ILLINOIS NATURAL HISTORY SURVEY

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, C.S. Deboom, J.J. Mulhollem,
D.P. Philipp, and D.H. Wahl

Submitted to
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Illinois Department of Natural Resources
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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. 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. 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.

There was no new activity in Job 101.1 as final recommendations were presented in previous reports. In Job 101.2, we continued our evaluation of stocking success of largemouth bass. We conducted additional data analysis in a study comparing intensive and extensive rearing techniques. Intensively reared fish were raised in raceways and fed pellets, whereas extensively reared fish were raised in ponds and fed zooplankton and minnows. Extensively reared fish experienced better survival through the spring following stocking, but by the following fall (age-1) there was no difference in abundance between the two rearing techniques. We observed a high level of variation in the number of fish produced in the rearing ponds. Cost of rearing was much higher for the extensively reared fish for both hatchery ponds and lake side rearing facilities. Higher initial survival and larger size in the fall of extensively reared fish initially appears to justify the added cost. However, long term survival was low for both rearing types and very few stocked fish were recruited to the fishery. In this segment, we also continued to evaluate different stocking techniques to improve survival of stocked largemouth bass. Three lakes were stocked with largemouth bass, with half the fish stocked at the boat ramp and half dispersed throughout the lake and into woody or vegetated habitat. Very few stocked fish have been recaptured from any stockings conducted thus far regardless of method. We plan to continue additional stockings and adjust stocking time to minimize high temperatures and potential related mortality. CPUE of stocked fish in this experiment has been lower than observed in stockings conducted as previous parts of this project and we hope to observe greater survival in the future in order to evaluate the success of these two stocking strategies.

In Job 101.3, we evaluated the survival and reproductive success of stocked largemouth bass relative to resident populations. To determine the contribution of stocked fish, the MDH B2B2 allele was used as a genetic tag for fingerlings stocked into six study lakes. Once these fish were part of the reproducing population, it was possible to assess the reproductive success and recruitment of these stocked fish in five of the six lakes by comparing the pre-stocking with post stocking MDH B2 allele frequencies. We also looked at lake size and resident bass CPUE as a possible factors that may have influenced reproductive success. Stocked fish survival to adulthood was variable in the five study lakes, ranging from less than 10% to around 35%. Contribution of stocked fish to reproduction was also variable and was higher in small lakes than in larger ones. The density of resident bass as measured by CPUE had no relationship to the contribution of stocked bass reproduction in the lakes that we studied. Based on the proportion of stocked adults in the populations we could predict the change in the frequency of the MDH B2 allele to determine how reproductive success of stocked fish compared to wild fish. We found that reproductive success of stocked fish was similar to wild fish. Our results indicate that stocking is most likely to be successful in small lakes and that the genetic influence of stocked fish will persist in successive generations. In future reports, we will examine how prey availability could affect stocked largemouth bass condition and ability to secure good nesting sites differently than wild fish.

In Job 101.4, we continued a multi lake experiment examining the influence of vegetation on largemouth bass recruitment. Lakes were divided into treatments by the vegetation management strategy. Two lakes (Stillwater and Airport) were treated for vegetation in an effort to reduce the vegetation present and yield more intermediate vegetation densities. The vegetation treatments were initiated in this segment and have been successful at reducing vegetation in Stillwater Lake, but not Airport Lake. Two lakes (Paradise and Dolan) experienced management to increase vegetation. Vegetation planting was initiated in 2008 in Lake Paradise and planting efforts continued in this segment. We are evaluating the success of different species of vegetation and the size of cage used. American pondweed has shown the greatest long-term survival and the large cages have been most effective in producing vegetation. In this segment, American pondweed was planted in 5 additional cages and a number of cages were expanded to promote the spread of successful cages. We also evaluated fish and invertebrate communities associated with vegetated and non-vegetated cages and observed higher densities of both fish and invertebrates in vegetated cages. Rehabilitation at Dolan Lake has continued to yield higher vegetation and reduced gizzard shad and carp numbers. There is some evidence of gizzard shad populations rebounding. Four lakes with experimental treatments and 7 control lakes were monitored for fish populations, vegetation densities, and prey organisms and will be compared through time as the management experiment continues. CPUE of young of year largemouth bass was higher in lakes with greater vegetation densities, but differences were not significant. The density of larval gizzard shad was significantly correlated with the proportion of lake area and perimeter that was vegetated. No other lake conditions that were measured were related to vegetation density. We will continue to monitor vegetation, fish, and prey communities in the 11 research lakes to evaluate the role of vegetation management to increase largemouth bass recruitment.

In this segment, we also continued to examine patterns in abundance of young-of-year largemouth bass, other fish species, and associated biotic communities among vegetated, woody, and open lakeshore habitat types in two Illinois lakes. While we did not find significant differences in age-0 largemouth bass densities among the microhabitat types sampled in our enclosure surveys, we did find significant differences in the community composition and abundance of potentially important prey items (juvenile sunfishes, caddisflies, chironomids, stonefiles and cyclopoid copepods). Increases in abundance of potential invertebrate and fish prey in vegetated and wooded sites supports the idea that these habitats are important sources of littoral productivity.

There is potential for dam escapement to influence largemouth bass recruitment. In order to access dam escapement, we sampled downstream of the dam on two reservoirs, Ridge Lake and Forbes Lake via backpack electrofishing and seines. Some largemouth bass were observed in sampling below the dam at both Forbes and Ridge Lake following high water events however there were few fish in all sampling. 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.

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. However, little is known about the effects of tournaments on largemouth bass recruitment. In Job 101.5, we continued to examine effects of tournaments for largemouth bass. In this segment, we also continued monitoring largemouth bass spawning activities at Lincoln Trail Lake. Water clarity limited our ability to identify largemouth bass nests in spring 2011. We will continue to evaluate nesting activity, nest guarding behavior, vulnerability to angling, and nest predation in future segments. In this segment, we continued to conduct largemouth bass tournaments in alternating years on Ridge Lake to evaluate their effect on recruitment. A series of spring tournaments were conducted in 2007 and 2010 and largemouth bass populations were compared among tournament and non-tournament years. Initial results show no differences in recruitment between tournament and non-tournament years. In addition, no changes were observed in adult largemouth bass abundance or size structure. These results are preliminary and additional years will be needed to evaluate treatment effects.

We are continuing a pond experiment examining the population effects of tournament angling during the spawning season on largemouth bass recruitment. In the current segment, we initiated the second year of the two-year study. Results from the first year indicate that tournament angling has a moderate effect on largemouth bass recruitment in terms of numbers, and a rather large effect on young-of-year largemouth bass biomass. After adjustment for summer zooplankton abundance, which was a significant covariate for largemouth bass recruitment, ponds in which tournament angling was conducted had approximately 22% less recruits and 64% less young-of-year biomass than control ponds. In the future segment, we will include data from the second year to strengthen results.

In this segment we also continued to evaluate tournament activity on nine Illinois lakes as well as 5 control lakes with no tournaments. Tournament data was used to calculate total tournament angler hours per acre as well as catch rates and statistics on the sizes and types of tournaments on each lake. We evaluated the largemouth bass population in each lake by performing electrofishing transects in the spring. CPUE of young-of-year largemouth bass and largemouth bass over 14 inches was not correlated with tournament pressure (angler hours/acre). The mean number of fish weighed in at a tournament was correlated with CPUE of largemouth bass over 14 inches and was also correlated with lake size. Tournament lakes did not have reduced recruitment when compared to lakes with no tournament angling. Tournament lakes had higher CPUE of largemouth bass larger than 14 inches than control lakes, but it is difficult to separate the effects of tournaments from the size of the lake and the fact that tournaments may target lakes with more abundant adult largemouth bass. We will continue to collect tournament and largemouth bass population data in future segments to further evaluate and understand how tournaments influence largemouth bass populations.

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. No increase in the number of largemouth bass has been observed throughout the lake. Sampling will continue at Clinton Lake to monitor largemouth bass populations for changes resulting from the refuge. We also continued sampling Otter Lake as an additional location to evaluate refuges. Electrofishing and seine samples were conducted in two refuge sites as well as three control sites. The refuge was closed to fishing in June 2010 and we initiated sampling for post refuge conditions.

We also began assessing effects of harvest regulations on largemouth bass populations. In this segment, we expanded our database of lakes using the Fisheries Analysis System (FAS) containing electrofishing data from 2000-2007 collected by DNR biologists. We grouped lakes by regulation type into 7 groups; Bag by Size (Bag limit above and below a specified size), Catch-and Release (no harvest allowed), Standard (14" length limit, 6 fish creel), Lowered Bag (14" length limit, <6 fish bag limit), Raised Length (>14" length limit, 6 fish bag limit), Raised Length/Low Bag (>14" length limit, <6 fish bag limit), No Length (No minimum size limit), and Slot (no fish harvest slot). We compared catch rates of young-of-year and adults (greater than 14 inches), memorable (greater than 510 mm), and proportion stock density (PSD). Lakes with slot limit regulations had the highest CPUE of young-of-year, total, and memorable sized largemouth bass. No other significant differences existed among groups. In future segments, we will combine FAS, INHS sampling and creel data to further evaluate regulations and how they affect angler catch rates. 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 predator/prey balance in a fish community. 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 previous segments, we evaluated success of three sizes of stocked largemouth bass. We found low survival of all size classes. Small fingerlings (2 inch) experienced high levels of predation and stocking mortality and had no long term survival. Medium (4 inch), large (6 inch), and advanced (8 inch) fingerlings had some initial size differences, but there was no long term difference in abundance or growth. Four inch fingerlings were the cheapest to produce and survived as well as other stocking sizes and were the recommended stocking size for producing hatchery largemouth bass. Because of the low overall survival of stocked largemouth bass in these earlier segments, we continue to evaluate stocking success and determine if using alternative rearing and stocking methods will increase survival.

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.

PROCEDURES:

Rearing Technique: Intensive v. Extensive

The effects of rearing techniques on growth and survival of stocked largemouth bass were evaluated in lakes Shelbyville, Jacksonville and Walton Park. 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 in early August. Jacksonville and Shelbyville utilized lake side rearing ponds. Fish were delivered to the rearing pond in June along with minnows for prey and were allowed to grow until fall. The rearing ponds were drained in late August and fish were marked using fin clips and stocked into the main 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 previous segments, we concluded sampling for fish stocked as part of this study. The last stocking occurred in 2004 and we have monitored these fish until they are no longer found in electrofishing samples. 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 stocking year and rearing type was determined for each fish using the age of the fish and the existing 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 for each age class at the time of sampling. In this segment, we acquired data on stocking numbers and sizes from the Jacksonville rearing pond that were not previously available and were able to calculate stocking costs. Hatchery costs of producing fish were provided by the hatchery and included the feed cost per fish as well as the estimated hatchery labor and operation cost. The cost of operating the lake side rearing facilities were determined as the price of electricity used to pump the ponds, and the cost of fertilizer and minnows. Data was available for cost per fish produced from the rearing pond on Lake Shelbyville, Lake Jacksonville, and the Little Grassy fish hatchery which served as the rearing pond for Walton Park. Cost per fish was then used to estimate the mean total cost of producing fish per acre for each lake. We calculated the cost per number of fish surviving as the total cost of stocking divided by the CPUE from electrofishing in the 1st, 2nd, and 3rd fall following stocking. Rearing pond survival was also evaluated for each lake and compared to the number of fish stocked from the hatchery.

Stocking Technique: Boat Ramp v. Dispersed

In this segment, we continued to evaluate the influence of stocking location on survival of stocked largemouth bass. Otter Lake, Homer Lake, Mingo Laker, and Lake Charleston (n=4) were stocked with 100mm largemouth bass fingerlings in 2010 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 left pelvic fin clip and fish to be dispersed were given a right 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. The CPUE from this segment was combined with the data from 3 years of previous stockings in the same lakes. Catch rates and mean size were calculated for each year class and compared between the two rearing techniques. CPUE from electrofishing was 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.

FINDINGS:

Rearing Techniques: Intensive v. Extensive

We have concluded electrofishing sampling in the three stocked reservoirs, and can now conduct final analyses. Mean survival of fish stocked into the rearing pond was 46% in Jacksonville and 42% in Shelbyville. We could not estimate pond survival for Walton Park because the fish were provided directly from the hatchery. The mean number of extensively reared fish stocked per year was similar to the intensively reared fish in Jacksonville (ext. n =

5511 ± 2271 SE; int. n = 4250 ± 750 SE), Shelbyville (ext. n = 8684 ± 1821 SE; int. n = 8813 ± 12.5 SE), and Walton Park (ext. n = 625 ± 0 SE; int. n = 625 ± 0 SE) and no significant difference existed between the number of intensive or extensive fish stocked (paired t-test; t= -12; P = 0.91). Because there were no significant differences in the number stocked, we did not adjust CPUE when evaluating survival. Variation in number stocked was much greater for the lake side rearing ponds than for fish produced by the hatchery. Mean stocking size was larger for extensively reared fish than intensively reared fish in Jacksonville (ext. = 144.5 mm; int. = 99.0 mm) and Walton Park (ext. = 119.8 mm; int. = 101.4 mm), but stocking size was similar for both stocking techniques in Shelbyville (ext. = 101.4 mm; int. = 108.3mm) fish.

Significant differences existed between CPUE of largemouth bass from each of the 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 A., T-K, t = 4.11, P = 0.02) and the following spring (T-K, t = 4.33, P = 0.007). After the first spring, catch rates for both intensive and extensive fish declined to below 1 fish per hour of electrofishing and there was no longer a significant difference in survival between the two rearing strategies (P > 0.05). Despite better initial survival of extensively reared fish, we found 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. There was again 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, P = 0.02) but not significantly larger than intensively reared fish (T-K, t = 3.06, 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. Extensively reared fish were similar in size to both wild (T-K, t = 2.64, P = 0.82) and intensive fish (T-K, t = 0.38, P = 1.00) and no difference existed between intensive and wild fish (T-K, t = 1.60, P = 1.00). Wild, intensive and extensive fish remained similar in size throughout the remaining months they were collected in electrofishing samples. Although extensively reared fish were larger than intensively reared fish and wild fish when they were stocked, size differences were short lived and by the spring following stocking there are no differences in size among these fish.

The cost of producing fish varied among rearing types and individual lakes. Lake Shelbyville was less costly to stock per acre due to its large size, but fish were stocked at a lower density. For all lakes, mean total cost of stocking was higher for extensively reared fish (Table 2-1) as a result of the greater cost per fish produced. The hatchery cost of producing the two inch fish to stock into rearing ponds is very low and a large number of fish can be produced at a low cost. However the cost of maintaining the fish in the rearing pond due to minnow expenses greatly increases the cost of producing fish to stock. Because the initial survival of extensive fish was higher than intensive fish, the cost per relative survival was similar in the first fall following stocking. However, extensive fish experienced low long term survival resulting in the cost per fish surviving to increase in subsequent years. Because of this the cost was twice that of the intensive fish when considering the high cost and no differences in long term survival.

<u>Stocking Techniques: Boat Ramp v. Dispersed</u>

Four lakes were stocked with four inch largemouth bass in 2010 for comparison of boat ramp and dispersed stocking. All lakes continued to have very low survival of both boat ramp and dispersed stocked fish to the first fall following stocking (Table 2-1). Only fish stocked at the boat ramp in Otter Lake were observed in the spring of 2011. Continued low survival of the stocked fish from both stocking methods has made it difficult to evaluate these methods. At this point there is no difference in mean CPUE of boat ramp or dispersed stocked fish in the first fall following stocking and catch rates the following spring are very low. We have begun to find some fish from previous stockings in our electrofishing samples, but the CPUE is very low and there is no consistent difference between stocking method. We will need to age these fish in order to determine which year they were stocked. The poor survival of all stocked fish may be due to the warm lake temperatures on the date of stocking. High mortality of dispersed fish could 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 good 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.

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. Extensive fish 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). The low long-term survival of stocked fish results in no differences in catch rates between rearing method after the first year. Many factors influenced the variation in the number of fish produced by the rearing ponds. In Lake Jacksonville, the rearing pond had green sunfish contamination which resulted in only 125 largemouth bass being produced in 2002. The Lake Shelbyville rearing pond had gizzard shad accidentally introduced during a high water year that yielded a larger size variation in the fish produced. Rearing pond production is less predictable and varies greatly in success and this must be considered in producing fish for stocking.

Raising fish in a rearing pond greatly increases the cost of production, however when fish are harvested from the pond, they are generally larger than the intensively produced fish. In addition, the greater survival of extensively reared fish until the second fall following stocking suggests there is potential for extensive rearing to produce more harvestable fish, however long term mortality was high and there was no difference in abundance after the second fall. Because the cost of producing extensive fish is much greater than that for intensive fish, there was no difference in cost per CPUE in the first fall following stocking. The cost per CPUE for extensive fish increased through time as the catch rates decreased making the cost per CPUE much higher than intensive fish. We do not know the absolute number of stocked fish surviving through time, but the cost per CPUE can be used to compare between the two rearing methods because the relative abundance can be measured from electrofishing CPUE. The ratio of intensive and extensive fish captured can be used to evaluate the relative cost of each rearing strategy. There may be other benefits to using lakeside rearing ponds for producing fish due to the rearing occurring in a more natural environment and allowing the fish to feed on natural prey rather than artificial feed before stocking. Due to the close proximity to the stocking lake, these fish should experience a similar thermal regime to their destination lake and may reduce the acclimation time required when released in the lake. Experience with feeding on fish prior to stocking has been shown to result in greater growth and survival following stocking for other species (Suboski and Templeton 1989; Szendrey and Wahl 1995; Wahl et al. 1995b) as well as for largemouth bass in laboratory experiments in this project (see previous reports). However, low survival of all stocked largemouth bass led to few fish growing large enough to contribute to the fishery. Fish did not reach 14 inches until their fourth year in the lake. CPUE for these fish was less than 0.5 per hour of electrofishing and they did not significantly contribute to the adult largemouth bass population.

We will continue evaluating stocking location to assess the potential to increase survival of stocked largemouth bass. In the first three years, we have observed very low survival of largemouth bass stocked both at the boat ramp and dispersed throughout the lake. Survival of fish in this study 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 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 2011 we will stock Lake Charleston, Homer Lake, Lake Mingo, and Otter Lake using these two methods. 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 best stocking method.

Our results continue to suggest the need to evaluate long-term survival of 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 adulthood. 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 future 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 will continue to evaluate different stocking methods which may increase long term survival of stocked largemouth bass. At this point, we have not been able to find benefits of stocking extensively reared fish or larger fish. Future efforts will be required to assess if stocking fish into optimal 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.

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:

Fish stocking is common throughout North America for a number of species. Fish may be stocked to introduce a species to a new system (Douwalter and Jackson 2005), sustain a population in areas where the fish do not reproduce naturally (Santucci et al. 1994), supplement wild populations that have been reduced due to anthropogenic influences (i.e. fishing, habitat degradation; Wingate 1986) or to alter the genetics of a population (Maceina et al. 1988, Buckmeier et al. 2003). The initial success of a stocking program depends on the survival of introduced fish. Much research examining the success of stocking programs has focused on initial survival (Boxrucker 1986, Buckmeier and Betsill 2002, Hoffman and Bettoli 2005), Though more recent work has focused on survival to adulthood (Diana and Wahl 2008, Buynak and Mitchell 1999, Wahl and Stein 1993).

Despite high initial survival, stocked fish often represent only a small proportion of the population as adults (Diana and Wahl 2008, Buynak and Mitchell 1999). The reasons for the poor survival between introduction and adulthood often remain unclear, but does suggest that stocked fish are less equipped for long-term survival than wild fish (Buynak and Mitchell 1999). If the longterm goal of stocking includes increasing the population of the stocked species, success depends not just on survival to adulthood, but also on long-term reproductive abilities (Currens and Busack 1995, Waples and Do 1994). However, understanding how stocked fish contribute to the reproductive output of the populations into which they are stocked has received little attention.

If poor survival of stocked fish is tied to their ability to obtain resources or exploit preferred habitats (Donovan et al. 1997, Szendrey and Wahl 1996), then those fish that do survive to adulthood may exhibit poorer reproductive output compared to their wild counterparts. Furthermore, hatchery rearing conditions (high density, disease treatments, water quality issues), may also affect the development of reproductive organs (Huntingford 2004) or modify the behavior of fish in such a way that it could affect reproductive ability of adults (Berejikian et al 1997, Jonsson and Jonsson 2006). For example, stocked Atlantic salmon females have been found to deposit fewer eggs, display fewer courtship behaviors, spend less time breeding, and have lower survival of eggs than wild fish (Jonsson 1997). Likewise, stocked male Atlantic salmon have lower success at mate acquisition than their wild counterparts (Jonsson 1997). As stocked fish become part of the adult population, it is important to understand the reproductive abilities of these fish in order to determine how stocking affects long-term population dynamics.

Largemouth bass are stocked regularly into lakes and reservoirs throughout their range and are often used to supplement naturally reproducing populations (Boxrucker 1986, Maceina et al. 1988, Buynak et al. 1999). Previous work examining success of stocked fish to adulthood have found that survival is often lower than wild fish (Diana and Wahl 2008, Buynak and Mitchell 1999). Although it is assumed that increases in the standing stock of populations are the direct result of stocking efforts, little data exist to either refute or support that idea for largemouth bass. If the stocking does indeed increase the standing stock of adult largemouth bass, it also remains unclear how those increases effect reproduction and recruitment in subsequent generations.

Largemouth bass likely home to natal areas to spawn (Ridgway et al. 1991, Waters and Noble 2004), and it is possible that introduced fish may not compete successfully with resident fish 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. 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. Preliminary sampling of largemouth bass began in 2002 and continued through 2010. Clips on fish were noted to determine the survival of stocked fish from initial stocking through reproductive ages. One hundred YOY largemouth bass per lake were collected starting in 2002, when the earliest stocked fish should have begun reaching maturity. 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.

To determine if stocked fish survived to adulthood in these lakes we ran an analysis of variance on the proportion of stocked fish in the population immediately after stocking versus the average proportion of stocked fish in the population in the years following the stocking. Correlation analysis was used to determine if measured variables 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 proportion of B2B2 adults in the population, lake size and adult largemouth bass catch per unit effort (CPUE) (see Job 101.4 for electrofishing sampling methodology).

Finally, to determine if B2B2 adults were contributing to reproduction in proportion to their presence in the population, observed MDH B2 allele frequency was regressed against predicted frequency. To estimate the predicted MDH B2 allele frequency of naturally spawned young-of-year from adult fish, we calculated the total frequency of the MDH B2 allele in the adult population. The proportion of natural adult largemouth bass was multiplied by the background MDH B2 allele frequency for those fish and was added to the proportion of B2B2 adults in the population. If stocked 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 young-of-year fish should equal 1. Deviations from 1 indicate either lower or greater contribution than expected.

FINDINGS:

In previous reports, largemouth bass fingerlings stocked into each lake were verified to be 100% MDH B2B2 genotype with the exception of one stocking in 2001. In that case, a correction factor was used to analyze those samples. The background frequencies of the MDH B2 allele were determined in each lake (Table 3-1). The higher frequency of the MDH B2 allele from McLeansboro is problematic and this lake was eliminated from other analysis. Stocked fish survived to maturity with the proportion of stocked fish remaining unchanged between initial stocking and adults (no $P<0.14$). The lakes varied greatly in the change in the MDH-B2 allele frequencies (Figure 3-1), with Walton Park showing the greatest change followed by Sam Parr and Lake Murphysboro. Forbes Lake and Lake Shelbyville showed only minor influence of stocked fish contributing to the reproducing population. 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 $r = 0.65$, $P = 0.0006$). Thus it appears that stocked largemouth bass that survive to maturity do contribute to reproduction.

Lake size showing a significant negative relationship with the change in the frequency of the MDH B2 allele (Pearson $r = 0.91$, $P = 0.03$). In this segment we examined the effect of density of adult largemouth bass on success of stocked fish reproduction. Higher densities of adult largemouth could reduce the success of stocked fish reproduction and potentially suppress the change in frequency of the MDH B2 allele. However, the CPUE of adults was not related to the change in the frequency of the MDH B2 allele (no $P<0.4$ Figure 3-2).

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 3-3). 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 two of the study lakes (Forbes 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 three of the smaller lakes, Lake Murphysboro, 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. Overall adult largemouth bass density could potentially affect the success of stocked largemouth bass reproduction by diluting the effect on stocked fish that survived to adulthood or by affecting the ability of stocked fish to secure good nesting sites. However, our data indicate that CPUE of adult fish in a population does not affect the contribution to reproduction of stocked fish. Prey availability can possibly affect stocked largemouth bass condition differently than wild largemouth bass and will be examined in future reports. In addition, other factors that affect the success of stocked bass reproductive contribution 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. Once stocked largemouth bass do reach sexual maturity, they appear to make comparable 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.

Spatial heterogeneity in physical littoral habitat has been shown to influence many population and community characteristics of fish assemblages within lake ecosystems. Studies focused on largemouth bass have shown littoral habitat to be an important determinant of age-0 fish distribution and these studies generally have found that largemouth bass prefer structurally complex habitats in the form of woody cover, leaf pack, coarse substrates and aquatic vegetation (Annett et al. 1996; Irwin et al. 1997). Laboratory and field studies have shown that complex physical habitat provides a refuge from predation for juvenile fishes while simultaneously increasing prey resources (Savino and Stein 1982; Miranda and Pugh 1997). While previous research has identified influences of habitat variability on population dynamics of largemouth bass (Meals and Miranda 1991) the majority of studies have been conducted on spatial scales that incorporate multiple habitat patches which has made it difficult to discern how fish use qualitatively different microhabitats (Summerfelt 1993; Annett et al. 1996). In addition, specific differences in the biotic communities among microhabitats (e.g. macroinvertebrates, zooplankton) within the littoral zone have not received considerable attention. In this segment we are sampling 3 common and distinct shoreline microhabitats including vegetated shorelines, shorelines with laydown coarse woody debris, and bare shorelines across two Illinois lakes to examine microhabitat associations of fish communities and invertebrates. This work is intended to identify the degree to which fish and invertebrate communities can be distinguished based on microhabitat associations and also will aid in the identification of patterns in abundance of food web components that may be important to age-0 largemouth bass.

Another potential factor influencing largemouth bass recruitment is dam escapement. Escapement from reservoirs generally increases 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 11 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.

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 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. 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 in 2008 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 along low sloping shoreline, with adequate sunlight, and shorelines protected from southern wind in order to promote successful establishment and growth of aquatic vegetation.

Exclosures were visited in summer 2008-2010 to evaluate planting success. Each exclosure was divided into 4 quadrates. Each quadrate was visually assessed for percent cover of planted vegetation. We supplemented the initial plantings by adding American pondweed and wild celery in cages where there was no survival from previous plantings in July 2009. American Pondweed was planted in 11 large cages and 20 small dispersed cages and wild celery was planted in 12 large cages and 33 small dispersed or clustered cages. These cages were revisited and scored for vegetation in summer of 2009 and 2010. At this time, cages that were initially planted and had plant survival were revisited and scored for percent cover. In 2010, cages were scored for presence of vegetation in late July. Five cages that have had consistent survival of American pondweed were expanded to 9.14 m perimeters (2.9 m diameter). An additional 5 cages were replanted with American pondweed. All cages will be scored in summer of 2011 and the subsequent 2 years.

A subsample of exclosures were sampled for fish, macroinvertebrates and biomass of vegetation in summer of each year. 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 July and August in future segments.

We have been monitoring two lakes as part of the vegetation removal treatment. Stillwater Lake and Airport Lake have high vegetation densities and are in need of treatment to remove vegetation. Monitoring of pre vegetation management began in previous segments and continued in this segment. Treatment for vegetation began in the spring of 2010. Sonar was applied to Stillwater with the intention of completely removing Eurasian milfoil from the lake as well as other vegetation which has become overabundant. Eurasian milfoil is the dominant vegetation type and is invasive in Illinois. Airport Lake was treated in 2010 with Reward two times, once in the spring and once in July. Reward is being applied to reduce the vegetation lake wide and was targeted to remove Eurasian milfoil which had begun to establish in the lake. We will monitor changes in largemouth bass populations and prey organisms throughout and following 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 11 lakes including seven for control conditions, two for rehabilitation conditions and two for the vegetation removal. Largemouth bass populations, vegetation, prey resources, and fish communities were monitored. Three AC electrofishing transects were sampled on two dates 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 (excluding the root mass), 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. 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.

Vegetation and Woody Habitat Enclosures

In this segment we continue to examine patterns in abundance of yoy largemouth bass, other fish species, and associated biotic communities including zooplankton and macroinvertebrates among three common lakeshore habitat types in two Illinois lakes. During August 2009 and again in August 2010 three replicate vegetated, wooded and open shoreline sites were randomly selected in Lincoln Trail Lake and Lake Paradise. At each site, a block net (100 X 3.04 m) was used to enclose an area of shoreline (mean area ± SE = 48.5 ± 1.7 m^2) during sampling. Within vegetated sites three 0.5 m diameter circular quadrats were sampled for species identify, stem density and standing biomass of macrophytes. Benthic macroinvertebrates were sampled from littoral sediments using a modified stovepipe sampler as described in previous sections. Three zooplankton samples were collected in each site using a 9.5 cm diameter tube sampler (mean volume ± SE = 9.7 ± 0.07 liters). Each of the three subsamples was pooled by passage through a 64-µm-mesh filter. Storage and processing of zooplankton and invertebrate samples was as described in previous sections. In addition to zooplankton and benthic macroinvertebrate samples the macroinvertebrate communities associated with the surface of coarse woody habitat were sampled from wooded sites. Woody debris was sampled for macroinvertebrates by first enclosing individual branch segments (N = 3 per site) in a 64 µm mesh bag and clipping the segment using a hedge clipper. Samples were then lifted from the water invertebrates were removed using a soft nylon brush held over a pan. Fish communities were sampled via three passes within the enclosed area using a backpack DC electrofisher. All collected fish were identified to species and measured for total length. Community data sets including fish species densities, macroinvertebrate densities, and zooplankton densities expressed as individuals per square meter (fish and macroinvertebrates) or per liter (zooplankton) were pooled across years and analyzed using correspondence analysis to examine the degree to which habitats could be distinguished based on the density of each taxa found. This approach allowed for a test of the degree to which each habitat could be distinguished based on its biotic community and also served as a data reduction step by identifying important taxa for further analysis. Data from each lake was analyzed separately due to known differences in community composition. Individual taxa were included in discriminant functions derived from correspondence analysis by using a stepwise selection procedure and all groups with a p-value <0.10 were included in final functions. When discriminant functions indicated significant effects of individual taxa these were further examined using univariate ANOVAs blocked by year to test for differences among habitat types. When a significant univariate ANOVA was found fisher's protected lsd was used to separate means and determine specific differences among habitats.

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.

To sample fish escapement from Forbes Lake, we set up three transects in the Lost 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. In addition, rainfall was recorded at the Sam Parr Biological station located approximately 1 mile downstream of the dam. Downstream area of the Ridge Lake dam was sampled in a similar manner in 2008. A 200 m stretch of the stream was sampled via electrofishing in an upstream direction and in one transect. Starting in the spring of 2010, all fish escaping over the spillway were collected in 12 m X 6 m catch basin with a 2.54 cm mesh gate. The catch basin was seined at regular intervals or after a major rainfall event and the fish collected were measured and checked for pit tags. Rainfall data was collected from the Eastern Illinois University rainfall gauge approximately 5 miles to the North. The total rainfall that fell between sampling dates was calculated and divided by the number of days in order to compare precipitation to escapement.

FINDINGS:

Vegetation Management Experiment

In this segment, the effort to increase vegetation and evaluate vegetation plantings continued on Lake Paradise. We expanded five cages that contained American pondweed consistently over the last three years to attempt to increase the area vegetated. Five additional small cages were also planted. These cages will be evaluated for survival in the next segment. All cages planted in 2008 and 2009 were scored for density of surviving vegetation. Cages planted with American pondweed had the greatest percent cover throughout the 3 years following planting (Table 4-1: A). All other vegetation planted in 2008 had no survival through 2010 with the exception of one cage planted with wild celery. Mean plant cover of cages in 2009 was lower than those planted in 2008 after 1 and 2 years. This may be due to planting location as all cages planted in 2009 were cages with no survival in 2008. American pondweed planted in 2009 again had the greatest mean plant cover of vegetation types planted (Table 4-1: B). When examined together, we observed similar results for vegetation planted in Lake Paradise across years. Cages were determined successful if they had any vegetation surviving from the previous year. Cages were over 50% successful for all vegetation types in the first fall following planting with the exception of Chara (Figure 4-1). After the first winter all vegetation types decreased in success and only American pondweed had any significant survival after the first winter. Mean vegetation cover ranged from 0 to 50% in successful cages across all vegetation types (Figure 4-2). When the cages were successful, American pondweed and wild celery had similar densities of vegetation. It is difficult to evaluate chara, coontail, and sago pondweed because the number of successful cages is very low and the mean density is based on very few number of cages.

We also examined the influence of cage size on survival of vegetation. All sizes of cages had high success through the fall following planting (Figure 4-3). The small clustered cages had no overwinter survival of vegetation and there was no vegetation present in the evaluations in the second or third year following planting. The dispersed small and the large enclosures experienced similar success in the second and third year and decreased through time. There were similar densities of plants in all three cage sizes when they were successful (Figure 4-4). Cage size does not appear to affect the density of plants in successful cages. Vegetation in the large cages did not differ from the small dispersed cages in success or density. Because the large cages cover a much bigger area, they did achieve larger vegetated plots.

In addition to evaluating the vegetation in the enclosures we examined the density of fish and benthic invertebrates associated with vegetated and non-vegetated enclosures. The density of fish collected from vegetated cages was slightly higher than non-vegetated cages (Table 4-2). The density of fish varied with plant type, but the sample sizes were low for sago pondweed, coontail and wild celery. Fish density was highest in wild celery followed by American pondweed. The highest density was observed in a single cage with sago pondweed, but this was the only cage due to low survival of sago pondweed. Species richness was much higher in vegetated cages (12 species) than in non-vegetated cages (7 species). The only largemouth bass that were observed were associated with cages that contained vegetation. Density of invertebrates was higher in the vegetated cages than non-vegetated cages (Table 4-2 B) due primarily to the very high density of chironomids found in cages containing vegetation. Invertebrate density varied by vegetation species with the highest being associated with sago pondweed, followed by wild celery and American pondweed. In general, prey fish and invertebrates appear to be found in greater density in the vegetated cages and the vegetation plantings may produce preferred habitat for young-of-year fish.

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/hour in 2005 to 2.0 fish/hour in 2008 and 1.6 fish/hour in 2009. In 2010, gizzard shad abundance had increased to 4.1 fish/hour, which is lower than densities before the drawdown, but are increasing each year and we expect the numbers to continue to increase. The density of gizzard shad in larval fish samples was low compared to other lakes with gizzard shad, but reproduction is occurring in Dolan Lake.

CPUE for common carp in Dolan Lake dropped from 0.8 in 2005 to 0.0 in 2008 and 2009. No common carp were sampled in electrofishing efforts in spring or fall of 2010. Although carp numbers were not high in electrofishing samples prior to the drawdown, we have not observed carp in any sample since the rehabilitation effort. In addition, larval carp were not observed in any of the monthly sampling in Dolan Lake. Decreases in gizzard shad and carp densities should allow water quality changes and reduce feeding and uprooting of vegetation allowing the density of plants to increase. Before the drawdown and rotenone treatment, Dolan had a mean of 1.4% of the surface area and 5.7% of the perimeter vegetated from 2002 through 2005. In 2007, 76% of Lake Dolan's shoreline contained vegetation. Vegetated shoreline increased to 93% in 2008 providing evidence that vegetation may be increasing. In 2010, the mean percent shoreline that was vegetated was intermediate at 83% and has continued to be much higher than in pretreatment assessments. In Dolan Lake in 2010, the CPUE of largemouth bass over 200mm was the highest in all lakes sampled as part of this job (58.8 fish/hour). However the CPUE of young-of year fish in the fall was among the lowest (6.8 fish/hour). The largemouth bass population was intentionally reduced and restocked as part of the 2007-2008 drawdown. There is a substantial spawning population at Dolan Lake and we expect that recruitment should increase in Dolan Lake. The increase in vegetation should allow for adequate habitat for newly spawned fish. We will continue to monitor Dolan Lake in order to evaluate long-term changes in largemouth bass populations.

In this segment, we continued to monitor 11 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). Lake vegetation has varied among lakes across years, but lakes maintained their high, medium or low vegetation designation throughout the pre-treatment time period (2007-2009). In 2010 Airport Lake and Stillwater were treated chemically to remove vegetation. The treatment in Airport Lake occurred shortly following our spring vegetation assessment. The vegetation was reduced immediately following treatment, but the lake was highly vegetated by the fall assessment and no long term change in vegetation density was observed. Stillwater Lake was treated prior to the spring vegetation assessment and the vegetation had already begun to decrease. The density of vegetation in Stillwater Lake was very low when assessed in the fall and had dropped from 100% in 2007 through 2009 to only 1% of the total lake area. We will continue to follow vegetation changes in these two lakes and evaluate changes in largemouth bass recruitment in the spring and fall sampling. Percent of the lake area that was vegetated continued to be significantly correlated with the perimeter of the shore that is vegetated (Spring: $r = 0.92$; $P < 0.0001$; Fall: $r = 0.94$; $P < 0.0001$). Both vegetated area and perimeter were also significantly correlated from the spring to the fall for both percent vegetated area ($r = 0.96$; $P < 0.0001$) and vegetated perimeter ($r = 0.99$; $P < 0.001$).

We also continued to monitor larval, 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. Young-of year (yoy) largemouth bass CPUE from electrofishing was not significantly correlated with any measure of vegetation density in the 11 research lakes in 2010 ($p > 0.05$). These results differed from 2009 where the CPUE of yoy largemouth bass was significantly correlated with percent of the lake perimeter that was vegetated in both the spring ($r = 0.79$; $P = 0.004$) and the fall ($r = 0.65$; $P = 0.03$). The only factor that was significantly correlated with vegetation density in 2010 was the density of larval gizzard shad ($r = 0.93$; $P < 0.0001$). The CPUE of adult largemouth bass was significantly correlated with the mean density of larval fish ($r = 0.73$; $P = 0.01$) as well as larval bluegill density ($r = 0.76$; $P = 0.007$). In order to evaluate differences in largemouth bass recruitment related to varying vegetation densities, we separated the 11 study lakes into categories based on the proportion of the lake area and perimeter that was vegetated in 2010. The categories were low (n=3; 0-10%), medium (n=4; 20-80%), and high (n = 4; 90-100%). We performed an ANOVA to determine if there as a significant difference in yoy largemouth bass cpue from fall electrofishing among groups. Yoy largemouth bass densities were lowest in low vegetation lakes, followed by medium density and the highest in high density vegetation lakes (Figure 4-5). These differences however were not significant ($F = 0.13$; $P = 0.88$). We will continue to monitor vegetation densities, largemouth bass populations, fish assemblages, prey resources and lake characteristics in control and vegetation treatment lakes including addition and removal.

Vegetation and Woody Habitat Enclosures

Fish Communities

Correspondence analysis indicated that fish community composition was a significant predictor of habitat types in Lincoln Trail Lake (Pillai's Trace = 1.27; df = 12, 22; $P < 0.01$). Further examination of discriminant functions indicated that a combination of species densities including bluegill, warmouth sunfish, yellow bullhead, and redear sunfish and crayfish density could correctly classify 89% of sites. Univariate tests indicated that bluegill (ANOVA; $F_{2,14}$ = 7.9; $P < 0.01$) and warmouth sunfish densities differed significantly among habitats (ANOVA; $F_{2,14}$ = 3.6; $P = 0.05$). Post hoc tests for bluegill indicated that vegetated areas had significantly higher bluegill densities than open shorelines ($P = 0.03$) whereas wooded enclosures had intermediate densities (Figure 4-6 A). Post hoc tests for warmouth sunfish indicated that this species was significantly more abundant in wooded and vegetated sites than open shorelines (all $P < 0.05$) while vegetated and wooded shorelines had similar warmouth densities (Figure 4-6 B).

In Lake Paradise discriminant analysis indicated that fish community composition was not a strong predictor of habitat types (Pillai's Trace =0.25; df = 2,15; $P = 0.11$). Examination of ordination plots indicated that white crappie density was the only important factor suggested by discriminant analysis. Subsequent univariate tests indicated a marginally significant overall effect of habitat type on density of white crappie (ANOVA; $F_{2,14}$ = 3.1; $P = 0.07$). Post hoc comparisons indicated that white crappie density was significantly higher in wooded habitats than in either open or vegetated sites (all $P < 0.05$; Figure 4-6 C).

Zooplankton Communities

In Lincoln Trail Lake correspondence analysis indicated that habitat types could be distinguished based on zooplankton communities ((Pillai's Trace = 1.11; df = 10,24; $P = 0.01$). A discriminant function that included densities of cyclopoid copepods, as well as organisms of the families bosminidae, sididae and chydoridae could correctly classify 88% of habitat types. Univariate tests across habitat types for these taxa indicated significant differences in the density of cyclopoid copepods (ANOVA; $F_{2,14}$ =3.55; $P = 0.05$) and chydorids (ANOVA; $F_{2,14}$ =4.71; $P = 0.02$). Post hoc tests comparing cyclopoid densities between habitat types revealed that cyclopoid copepods were significantly more abundant in vegetated habitats than in open habitats ($P < 0.03$) with wooded habitats being intermediate (Figure 4-7 A). Post hoc tests on densities of chydorids between habitat types indicated that these organisms were significantly more abundant in vegetated habitats than either open or wooded sites (all $P < 0.03$; Figure 4-7 B).

In Lake Paradise correspondence analysis indicated that habitat types could be distinguished based on zooplankton communities (Pillai's Trace = 0.55; df = 4,30; $P = 0.04$). A discriminant function that included densities of sididae and harpacticoid copepods could correctly classify 61% of sites by habitat. Univariate comparisons of sididae densities between habitats indicated that densities of these organsisms differed between habitats (ANOVA; $F_{2,14}$ = 3.48; $P = 0.05$). Post hoc tests revealed that sididae were more abundant in vegetated habitats than in open habitats ($P = 0.02$) with wooded habitats being intermediate (Figure 4-7 C).

Macroinvertebrate Communities

Macroinvertebrate communities were significant predictors of habitat types in Lincoln Trail Lake ((Pillai's Trace = 0.64; df = 6,40; $P = 0.01$). A discriminant function incorporating densities of pelecoptera and trichoptera could correctly classify 50% of sites to habitat type.

Univariate comparisons of pelecopteran densities across habitat types indicated that there was a marginally significant difference among habitat types (ANOVA; $F_{2,14} = 2.6$; P = 0.08). Post hoc tests revealed that pelecopterans were significantly more abundant in vegetated sites than on wood surfaces or wooded sediments (all P <0.05) with and open sites being intermediate (Figure 4-8 A). Univariate comparisons indicated that trichopteran densities also differed among habitat types (ANOVA; $F_{2,14} = 4.1$; P = 0.04). Post hoc tests revealed that trichopterans were more abundant on wood surfaces than on any of the other habitats (all P <0.05; Figure 4-8 B).

Similar to Lincoln Trail Lake macroinvertebrate communities were a strong predictor of habitat types in Lake Paradise ((Pillai's Trace = 1.1; df = 12,57; P < 0.01). A discriminant function including densities of chironomidae, dipteran pupae, ephemeropterans, and nematoda correctly classified 66% of habitat types. Univariate comparisons between habitats for these taxa indicated significant differences for chironomidae (ANOVA; $F_{3,19} = 6.57$; P <0.01); dipteran pupae (ANOVA; $F_{3,19} = 5.18$; P <0.01) and nematoda densities (ANOVA; $F_{3,19} = 3.15$; P = 0.04). Post hoc tests revealed that chironomid densities were significantly higher on wood surfaces than in all other habitats (all P < 0.02; Figure 4-8 C). Post hoc tests for dipteran pupae indicated that these organisms were more abundant in wooded sediments than all other habitat types (all P <0.05; Figure 4-8 D). Similarly post hoc tests on the density of nematodes found that these organisms were also more abundant in wooded sediment than in other habitats (all P < 0.05; Figure 4-8 E).

Dam Escapement

Preliminary data collected thus far suggests largemouth bass escapement in Forbes Lake is affected by precipitation and ultimately the amount of water exiting the spillway. The average number of largemouth bass that are sampled in Lost Fork appears to be related to the average precipitation for the month (Figure 4-9). As expected, adult largemouth bass collected in the stream appear to peak in spring and decline in the summer, whereas young of year largemouth bass appear later in the spring and summer (Table 4-5). However, it is important to note that largemouth bass sampling in Lost Fork represents only relative numbers of largemouth bass between sampling dates. The data from Ridge Lakes allows for a better estimate of the total numbers of largemouth bass exiting that lake. Early indications from this expanding data set are that the number of bass escaping Ridge Lake are low (Figure 4-10). In the 10 continuous months of sampling in 2010 and 2011, only 4 adult sized largemouth bass were collected in the Ridge Lake catch basin. Small numbers of young of year largemouth bass were also present in the catch basin in May and June (Table 4-5). The timing of escapement does not appear to be associated with rainfall (Figure 4-10), nor does timing appear to be associated with time of year. Thus early data indicates that large numbers of adult and young of year largemouth bass are not being lost from this lake population due to dam escapement.

RECOMMENDATIONS:

Additional information on the role of aquatic vegetation to largemouth bass recruitment has been identified as an important goal for management in Illinois. 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 been measuring recruitment of largemouth bass in those systems. We have begun to treat vegetation in Stillwater and Airport Lakes and will continue to monitor changes of vegetation for several years. Vegetation removal in these lakes has been accomplished primarily through chemical treatments appropriate to reduce the dominant problem vegetation. We will monitor the vegetation in these lakes and evaluate the success of the removal process. 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 initial years with additional plantings of American pondweed in 2011. Results thus far suggest American pondweed as the species with the highest survival rate and future planting efforts in Lake Paradise will focus on this species. Large cages were shown to produce both larger continuous areas of plants and a greater survival rate of plants inside an enclosure. We recommend the use of larger cages when attempting to establish vegetation in a lake. There is a higher potential for large cages to pull away from the substrate, allowing turtles, carp and other animals to enter the cage and feed on the plants and extra effort should be spent when constructing these cages to ensure they are seated well into the substrate. In the next segment we will continue to expand the size of a number of both small and large cages where plants are established to attempt to spread the vegetation previously planted. We will also move cages that have had poor success and attempt to focus planting in areas of the lake where vegetation has survived successfully. During the next several years, we will monitor the lake-wide implications of these vegetation enhancement efforts. 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. Initial measurements of carp and gizzard shad indicate the fish removal efforts have successfully reduced their numbers. However, gizzard shad numbers have increased since the initial treatment and even though they are low, larval fish have been observed in samples and are increasing in number each year. Vegetation at Dolan Lake has increased since the drawdown and fish removal. We will continue to monitor control and treatment lakes and relate changes in largemouth bass recruitment, growth, and abundance to management practices. We will evaluate largemouth bass recruitment, abundance and growth in lakes with varying vegetation densities in order to identify critical levels of vegetation to target for management.

Previous research in reservoir ecosystems has documented significant effects of littoral habitat on relative abundance and distribution of juvenile and age-0 fishes however a majority of these studies have been conducted on systems with little vegetative or other complex habitat structure (Meals and Miranda 1991; Irwin et al. 1997). While we did not find significant differences in age-0 largemouth bass densities among the microhabitat types sampled in our enclosure surveys, we did find significant differences in the community composition and abundance of potentially important prey items (juvenile sunfishes, caddisflies, chironomids, stonefiles and cyclopoid copepods). Increases in abundance of potential invertebrate and fish prey in vegetated and wooded sites supports the idea that these habitats are important sources of littoral productivity. Differences in fish and invertebrate community structure may influence the foraging success and relative energetic value of different habitats to age-0 largemouth bass and other juvenile fishes. In the future we plan to design controlled experiments evaluating the potential influence of differences in community structure among habitats on the feeding performance of age-0 largemouth bass. These experiments will help to draw links between habitat heterogeneity, biotic community structure and energetics of age-0 fishes.

The assessment of dam escapement is in the early stages of implementation and evaluation and more data is needed to draw conclusions about the effect of escapement on largemouth bass populations and recruitment. Early indications suggest that escapement is not a major factor affecting largemouth bass populations and recruitment. However, differences between the two lakes sampled and their apparent link to precipitation may indicate that other factors (i.e. drainage size, lake size, spillway type, etc.) may affect the timing and numbers of largemouth bass lost due to escapement. Additional data still needs to be collected to determine if the trends observed thus far represent real patterns. Data will continue to be collected from both sites in future reports in order to build a large enough database to be able to answer questions about escapement effects on largemouth bass populations in a more rigorous manner.

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.

Removal of spawning males by angling has been shown to reduce the reproductive success of an individual largemouth bass, often causing brood reduction and nest abandonment (Philipp et al. 1997). However, the population-level impact of reduced reproductive success of some individuals is unclear. In the spring, male largemouth bass (Micropterus salmoides) build solitary, highly visible (depending on water clarity) saucer-shaped nests in the substrate in order to court and spawn with females (Kramer and Smith 1962; Pflieger 1966; Coble 1975). Once spawning is completed, females leave the nesting area and the male remains to provide all parental care of the developing offspring, a period that may last four or more weeks (Ridgway 1988; Cooke et al. 2002). While male bass are providing parental care for their broods, they are extremely aggressive (Ridgway 1988; Cooke et al. 2002) and, therefore, highly vulnerable to many angling tactics (Neves 1975; Kieffer et al. 1995). Even though this vulnerability has never been assessed accurately, many fisheries management agencies have invoked closed fishing periods, catch-and-release regulations, and various length and harvest limit scenarios in an effort to enhance or promote bass reproduction and recruitment (see Schramm et al. 1995). We are assessing the relationship between nesting success and recruitment in Lincoln Trail Lake. In addition, we are also directly testing the effect of angling on recruitment through manipulative pond experiments. 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, which has not been specifically determined. Also, density-dependent interactions in young-of-the-year largemouth bass may cause populations to compensate for the lost reproductive success of some individuals.

Exploring recruitment in a controlled setting allows us to isolate and test different mechanisms regulating survival. In order to further explore the effects of angling largemouth bass during the spawning period, we completed one pond experiment and began an additional pond experiment during this segment. In the first experiment, we assessed the effects of removing the earliest broods in a population as those have been shown to have the greatest effect on recruitment. There is potential for angling to have a large influence on largemouth bass populations. In particular, competitive tournament fishing for black bass has grown rapidly over the past several years. Previous work has shown high levels of mortality associated with these tournaments in other parts of the United States, but tournament procedures continue to improve. In previous segments, we evaluated the effects of small club style tournaments for largemouth bass. Mortality at small, club-style tournaments at Evergreen Lake was low, and never exceeded 5%. 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 also identified nest abandonment rates for fish exposed to tournament angling, catch and release angling and no angling controls. We found almost all fish exposed to tournaments abandoned their nests after 24 hours and 33% abandoned after catch-and release-angling. In pond experiments we saw similar abandonment of the nest. When nests were guarded from predators using screens, fish were less likely to abandon the nest upon return, possibly due to reduced predation on eggs and reduction in brood on a nest. We also reported that increased distance of release from the nest and time off the nest both increased abandonment rates. We also monitored largemouth bass tournaments during the spawning period and post spawn to determine if nesting bass were targeted. We did not observe a shift in the sex of fish depending on season although a large number of ripe and running fish were angled in springtime tournaments. Thus far we have shown effects of tournaments on largemouth bass at the individual level, but the influences of tournament angling on lake wide recruitment are unknown. Therefore, we also initiated a second pond experiment to directly examine the population consequences of tournament angling during the spawning season. In addition we conducted spring largemouth bass tournaments at Ridge Lake in order to examine the effects on tournament angling on largemouth bass recruitment at the lake level. These pond and lake experiments will allow us to further evaluate the potential effects of spring tournament angling on largemouth bass recruitment.

Despite low mortality and stress associated with small tournaments, there can be substantial mortality and sub lethal stress associated with large scale tournaments with extensive weigh-in procedures (Wilde 1998; Allen et. al 2004; Suski et. al 2003; Suski et. al 2004). Due to the stress and mortality associated with these large tournaments, we continued to evaluate the use of paper tournaments to reduce potential negative effects. Paper tournaments allow anglers to release fish shortly after they are caught and in the same vicinity as their capture as well as remove the stress associated with livewell confinement and weigh-in procedures. Little is known about how varying tournament angling pressure can influence the life history traits of largemouth bass populations. Therefore, we are also evaluating the long term influence of tournament activities on populations of largemouth bass. Our objective is to quantify tournament pressure for a number of lakes and examine differences in largemouth bass populations in lakes with varying tournament pressure.

PROCEDURES

Nest observations

Snorkeling surveys were used to assess bass spawning activity, nest site selection by males, aggressiveness of males guarding a nest, and the level of nest predation in Lincoln Trail Lake. Snorkel surveys commenced on April 13th, 2011. 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 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.

Influence of Spring Tournaments on Reproduction

Tournament angling for largemouth bass has been shown to cause nest abandonment for fish angled off the nest. However the population level effects of nests abandonment have not been examined. In this segment we continued 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. Ridge Lake has a controlled creel operated by the Illinois Natural History Survey. The lake has traditionally been closed to fishing until mid-May and no tournaments have been conducted at Ridge Lake prior to the beginning of this experiment. In the early spring of 2007 and 2010, seven angling tournaments were conducted during the spawning season (April 22 - May 22, 2007; April 17 – May 17, 2010) on Ridge Lake, prior to the opening of the regular public angling season. During each tournament, anglers fished for four hours targeting largemouth bass. All fish caught were brought back to the dock, measured for total length, weighed, and scales were collected. The fish were then kept in a lakeside pen for 2 hours following the tournament when they were released back into the lake. Recruitment of largemouth bass was measured 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. Prey resources were also monitored at Ridge Lake throughout the season (zooplankton, larval fish, seine, benthos cores, and water quality; see job 101.4 for methods). We will monitor largemouth bass populations and prey resources in Ridge Lake through both tournament and non-tournament years and examine the relationship between spring angling tournaments and lake wide recruitment. No tournaments were conducted in 2006, 2008 and 2009 and these years will be used as a comparison with the years where tournaments were conducted.

We are currently conducting a manipulative pond experiment aimed at assessing the direct effect of tournament angling during the spawning period on recruitment. Most research has focused on the effects that angling treatments have on success of an individual bass, but the cumulative impact on recruitment is still relatively unknown. Also, willingness of individual fish to strike a lure and other behavioral factors have yet to be considered when testing angling effects on population recruitment. To address these questions, we have designed a two-year experiment simulating the effects of tournament angling on adult largemouth bass.

In both 2010 and 2011, eight 1-acre ponds were stocked with natural densities of adult largemouth bass (12 females and 10 males), adult bluegills (15 females and 15 males), and juvenile bluegills (approximately 2,200). Each year, ponds were randomly designated as treatment or controls. During the spawning season, treatment ponds were subjected to tournament-style angling, with each receiving four angler hours per week. To simulate tournament practices, caught bass were then weighed, measured, and held in a livewell for four hours before being released. Snorkelers monitored bass nests in all ponds to assess nest success and to determine abandonment due to the treatment.

Ponds were also sampled throughout the spring and summer for several variables that could potentially effect recruitment, including abundance of zooplankton, benthic invertebrates, and vegetation. Abiotic factors such as water transparency, nutrient content, and temperature were also monitored for the duration of the experiment. We ended the experiments in the fall, when each pond was drained and all juvenile largemouth bass were counted and weighed.

Long-Term Effects of Tournaments

We began to evaluate how long-term harvest and varying tournament pressure has impacted the population abundance and size structure of largemouth bass populations through selection-driven changes in life history traits. Electrofishing transects were performed in twelve lakes in the spring of 2010 and all largemouth bass were collected, measured for total length and weighed. Lakes were categorized as high tournament pressure, low pressure, or no tournament pressure lakes. 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 and returned to the laboratory. Tournament pressure was determined for lakes where we could identify all tournament activity on a lake. We have coordinated with DNR biologists, lake managers and tournament organizers to obtain records of all tournaments conducted on a number of lakes. We also worked with tournament organizers and lake managers to obtain tournament results and weigh-in data for all tournaments conducted. When all weigh-in results were not available, we estimated weigh-in results using similar tournaments from the same 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.

FINDINGS:

Nest Observations

Snorkeling was initiated in Lincoln Trail on April 13, 2011. A total of 14 fish were observed on the nest. The secchi depth was 1.8m and water clarity was sufficient to identify nests, although not ideal. Following the initial snorkeling effort, there were high levels of precipitation and storms which greatly reduced water clarity in Lincoln Trail. We returned to lake for future snorkeling on April 21 and the secchi depth had decreased to 0.8 m and water clarity was not sufficient to snorkel. The lake was assessed on 2 additional dates (April 28, 2011 and May 3, 2011) and water clarity continued to limit the visibility in Lincoln Trail making nest identification not feasible. We will continue to perform snorkeling transects in future segments.

Influence of Spring Tournaments on Reproduction

Tournaments were conducted in the spring of 2010 on Ridge Lake from April 17 to May 17 while largemouth bass spawning was occurring. A total of 7 tournaments were conducted and the average angler hours per tournament was 22.3 hours (Table 5-1). The anglers caught 167 fish totaling 180.9 pounds. Recent population estimates at Ridge Lake averaged 311 largemouth bass implying a large portion of the spawning fish were captured in the tournament and that the spring tournament angling is affecting a majority of the population. Tournament data from 2010 added to previous tournament data from the 2007 spawning season and fish populations and prey resources were compared to non-tournament years in 2006, 2008, and 2009 (Table 5-2). Recruitment was assessed as CPUE of young-of-year largemouth bass from fall electrofishing. There was no significant difference between tournament and non-tournament years for CPUE of young-of-year largemouth bass ($F = 0.01$; $P = 0.93$), CPUE of largemouth bass greater than 200 mm ($F = 0.02$; $P = 0.89$) or CPUE of bluegill ($F = 0.30$; $P = 0.62$) from fall electrofishing samples (Figure 5-1). We also observed no significant differences in prey resources in tournament and non-tournament years ($P > 0.05$ for larval fish, zooplankton, and benthos densities). These results are based on only a few years of tournament and non-tournament fishing data and any interpretation should be made cautiously until additional data are collected. It is difficult to detect differences with a low number of repetitions. These preliminary results suggest that spring tournaments may not adversely affect reproduction. We plan to conduct tournaments in the spring of 2012 and no tournaments were conducted in the spring of 2011 to add to these data. Future segments will allow further evaluation of the influence of tournaments during the largemouth bass spawning season.

Our initial results from pond experiments indicate that tournament angling does seem to have an effect on largemouth bass recruitment in experimental ponds. Zooplankton densities during the spring and early summer are also a key driver to overall recruitment (Figure 5-2), while the other measured variables proved to be less important. After zooplankton abundance in May and June were taken into account, there was a moderately significant effect of the treatment on total numbers of young-of-year bass (p value = 0.06; Figure 5-3), and a very significant effect on young-of-year juvenile bass biomass (p value = 0.02; Figure 5-4). The number of recruits in the fall averaged 1,917 for control ponds, and declined to 1,488 for ponds subjected to the angling treatment. The more pronounced effect on young-of-year biomass (control average = 23,131g, treatment average = 8,231g) was partially due to a shift in the size distribution of treatment ponds to a population with smaller individuals. While there was no significant differences in the number of small individuals (<110mm) between control and treatment ponds (p value = 0.96, Figure 5-5), treatment ponds lacked the many large individuals (>110 mm) that were present in control ponds (p value = 0.20; Figure 5-6). This could be due to the abandonment of some early nests in treatment ponds due to simulated tournament angling, causing there to be less early-hatched fish in treatment ponds. These results also support our findings in previous segments that the first individuals hatched during a spawning season are the most likely to contribute to end-of-the-year recruitment. The shift in size distribution could also be partly explained by cannibalism of early-hatched fish on later hatched cohorts.

In the next segment, we will include data from both years of the study to strengthen the power of the experiment. We will also include age data on seined individuals from the summer to test for a shift in average hatch dates between treatments. Also, a more complete analysis of the effects of the abiotic and biotic variables will be included, and their relative importance compared to that of the treatment will be assessed.

<u>Long-Term Effects of Harvest</u>

In this segment, we continued to collect information on tournament activity from 9 lakes with varying tournament pressure. All tournament activity was recorded for each lake and tournament results are used to evaluate the tournament pressure, catch rates, and angler success (Table 5-2). In addition we identified 5 lakes where no largemouth bass tournaments occur and use these lakes as a control to compare largemouth bass populations across varying tournament pressure. Tournament pressure was calculated as angler hours per acre and varied from 0 to 21.6 hours/acre. The mean number of participants across tournament lakes was 33.5 anglers and the average tournament was 6.8 hours long. When examining only the lakes with tournaments, lake size was significantly correlated with the number of anglers per tournament ($r = 0.80$; $P = 0.009$). Larger lakes tended to have larger tournaments with a higher number of participants. Despite having larger tournaments, the size of the lake was not significantly correlated with total tournament pressure on a per area basis (angler hours per acre; $r = -0.09$; $P = 0.77$) or the number of tournaments ($r = 0.31$; $P = 0.29$). Catch rate measured as fish caught per angler was not significantly correlated with tournament pressure ($r = 0.27$; $P = 0.49$). No relationships existed between catch rate and the number of tournaments, length of tournaments, and number of anglers in a tournament ($P > 0.05$). Lakes with the highest number of tournaments had the lowest mean weight per fish caught ($r = -0.68$; $P = 0.04$; Figure 5-7). Catch per unit effort from spring electrofishing samples of all largemouth bass, young-of-year largemouth bass, and largemouth bass greater than 14 inches was not significantly correlated with tournament pressure ($P > 0.05$; Figure 5-8). CPUE of largemouth bass greater than 14 inches was significantly correlated to lake size ($r = 0.82$; $P = 0.001$) and the mean number of fish weighed in at a tournament ($r = 0.58$; $P = 0.048$). As expected, the total number of fish weighed in is also significantly correlated with lake size ($r =0.75$; $P = 0.02$). Angler catch rates were related to the abundance of fish in electrofishing transects and was higher on larger lakes. We did not detect any changes in abundance or size structure of largemouth bass vulnerable to tournament angling or production of young-of-year fish related to tournament pressure. However, these data are preliminary and are based on two years of data. We will continue to collect tournament and largemouth bass population data on these lakes and add additional lakes to this analysis to further understand the influence of tournaments on largemouth bass populations.

RECOMMENDATIONS:

Largemouth bass tournament angling continues to be popular and we have continued to evaluate the effects of these tournaments on fish populations and recruitment. In previous segments, we have demonstrated that largemouth bass can be targeted during nest guarding and that these angled fish are likely to abandon the nest. Thus far, we have been able to assess spawning activity and assess recruitment during seven 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 the next segment we will monitor nesting at Lincoln Trail and continue to evaluate nesting frequency, vulnerability to angling, nest guarding behavior, and predation of eggs and larvae on the nest. We will collect otoliths from young-of-year largemouth bass in the fall to determine the survival of fish from individual cohorts and relate them to nest frequency in the spring to determine if there is differential survival. We will continue to evaluate these factors in future segments and address their importance in determining recruitment.

In this segment we have continued to evaluate largemouth bass tournaments and their procedures and assess how they affect fish populations. Preliminary results from the experiment at Ridge Lake has not shown any evidence in reduction in recruitment of young-of-year largemouth bass due to springtime tournaments or changes in adult populations. To assess the effects of angling practices and tournaments on largemouth bass reproduction and recruitment we will continue experiments initiated at Ridge Lake. Experimental angling tournaments were conducted on Ridge Lake in 2007 and 2010. We will conduct a third season of tournament angling in the spring of 2012 providing assessment of 3 years of largemouth bass recruitment in years with tournament angling to compare to 3 years of non-tournament angling.

Pond experiments provide evidence of how angling largemouth bass during the spawning season can impact young-of-year bass and reduce the size of the year class. Initial pond experiments suggest that tournament angling during the spawning months does have an impact on recruitment dynamics that need to be confirmed in lakes. These results suggest that protecting spawning largemouth bass may helpful in some situations where largemouth bass recruitment is low. However, it should also be noted that prey resources, specifically early-summer zooplankton abundance, were the main driving force in determining young-of-year bass abundance. We will combine these initial results with those from the second year in subsequent reports.

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. In this segment we evaluated tournament pressure on 9 lakes where we can identify all tournament activity. We will continue to monitor tournament activity at these lakes as well as compile weigh-in results. These data will allow us to further examine the relationships between tournaments and fish populations and determine if they can influence fish populations. We will also incorporate creel data in order to assess fishing pressure on these lakes and relate them to largemouth bass size structure. In addition we will incorporate FAS data from DNR biologist electrofishing sampling to supplement INHS electrofishing data. 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. This will allow us to identify the potential impacts of tournaments and harvest to life history characteristics in largemouth bass populations.

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:

Refuges

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, previous segments) 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) proposed closing two large bays to fishing and boating, providing a spawning and fishing refuge for largemouth bass and other fish species. The two bays were closed to fishing in summer of 2010. 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.

Harvest Regulations

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 are also evaluating 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:

Refuges

Population abundance and size structure of largemouth bass are being assessed in Otter and Clinton Lake using spring and fall electrofishing and seining. The Clinton Lake refuge was closed in 2001 and samples were taken both before and now 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 2010 and the spring of 2011. Two, thirty minute electrofishing transects and two seine hauls were performed inside the refuge on each sampling date. Two transects were also electrofished and seined outside of the refuge. Sites outside of the refuge were located adjacent to and at approximately 2 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, in the summer of 2010, two refuges were closed to fishing in Otter Lake by running a buoy line with a no fishing marker attached. In this segment, we began the first year of post-refuge sampling in Otter Lake because the buoy lines were put in place after largemouth bass spawning was complete. One 30 minute electrofishing transect and one seine haul were conducted in each refuge location. In addition, three control sites were sampled (1 electrofishing transect and 1 seine haul in each) within the lake. 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.

Harvest Regulations

Largemouth bass angling regulations in Illinois Lakes are also being evaluated. In previous segments, regulations on lakes with largemouth bass population data from Job 4, (including recruitment, abundance and size structure) and FAS data from 2007 were used for initial analyses. In this segment we have included additional years of data (2000-2007) from lakes with differing regulations identified from the FAS database. Data collected through IDNR fall surveys were compiled. The FAS data base was reduced to the lakes that were sampled in the fall at some point from 2000-2007 using AC shoreline electrofishing and had regulations posted in the IDNR Fisheries Bulletin. The lakes were categorized by their existing regulations into eight categories, Bag by Size (Bag limit above and below a specified size), Catch-and Release (no harvest allowed), Standard (14” length limit, 6 fish creel), Lowered Bag (14” length limit, <6 fish bag limit), Raised Length (>14” length limit, 6 fish bag limit), Raised Length/Low

Bag (>14" length limit, <6 fish bag limit), No Length (No minimum size limit), and Slot (no fish harvest slot). These lakes were then compared across regulation type for differences in CPUE of young-of-year largemouth bass, CPUE of largemouth bass greater than 14 inches, and proportional stock density (PSD) with stock size being 200 mm and quality size being 300 mm. In addition we determined the number of memorable (510 mm and larger) sized fish in electrofishing samples.

FINDINGS:

Refuges

Mean CPUE for largemouth bass in Clinton Lake from 1999 through 2001 was 26 fish per hour of electrofishing. This is in the lower range of our study lakes, which have a range of CPUE from 15.2 to 83.3 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 2002 through 2011 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. Young- of-year largemouth bass densities have also increased inside the refuge. CPUE of young-of-year largemouth bass has fluctuated in the refuge sites but has increased since 2007 (Table 6-1A). The CPUE of young-of-year largemouth bass has decreased in the control sites since 2001. Densities of largemouth bass in seines is also the highest in the refuge sites and has increased after the refuge was closed (Table 6-2A). Despite the increase in adult and young-of-year largemouth bass in the refuge sites, there is no evidence of the benefits of the refuge extending into the remainder of the lake. 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 began monitoring refuge and continued monitoring reference sites in Otter Lake during this segment. The spring of 2011 was the first spawning season since the two refuges were closed to fishing and boating. In the spring and fall of 2007- 2010, we observed similar catch rates of adult and young-of-year largemouth bass in electrofishing samples in the refuge sites compared to the control sites (Table 6-1). The proposed refuge sites appear to be in areas with good largemouth bass abundance and closing these areas to fishing has the potential to increase recruitment. Spring electrofishing CPUE of largemouth bass in 2011 was lower than the mean pre-refuge conditions in both the refuge and control sites. Similar trends were observed in density of largemouth bass from seine hauls in the control and refuge sites (Table 6-2B). We would not expect large changes in the largemouth bass community in the first spring following implementation of a refuge and any conclusions from the data would be premature. We will continue to 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 than on Clinton due to its smaller size and the refuges will be further evaluated in future segments.

Harvest Regulations

In this segment we summarized 6 additional years of FAS data to expand the previous analysis of regulations. We calculated CPUE from fall electrofishing in all lakes reported in the FAS database from 2000-2007 resulting in catch rates for 429 lakes. Regulation data was then compiled from the Illinois Department of Natural Resources (IDNR) fishing regulations guide for these same lakes. The resulting database was 218 lakes that had both electrofishing data and regulation data available. Regulations were grouped into 8 categories; Catch and Release (n = 1), Bag by Size (n = 1), Standard (n = 50), Lowered Bag (n = 20), Raised Length (n = 26), Raised Length and Lowered Bag (n = 65), No Length (n = 37), and Slot (n = 18). Largemouth bass populations in lakes with slot limits differed the most from populations with other regulations. Mean CPUE of largemouth bass from electrofishing was significantly different among regulation types ($F = 3.38$; $P = 0.006$) with slot limits being the highest and significantly greater than all regulation types except No Length regulation lakes (Figure 6-1). There was also significant differences in the CPUE of young-of-year largemouth bass ($F = 3.67$; $P = 0.003$) with Slot Limits being significantly higher than Raised Length, Standard, and Raised Length Lowered Bag lakes (Figure 6-2). CPUE of memorable fish was low in all lakes (0.19 to 0.88) but there were significant differences among regulation types ($F = 5.09$; $P = 0.0002$). Again slot limit lakes had the highest CPUE of memorable fish and was significantly greater than all regulation types except Standard. PSD was also different among lakes ($F = 2.41$; $P = 0.04$) but only between Slot Limit lakes and Standard regulation lakes ($P < 0.05$). The Slot limit lakes had the lowest PSD of all regulation types due primarily to the high number of smaller fish in these lakes rather than a lack of larger fish.

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 in Otter Lake 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. 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 continue to develop and analyze a large database of lakes with differing regulations. 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. Our analysis thus far shows that lakes with slot limits have the most differences from other regulation types. It is unclear if this is a result of the regulation, or reason the regulation was implemented. Usually a slot limit is implemented when there is a need to protect fish in a critical size range to allow them to grow into the upper slot. However, it also allows for harvest of small size fish and can be implemented to encourage harvest of smaller size classes when their density is high enough that the population could be limited by resources. In future segments, we will examine time series data to determine changes in populations as regulations are implemented. If possible, data before and after regulation changes will be examined and the length of time a regulation has been implemented will be evaluated. We will also utilize creel data that is available to determine the level of harvest associated with each regulation and if harvest rates are high enough to induce changes in fish populations.

In future segments we will continue to incorporate lakes with FAS data and INHS sampling to develop a long term database of lakes with fish community data and creel sampling. The number and frequency of lakes where angling creels were performed will limit the number of lakes that can be included in this aspect of the study. We will create an extensive database that can be used to examine differences in electrofishing catch, and a reduced database including creel data. We will contact DNR district biologists and determine when regulations were initiated and use creel and FAS data to compare catch rates of anglers, CPUE from electrofishing and size structure of largemouth bass in these lakes before and after the regulation were put in effect. In doing so, we hope to better understand the value of differing management regulations on lakes throughout Illinois. 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. Cost of producing fish for three lakes in Illinois stocked for 5 years with both intensively reared and extensively reared fish. Extensively reared fish were produced in ponds and fed zooplankton and fathead minnows, whereas intensively reared fish were produced in raceways and fed pelleted diet. Mean total stocking cost is calculated as the cost per fish multiplied by the mean number of fish stocked into the lake. Total Cost per CPUE is calculated as the total stocking cost of stocking divided by the CPUE (#/hr.) from electrofishing in the 1st, 2nd, and 3rd fall following stocking.

Lake	Lake Area (acres)	Rearing Method	Hatchery Cost / Fish	Rearing Pond Cost / Fish	Total Cost per Stocked Fish	Mean Total Stocking Cost	Total Cost per CPUE		
							1st Fall	2nd Fall	3rd Fall
Jacksonville	476	Extensive	$0.03	$0.48	$0.51	$3,095	$900	$2,579	$4,486
Shelbyville	11,100	Extensive	$0.03	$0.48	$0.51	$7,758	$2,255	$6,465	$11,244
Walton Park	30	Extensive	$0.05	$0.55	$0.60	$375	$109	$313	$543
					Mean	$3,743	$1,088	$3,119	$5,424
Jacksonville	476	Intensive	$0.15	NA	$0.15	$638	$759	$1,821	$1,875
Shelbyville	11,100	Intensive	$0.15	NA	$0.15	$1,322	$1,574	$3,777	$3,888
Walton Park	30	Intensive	$0.15	NA	$0.15	$94	$112	$268	$276
					Mean	$684	$815	$1,955	$2,013

Table 2-2. Stocking information for four lakes stocked with largemouth bass both at the boat ramp and dispersed into habitat throughout the lake. CPUE is catch per hour from electrofishing transects conducted 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
	8/25/2009	3500	0.8	0	3500	0	0.7
	9/2/2010	3500	1.3	0	3500	1.3	0
Homer	8/16/2007	1400	0	0	1400	0.3	0
	8/24/2009	1000	0	0	1000	0.3	0
	8/26/2010	1000	1.7	0	1000	0	0.7
Mingo	8/16/2007	3400	0.7	0	3400	2.0	0
	8/14/2008	2150	5.7	0	2150	3.7	0.7
	8/24/2009	2125	0	0	2125	0.3	0
	8/26/2010	2125	1.3	0	2125	0.3	0
Otter	8/15/2007	7650	0	0	7650	0	0
	8/13/2008	11400	0.8	0	11400	0.2	0
	8/25/2009	7650	0.4	0	7650	0	0
	8/25/2010	7650	0.9	1.7	7650	0.4	0
Mean Total			1.1	0.1		0.8	0.2

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 4-1: Mean percent cover for each species of vegetation planted in Lake Paradise in June and July of 2008 (A.) and July of 2009 (B.). Percent cover was visually assessed in each of three sizes of enclosure (large, small dispersed, and small clustered).

A. Planted in 2008

Vegetation Planted	Size	Number Planted	Percent Cover		
			2008	2009	2010
American Pondweed	Large	6	78	5	34
American Pondweed	Small	12	61	2	12
Chara	Large	6	1	0	0
Chara	Small	12	0	0	0
Chara	Clustered	4	0	0	0
Coontail	Large	7	16	1	0
Coontail	Small	16	3	0	0
Coontail	Clustered	4	0	0	0
Sago	Large	4	23	0	0
Sago	Small	34	12	6	0
Sago	Clustered	16	12	0	0
Wild Celery	Large	13	22	1	0
Wild Celery	Small	59	14	1	1
Wild Celery	Clustered	52	15	1	0

B. Planted in 2009

Veg Planted	Size	Number	Percent Cover	
			2009	2010
American Pondweed	Large	11	19	6
American Pondweed	Small	20	11	17
Wild Celery	Large	12	4	3
Wild Celery	Small	33	4	5

Table 4-2: Density of fish from backpack electrofishing and density of invertebrates from stovepipe core samples associated with vegetation enclosures planted in Lake Paradise in 2008 and 2009.

Vegetation	N	Density (#/m2)
	Fish	
American Pondweed	21	0.71
Coontail	1	0.80
Sago	1	2.55
Wild Celery	6	0.94
All vegetated cages	29	0.82
No Vegeation	26	0.70
	Benthic Invertebrates	
American Pondweed	12	22672
Sago	1	44012
Wild Celery	9	35250
All vegetated cages	22	28788
No Vegetation	9	17610

Table 4-3: Data from spring and fall vegetation assessments on 11 Illinois lakes. 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. Dashes indicate data still being analyzed.

Lake	Type	Lake Area (m^2)	Lake Perimeter (m)	Area Vegetated				Percent of Lake Vegetated			
				Spring		Fall		Spring		Fall	
				Area (m^2)	Perimeter (m)	Area (m^2)	Perimeter (m)	Area (%)	Perimeter (%)	Area (%)	Perimeter (%)
Airport	Removal	89246	1171	95794	1171	89246	1174	100	100	100	100
Stillwater	Removal	89363	2215	19802	2232	1113	226	22	100	1	10
Dolan	Drawdown	302869	5335	59698	4384	78241	4504	20	82	26	84
Paradise	Planted	706098	7287	17495	2428	82980	4244	2	33	12	58
Forbes	Control	2056612	29364	281242	26983	276949	23424	14	92	13	80
Lincoln	Control	584546	10033	135213	9599	143317	9753	23	96	25	97
LOTW	Control	103090	2259	1030	114	197	88	1	5	0	4
Pierce	Control	647830	6406	145780	5703	143431	5934	23	89	22	93
Ridge	Control	44013	1132	16893	1195	20680	1484	38	100	47	100
Walnut	Control	215810	9396	2865	586	5248	589	1	6	2	6
Woods	Control	127217	3241	0	0	0	0	0	0	0	0

Table 4-4: CPUE for young-of-year and adult largemouth bass in 11 lakes with varying vegetation densities (see Table 4-3). In addition, mean larval fish, zooplankton, and benthic macroinvertebrate density for each lake from spring, summer and fall samples.

Lake	Type	Fall Electrofishing CPUE (#/hr)			Larval Fish Density (#/m3)			Mean Total Zooplankton Density (#/L)	Mean Total Benthos Density (#/m^2)
		YOY LMB (<200mm)	BLG	LMB >200mm	Shad	Lepomis	Total		
Airport	Removal	9.0	152.7	6.2	0.0	0.3	0.3	491	13833
Stillwater	Removal	69.0	66.7	14.3	0.0	5.8	7.0	66	6118
Dolan	Drawdown	6.8	104.0	58.8	0.2	12.3	12.4		7779
Paradise	Planted	14.7	100.0	36.0	1.3	3.4	4.7	210	7171
Forbes	Control	11.0	100.7	20.2	3.8	2.6	6.7		2493
Lincoln	Control	72.3	100.0	34.7	0.0	6.9	6.9	295	9742
LOTW	Control	12.8	94.0	20.0	0.6	3.2	4.3	124	12872
Pierce	Control	30.7	67.0	21.0	0.1	0.3	0.4	23	11565
Ridge	Control	18.1	66.0	15.6	0.0	3.4	3.4	135	10066
Walnut Point	Control	48.0	58.7	19.3	0.0	3.5	3.6	911	11217
Woods	Control	6.4	161.0	13.6	0.4	5.6	6.1	294	19997

Table 4-5: Numbers of young of year largemouth bass found in the streams below the dams of both Forbes Lake and Ridge Lake by month.

Lake	April	May	June	July-Oct.
		YOY		
Forbes	0	3	2	32
Ridge	0	8	26	0
		Age 1+		
Forbes	5	6	2	1
Ridge	2	0	0	2

Table 5-1: The total number of boats, fish caught, and weight for tournaments conducted in the spring of 2010.

Date	Number of Boats	Total # of Fish	Total Weight (lbs)
4/17/10	9	26	25.8
4/21/10	5	27	29.1
4/25/10	4	17	20.1
4/28/10	6	24	29.2
4/30/10	6	27	31.2
5/5/10	3	21	21.8
5/17/10	6	25	23.7
Total	39	167	180.9

Table 5-2: Lake characteristics of Ridge Lake in years with springtime tournaments and years with no tournaments.

Year	Type	Mean Fall Electrofishing CPUE (#/hour)			Larval Fish Density (#/L)	Zooplankton Density (#/L)	Benthos Density (#/m2)
		YOY LMB (<200mm)	BLG	LMB >200mm			
2010	Tournament	18.1	66	15.6	3.4	135.1	10065.59
2009	No Tourn.	52.5	80.6	19.2	9.2	1150.7	5127.31
2008	No Tourn.	39.2	96.8	49.9	0.11	458.8	11502.06
2007	Tournament	59.2	67.2	52.3	1.15	399.4	7563.53
2006	No Tourn.	29.1	50.8	41	0.5	352.2	3859.86

Table 5-3: Mean tournament pressure for 2009 and 2010 on nine lakes located throughout Illinois. Tournament participation and catch rates were obtained from organizers of events on each of the lakes.

Lake	Size (acres)	Mean Number of Tournaments	Mean Number of Participants	Mean Hours Fished	Mean # of Fish Weighed in	Mean Weight (lbs.)	Mean Annual Angler Hours	Angler hours per acre
Bloomington	635	14.0	33.6	5.4	32.0	2.7	2540	4.0
Clinton	5000	25.0	54	9.3	47.2	3.1	12555	2.5
Coffeen	1100	49.0	27.4	7.4	53.1	2.1	9935	9.0
Evergreen	886	15.5	28.6	5.4	28.9	3.4	2394	2.7
Forbes	525	41.0	27.6	5.8	19.1	2.2	6563	12.5
Mattoon	1050	8.5	23.8	4.9	17.2	2.4	991	0.9
Mill Creek	811	94.0	28.7	6.5	47.6	1.9	17536	21.6
Sangchris	2165	48.0	28.5	8.0	58.5	1.8	10944	5.1
Shelbyville	11100	45.0	49.2	8.1	79.2	2.1	17933	1.6

Table 5-4: Catch per unit effort on lakes with and without tournaments in Illinois from spring electrofishing transects for all largemouth bass (Total), young-of-year largemouth bass (YOY), largemouth bass over 14 inches, and memorable largemouth bass. PSD is the proportion of stock density for each lake. Lakes were separated into None, Low and High based on the level of tournament activity.

Lake	Tournament Pressure	Total	YOY	Over14	Memorable	PSD
Bloomington	Medium	11.4	4.0	2.0	0.7	27.3
Charleston	None	11.0	0.7	3.0	0.3	83.9
Clinton	Low	13.8	1.0	5.1	0.0	56.0
Evergreen	Low	19.3	5.3	5.3	0.0	57.1
Forbes	High	20.0	0.7	4.7	0.7	46.6
Lincoln	None	27.2	9.6	0.4	0.0	18.2
LOTW	None	18.7	1.4	7.5	0.0	67.6
Mattoon	Low	21.3	0.0	6.0	0.7	71.9
Mill Creek	High	12.7	6.0	0.0	0.0	50.0
Shelbyville	Low	43.7	4.7	16.0	0.0	69.2
Walnut	None	14.0	7.7	1.7	0.3	52.6
Woods	None	7.7	1.0	2.3	0.0	60.0

Table 6-1: Catch per unit effort (#/hour) of largemouth bass and young-of-year largemouth bass in spring and fall electrofishing on Clinton Lake (A) and Otter Lake (B). Refuge sites were located in areas of the lake closed to fishing and boating and control sites were located outside of the closed areas.

A. Clinton Lake

Year	Control Sites				Refuge Sites			
	Total LMB CPUE		YOY LMB CPUE		Total LMB CPUE		YOY LMB CPUE	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Pre Refuge								
1999	19.8	23.3	10.6	10.4	56.0	24.0	32.0	12.0
2000	32.4	5.5	16.9	4.0	18.0	0.0	8.0	0.0
2001	26.0	48.7	6.0	30.7	10.0	22.0	0.0	8.0
Pre Refuge Mean	26.1	25.8	11.2	15.0	28.0	15.3	13.3	6.7
Post Refuge								
2002	8.3	29.0	1.0	17.3	NA	NA	NA	NA
2003	21.5	23.8	5.5	6.0	NA	87.5	NA	12.0
2004	20.7	28.3	2.5	7.0	42.0	146.0	9.0	16.0
2005	25.1	18.3	1.9	4.3	32.0	25.0	0.0	8.0
2006	13.9	16.5	1.4	3.4	48.0	98.0	8.0	32.0
2007	12.7	32.7	4.0	6.0	90.0	88.0	14.0	12.0
2008	36.5	36.0	6.3	4.3	76.0	220.0	0.0	18.0
2009	15.0	29.2	0.0	9.8	75.0	98.0	5.0	18.0
2010	13.0	5.0	2.0	2.0	14.6	78.0	0.0	22.0
2011	16.0	NA	2.0	NA	86.0	NA	6.0	NA
Post Refuge Mean	18.3	24.3	2.7	6.7	58.8	105.1	5.3	17.3

B. Otter Lake

Year	Control Sites				Refuge Sites			
	Total LMB CPUE		YOY LMB CPUE		Total LMB CPUE		YOY LMB CPUE	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Pre Refuge								
2007	NA	43.6	NA	11.8	NA	69.0	NA	33.0
2008	25.8	45.5	1.0	16.8	14.9	23.0	0.0	0.0
2009	28.8	55.0	4.5	16.8	23.0	51.9	5.0	8.3
2010	35.5	31.5	7.3	7.6	26.0	34.0	12.0	6.0
Pre Refuge Mean	30.0	43.9	4.3	13.2	21.3	44.5	5.7	11.8
Post Refuge								
2011	19.9	NA	1.7	NA	9.2	NA	1.5	NA

Table 6-2: Density of fish from seine hauls performed in refuge (n=2) and control sites (n=2) on Clinton Lake (A) and Otter Lake (B). Density is reported for all fish (Total), largemouth bass (LMB), bluegill (BLG), and gizzard shad (GZS).

A. Clinton Lake

Year	Control Seine Density (#/m2)				Refuge Seine Density (#/m2)			
	Total	LMB	BLG	GZS	Total	LMB	BLG	GZS
Pre Refuge								
1999	0.37	0.02	0.12	0.25	0.35	0.03	0.04	0.11
2000	0.34	0.01	0.05	0.05	0.25	0.01	0.04	0.28
2001	0.36	0.01	0.09	0.06	0.38	0.03	0.07	0.10
Pre Refuge Mean	0.35	0.01	0.09	0.12	0.33	0.02	0.05	0.16
Post Refuge								
2002	0.43	0.02	0.08	0.09	0.44	0.05	0.25	0.11
2003	0.75	0.12	0.12	0.26	1.11	0.02	0.26	0.11
2004	0.64	0.04	0.13	0.34	0.34	0.03	0.04	0.02
2005	0.41	0.12	0.11	0.05	0.65	0.19	0.14	0.05
2006	0.21	0.03	0.06	0.02	0.54	0.09	0.30	0.08
2007	0.48	0.01	0.10	0.06	0.48	0.03	0.07	0.03
2009	0.41	0.00	0.01	0.21	0.22	0.00	0.05	0.13
2010	0.20	0.00	0.04	0.00	0.20	0.03	0.03	0.00
2011	0.14	0.00	0.00	0.00	1.33	0.29	0.00	0.00
Post Refuge Mean	0.41	0.04	0.07	0.11	0.59	0.08	0.13	0.06

B. Otter Lake

Year	Control Seine Density (#/m2)				Refuge Seine Density (#/m2)			
	Total	LMB	BLG	GZS	Total	LMB	BLG	GZS
Pre Refuge								
2007	0.14	0.03	0.17	0.00	0.23	0.02	0.21	0.00
2008	0.27	0.02	0.28	0.00	0.10	0.00	0.13	0.00
2009	0.06	0.00	0.08	0.00	0.29	0.27	0.15	0.00
2010	0.10	0.02	0.09	0.00	0.05	0.00	0.05	0.00
Pre Refuge Mean	0.14	0.02	0.15	0.00	0.17	0.07	0.14	0.00
Post Refuge								
2011	0.02	0.00	0.02	0.00	0.05	0.01	0.03	0.01

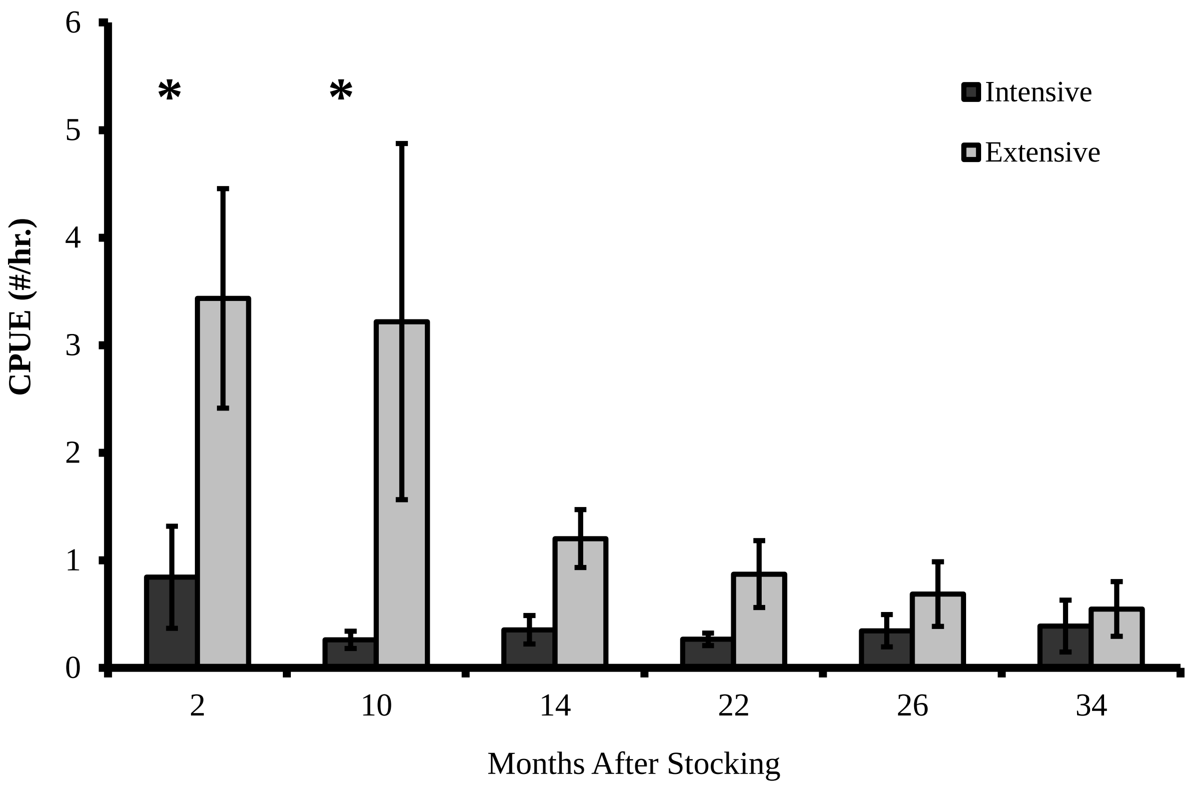

Figure 2-1: Mean CPUE of intensive and extensive fish collected in AC electrofishing samples following stocking. Samples were collected in the fall following stocking and each spring and fall for 5 years thereafter. The stars indicate time periods where there were significant differences in CPUE of intensively and extensively reared fish.

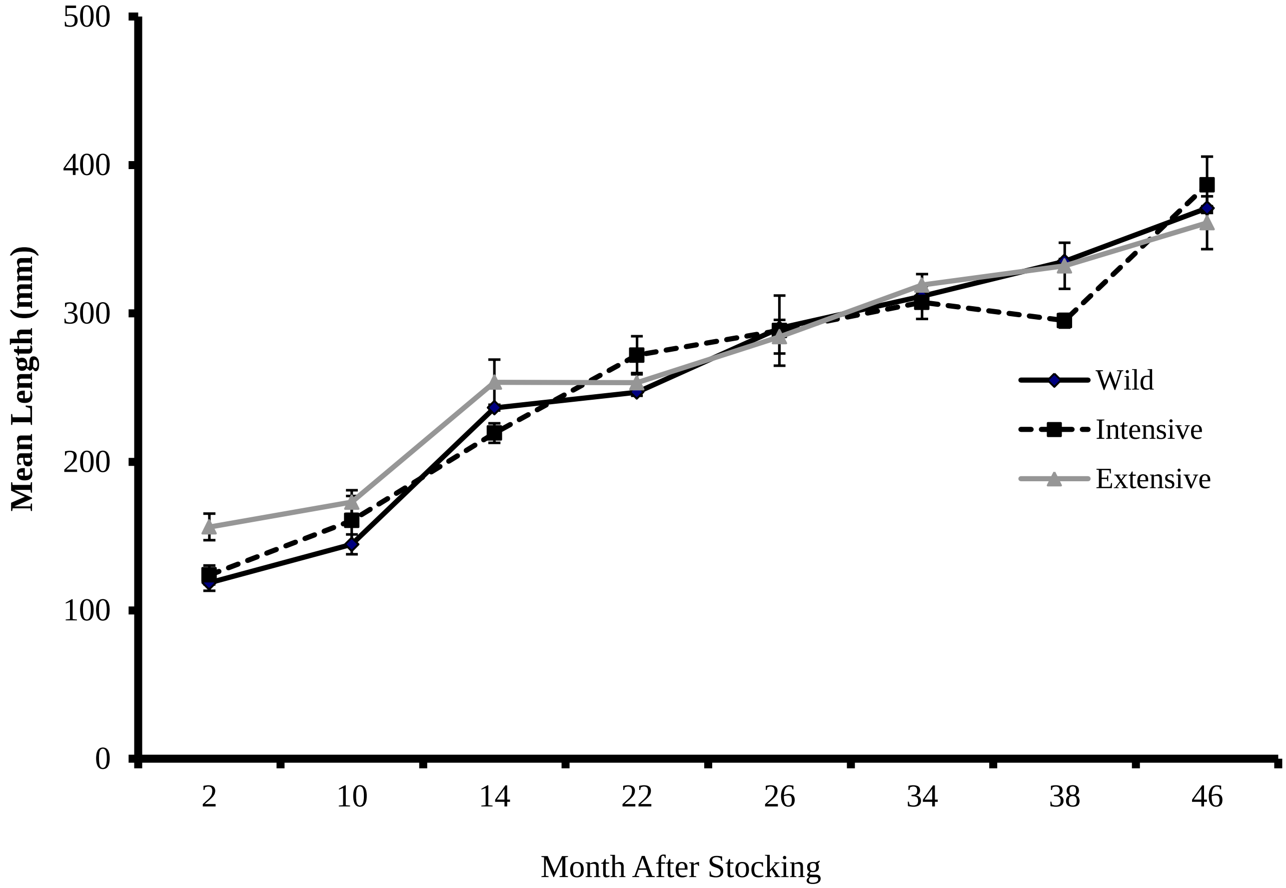

Figure 2-2: Mean length of intensive, extensive, and wild fish collected in AC electrofishing samples in the months following stocking. Samples were collected in the fall following stocking and each spring and fall for 5 years thereafter.

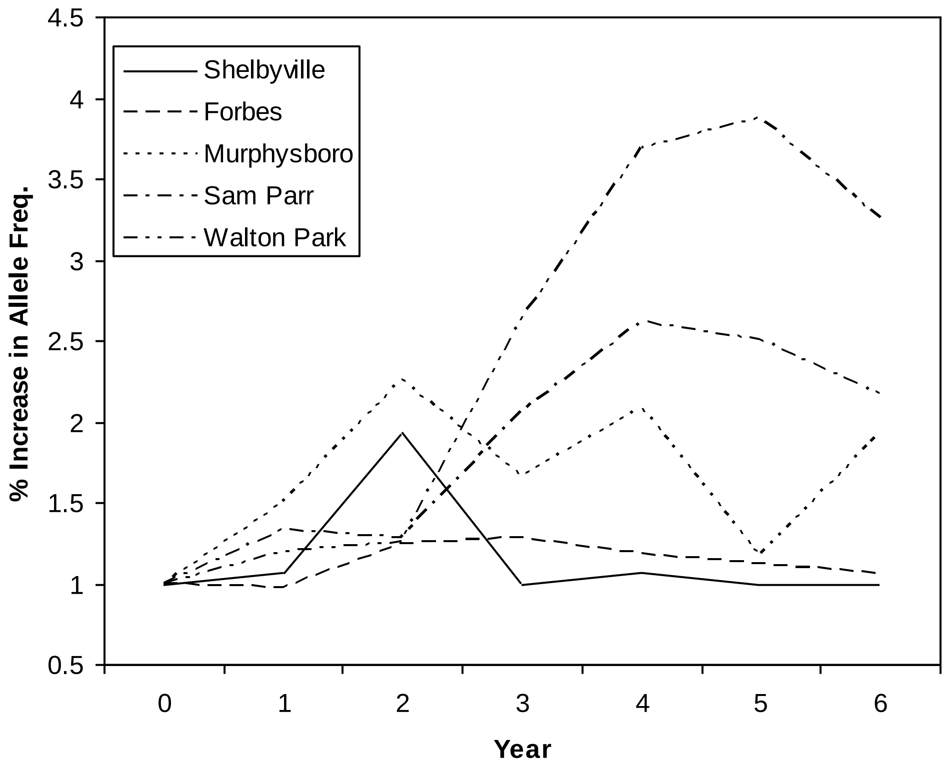

Figure 3-1: Frequency of the B2 allele in the five study lakes previous to stocking and in 2002-2007 during which stocked bass were expected to be contributing to reproductive population.

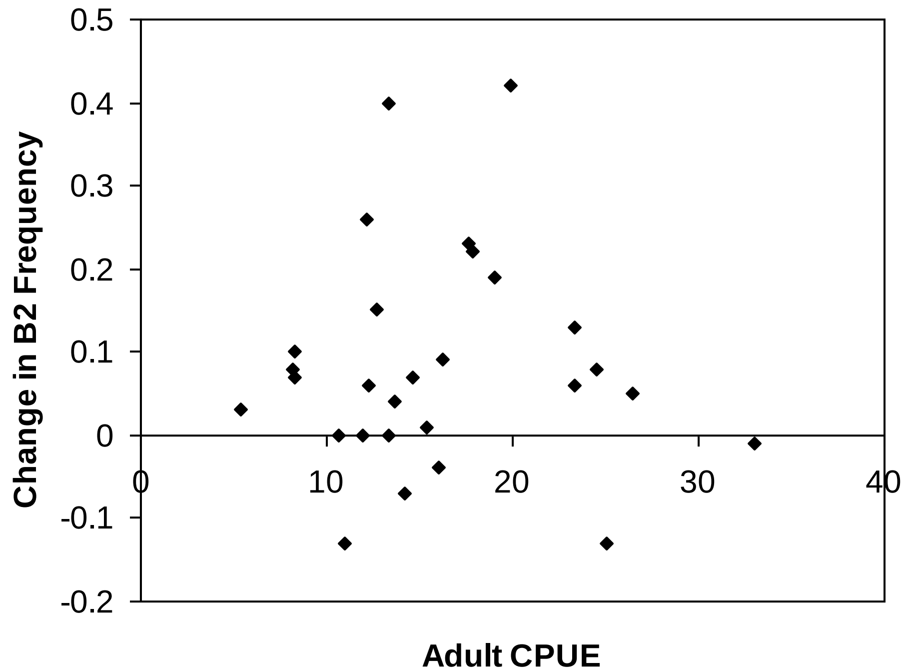

Figure 3-2: Change in B2 allele frequency against natural adult largemouth bass catch per unit effort for the five study lakes for each year between 2002 and 2007.

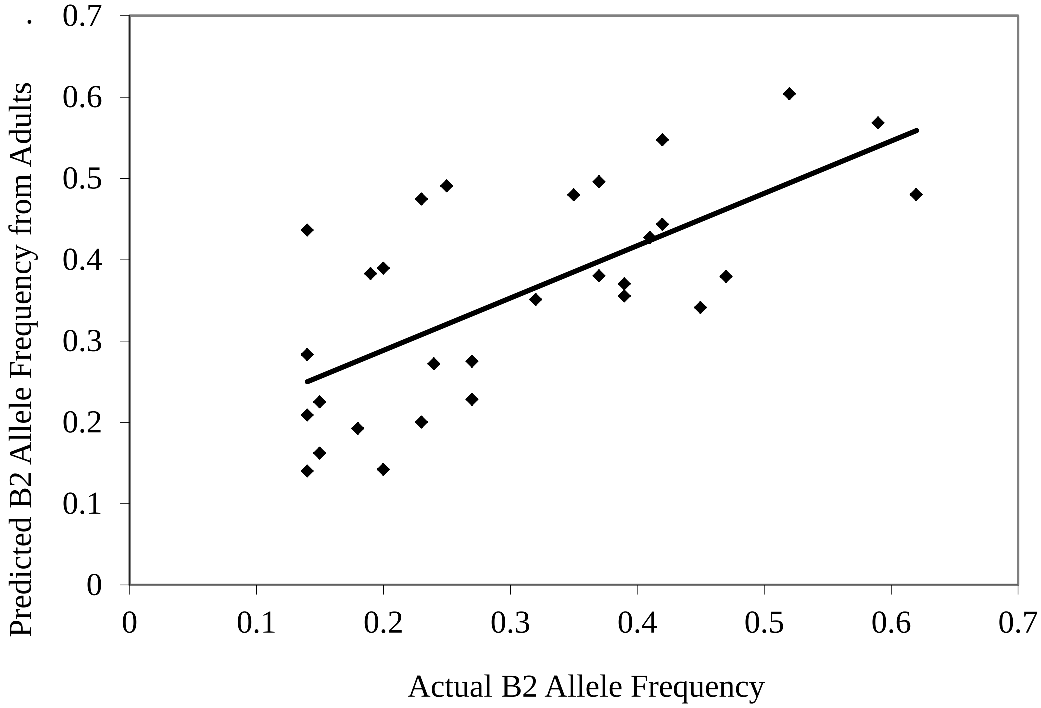

Figure 3-3: Regression of actual and predicted B2 allele frequency based on stocked adult fish for five study lakes for each year from 2002-2007.

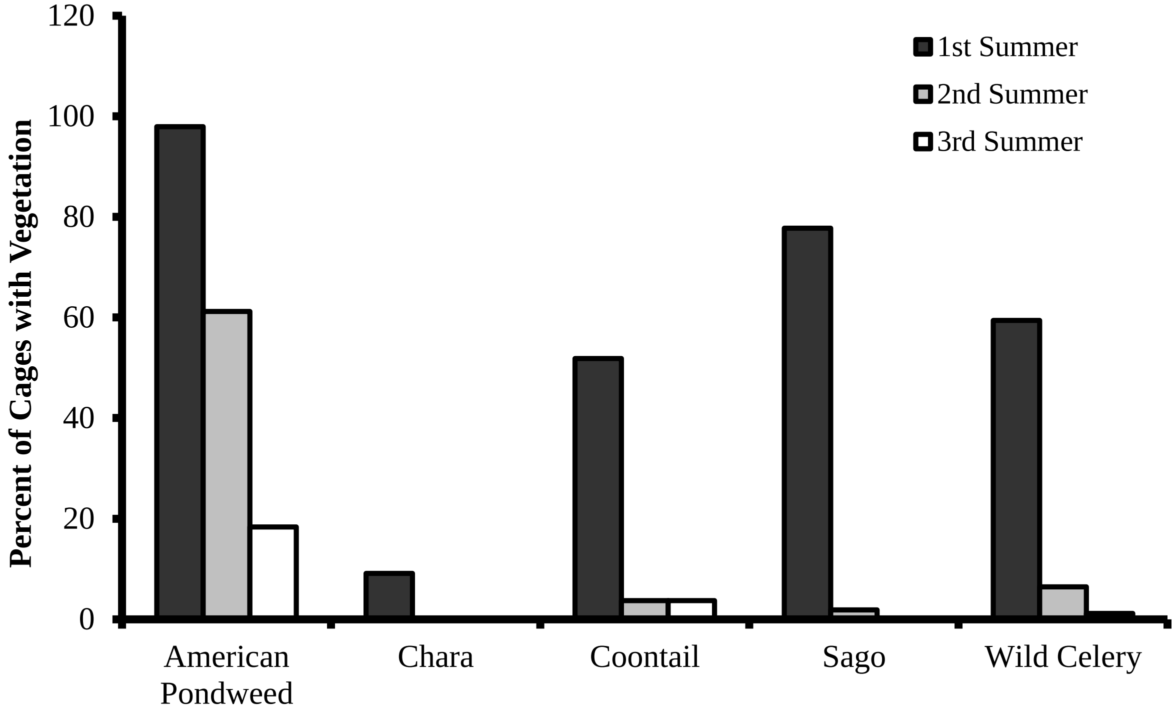

Figure 4-1: The percent of cages that were planted in 2008 and 2009 that had vegetation surviving through the 1st, 2nd, and third summer following planting. A cage was considered vegetated if it had any of the vegetation type planted present. Cages are separated into categories based on the species of vegetation planted.

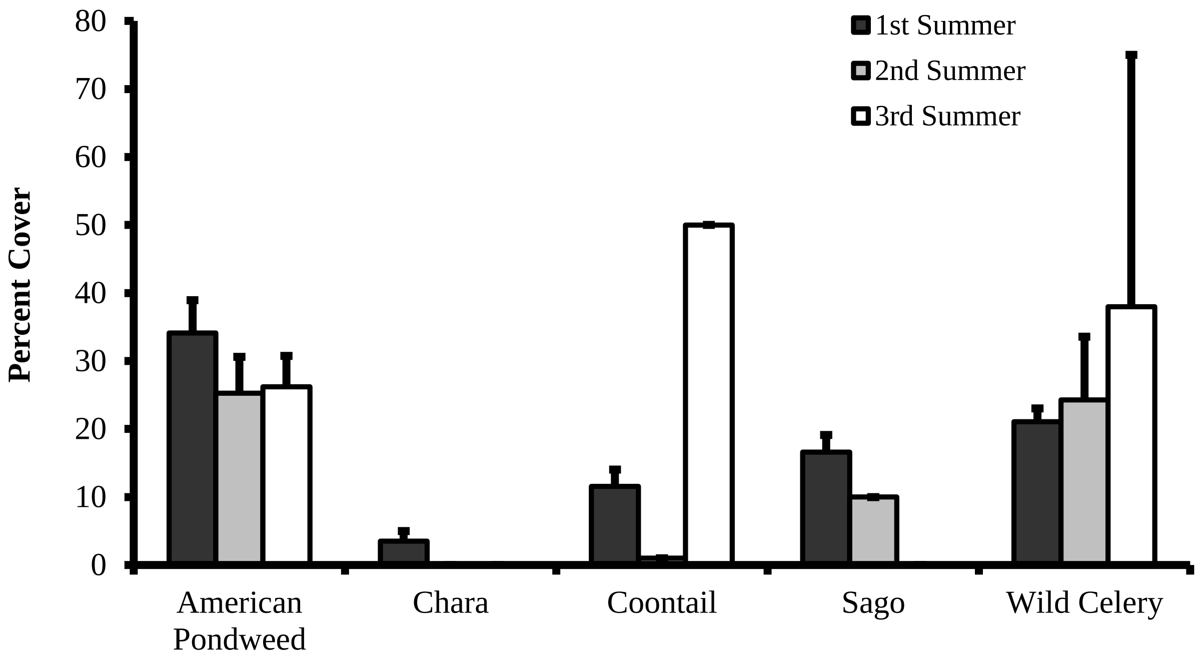

Figure 4-2: Percent cover of vegetation in cages that were vegetated in the 1st, 2nd and 3rd summers following planting. Percent cover was visually assessed in annually in August for three years following planting.

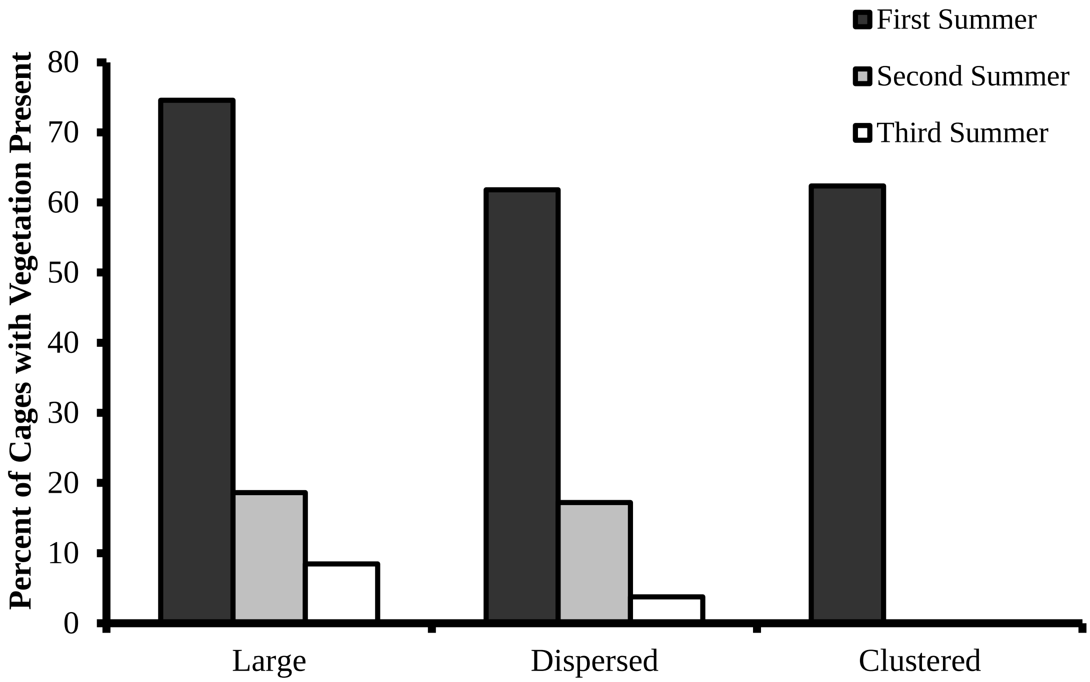

Figure 4-3: The percent of cages that were planted in 2008 and 2009 that had vegetation surviving through the 1st, 2nd, and third summer following planting. A cage was considered vegetated if it had any presence of the vegetation type planted. Cages are separated into categories based on the size and orientation.

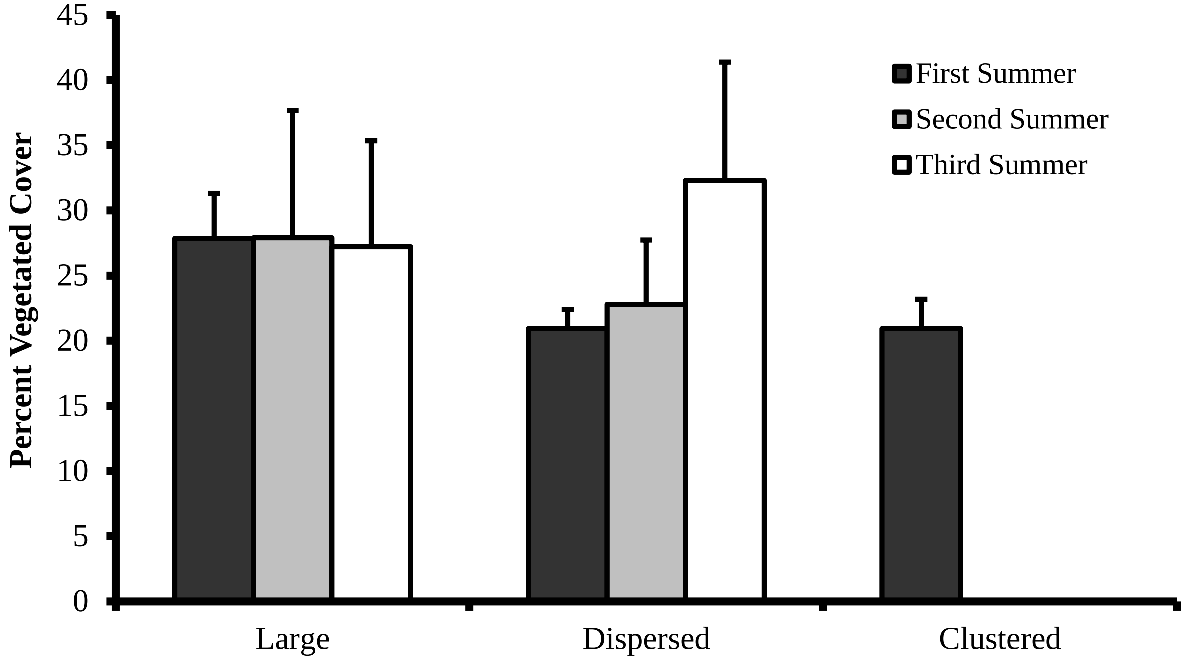

Figure 4-4: Percent cover of vegetation in cages that were vegetated in the 1st, 2nd and 3rd summers following planting. Percent cover was visually assessed in annually in August for three years following planting and compared among size and orientation of the cage.

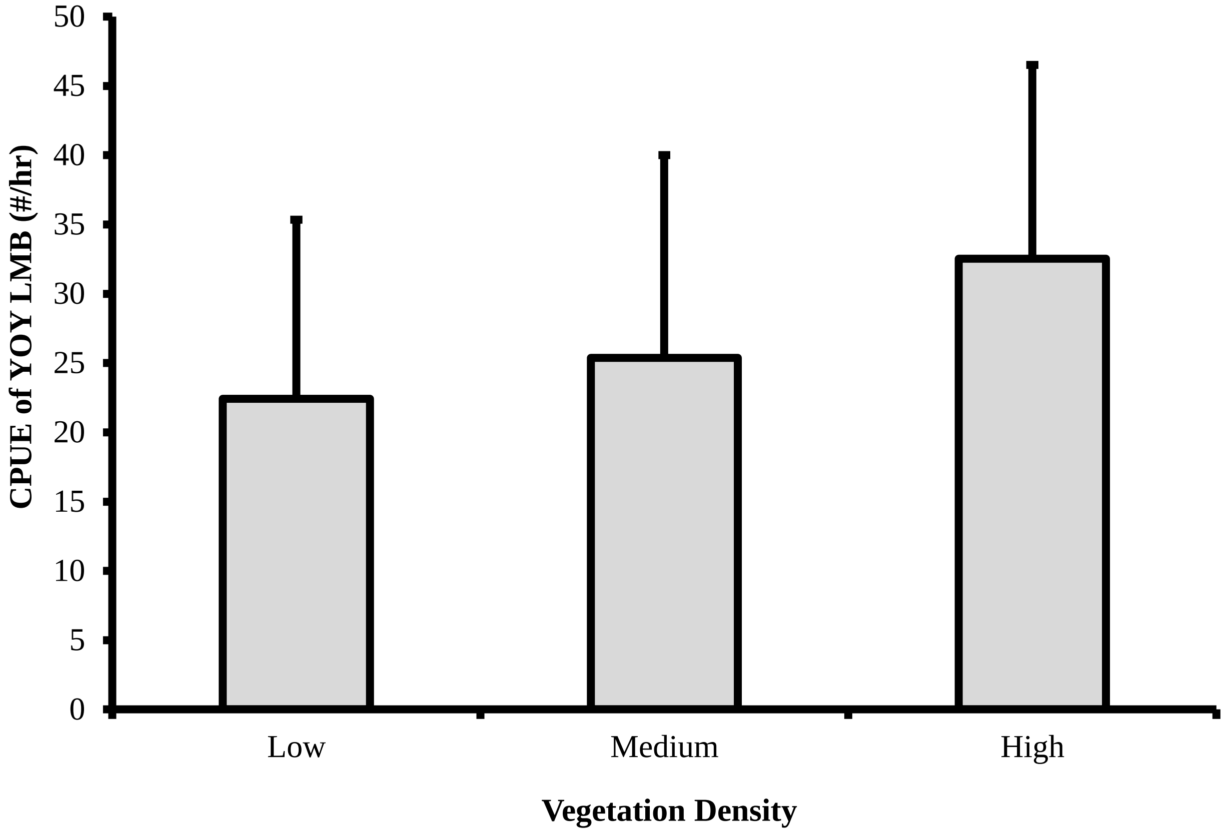

Figure 4-5: Mean CPUE of young-of-year largemouth bass (YOY LMB) from fall electrofishing samples in 11 lakes in Illinois separated into 3 categories based on the density of vegetation present. Error bars represent the standard error.

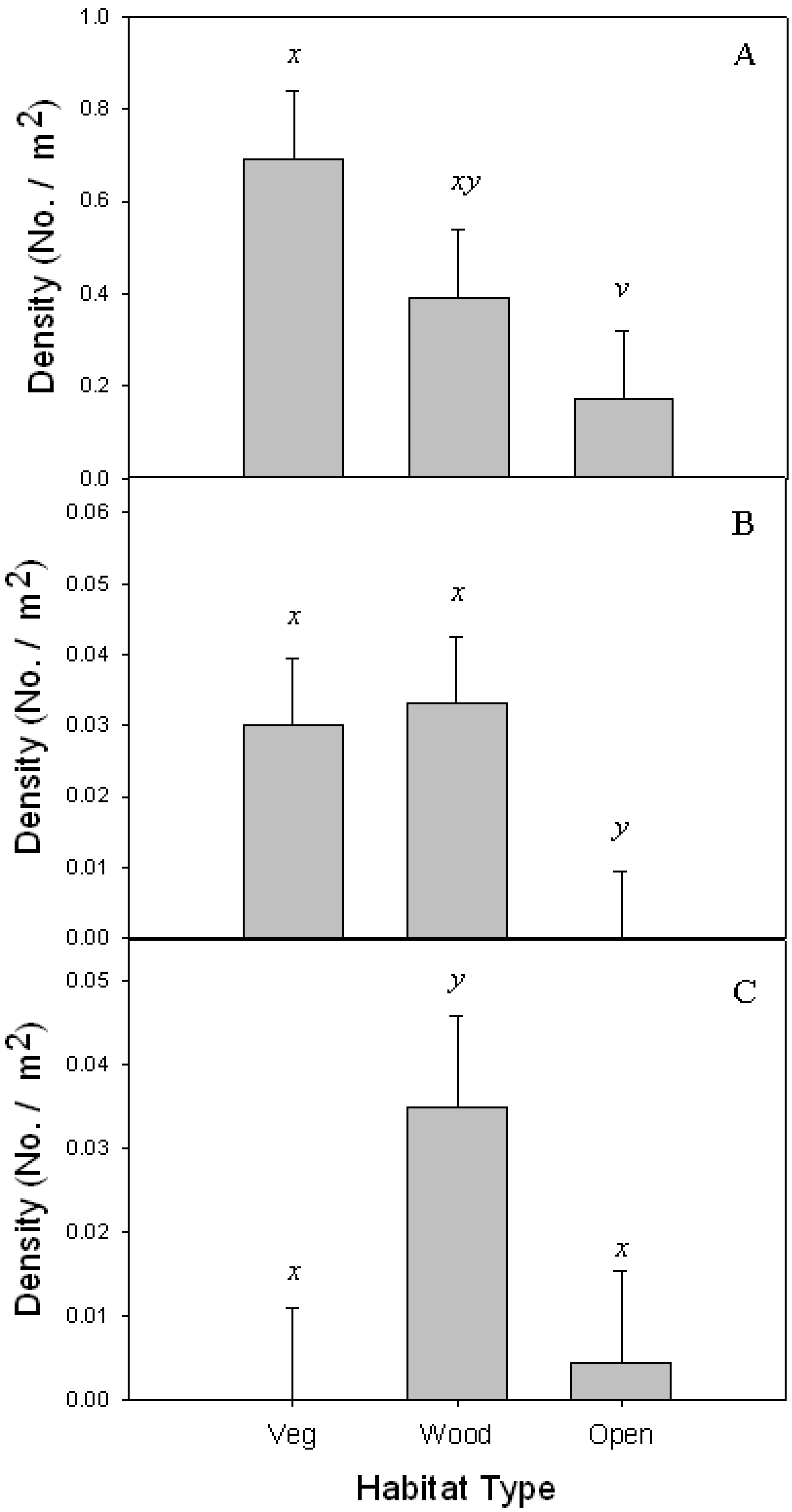

Figure 4-6: Mean densities of bluegills (panel A), and warmouth sunfish (panel B) in Lincoln Trail Lake and white crappie in Lake Paradise (panel C) sampled from vegetated, wooded and open shorelines during August of 2009 and 2010. Each bar represents an average of three sites of each category from each lake for two years (total N = 6 samples per habitat type). Lower case letters indicate significant differences between habitat types.

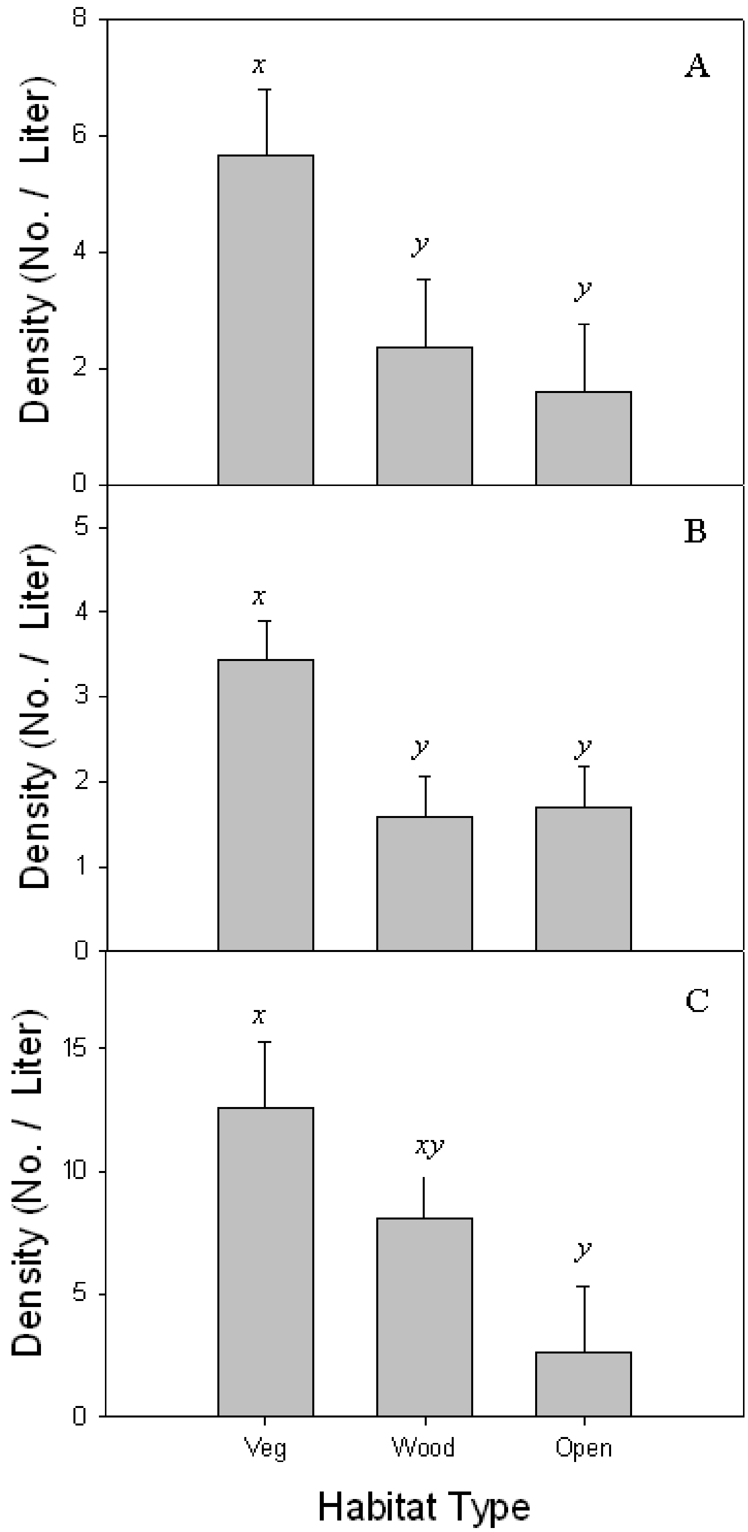

Figure 4-7: Mean densities of cyclopoida (panel A), and chydoridae (panel B) sampled in Lincoln Trail Lake and sididae sampled in Lake Paradise sampled from vegetated, wooded and open shorelines during August of 2009 and 2010. Each bar represents an average of three sites of each category from each lake for two years (total N = 6 samples per habitat type). Lower case letters indicate significant differences between habitat types.

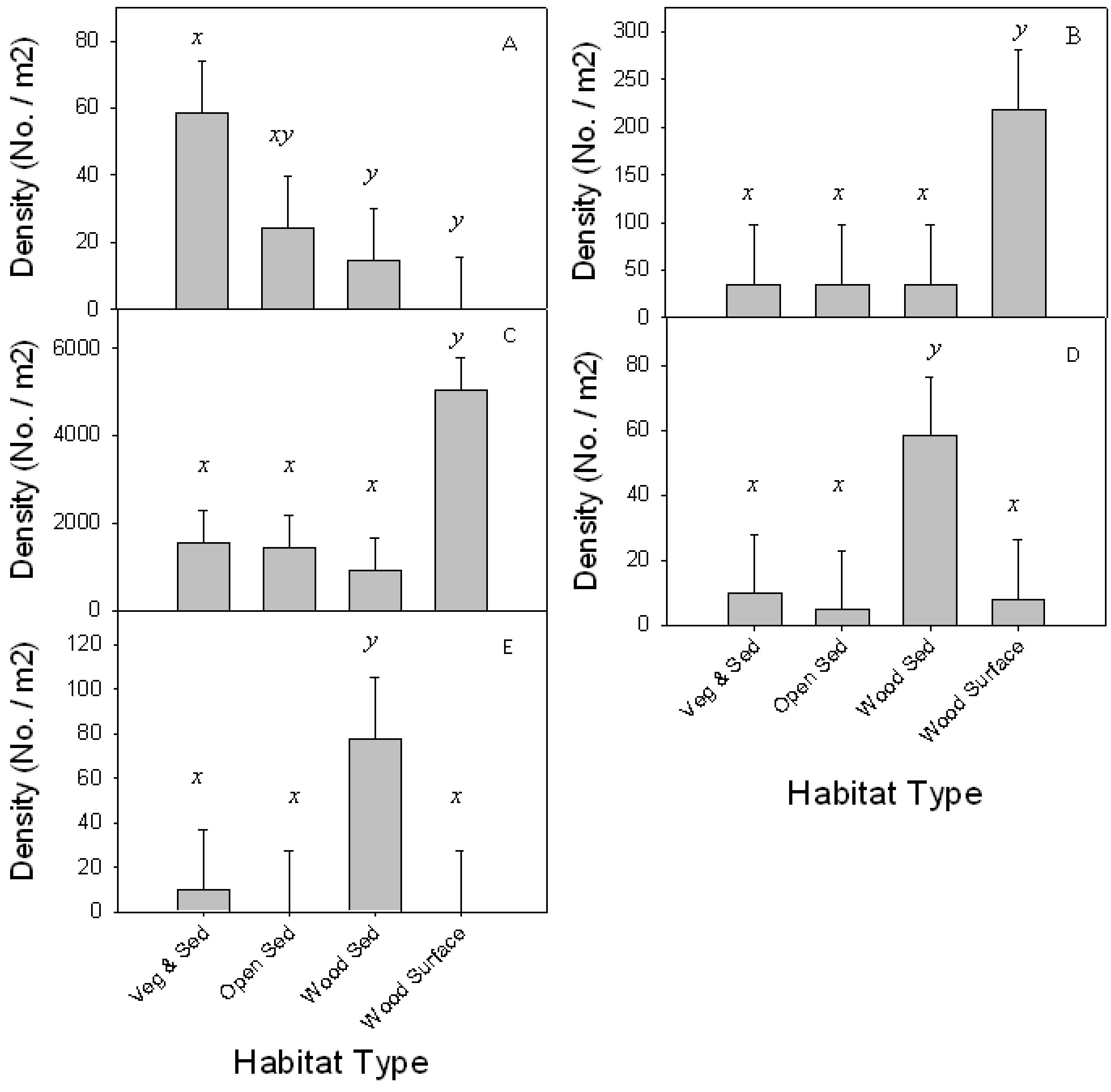

Figure 4-8. Mean density of macroinvertebrates of the family pelecoptera (panel A) and Trichoptera (Panel B) in Lincoln Trail Lake and mean density of chironomidae (panel C), dipteran pupae (panel D) and nematoda (panel E) in Lake paradise sampled from open sediment, vegetated sediment, wooded sediment and coarse woody debris surfaces sampled during August of 2009-2010. Each bar represents an average of three sites of each category from each lake for two years (total N = 6 samples per habitat type). Lower case letters indicate significant differences among habitat types.

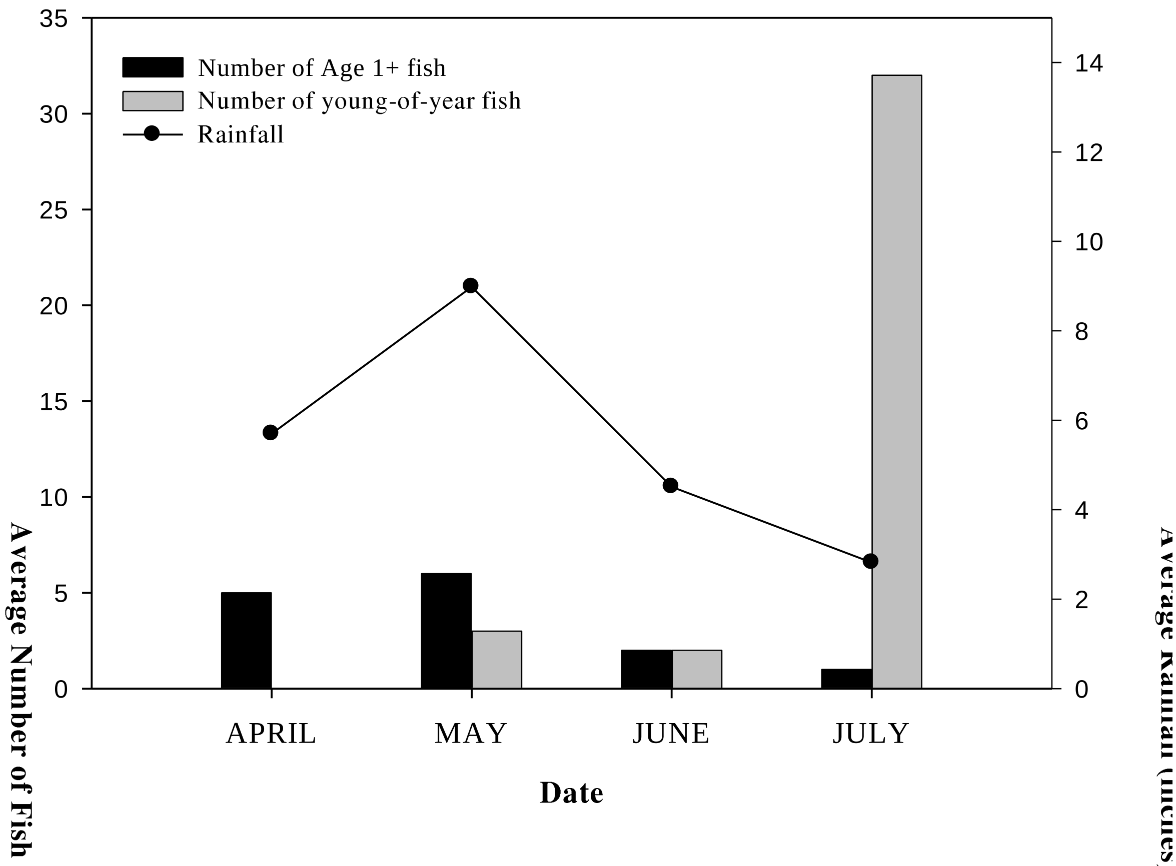

Figure 4-9: Average number of young of year and age 1+ largemouth bass collected by backpack electrofishing and rainfall by month in the Lost Fork stream below Forbes Lake.

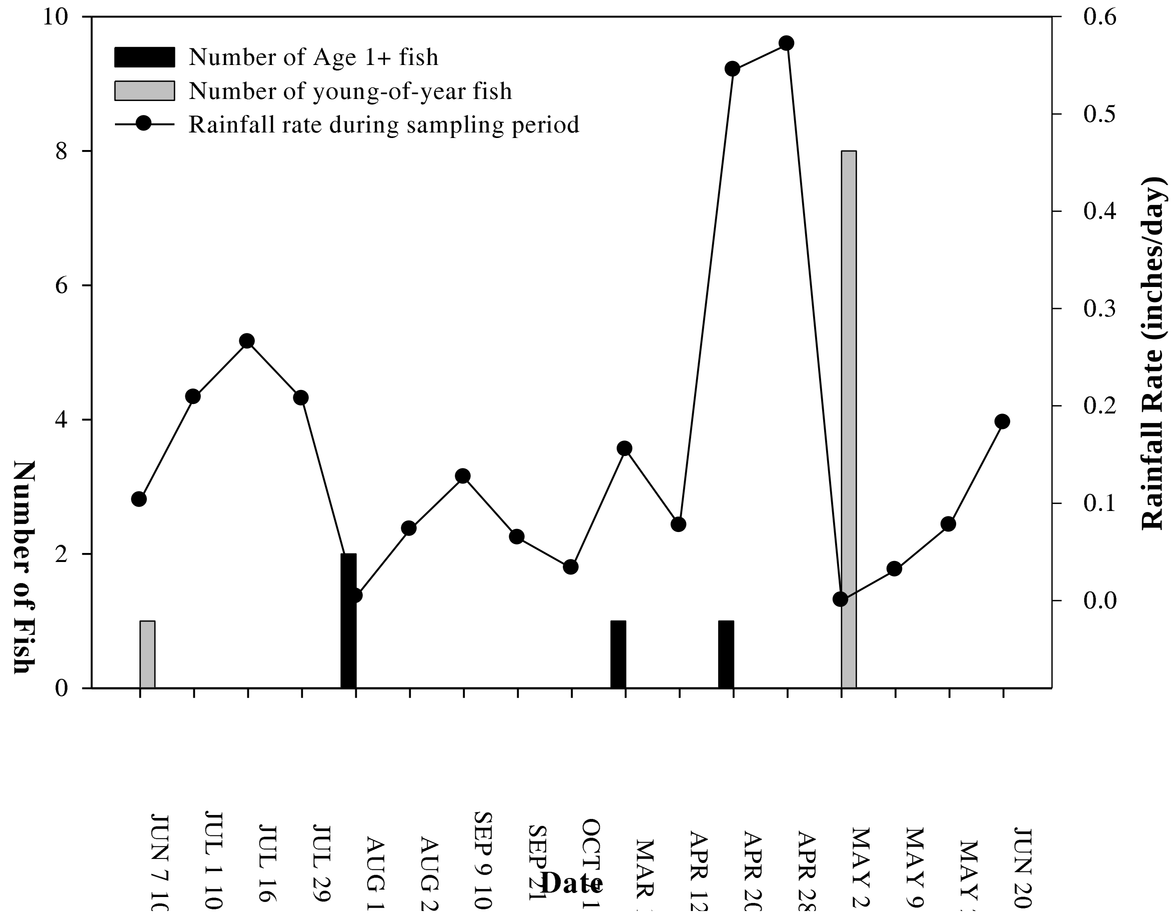

Figure 4-10: Total numbers of adult largemouth bass collected in the catch basin below the dam at Ridge lake during each sampling date related to precipitation. Rainfall rates are the precipitation per day during the sampling period as measured at the Eastern Illinois University rain gauge in Charleston, IL.

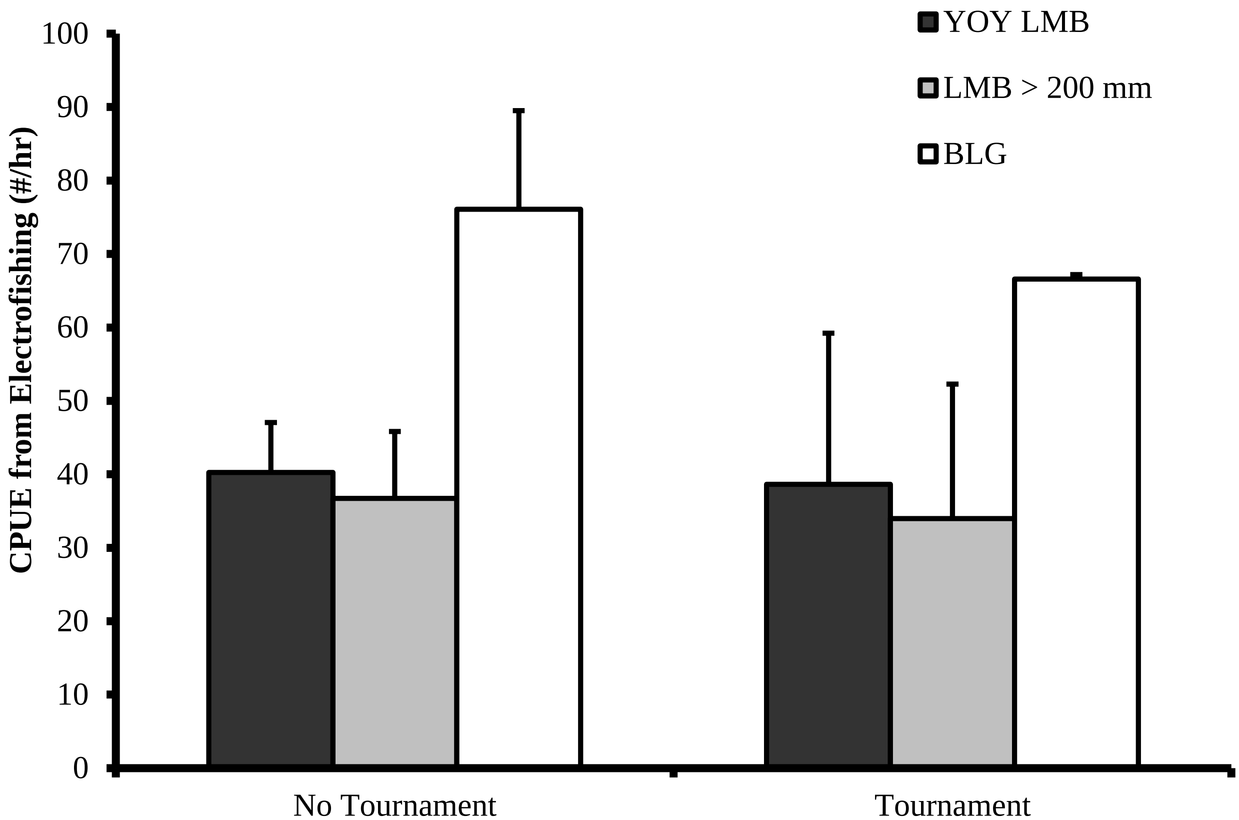

Figure 5-1: Catch per unit effort from fall electrofishing from Ridge Lake in 2006 through 2010 for young-of-year (YOY LMB), adult largemouth bass (LMB > 200mm), and bluegill (BLG). Values are for years where fishing was closed in the spring (2006, 2008, and 2009; No Tournament) and years where spring tournaments were conducted (2007 and 2010; Tournamnet). Error bars represent the standard error.

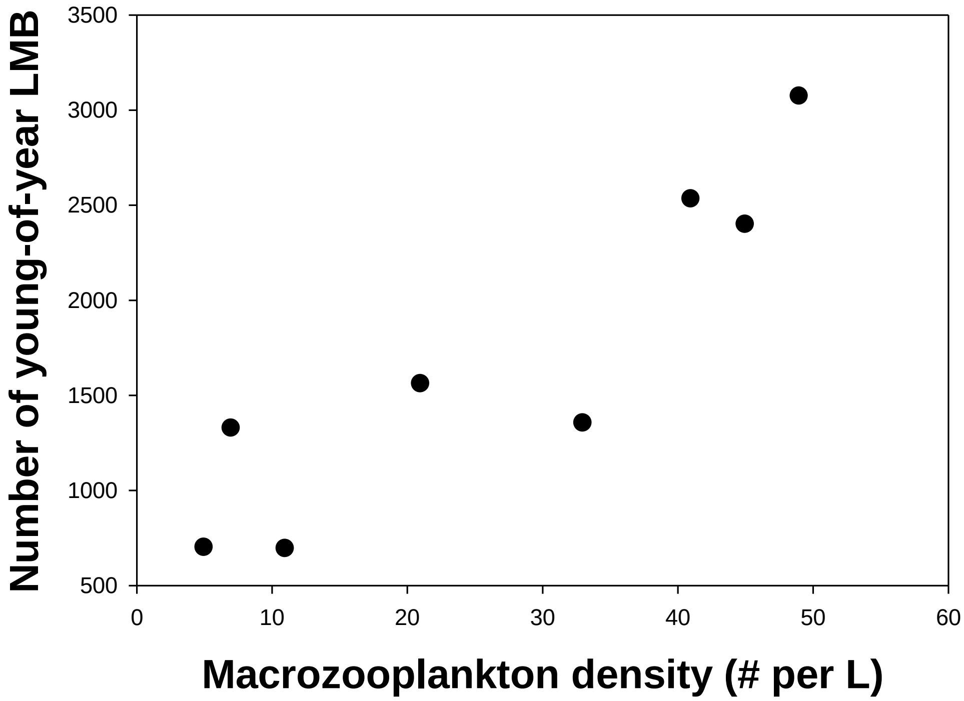

Figure 5-2: Comparison of zooplankton densities measured in the early summer of 2010 and the total number of young-of-year largemouth bass found in each pond, regardless of treatment. Zooplankton lacking sufficient size to be used as bass prey (rotifers and nauplii) were omitted.

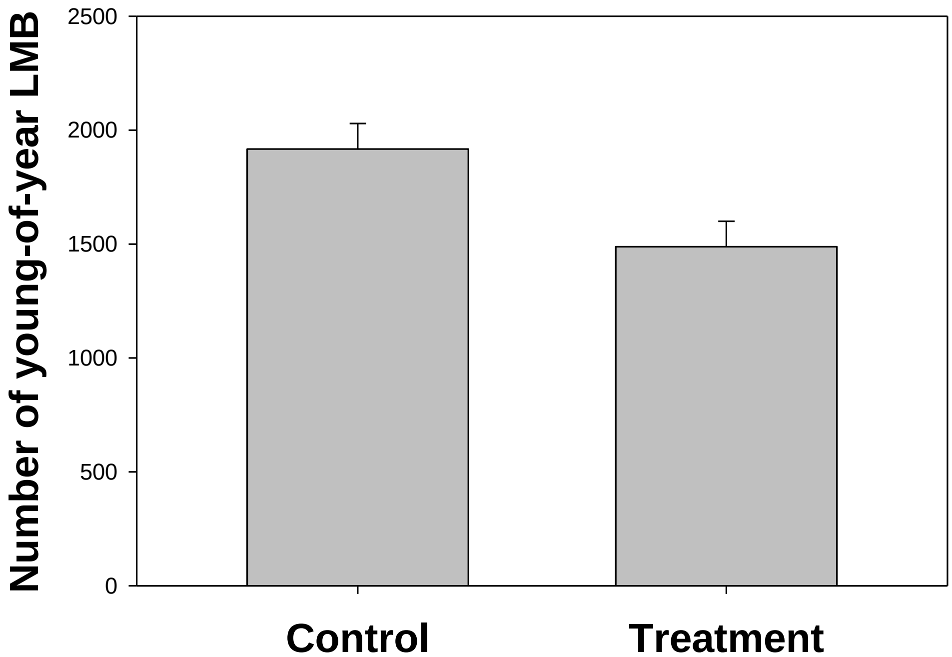

Figure 5-3: Average number of young-of-year largemouth bass present in the fall of 2010 from control ponds versus those receiving simulated tournament angling during the spawning season (p value = 0.06).

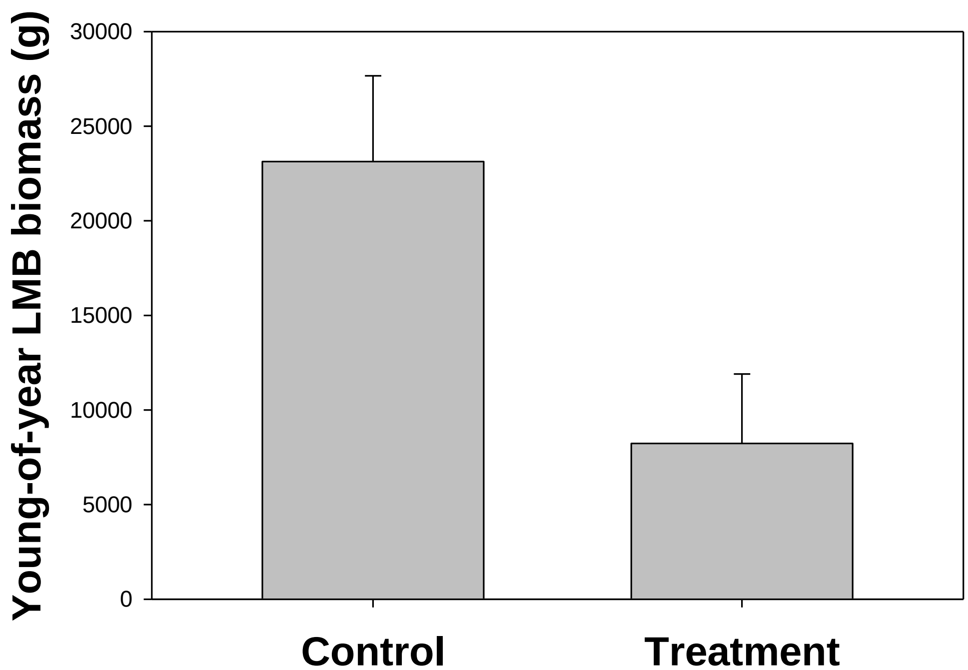

Figure 5-4: Average biomass (g) of young-of-year largemouth bass present in the fall of 2010 from control ponds versus those receiving simulated tournament angling during the spawning season (p value = 0.02).

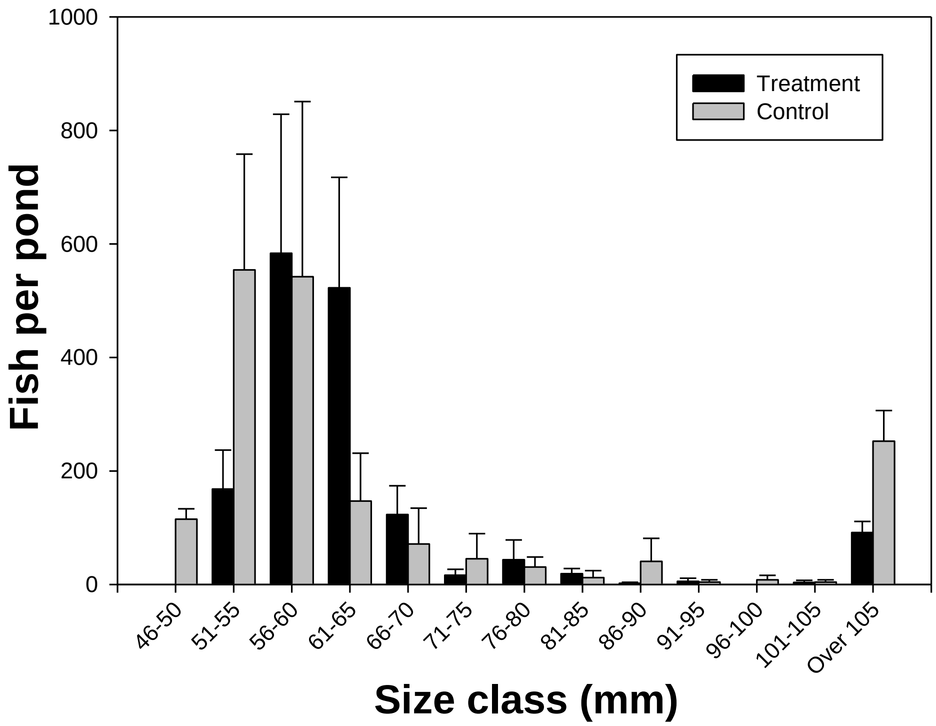

Figure 5-5: Size distribution of young-of-year largemouth bass from control and treatment ponds. The number of fish under 105 mm did not differ between controls and treatments (p value = 0.96).

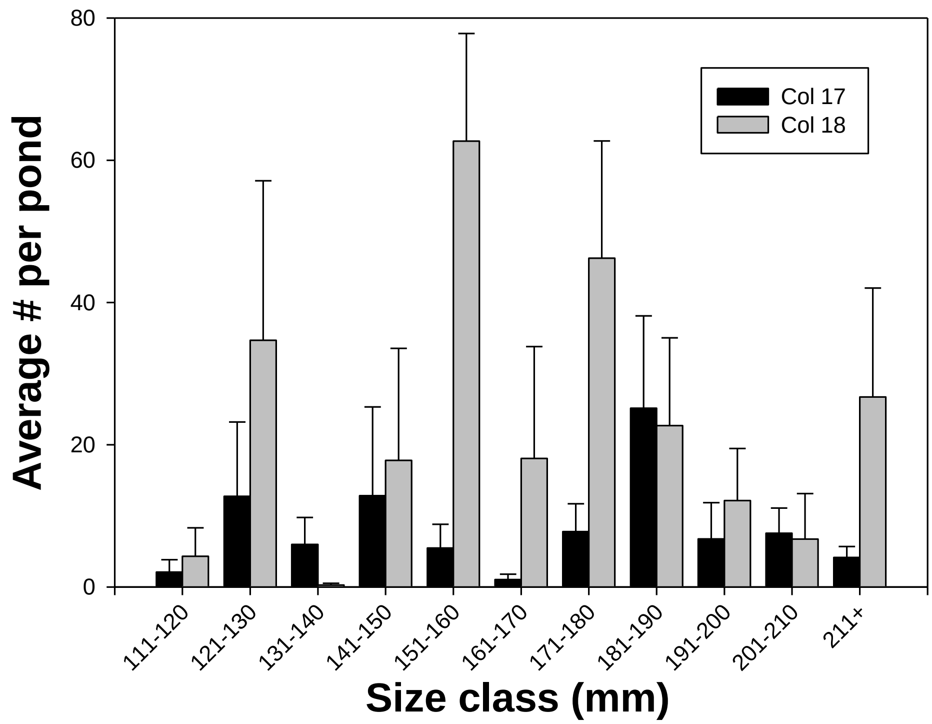

Figure 5-6: Size distribution of young-of-year largemouth bass larger than 110 mm from control and treatment ponds. More fish above this length were found in the control ponds, but did not differ significantly from the treatments (p value = 0.20).

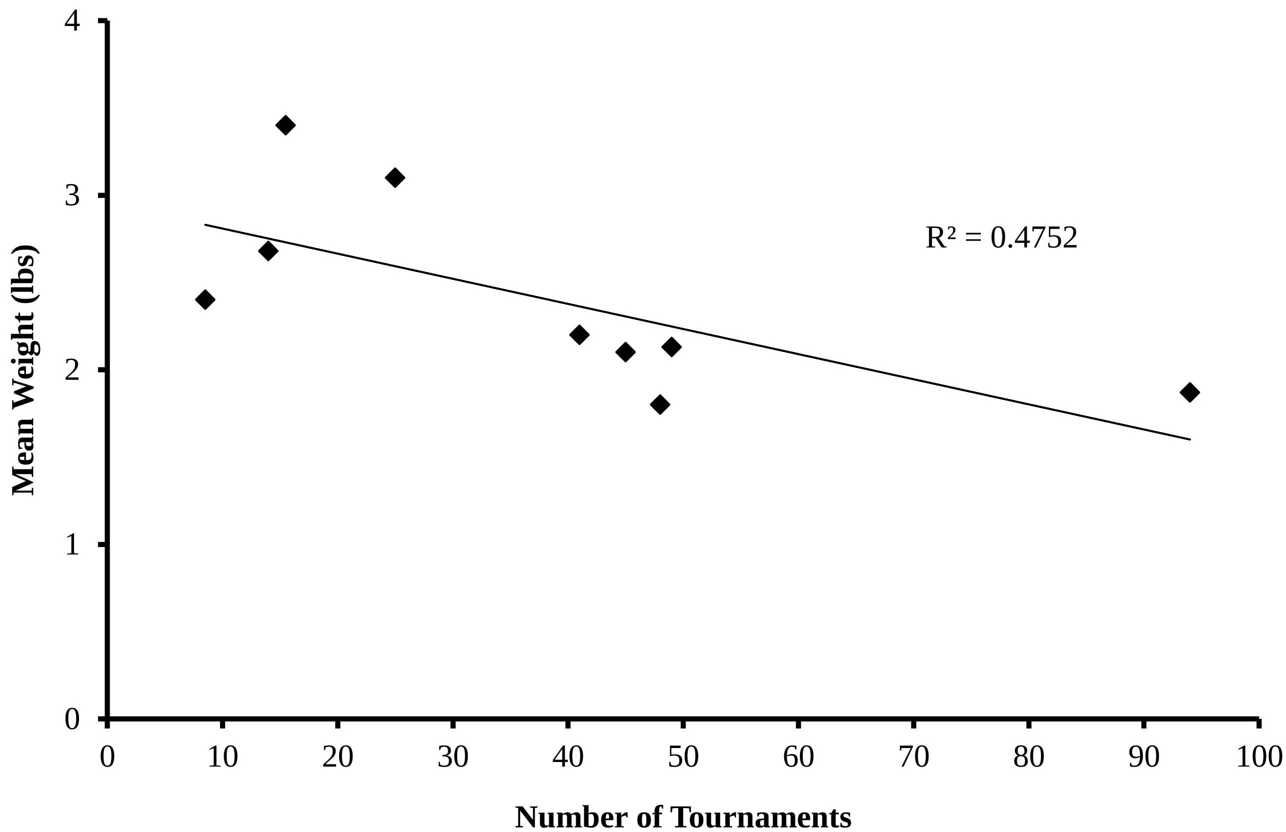

Figure 5-7: Mean weight of fish caught in tournaments in 2009 and 2010 in Illinois as a function of the number of tournaments on lakes with known tournament activity.

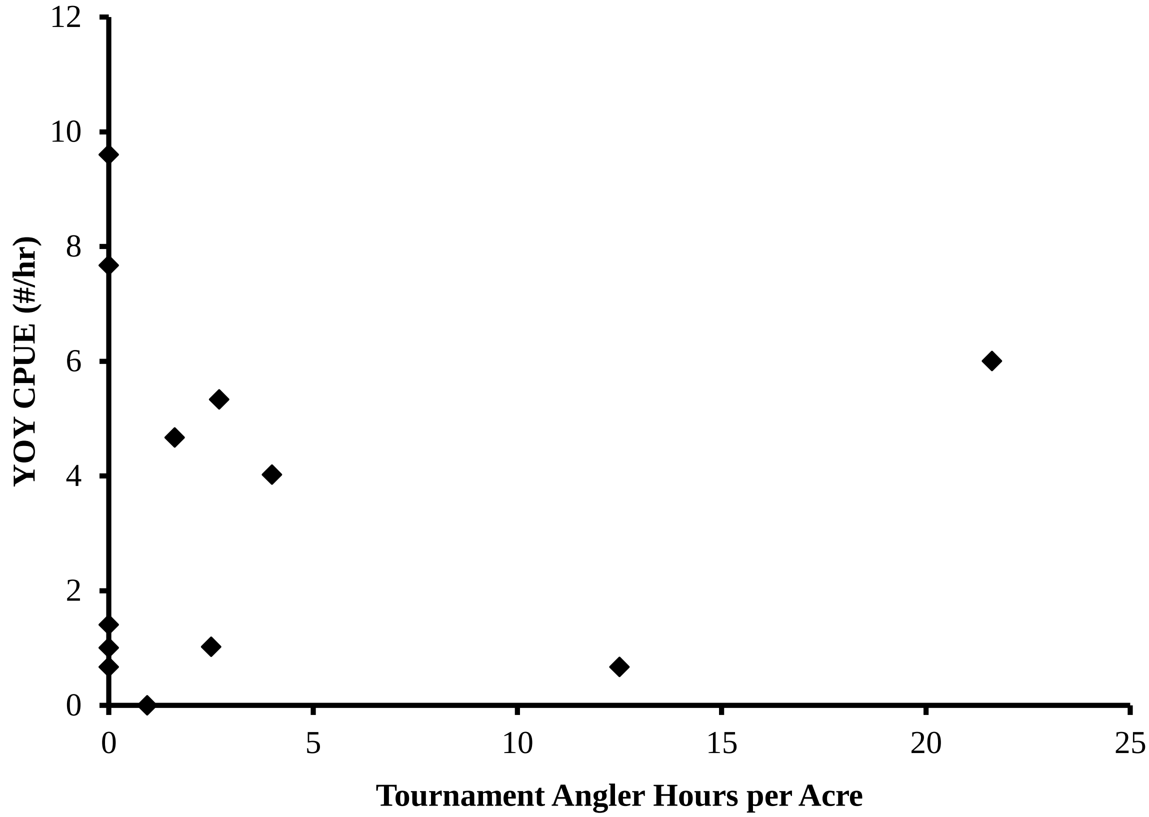

Figure 5-8: Catch per unit effort of young-of-year largemouth bass from spring electrofishing in lakes with varying tournament pressure. Tournament pressure is expressed as angler hours per acre based on the annual number of anglers and length of tournaments in 2009 and 2010.

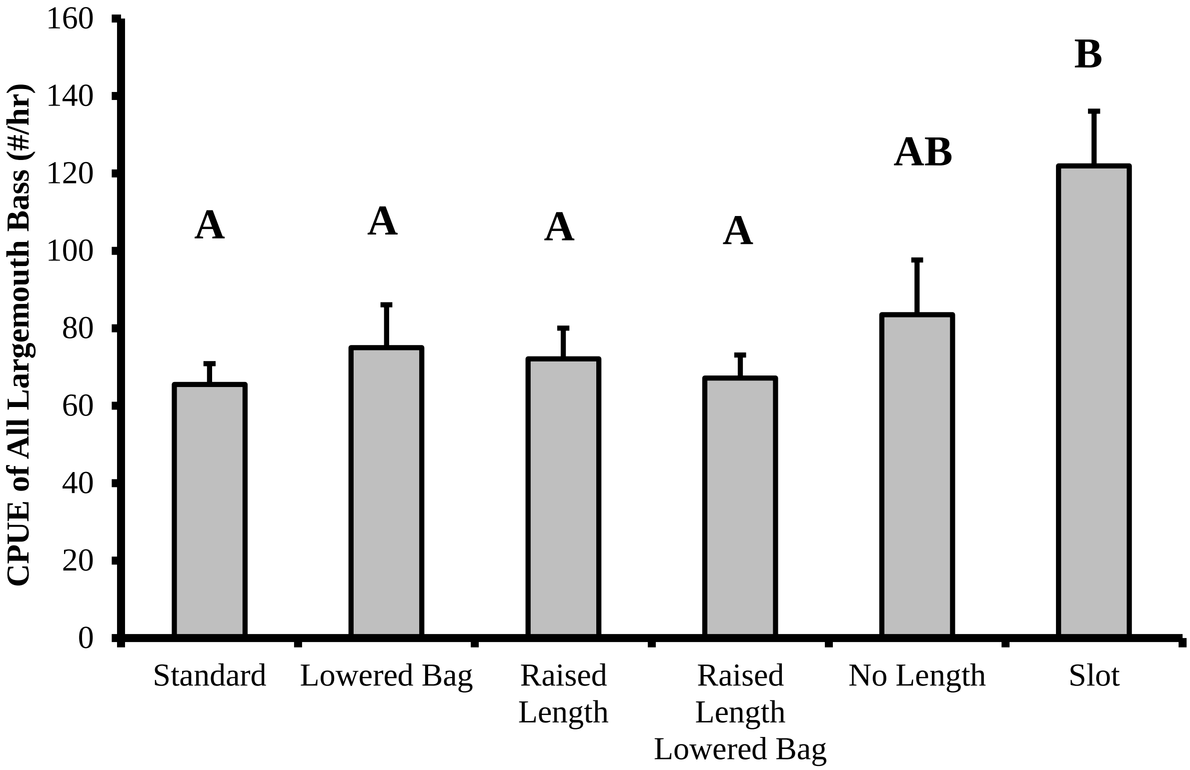

Figure 6-1: Catch per unit effort of all largemouth bass from fall electrofishing in 218 lakes in Illinois sampled from 2000 to 2007 in 6 different regulation categories. Letters indicate bars that are not significantly different (P > 0.05). Error bars represent the standard error.

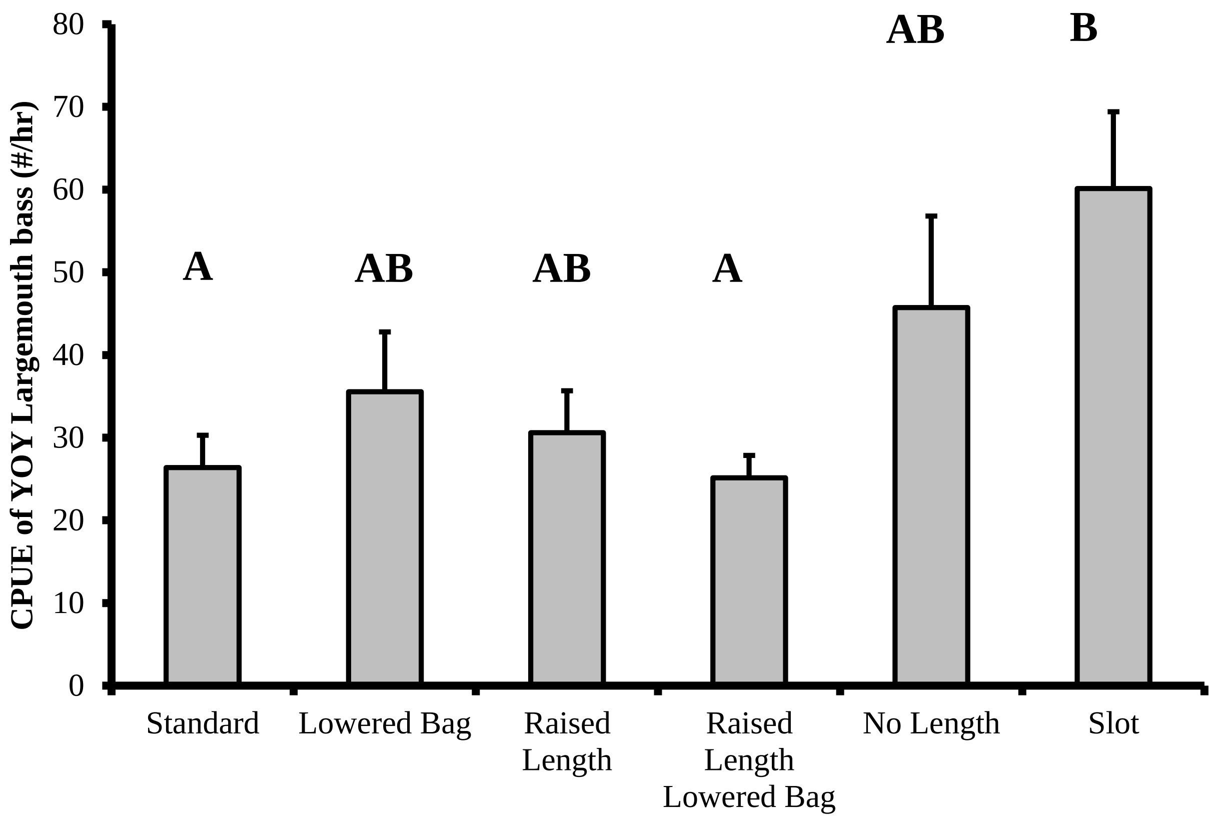

Figure 6-2: Catch per unit effort of young of year largemouth bass from fall electrofishing in 218 lakes in Illinois sampled from 2000 to 2007 in 6 different regulation categories. Letters indicate bars that are not significantly different (P > 0.05).

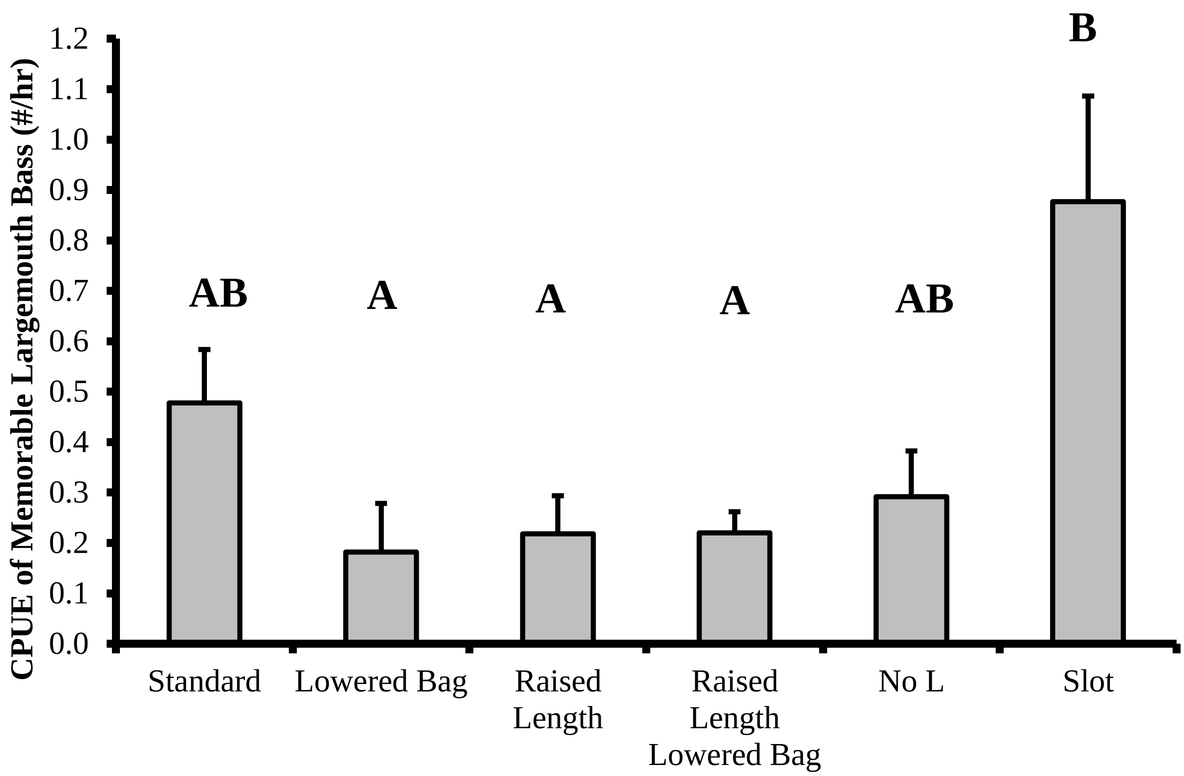

Figure 6-3: Catch per unit effort of memorable sized largemouth bass from fall electrofishing in 218 lakes in Illinois sampled from 2000 to 2007 in 6 different regulation categories. Letters indicate bars that are not significantly different (P > 0.05).