a percentage of the total number of fish weighed-in (actual number of fish is in parentheses). Initial mortality is for fish that are deceased prior to weigh-in. Delayed mortality describes the fish that were alive prior to weigh-in but died within 72 h following the conclusion of the tournament while being held in a submerged holding pen. Total mortality is the sum of initial and delayed mortality.

	Season			
	Early-Spring	Early-Summer	Mid-Summer	Fall
Total # fish weighed-in	25	25	26	20
Initial mortality	0 %	4 % (1)	3.8 % (1)	0 %
72 h delayed mortality	0 %	0 %	0 %	5 % (1)
Total # control fish monitored	15	14	15	10
Total mortality	0 %	4 % (1)	3.8 % (1)	5 % (1)

Table 5-2: Tournament information of the 7 paper tournaments conducted on Clinton Lake, Lake Sara, Mill Creek Lake and Shelbyville. Paper tournament participants recorded the length of each fish caught in quarter inch increments.

Lake	Date	Start Time	End Time	# of Anglers	Total number of Fish Weighed In	# of Paper Participants
Clinton	7/10/2004	5:45	13:45	20	6	14
Lake Sara	5/22/2004	5:45	13:45	24	27	16
Lake Sara	5/23/2004	5:45	13:45	25	27	16
Mill Creek	5/8/2004	6:30	14:30	26	4	14
Shelbyville	6/12/2004	5:30	13:30	22	9	13
Shelbyville	6/13/2004	5:30	13:30	23	8	16
Shelbyville	5/22/2005	6:00	15:00	65	152	33

Table 5-3: The number of anglers that were ranked in the top five in the official weigh-in that were no longer ranked in the top five under a variety of paper tournament scenarios. Paper tournaments were conducted on 6 lakes where anglers recorded the length of each fish caught to the nearest quarter inch. Paper tournaments for all fish included data from all fish caught, while paper tournaments of legal fish included only fish larger than the legal length limit of the lake.

Lake	Date	Number of Anglers			
		Paper Weight All Fish	Paper Length All Fish	Paper Weight Legal Size	Paper Length Legal Size
Clinton	7/10/2004	0	0	0	0
Lake Sara	5/22/2004	4	4	2	2
Lake Sara	5/23/2004	3	4	1	1
Mill Creek	5/8/2004	1	2	0	0
Shelbyville	6/12/2004	1	1	1	1
Shelbyville	6/13/2004	1	3	0	0
Shelbyville	5/22/2005	2	2	2	2
	Mean Total	1.5	2.0	0.8	0.8

Table 5-4: Largemouth bass recruitment for Ridge Lake in a year where spring tournaments occurred (2007) and a year where no tournaments occurred (2008). CPUE is the catch per unit effort from fall AC electrofishing samples whereas seining provides fall estimates of young-of-year density.

Year	Spring Tournament	Young of Year Largemouth Bass			LMB Fall CPUE >200mm (#/hr)
		Fall CPUE (#/hr)	Mean Length (mm)	Fall Seine Density (#/m2)	
2007	Yes	85.4	93.3	0.11	72.6
2008	No	40.6	67.0	0.06	47.2

Table 5-5: Tournament data for Lake Shelbyville from 2002 through 2008. Tournament directors are required to report total number of anglers, length of tournament, and total catch for each tournament.

Year	# of Tournaments	# of Anglers	Total Tournament Hours	Total Angler Hours	# of Fish Caught
2002	68	4356	565	36557	3388
2003	50	3536	415	29513	3118
2004	64	4712	521	39049	2935
2005	45	2207	367	18369	1978
2006	18	1253	151	10669	1632
2007	60	2797	472	23413	2904
2008	26	1772	213	14977	1787

Table 5-6: Chi-squared residuals for largemouth bass nesting substrate. Absolute values greater than 1.96 indicate substrates that were significantly over expressed (positive values) or under expressed (negative values) relative to their availability.

Year	Vegetation	Wood	Sticks	Leaves	Detritus	Sand	Gravel	Cobble	Pebble
2006	-1.97	5.06	4.58	-2.26	-2.70	-0.69	-0.30	3.11	3.83
2007	-2.49	0.27	0.30	-1.79	-1.09	0.91	2.27	3.38	3.28
2008	-2.75	0.84	0.35	1.07	-0.77	-1.36	3.51	2.84	1.69

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	36.0	36.0	38.0	110.0
2009	15.0	-	75.0	-

B. OTTER LAKE

Year	Control		Refuge	
	Spring	Fall	Spring	Fall
2007	-	37.4	-	55.2
2008	23.2	37.7	26.5	46.0
2009	22.0	-	31.5	-

Table 6-2: Largemouth bass regulations in existence on a number of lakes currently being sampled for other objectives in the study. LMB harvest and catch data are summaries of the most recent creel performed on each lake.

Lake	Length Limit (inches)	Creel Limit	Size (acre)	Year of Most Recent Creel	Total Angler Effort (hrs)	LMB Harvest		LMB Total Catch	
						Total #	#/ hour	Total #	#/ hour
Airport Lake	14	6	22	No Creel since 2000					
Charleston Lake	14	6	346	No Creel since 2000					
Clinton Lake	16	3	4895	2000	193374	782	0.002	43221	0.134
Dolan Lake	18	1	72	2003	12546	121	0.004	1018	0.047
Evergreen	15	6	925	2006	65176	781	0.005	22464	0.232
Forbes Lake	14	6	558	2005	37136	5014	0.093	24272	0.352
Lake Kakusha	14	3	53	2004	6965	78	0.004	1614	0.14
Lake Le-Aqua-Na	14	1	43	2004	21434	180	0.005	4392	0.143
Lake Mattoon	14	6	983	2007	25842	164	0.004	3907	0.065
Lake Mingo	15	6	172	2003	37173	340	0.008	11451	0.296
Lake-of-the-Woods	15	1	25	2005	16291	63	0.002	1390	0.104
Lake Paradise	14	6	174	No Creel since 2000					
Lake Shelbyville	14	6	10191	2003	175360	640	0.003	32728	0.12
Lincoln Trail Lake	14-18 Slot	4, 1>18	137	2004	21187	545	0.013	5175	0.199
Mill Creek	12-15 Slot	6	716	2006	57185	215	0.003	36828	0.213
Stillwater Lake	No Fishing	0	22	No Fishing	0	0	0	0	0
Otter Lake	15	3	765	No Creel since 2000					
Pierce Lake	14	1	147	2003	77814	2716	0.028	8276	0.176
Ridge Lake	14	6	14	2008	630.5	4	0.011	507	0.41
Walnut Point Lake	12-15 Slot	6	52	2003	17758	648	0.031	8226	0.358
Woods Lake	14	6	27	2003	3834	18	0.001	602	0.048

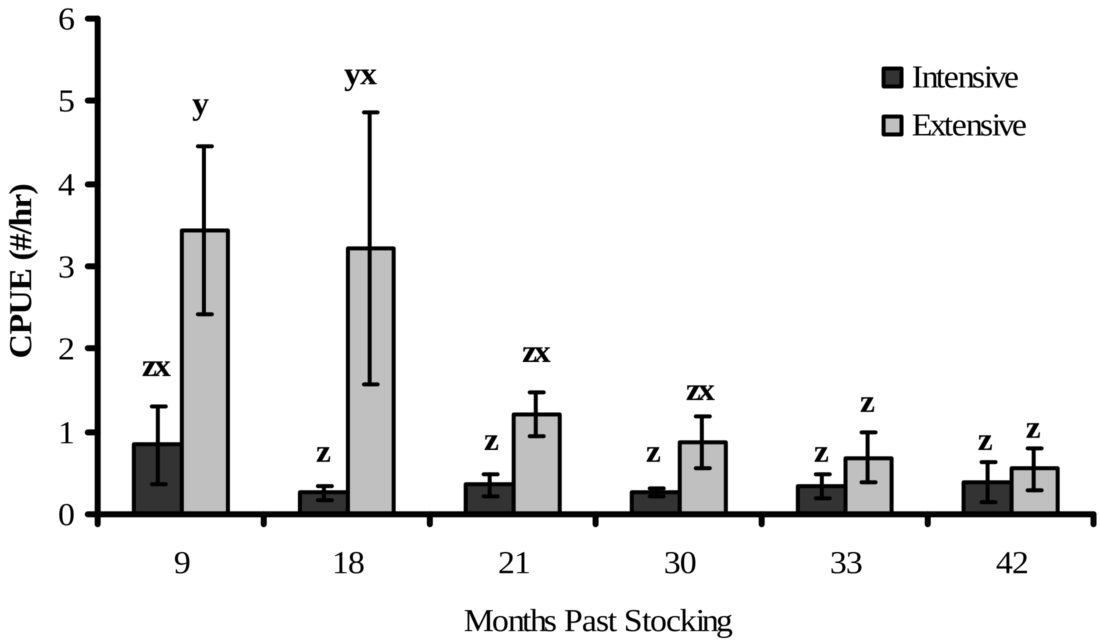

Figure 2-1: Mean CPUE of intensive and extensive fish collected in AC electrofishing samples in the months following stocking. Samples were collected in the fall following stocking (9) and each spring and fall from 1998 through 2009.

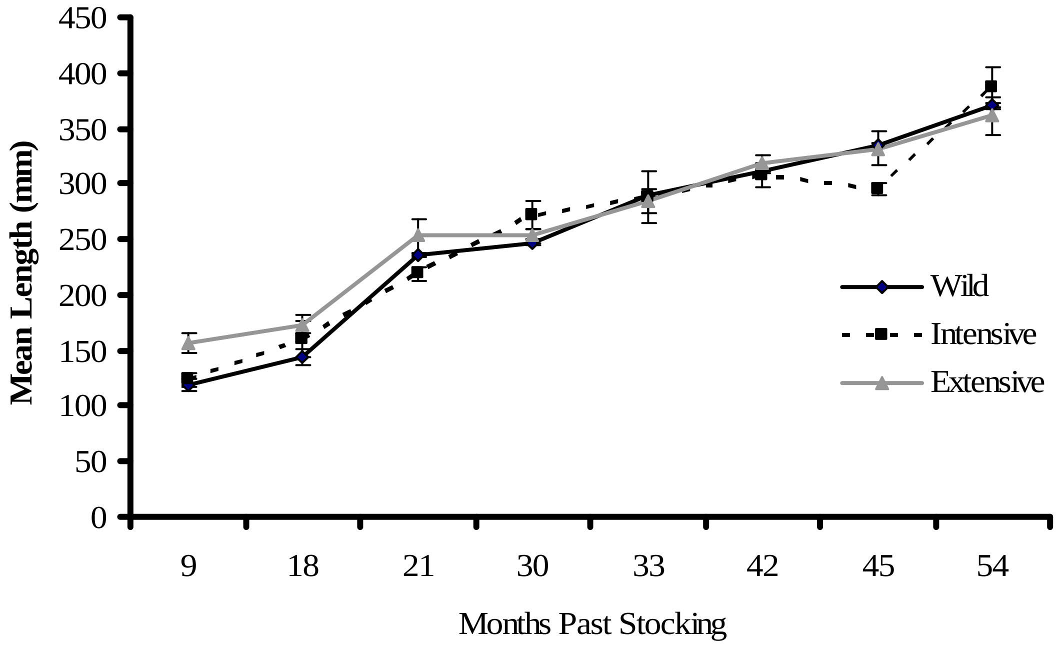

Figure 2-2: Mean length of intensive, extensive, and wild fish collected in AC electrofishing samples in the months following stocking. Samples were collected in the fall following stocking (9) and each spring and fall from 1998 through 2009.

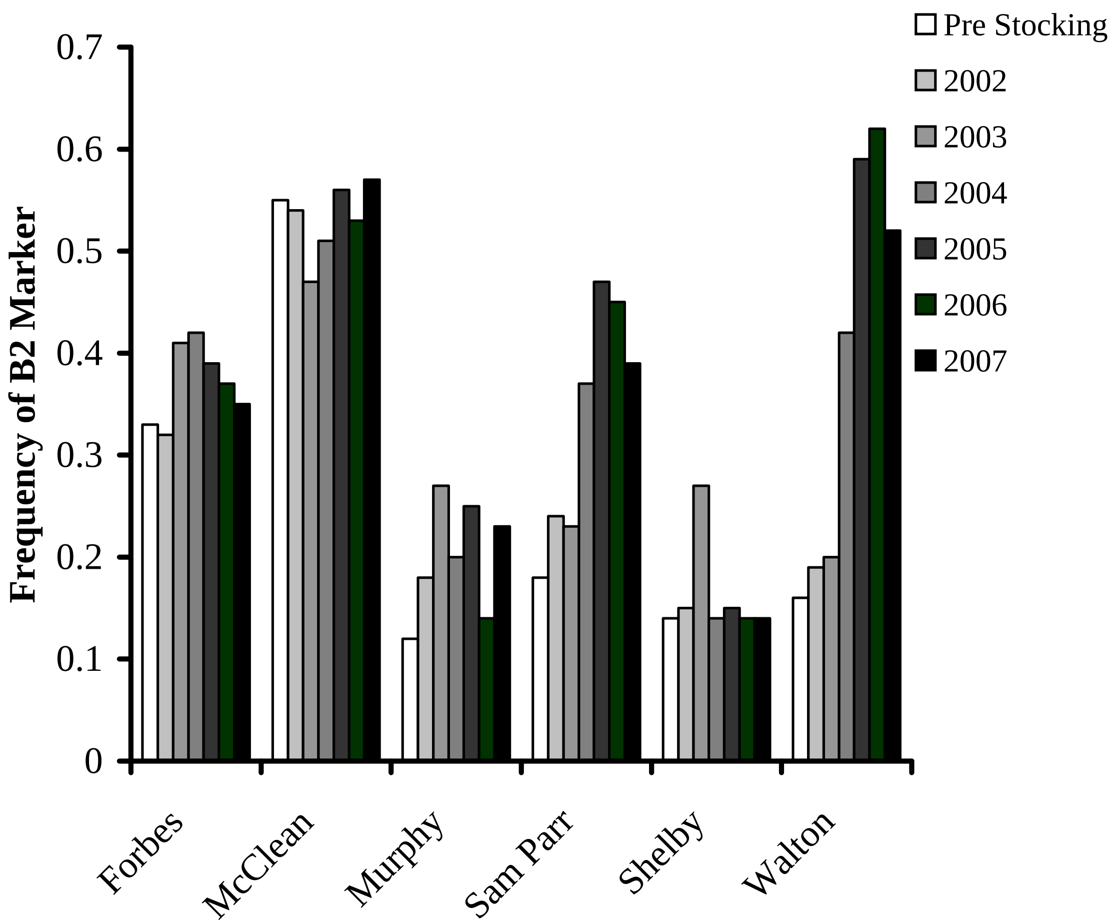

Figure 3-1: Frequency of the B2 allele in the six study lakes previous to stocking and in 2002-2007 during which stocked bass were expected to be contributing to reproductive population.

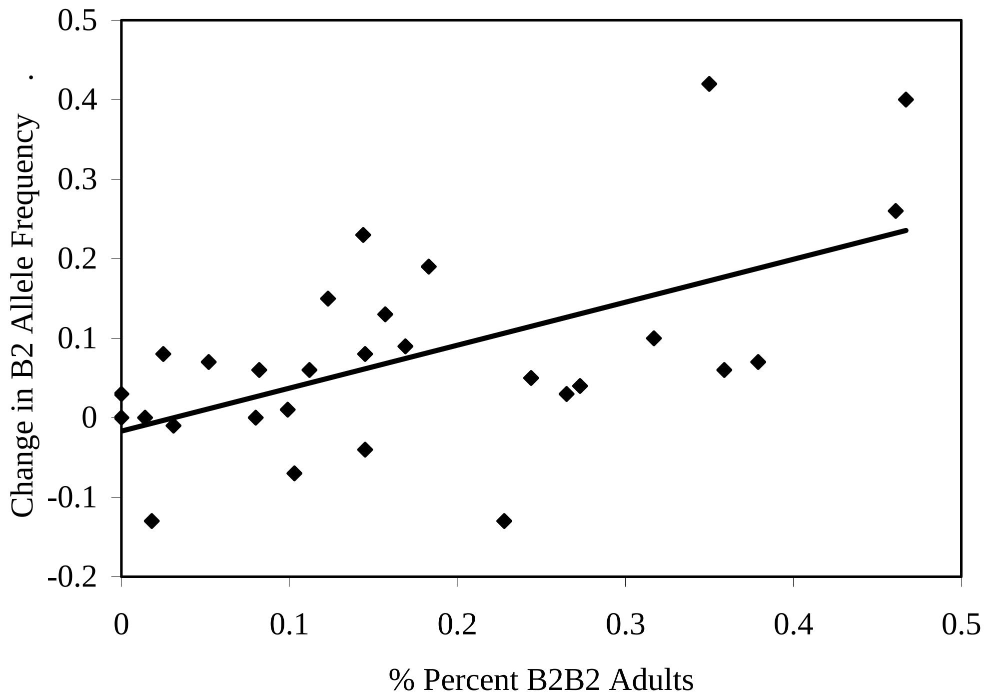

Figure 3-2: Change in B2 Allele Frequency with the proportion of B2B2 adults in the population for five study lakes for each year between 2002 and 2007.

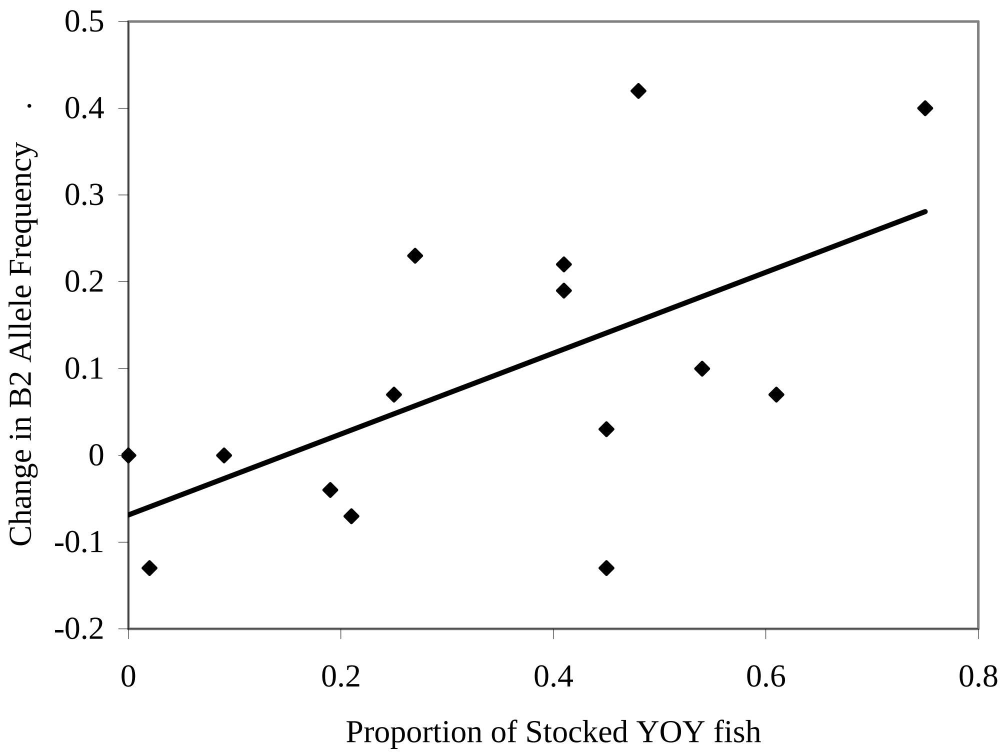

Figure 3-3: Change in B2 allele frequency with the proportion of stocked YOY largemouth bass for five study lakes for each year between 2002 and 2007.

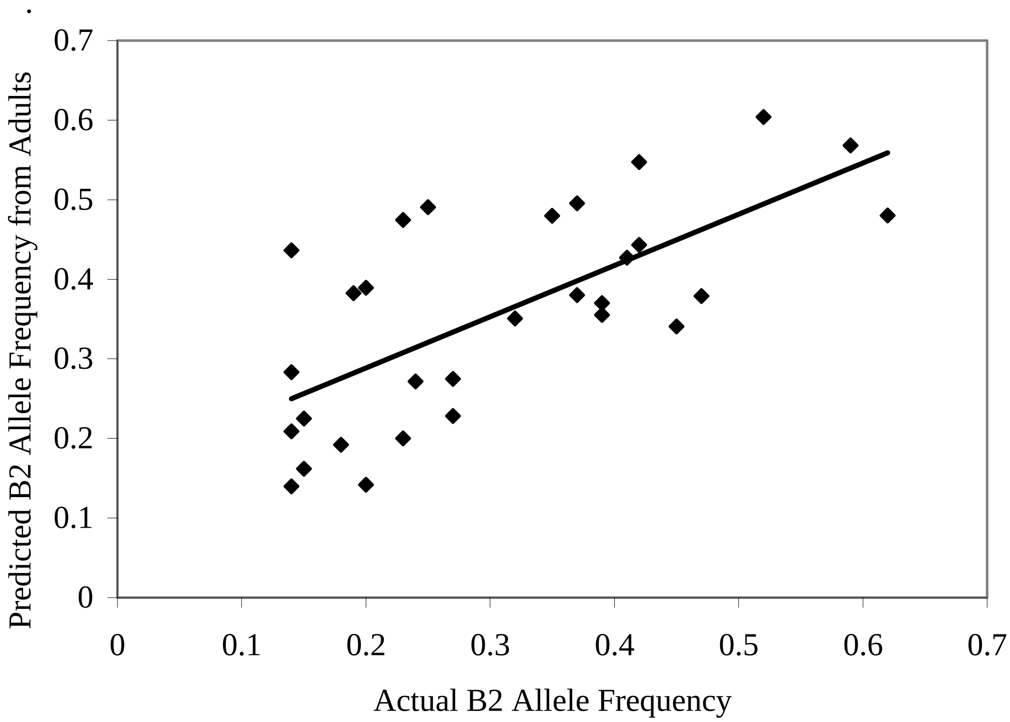

Figure 3-4: Regression of actual and predicted B2 allele frequency based on stocked adult fish for five study lakes for each year from 2002-2007.

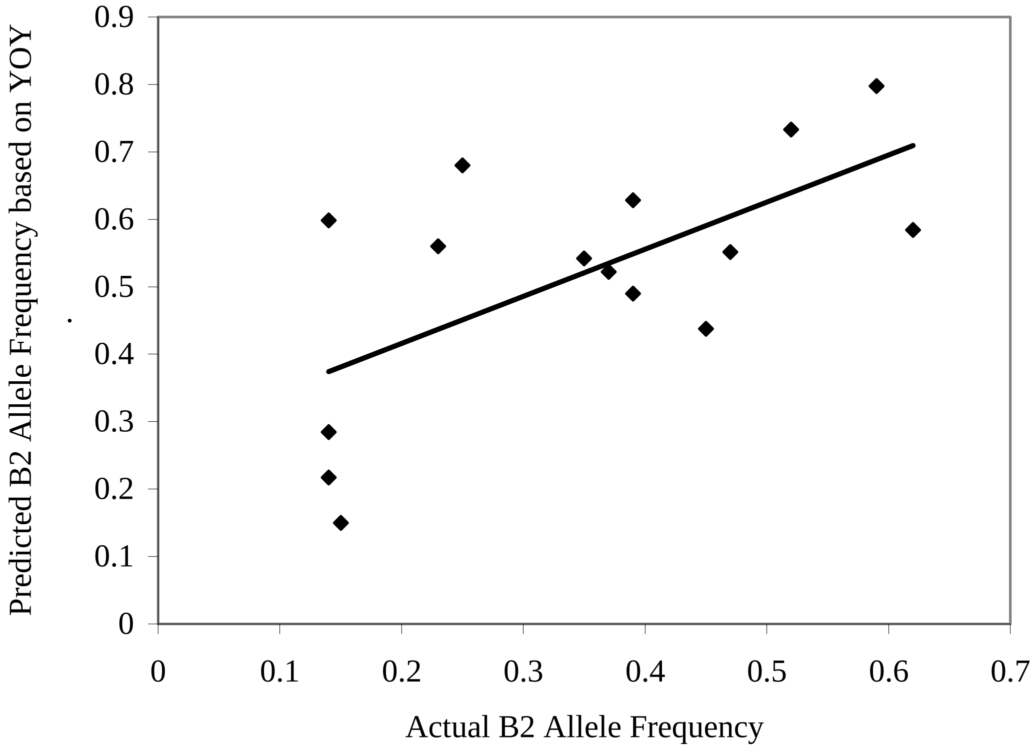

Figure 3-5: Regression of actual and predicted B2 allele frequency based on the proportion of stocked YOY fish for five study lakes for each year from 2002-2007.

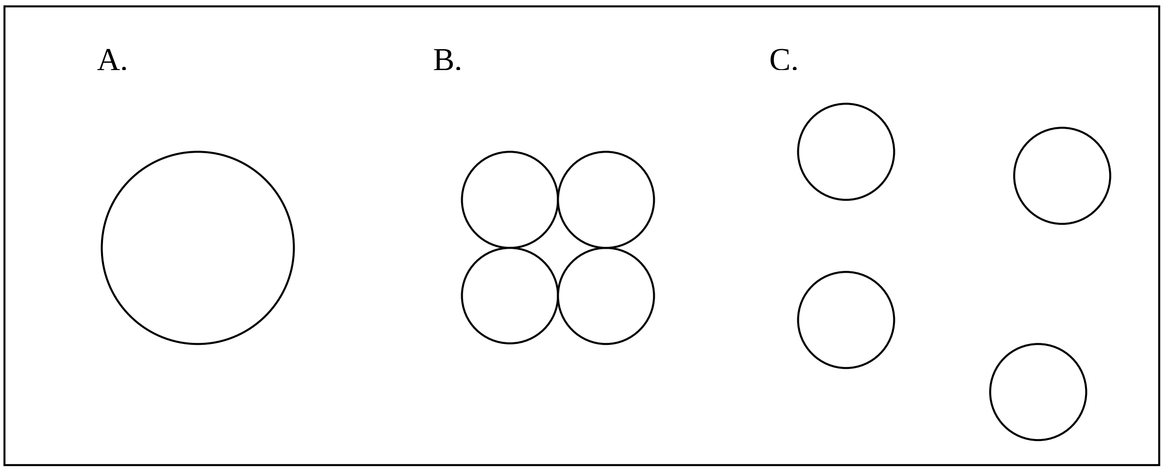

Figure 4-1: Experimental enclosure design used for the testing of planting success for sago pondweed and wild celery tubers. One replicate included (A.) one large enclosure (area = 31.8ft^2), (B.) four small clustered enclosures (area = 7.9 ft^2), and (C.) four small dispersed enclosures.

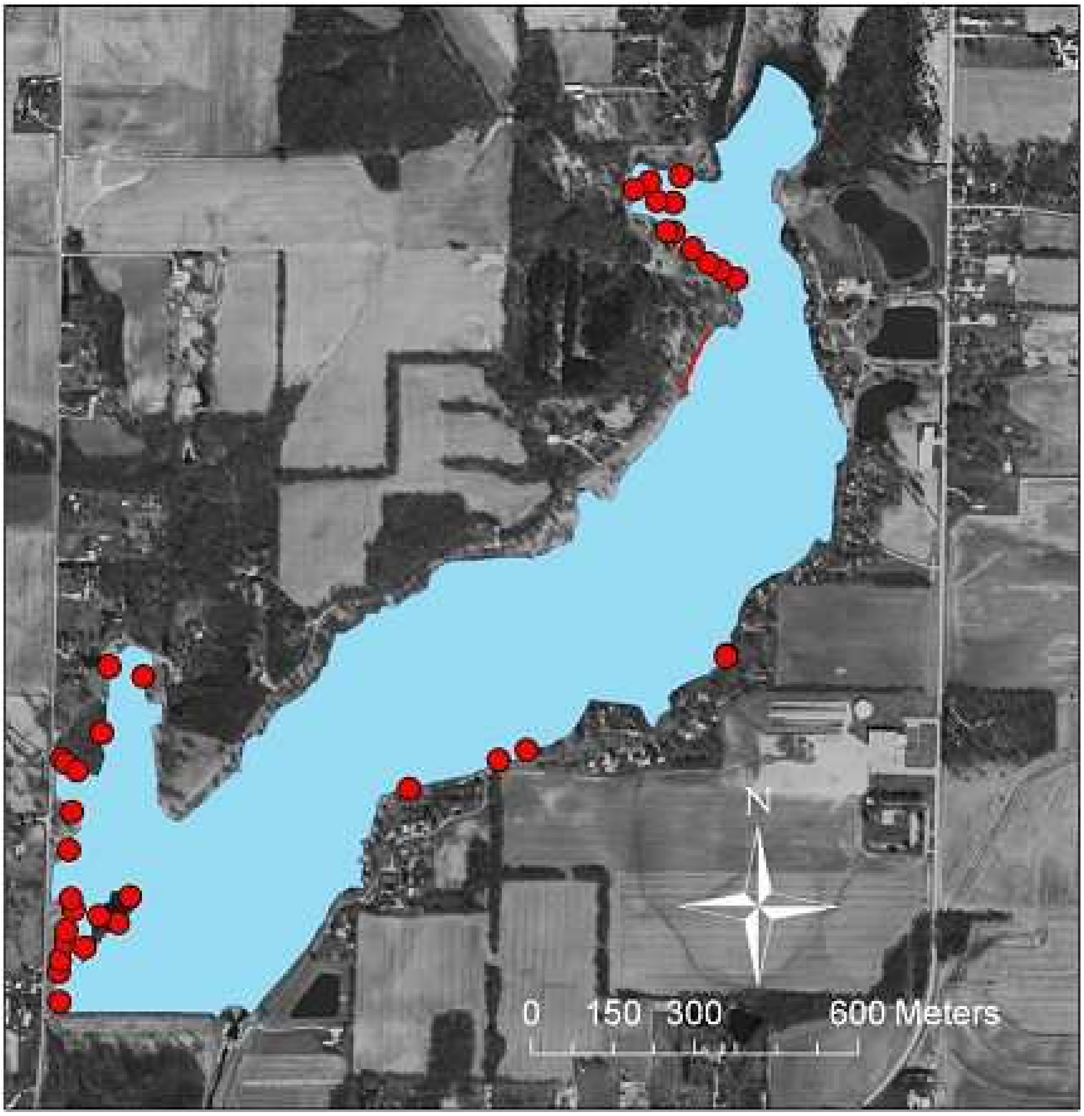

Figure 4-2: Location of each experimental cluster of vegetation enclosures constructed on Lake Paradise in the spring of 2008.Each dot represents 1 large enclosure, 4 dispersed small enclosures, or 4 small clustered enclosures.

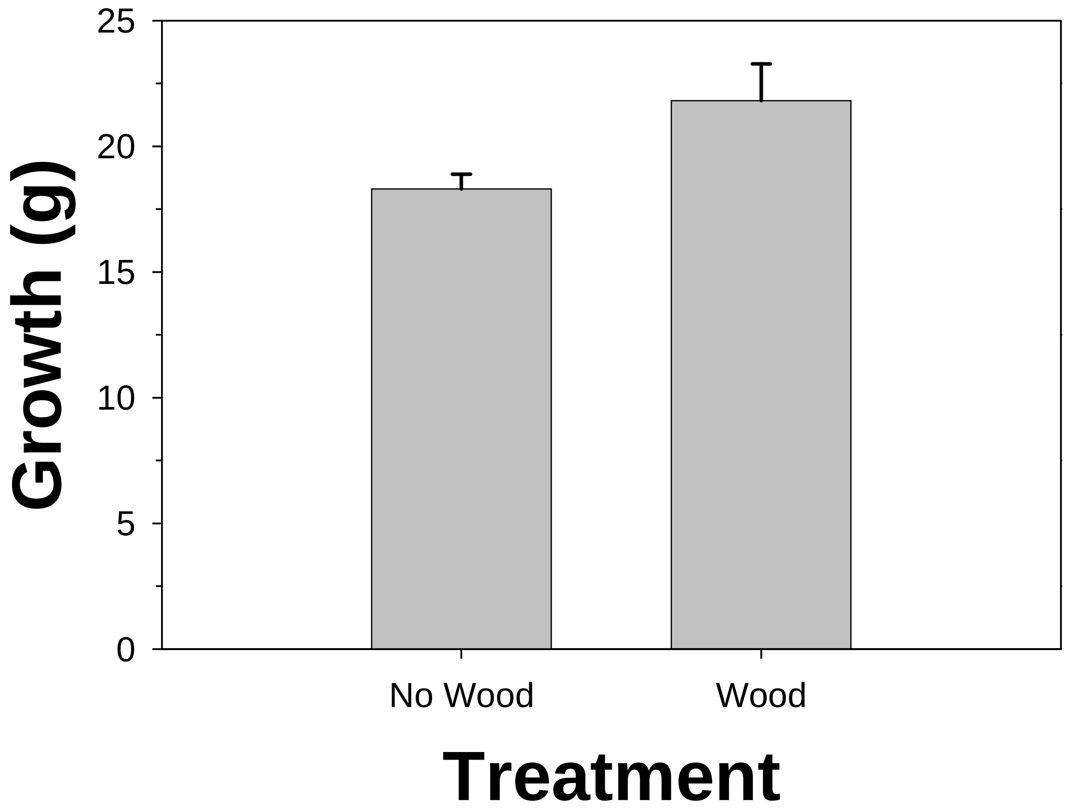

Figure 4-3: Average growth of adult bluegill in tenth-acre ponds with and without coarse woody habitat. Growth is measured as the average change in mean weight of adult bluegill from beginning the experiment to draining for each pond (N = 5 ponds per treatment).

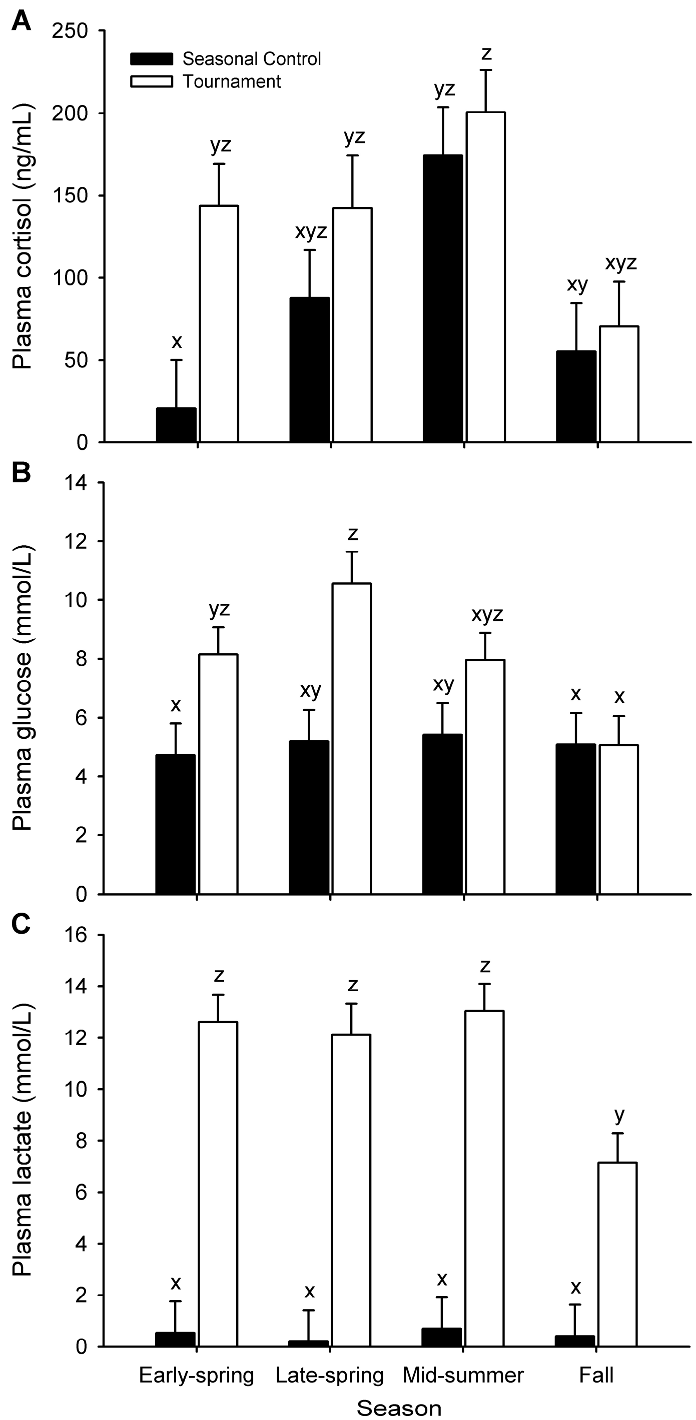

Figure 5-1: Concentrations of plasma cortisol (A), glucose (B), and lactate (C) in largemouth bass during four seasons. Fish were either sampled immediately following a club-style angling tournament in each season (Tournament, open bars) or were collected using DC electrofishing gear in each season and sampled after a 60 h recovery period in the laboratory (Seasonal Control, filled bars). Mean separation is indicated by uppercase letters; statistically different means do not share letters.

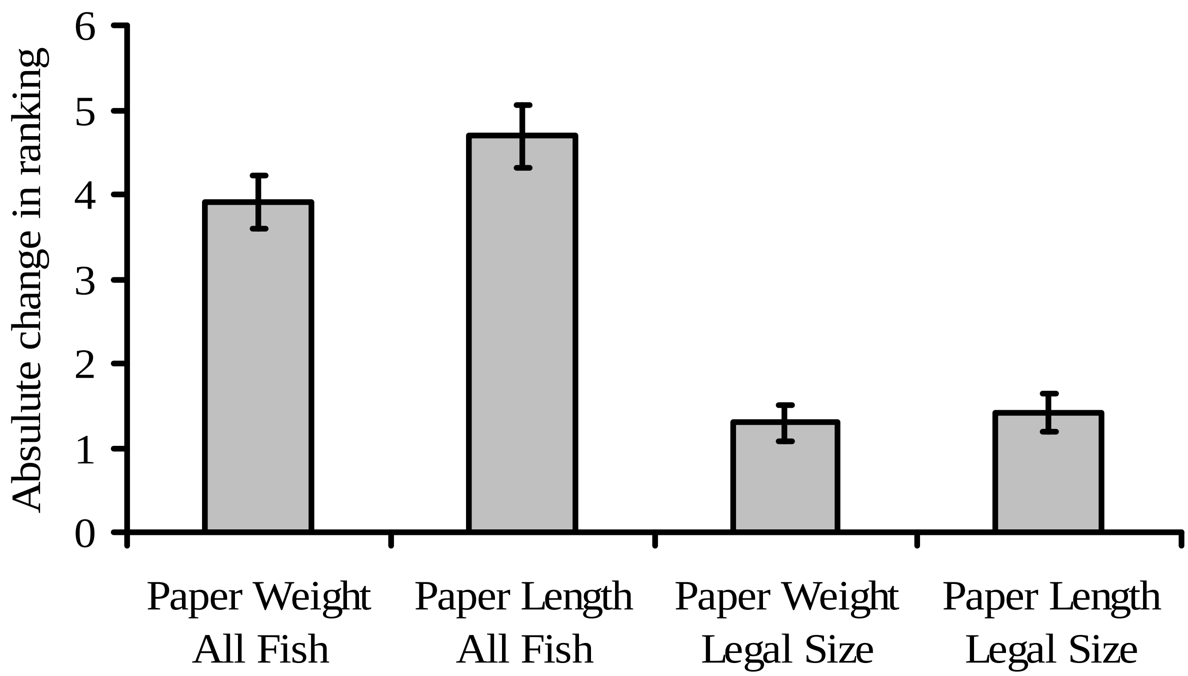

Figure 5-2: Mean absolute change in ranking from a typical weigh-in for 4 different paper tournament scenarios. The length of each fish caught was recorded by anglers to produce paper length. Length-weight regressions were used to convert paper length to paper weight. All fish refers to the cumulative of all fish caught by an angler, where legal size only included fish caught that were larger than the legal limit for the lake on which the tournament was held. Error bars represent the standard error.

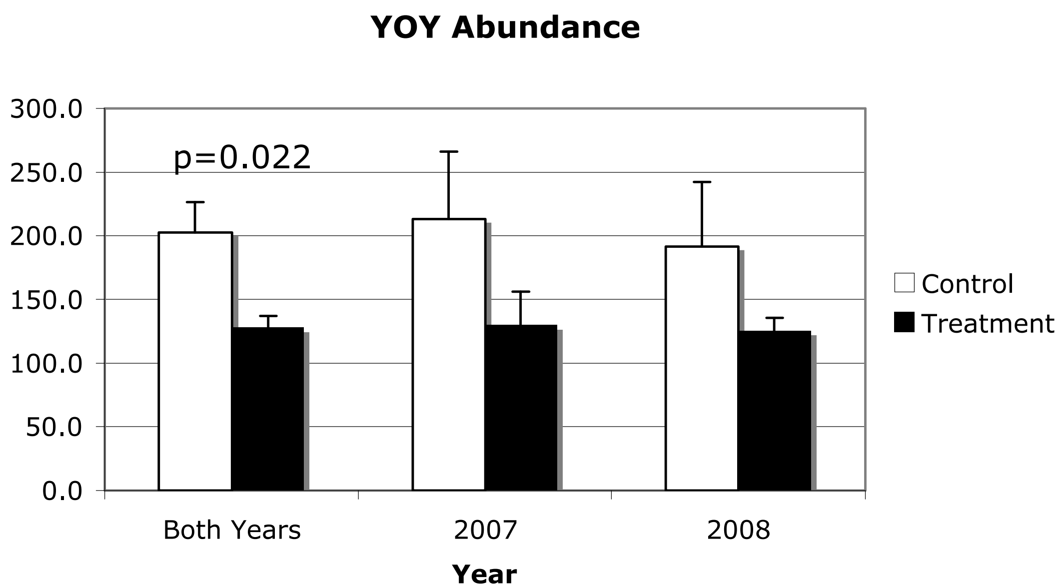

Figure 5-3: Total YOY produced in control (no manipulation) and treatment (50% brood reduction) ponds in 2007 and 2008.

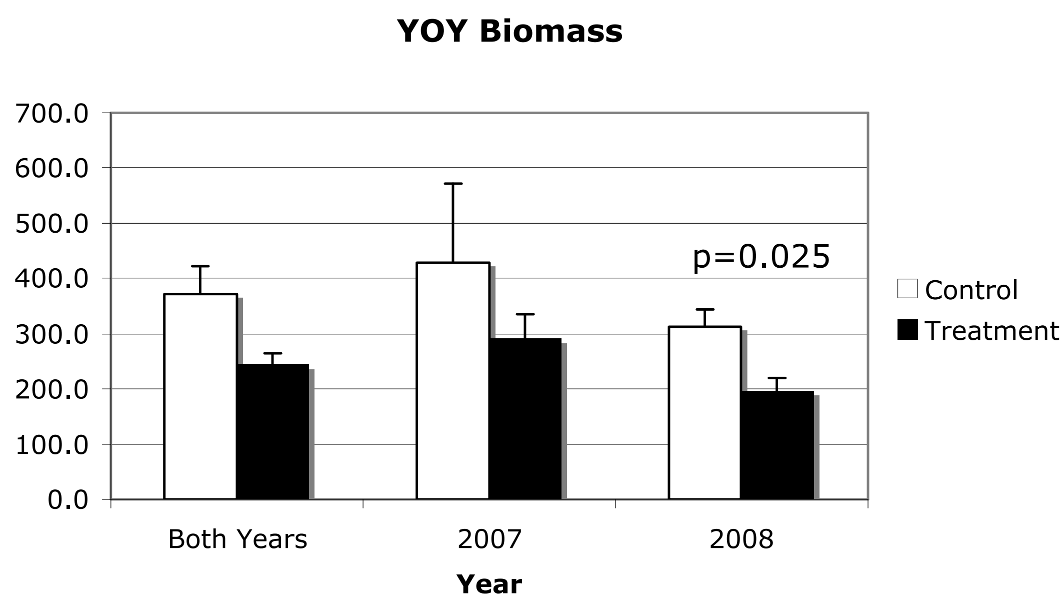

Figure 5-4: Total YOY biomass in control (no manipulation) and treatment (50% brood reduction) ponds in 2007 and 2008.

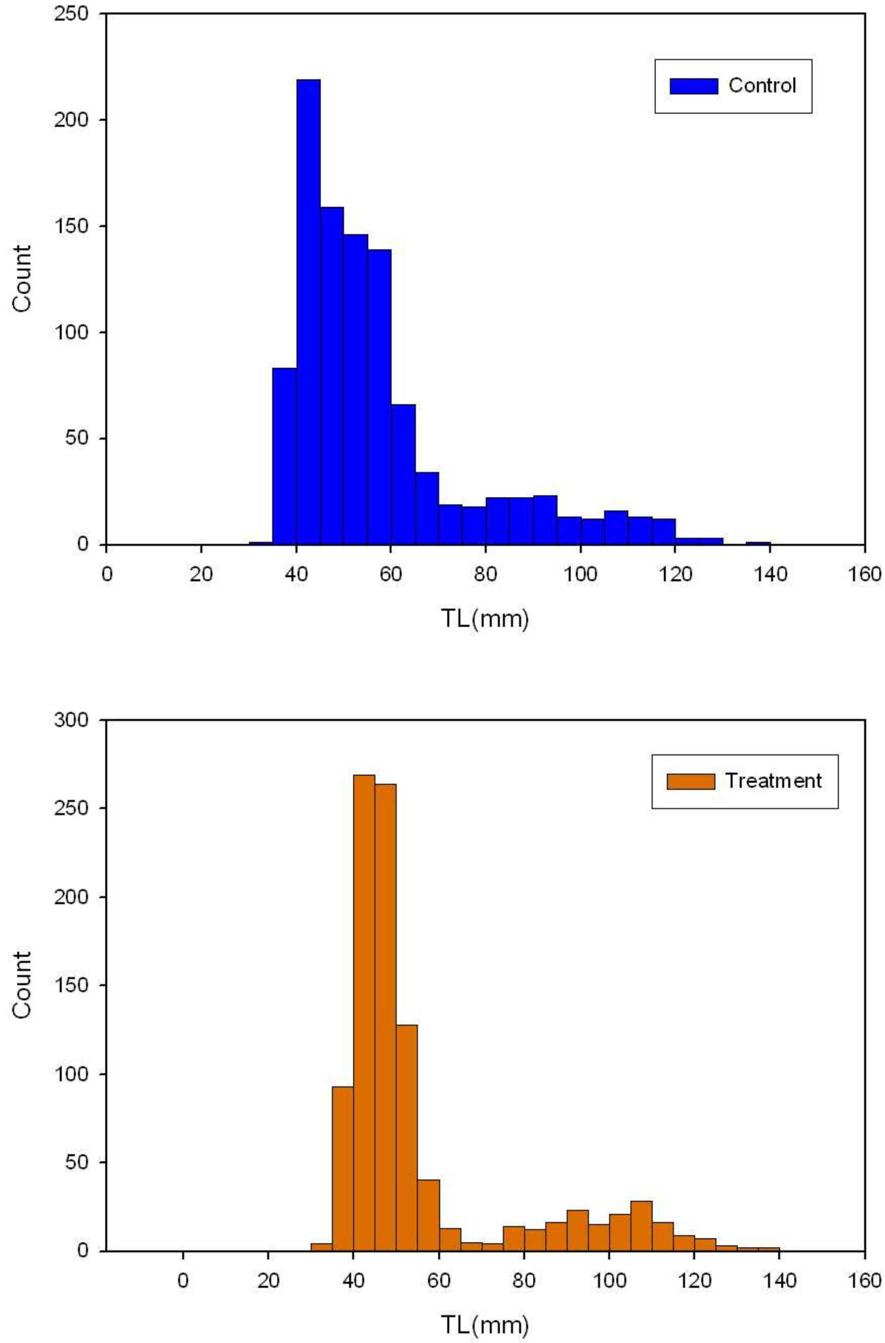

Figure 5-5: Length-frequency histogram of total length of YOY largemouth bass in control (top) and treatment (bottom) ponds in 2007 and 2008.

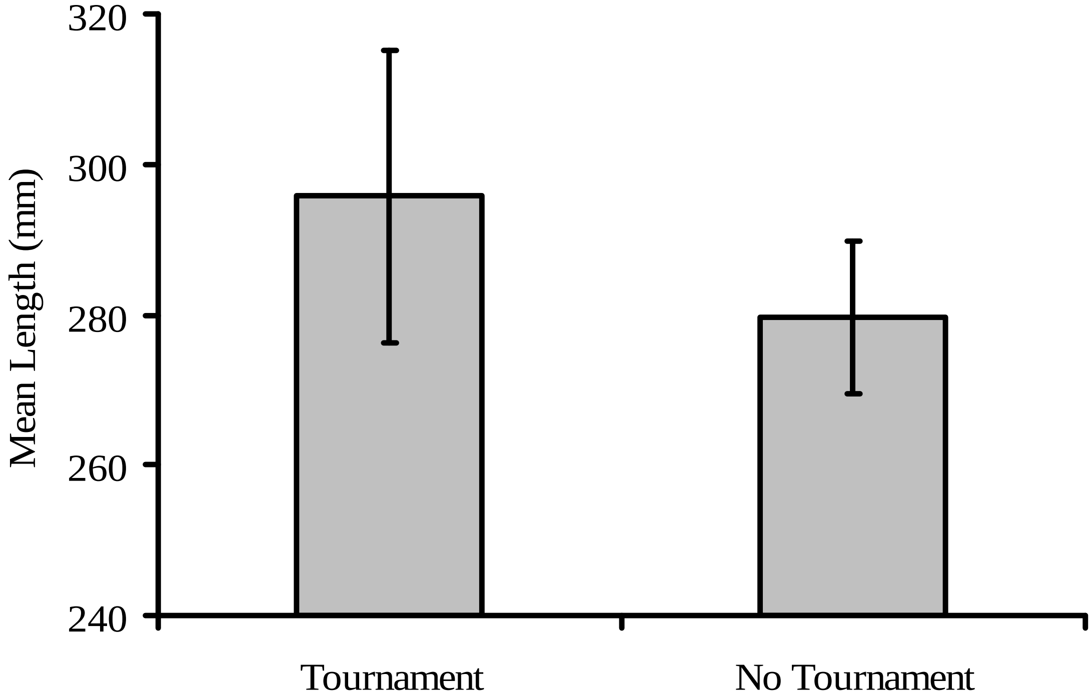

Figure 5-6: Mean size of age-3 fish from spring electrofishing samples in lakes with tournaments and lakes with no tournaments. Age of fish was determined from scale readings. Error bars represent the standard error.

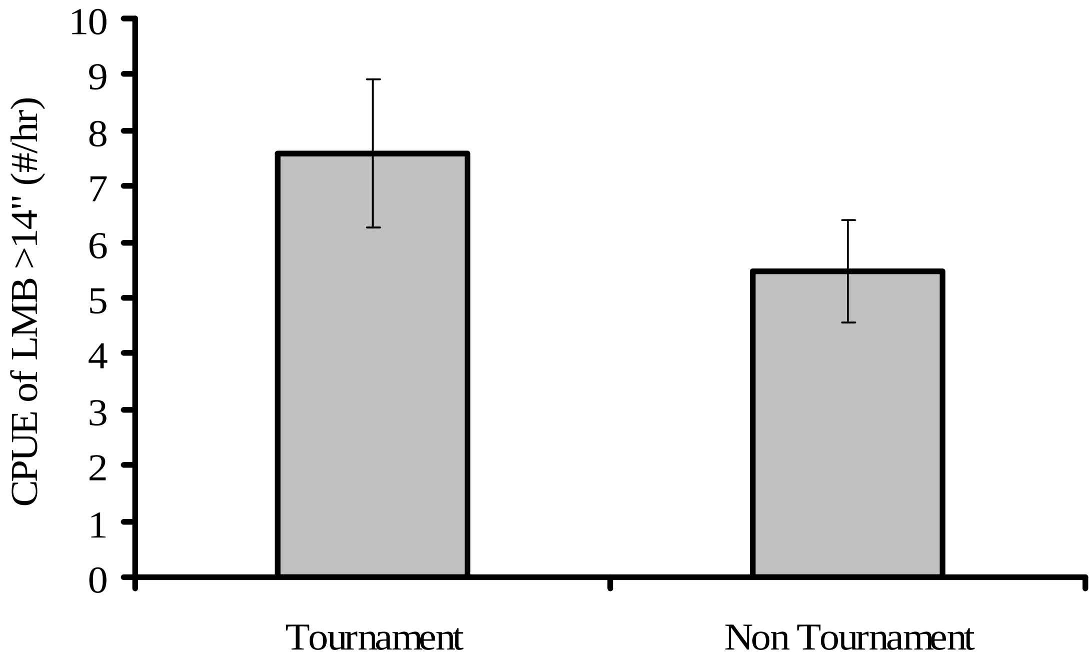

Figure 5-7: Catch per unit effort (CPUE) of largemouth bass greater than 14 inches in electrofishing samples from 2007 through 2009 in lakes where largemouth bass tournaments occur and lakes that have no tournaments.

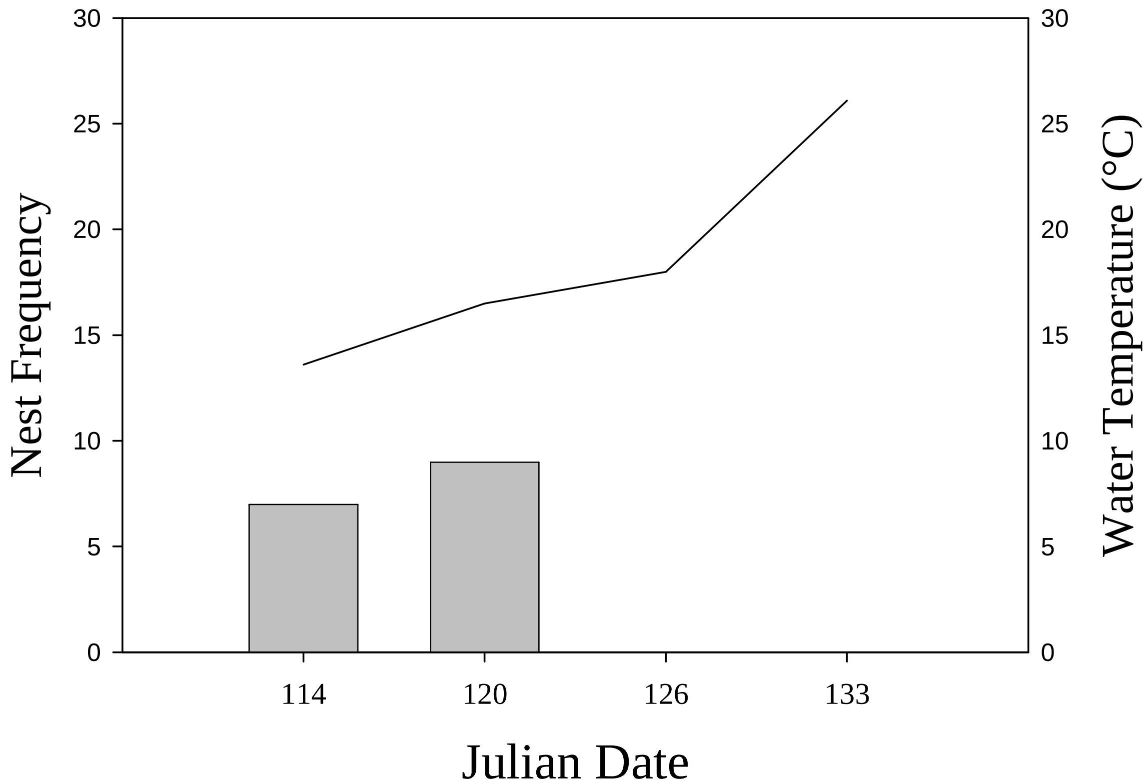

Figure 5-8: Nest frequency (bars) and water temperature (line) through time during spring 2009 in Lincoln Trail Lake.

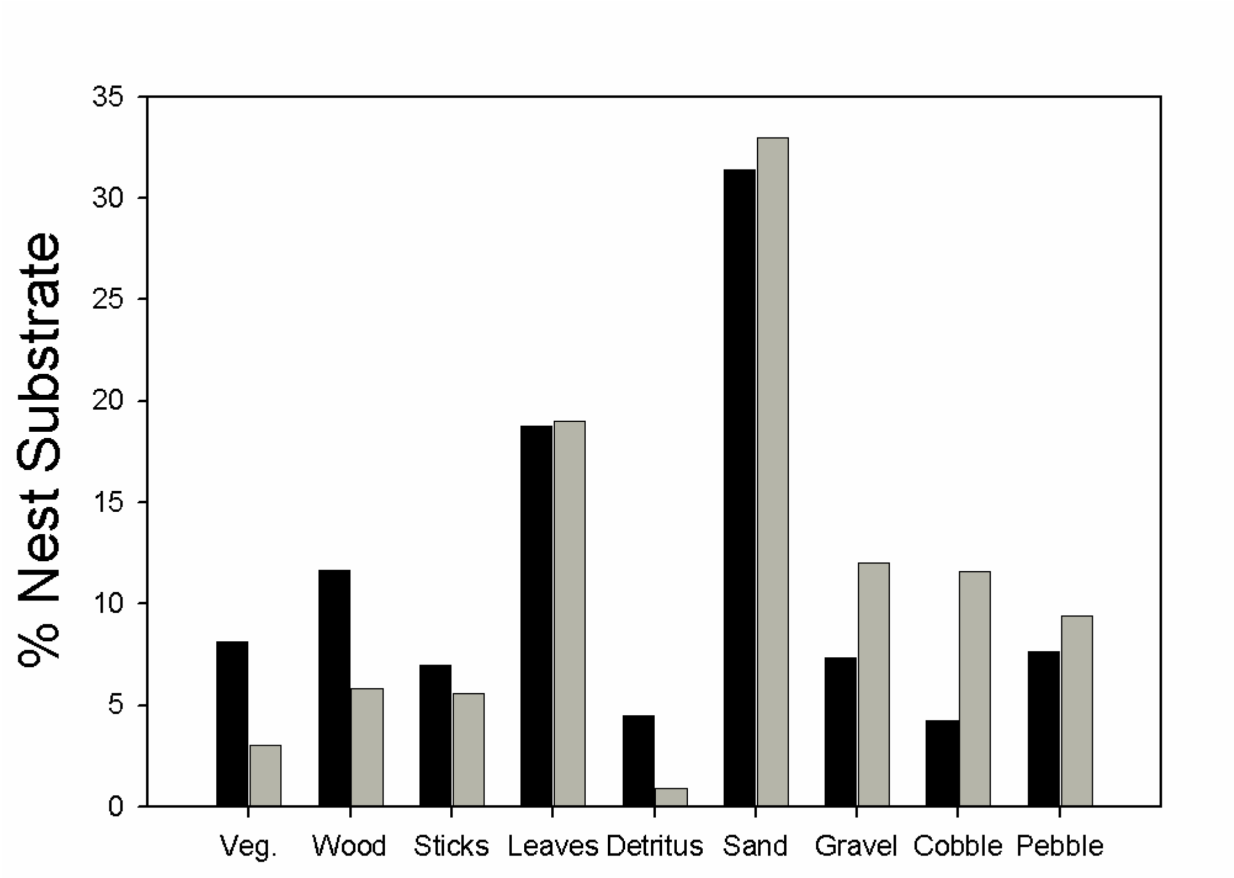

Figure 5-9: Composition of largemouth bass nest habitat in Lincoln Trail Lake with (light bars) and without (dark bars) potential nest predators.

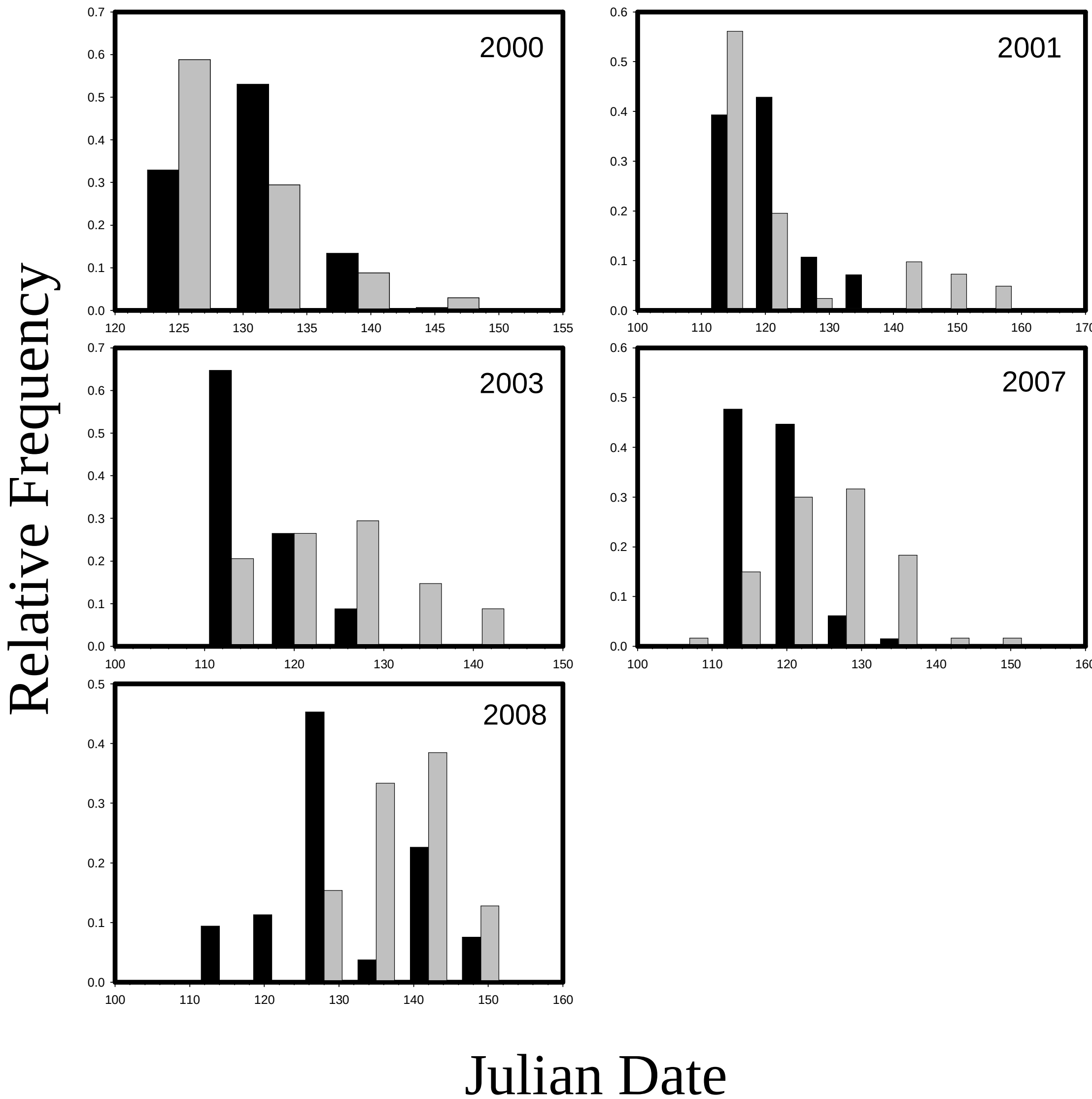

Figure 5-10: Relative frequency of largemouth bass nests (dark bars) and relative abundance of YOY in fall (light bars) through time in Lincoln Trail Lake. YOY spawn date was back-calculated using daily otolith rings.

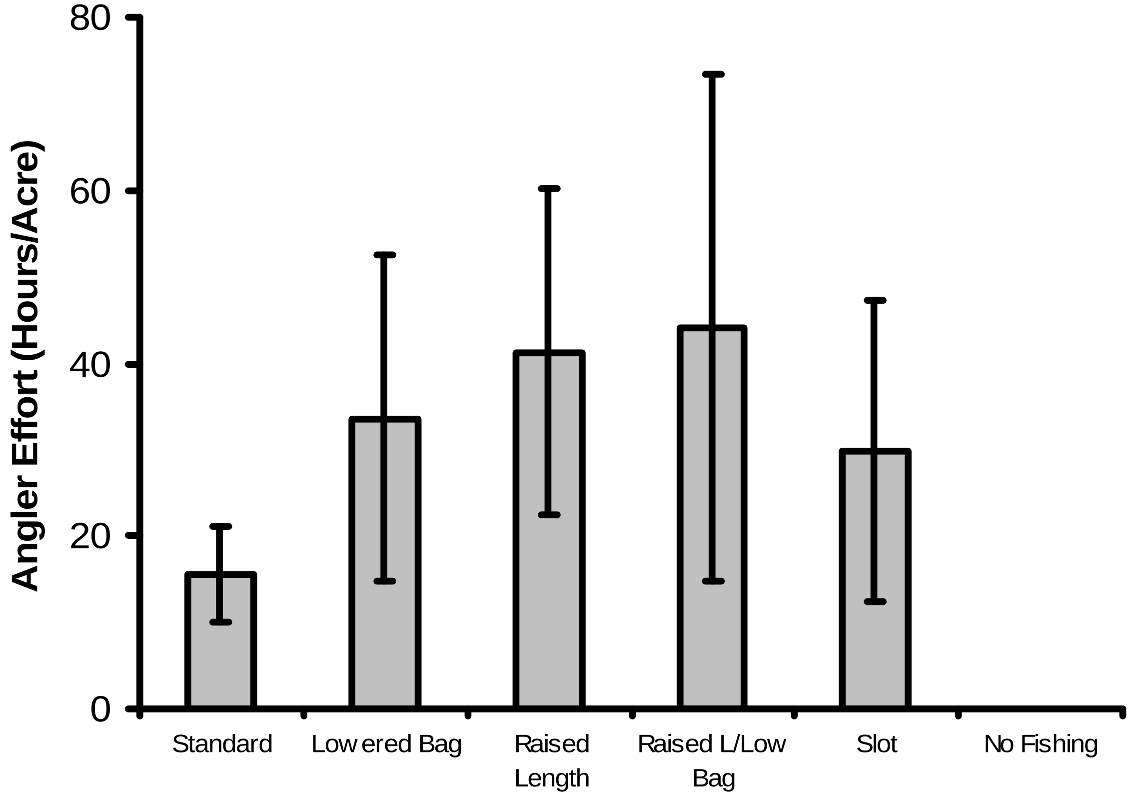

Figure 6-1: Angler effort from creel estimates across six different regulation types. Standard regulation is a 14 inch length limit and a 6 fish bag limit. See text for description of other regulation types.

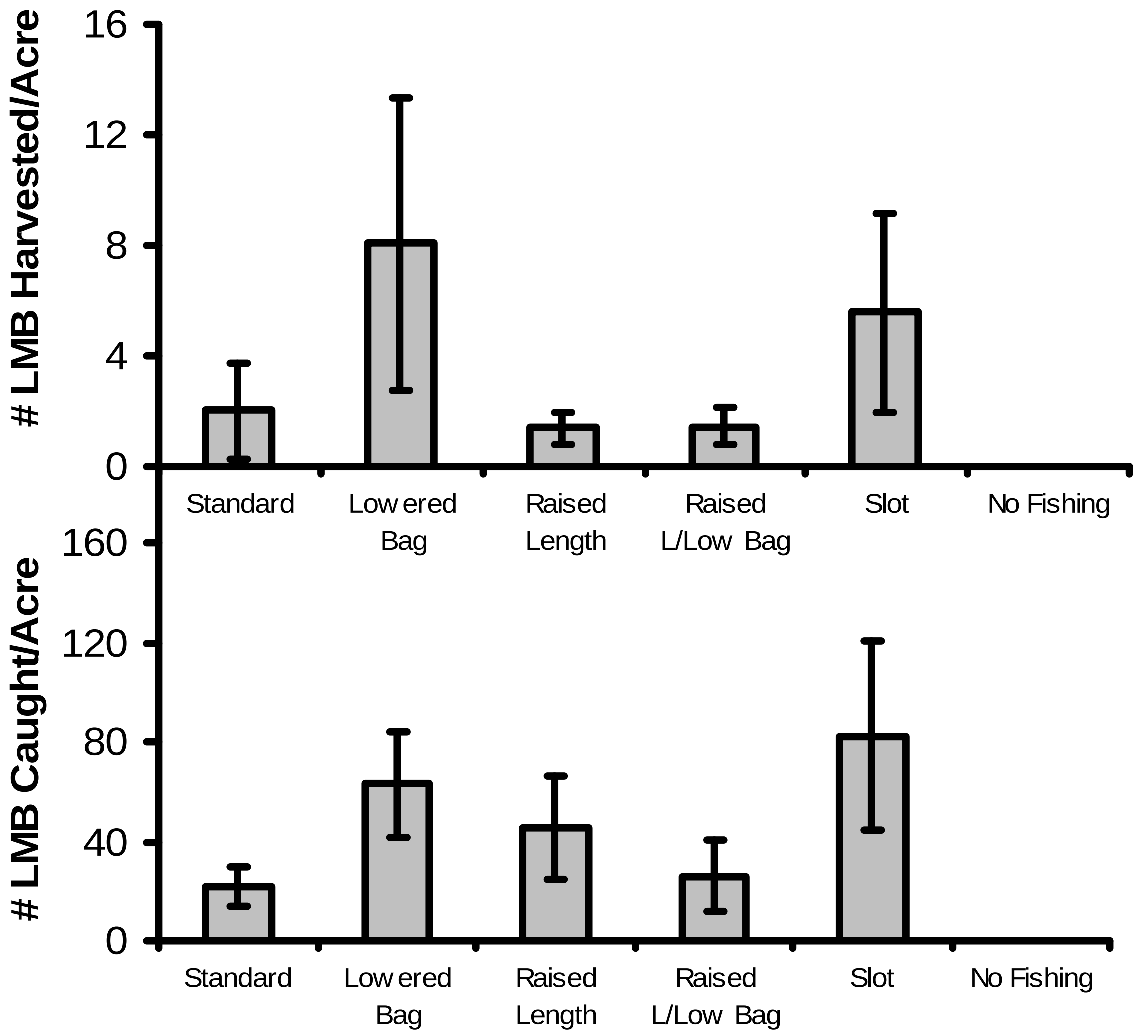

Figure 6-2: Mean number of largemouth bass harvested and caught (harvested and released) per acre for 17 lakes in Illinois across 6 different fishing regulation categories. Standard regulation is a 14 inch length limit and a 6 fish bag limit. See text for description of other regulation types.

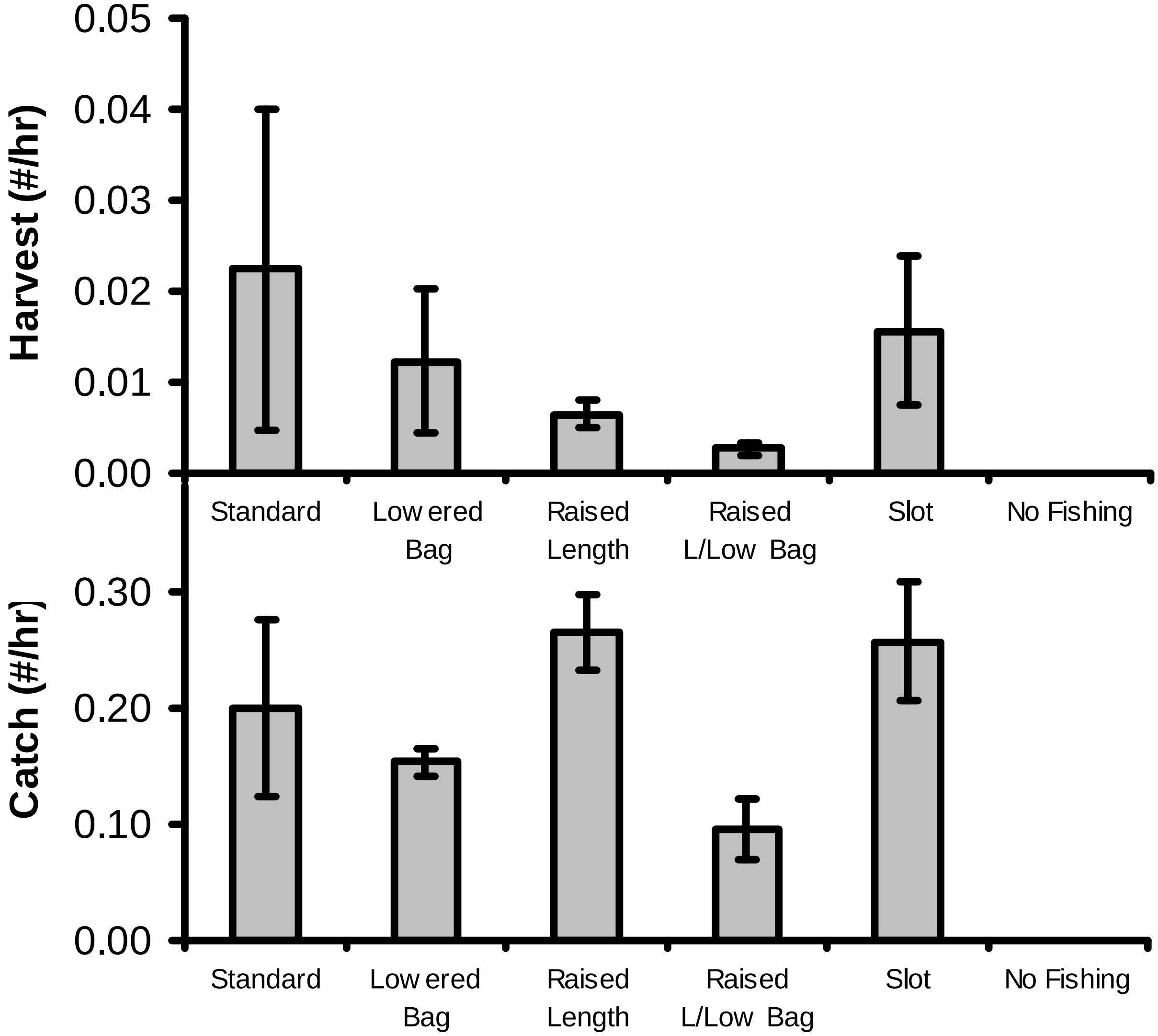

Figure 6-3: Mean catch per unit effort (CPUE) of largemouth bass harvested and caught (harvested and released) per acre for 17 lakes in Illinois across 6 different fishing regulation categories. Standard regulation is a 14 inch length limit and a 6 fish bag limit. See text for description of other regulation types.

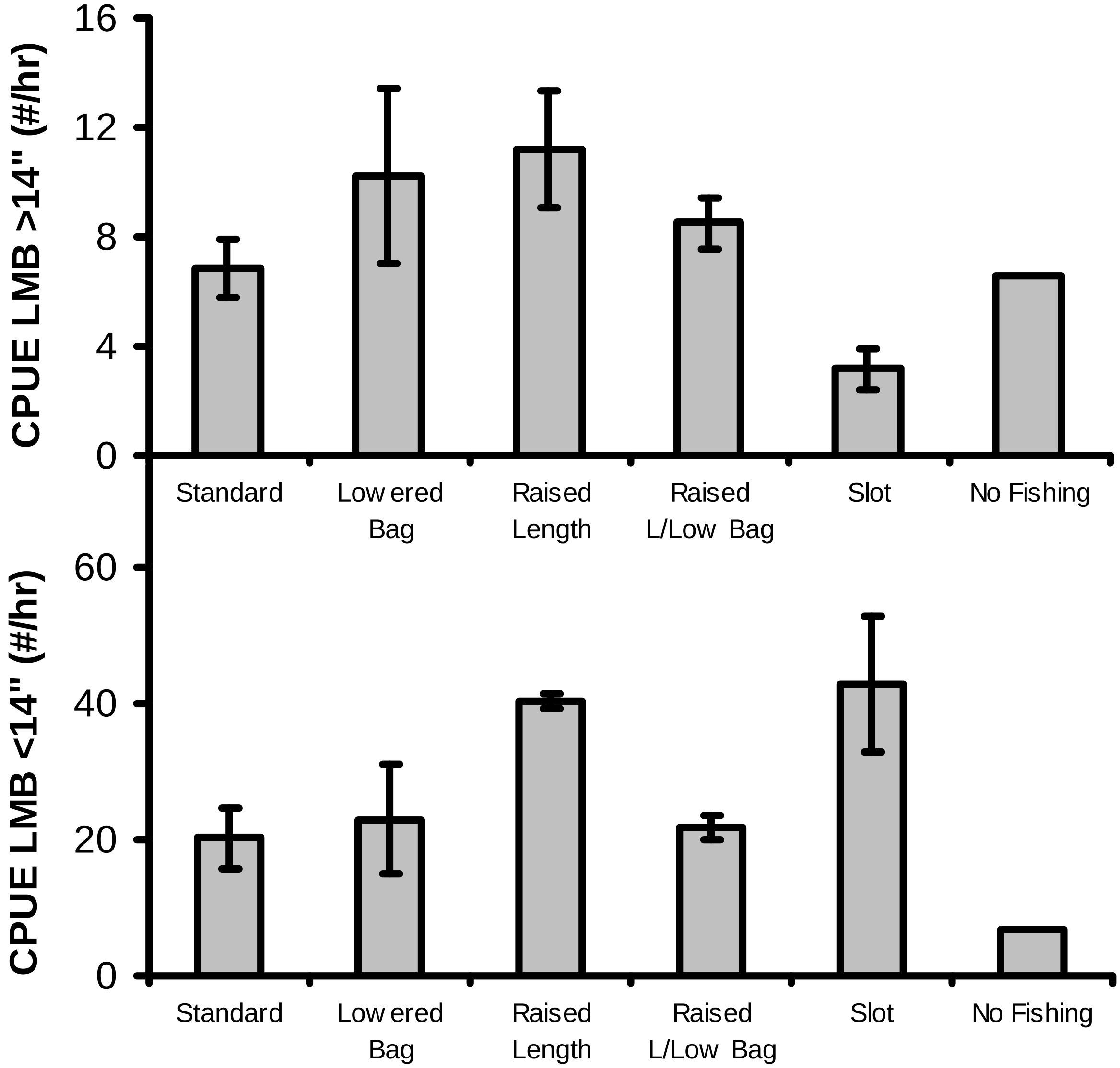

Figure 6-4: Mean catch per unit effort (CPUE, #/hr) or fish greater than and less than 14 inches from spring electrofishing transects for 2008 and 2009 for 17 lakes in Illinois across 6 different fishing regulation categories. Standard regulation is a 14 inch length limit and a 6 fish bag limit. See text for description of other regulation types.