THE EFFECTS OF TOURNAMENT FISHING ON DISPERSAL, POPULATION CHARACTERISTICS, AND MORTALITY OF BLACK BASS IN LAKE MARTIN, ALABAMA

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THE EFFECTS OF TOURNAMENT FISHING ON DISPERSAL, POPULATION CHARACTERISTICS, AND MORTALITY OF BLACK BASS IN LAKE MARTIN, ALABAMA

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THE EFFECTS OF TOURNAMENT FISHING ON DISPERSAL, POPULATION

CHARACTERISTICS, AND MORTALITY OF BLACK BASS

IN LAKE MARTIN, ALABAMA

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THESIS ABSTRACT

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A great deal of black bass *Micropterus spp.* tournament activity occurs at Wind Creek State Park (WCSP), located at the north end of Lake Martin, Alabama. Because of the popularity of this location as a tournament processing site, displacement, dispersal, effects on body condition, and mortality of black bass due to tournament activities were examined.

Tournament-caught black bass (N = 9,750) were coded wire tagged (CWT) and released at WCSP from fall 2003 to spring 2005. Electrofishing was used in fall 2004, spring 2005, and five times over a 42-day period in February - March 2005, to estimate dispersion, relative abundances, and relative weights of marked and unmarked fish over 300 mm total length. Initial mortalities were quantified by counting all dead fish at the release site. Radio telemetry was used to estimate delayed mortality, by lack of movement and mortality sensors, of largemouth bass *M. salmoides* and spotted bass *M. punctulatus* caught in tournaments from February to May 2005 and in September 2005.

A high proportion (> 50%) of released tournament-caught largemouth bass remained within 3 km from the release site up to 3 months after release, and relative abundance of these fish tended to be higher near WCSP. However, after 3 months, the proportion of released tournament-caught largemouth bass declined near WCSP, which suggested that these fish dispersed from the release area. Tournament-caught spotted bass, tagged fall 2003 through spring 2004 and fall 2004, dispersed at a faster rate than largemouth bass, as proportions of tagged tournament-caught spotted bass within 6 km of the release site were low (3 - 5%) in 2004 and decreased to 0% in 2005. In addition, after forty-two days after release, very few tournament-caught spotted bass were collected within 4 km from the release site (< 10%).

In Lake Martin, 7% of tagged largemouth bass and 3% of tagged spotted bass were recaptured by tournament anglers. Tournament recapture rates by anglers remained consistent over time for fish at large from 4 to 16 months. Previously caught fish at large for less than 4 months, expressed higher angler catch rates in spring 2005.

Relative weights of tournament caught largemouth bass and spotted bass were either similar or lower than those for wild fish inhabiting Lake Martin. Thus, tournament

activities at times likely affect the physiology of black bass even months after capture and release.

Water temperature was positively related to initial mortality of largemouth bass and both initial and delayed mortality of spotted bass. Furthermore, tournament-caught spotted bass were more likely (62%) to experience delayed mortality within 10 days of release than largemouth bass (33%). I estimated that at water temperatures greater than 26°C, more than 50% of the tournament-caught black bass would die.

In summary, over time black bass tended to disperse from tournament release sites in Lake Martin, although short-term accumulations did occur. At higher water temperatures, initial and delayed mortality rates were high and during these conditions, the use of the live-release boat should be discontinued. At times, angler capture and release of black bass were related to lower body condition which could adversely effected growth and reproductive output.

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INTRODUCTION

Participation in tournament fishing for black basses *Micropterus spp*. has grown tremendously in popularity in the past 25 years (Quinn 1996; Schupp 2002). An estimated 25,000 organized black bass fishing tournaments occur each year in the United States and Canada (Kerr and Kamke 2003). Larger tournaments attract non-resident anglers and provide substantial economic benefits to local communities (Bryan 1995). With the growth of black bass tournaments across the United States, numerous concerns have been raised (Schramm et al. 1991; Gilland 1999; Kerr and Kamke 2003). These include displacement of captured fish, accumulation of fish near release sites, physiological effects on body condition, and mortality associated with tournament handling.

Displacement of black bass caught by anglers and their movement after release was variable with some fish returning to the site of capture, while others remain near the release site (Stang et al. 1996; Gilliand 1999; Richardson-Heft et al. 2000; Pearson 2002; Ridgway 2002). Stang et al. (1996) found that 19% of the black bass caught and displaced returned to the vicinity of their capture site within 2 to 22 weeks, while 29% moved less than 1 km and 57% moved less than 3 km from release sites in New York. In addition, non-tournament anglers harvested 56% of tournament-released fish, due to high fish concentrations at the release site (Stang et al. 1996). In a 2,500 ha Oklahoma reservoir tournament-caught largemouth bass *M.*

salmoides showed little dispersal with 49% of fish found within 0.8 km of the release site and 64% found within1.6 km of the release site during the first year (Gilliland 1999). Dispersal increased during the second year, but 35% of fish were within 0.8 km of the release site and 46% were within 1.6 km of the release site (Gilliland 1999). The maximum movement by a displaced fish was 12 km with a median distance of 1.6 km after 18 months (Gilliland 1999). In a study where largemouth bass were displaced 1.5 to 16.5 km, 37% returned to the site of capture however, none of the fish that returned to the site of capture were displaced over 8 km (Ridgway 2002). Richardson-Heft et al. (2000) found that radio-tagged largemouth bass moved on average 9.5 km from their release site, however return movement time varied seasonally, taking 7-12 months in the fall and 3 months in spring. Stang et al. (1996) expressed concern that large-scale angler movement of largemouth bass in water bodies with numerous tournaments, could have negative effects on growth, survival, and reproduction due to the large numbers of fish accumulating in an area. In addition, because largemouth bass reach larger sizes than smallmouth bass *M. dolomieui* in New York, anglers often target largemouth bass, which may cause tournament effects to be greater on the largemouth bass population (Stang et al. 1996).

Black bass suffer mortality during catch-and-release tournaments, primarily due to handling procedures and warm water temperatures (Schramm et. al. 1987; Plumb et al. 1988; Kwak and Henry 1995; Hartley and Moring 1995; Weathers and Newman 1997; Edwards et al. 2004). Estimates of tournament-related initial, delayed, and total mortalities of black bass have been highly variable. In tournaments conducted in the 1960s and 1970s, initial mortality for black bass tournaments ranged from 2 to 61% and delayed mortality ranged from 3 to 20% (Holbrook 1975). Technological advancements in livewell technology have reduced initial mortality (Wilde et al. 2002; Gilliand 2002). This reduction in mortality was attributed in large part to Bass Angler Sportsman Society (BASS) sponsored tournaments that required aerated live wells in boats and penalties for dead fish (Schramm et al. 1985; Wilde et al. 2002). In addition most tournaments are now solely catch-and-release with penalties for dead fish. These rules have decreased tournament mortality from 19.5 to 6.5 % between the 1970's and 1990's (Wilde et al. 2002). Even though tournament mortality has declined over the past 20 years, further decreases are unlikely unless tournament operations are changed substantially (e.g., paper tournaments; Wilde 1998).

For largemouth bass in Lake Eufaula, Alabama, initial mortality ranged from 2 to 18%, delayed mortality ranged from 1 to 50%, and total mortalities ranged from 9 to 68% (Weathers and Newman 1997). Steeger et al. (1994) found similar results on Lake Eufaula, with an average total mortality of 33%. Tournament associated mortalities of largemouth bass and smallmouth bass were lower in Maine, where estimates of initial mortality ranged from 0 to 15 %, and delayed mortality from 0 to 9% (Hartley and Moring 1995). In Minnesota, tournament-induced mortality of largemouth bass contributed 2 to 6% to angling mortality, and 1 to 3% of total mortality (Kwak and Henry 1995). In these tournaments, delayed mortality was 2.5 times greater than initial mortality (Kwak and Henry 1995). Conversely, Schramm et al. (1985) found that delayed mortality rates were relatively low when compared to initial mortality.

Tournament-induced mortality of black bass can be greater at warmer water temperatures. Tournaments in Florida, where temperatures are higher year round, largemouth bass generally displayed initial mortalities from 20 to 60% (Chapman and Fish 1985). Schramm et al. (1985; 1987) estimated ranges of initial (0 to 43%), delayed (0 to 33%), and total mortalities (1 to 48%) of largemouth bass in Florida tournaments. Positive correlations were computed between water temperature and initial, delayed, and total mortality (Wilde 1998). Post spawn stress and warmer water temperatures contributed to higher mortality (Hartley and Moring 1995). Gilliland (2002) found similar results as mortality of black bass was 34% in summer compared to 3% in spring. Typically at water temperatures less than 23°C tournament-related mortality of black bass was less than 10%, while at temperatures greater than 28°C, mortality was greater than 25% and as high as 60% (Holbrook 1975; Schramm et al. 1987; Plumb et al. 1988; Steeger et al. 1994; Hartley and Moring 1995; Weathers and Newman 1997; Wilde 1998; Ostrand et al. 1999 Gilliland 2002). Wilde (1998) described that initial mortality of largemouth bass increased exponentially with temperature:

$$IM = 0.00194 * TEMP^{2.4569}$$

(where IM is initial mortality and TEMP is temperature in Celsius). Schramm et al. (1987) suggested that in addition to water temperature, air temperature also may have had an effect on survival of tournament-caught largemouth bass.

Tournament-related mortality also may be species specific. Hartley and Moring (1995) observed that initial mortality of smallmouth bass (9%) was three times greater than for largemouth bass (3%), possibly due to physiological differences between species. Largemouth bass generally are found in shallower and warmer waters than smallmouth bass, which may cause smallmouth bass to be more susceptible to handling and livewell confinement (Hartley and Moring 1995).

Size of black bass caught in tournaments also was an important variable associated with tournament-caught black bass mortality, given that larger fish are often held in livewells longer, while smaller fish are often culled and released. Larger fish generally have higher initial mortalities, but lower delayed mortalities, likely due to higher oxygen demand while being held in livewells and in bags during weigh-ins (Meals and Miranda 1994; Wilde 1998). Conversely, Weathers and Newman (1997) reported delayed mortality of 510 to 629 mm largemouth bass was twice as great when compared to fish that ranged from 300 to 509 mm. Meals and Miranda (1994) found largemouth bass over 457 mm suffered significantly higher initial mortalities than largemouth bass that were 305 to 356 mm.

The number of tournament participants can be indirect measure of the amount of organization, rules, and procedures for weigh-in practices. The higher levels of organization, rules and procedures found in larger tournaments generally resulted in higher black bass survival. In Texas, largemouth bass experienced slightly lower initial mortality in larger tournaments (2%) than smaller tournaments (4%; Ostrand et al. 1999). An increase in the number of rules and regulations enforced in larger tournaments (> 50 anglers) was associated with a reduction in initial mortality of largemouth bass (Ostrand et al. 1999). Wilde (1999) found a negative relation between the number of tournament participants and initial mortality of largemouth bass, but a positive relation between the number of tournament participants and delayed mortality of largemouth bass. However, Hartley and Moring (1995) found that black bass had a higher probability of surviving in smaller tournaments than larger tournaments, which could be attributed to decreased handling times. Black bass caught in larger tournaments often have lower initial mortality, but higher delayed mortalities (Wilde 1998). However if initial and delayed mortalities of black bass were not correlated, as Wilde (1998) suggested, decreasing initial mortality may have no effect on delayed mortality.

May (1972), Meals and Miranda (1994), and Weathers and Newman (1997) found that high densities of black bass in the livewells negatively affected survival. Initial mortality was positively correlated with creel size, fish weight per angler, and number of fish per angler as well as two and three way interactions among creel size and weight per angler, creel size and number per angler; weight per angler and number per angler; and creel size, weight per angler, and number per angler (Wilde et al. 2002). The amount of time a fish spends in a livewell can increase mortality (Seidensticker 1974) and could be compounded by higher water temperature in livewells (Schramm et al. 1987).

In Lake Martin, (16,000 ha) Alabama, almost all of the tournament activity occurs at Wind Creek State Park (WCSP) located on the northern portion of this reservoir. Nearly every weekend from February through May and from September through November, at least one black bass tournament is held at this site. Lake Martin is very dendritic (shoreline development ratio of 25) and the furthest distance by water from WCSP to remote downstream regions of Lake Martin accessible by anglers is 45 km, with more than half the surface area of Lake Martin is more than 15 km from WCSP. Thus, the potential of large-scale displacement of black bass to the northern portions of Lake Martin and negative impacts on the populations of black bass inhabiting this area of the reservoir is possible. In addition, Lake Martin is relatively deep (mean depth = 13 m) and angling may cause high levels of initial and delayed mortality during tournaments due to angler catches in deep water and fish decompression (Feathers and Knable 1983; Shasteen and Sheehan 1997). Finally, mortality of spotted bass *M. punctulatus* associated with fishing tournaments has not been previously investigated. My objectives in the project included:

1) Estimate long-term and short-term dispersal rates of largemouth bass and spotted bass released from tournaments in the WCSP area of Lake Martin.

2) Document angler recapture rates of released tournament-caught largemouth bass and spotted bass in Lake Martin.

3) Estimate relative abundance of black bass in the vicinity of WCSP to determine if accumulation of fish has occurred.

4) Compare relative weights of tournament-caught and non-tournament largemouth bass and spotted bass in Lake Martin.

5) Estimate initial and delayed mortality of black bass associated with tournaments in Lake Martin.

METHODS

To estimate black bass dispersion after being caught in tournaments and transported to WCSP, all live tournament-caught black bass were injected with a coded wire tag (CWT) either on the right cheek in fall 2003 to spring 2004, the left cheek in fall 2004, and the base of the posterior end of the dorsal fin in spring 2005. A subset of fish tagged in spring 2005 (February 12-13, 2005) were tagged at the base of the anal fin. If a fish was recaptured in a tournament more than once, the fish was tagged in the peduncle in fall 2003 to spring 2004, the left pectoral fin base for fall 2004, and the pelvic fin base spring 2005. Release sites for all black bass were near the WCSP boat ramp or within 2 km downstream of the creek mouth (Figure 1) and the release sites were recorded with a GPS. After fall 2003, all fish were released at WCSP.

In fall 2004 and spring 2005, black bass longer than 300 mm were collected using electrofishing. Forty 15-min transects were conducted out to 8 km from the boat ramp in Wind Creek. In spring 2005, the addition of 10 transects extended the electrofishing surveys out to 10 km from the boat ramp. After each transect, fish were weighed, measured, scanned for a coded wire tag, and released. If tagged, location on the fish was recorded.

Frequency analysis and maximum likelihood chi-squared (χ^2) tests by species and by tag location for fish tagged fall 2003 to spring 2004, fall 2004, and spring 2005, were used to compare proportions of tagged and untagged fish. In addition, maximum likelihood P^2 was used to examine homogeneity of tagged and untagged fish among 1-km distance zones out to 8 km from the release point for fish tagged in fall 2003 and spring 2005, and 10 km from the release point for fish tagged in fall 2004 and spring 2005. Logistic regressions were calculated for each species and examined the probabilities of recapturing a fish over distance for fall 2004 and spring 2005 samples. Wald P^2 was used to test significance of these regressions.

To investigate short-term (< 6 weeks) dispersion of largemouth bass and spotted bass, tournament-caught fish were coded wire tagged at the base of the anal fin on February 12-13, 2005. Ten-minute electrofishing transects were completed at 2, 7, 14, 28, and 42 days after release, with 8 transects within 1 km, 7 transects between 1 and 2 km, and 7 transects between 2 and 3 km away from the release site at WCSP. Twenty-eight days after release, 5 transects were added between 3 and 4 km from the release site. After collection, fish were measured, weighed, and scanned for a CWT. If tagged, location was recorded.

To analyze short-term dispersion, frequency analysis and maximum likelihood P^2 tests for each species were computed to compare tagged and untagged proportions, and investigate homogeneity of proportions among 1-km distance zones out to 4 km from the release point. Logistic regression predicted the probability of recapturing a tagged fish over distance, time, and distance by time interaction over the 42-day release period for each species. Logistic regressions were computed to predict recapture probabilities at distance from the release site at distance at 2, 7, 14, 28, and 42 days after release. Logistic regressions also were computed to predict recapture probabilities over the 42-day release period at 1-km distance zones out to 3 km from the release point. Wald P^2 was used to test significance of these regressions.

From the CWT tournament-caught black bass recaptured in tournaments by anglers from spring 2004 to spring 2005, the relation between tournament recapture rate and time was examined with simple linear regression.

Catch-per-unit-effort at each 1-km strata and relative weights of tagged tournament-caught and untagged fish were computed. Relative weights were computed for each species using the standard weight equations presented by Anderson and Neuman (1996). Two-way analysis of variance was used to test the differences between $\log_{10}$ transformed catch-per-hour for each species among 1-km distance zones out to 4 km from the release point and time for fish collected 2, 7, 14, 28, and 42 days after release from WCSP. If differences existed, Student Newman Keuls multiple range test ($P < 0.05$) was used to test for differences in catch-per-hour rates for each 1-km distance zone. One-way analysis of variance was used to detect differences in $\log_{10}$-transformed catch-per-hour rates between fall 2004 and spring 2005 samples by species at one-km distance zones out to 8 km in fall 2004 and 10 km in spring 2005. If differences existed, Student Newman Keuls multiple range test ($P < 0.05$) was used to test differences in mean catch-per-hour rates for each one-km distance zone. Because tournament-caught black bass tagged in fall 2003 and spring 2004 were released 0.56 km southeast of the mouth of Wind Creek in Lake Martin, and all fish tagged after spring 2005 were released in Wind Creek 0.86 km from the boat ramp at WCSP (Figure 1), the relation between catch rates and distance from the release site was examined for both release sites.

For largemouth bass collected fall 2004 and spring 2005, and for spotted bass collected spring 2005, t-tests were used to test for differences in relative weights of tournament-caught and untagged at quality, preferred and memorable lengths. A Bonferroni correction ($P = 0.1/N$ where N equals the number of comparisons) was used for largemouth bass. Length categories for largemouth bass and spotted bass relative weight analysis followed Anderson and Neuman (1996). In addition, the short-term impact of tournament capture on relative weight was examined with two-way analysis of variance and t-tests with a Bonferroni correction ($P = 0.02$) for quality, preferred and memorable lengths among samples taken 2, 7, 14, 28, and 42 days after release for each species.

To estimate tournament-associated mortality, initial mortality was measured by summing dead fish at tournaments including fish that died on the release boat which was provided by WCSP. To estimate delayed mortality of largemouth bass and spotted bass in Lake Martin, 26 spotted bass and 25 largemouth bass were fitted with 8.6-g radio tag (Advanced Telemetry Systems; Model 2020) and float assembly, following the procedures of Osborne and Bettoli (1995), during tournaments conducted from February to May 2005. Tags had a 4-month life expectancy, which allowed the tags to be used more than once. Tags were equipped with a mortality sensor that would double the cadence of the frequency after laying motionless for 24 hours. After accounting for the buoyancy of the float, the tag weight was less than 2% of the body weight following the criteria of Winters (1996). The tag and float assembly was attached to the dorsal musculature with degradable gut suture which allowed recovery after 2-3 weeks. Fish were located every other day, and latitude and longitude was recorded with a GPS unit. For each fish, weight, length, livewell water temperature and dissolved oxygen, reservoir water temperature and dissolved oxygen, and number of fish in livewell were recorded at weigh-in. Movement was calculated using ArchView. Finding the fish dead, a mortality signal from the tag, or movement of less than a 12-m diameter among the last three locations was used as the criterion to identify dead fish, and compute delayed mortality. The 12-m criteria was set based on fish known to be dead. During September 17-18, 2005, 14 spotted bass and 12 largemouth bass were fitted with the remaining 8.6-g radio tags that were used in spring 2005 (ATS; Model F2020). Tags were attached with monofilament suture through the dorsal musculature in the same manner used in spring 2005, but without the float assembly. Fish were tracked every other day for two weeks. Mortality was assigned based on either finding dead fish, or when the radio tag emitted a mortality signal. This new criterion was used due to problems designating mortality for fish tagged from February to May 2005 (e.g.: the float prevented the mortality sensor within the tag from sounding).

The relations between initial mortality and reservoir water temperature, reservoir dissolved oxygen, and number of boats were examined using correlation. Initial mortality for each species was regressed against water temperature using non-linear regression to determine the effect of reservoir water temperature on initial mortality. Delayed mortality data from spring and fall 2005 were pooled and regressed (logistic regression) against weight, length, livewell water temperature and dissolved oxygen, reservoir water temperature and dissolved oxygen, days at large, and number of fish in livewell for each species to identify variables that may have contributed to tournament-associated mortality in Lake Martin.

Total tournament mortality (TM) was the sum of initial (IM) and delayed (DM) mortality. Total tournament associated mortality for each species at reservoir water temperature was estimated by additively combining non-linear regressions of initial mortality and delayed mortality regressed against temperature.

RESULTS

Long-term dispersion of black bass

From October 10, 2003 to April 6, 2005, 2,963 largemouth bass and 6,787 spotted bass were brought to a weigh-in, tagged, and released at or near WCSP (Table 1). In fall 2003 and spring 2004, tournament-caught fish were released south of the mouth of Wind Creek a midpoint 0.56 km southeast of the mouth of Wind Creek (Figure 1) and this was designated as the release site for analysis. After fall 2004, all fish were released into Wind Creek 0.86 km from the boat ramp at WCSP (Figure 1) except for the subset of fish tagged February 12-13, 2005 which were release at the boat ramp at WCSP (Figure 1).

The ratio of tagged to untagged largemouth bass in fall 2003 and spring 2004, collected with electrofishing, were homogenous among one-km distance zones to a distance of 7 km from the release site for fish collected in fall 2004 (Maximum Likelihood Ratio $P^2 = 5.78$; $P > 0.1$; Figure 2). The proportions of tagged (from fall 2003 and spring 2004) and untagged largemouth bass also were not significantly different among 1-km distance zones to 8 km from the release site in spring 2005 (Maximum Likelihood Ratio $P^2 = 9.98$; $P > 0.1$). The proportion of largemouth bass tagged in fall 2003 and spring 2004 and recaptured within 7 km of the release site decreased from 7% for fish collected in fall 2004 to 4% for fish collected in spring 2005. In spring 2005, largemouth bass tagged in fall 2003 and spring 2004 were not collected in areas greater than 4 km from the release site (Figure 2). The predicted recapture probability of tagged largemouth bass collected in fall 2004 that were tagged in fall 2003 and spring 2004 decreased slightly as distance increased from the release site, but this trend was not significant (Wald P^2 = 0.95; P > 0.1; Figure 3). However, the predicted recapture probability of tagged largemouth bass collected in spring 2005, which were tagged in fall 2003 and spring 2004 decreased as distance increased from the release site (Wald P^2 = 4.83; P < 0.1; Figure 3). The model estimated the recapture probability of tournament-caught largemouth bass tagged in fall 2003 and spring 2004 decreased with distance from 17% at 0.74 km from the release site to about 0.2% at a distance of 7.28 km from the release site for fish collected in spring 2005 (Figure 3).

The proportion of tagged and untagged spotted bass tagged in fall 2003 and spring 2004 collected with electrofishing were homogenous among 1-km distance zones out to a distance of 6 km from the release site for fish collected in fall 2004 (Maximum Likelihood Ratio P^2 = 2.95; P > 0.1; Figure 4). For fish collected in spring 2005, the proportion of tagged and untagged spotted bass were similar among 1-km distance zones to 8 km from the release site (Maximum Likelihood Ratio P^2 = 4.49; P > 0.1). The proportion of spotted bass tagged in fall 2003 and spring 2004 that were within 6 km of the release site decreased from 3% for fish collected in fall 2004 to 0% for fish collected in spring 2005. Spotted bass tagged in fall 2003 and spring 2004 were collected in fall 2004 at the 2-3 and 3-4 km distance zones from the release site (Figure 4). Only one spotted bass tagged in fall 2003 and spring 2004 was collected in spring 2005 at the 7-8 km distance zone from the release site (Figure 4). The predicted recapture probability of tagged spotted bass collected in fall 2004 that were tagged in fall 2003 and spring 2004 remained constant as distance increased from the release site (Wald $P^2 = 0.89$; $P > 0.1$). Similar to the fall 2004 collection, the probability of recapture for spotted bass collected in spring 2005, and tagged in fall 2004 and spring 2005 did not change with distance from the release site (Wald $P^2 = 1.32$; $P > 0.1$).

The proportions of tagged and untagged largemouth bass tagged in fall 2004 were heterogenous among 1-km distance zones out to 8 km from the release site in Wind Creek for fish collected in fall 2004 with electrofishing (Maximum Likelihood Ratio $P^2 = 19.41$; $P < 0.01$; Figure 5). However, in spring 2005 collection proportions were homogenous among one-km distance zones out to 10 km from the release site (Maximum Likelihood Ratio $P^2 = 4.05$; $P > 0.1$; Figure 5). The proportion of largemouth bass tagged in fall 2004 and within 8 km of the release site in Wind Creek decreased from 11% for fish collected in fall 2004 to 3% for fish collected in spring 2005. The probability of recapture for largemouth bass tagged in fall 2004 collected in fall 2004 decreased with distance from the release site (Wald $P^2 = 8.64$; $P < 0.01$). The model estimated the recapture probability of tagged largemouth bass caught in tournaments in fall 2004 to decreased from 40% at 0.2 km from the release site, to 0.09% at 7.3 km from the release site (Figure 6). However, for largemouth bass tagged in fall 2004 and then collected in spring 2005 with electrofishing, the predicted recapture probability remained constant and approached 0% as distance from the release site in Wind Creek increased (Wald $P^2 = 0.04$; $P > 0.1$; Figure 6).

For fish collected with electrofishing in fall 2004, the proportion of tagged and untagged spotted bass tagged in fall 2004, were similar among one-km distance zones out to 7 km from the release site in Wind Creek (Maximum Likelihood Ratio $P^2 = 10.43$; $P > 0.1$; Figure 7). Only three spotted bass of the 132 fish collected in fall 2004 and spring 2005 were tagged fish from fall 2004 tournaments. For spotted bass tagged in fall 2004, the proportion of tagged fish within 7 km decreased from 5% for fish collected fall 2004, to 0% or no tagged spotted bass collected in spring 2005. Spotted bass tagged in fall 2004 were not collected greater than 1 km from the release site fall 2004 (Figure 7).

The proportion of tagged and untagged largemouth bass tagged in spring 2005 and collected with electrofishing in spring 2005 varied among 1-km distance zones out to 10 km from the release site in Wind Creek (Maximum Likelihood Ratio $P^2 = 37.56$; $P < 0.01$). The proportion of largemouth bass tagged in spring 2005, decreased with distance from 43% within 1 km from the release point to7% at 6-7 km from the release site in Wind Creek. No largemouth bass tagged in spring 2005 were collected greater than 7 km from the release site (Figure 8). The predicted recapture probability of largemouth bass tagged in spring 2005 declined with distance from the release site (Wald $P^2 = 20.16$; $P < 0.01$). The model estimated the recapture probability of tournament-caught largemouth bass tagged in spring 2005 decreased with distance from 45% at 0.24 km from the release point to 1.2% at a distance of 9.12 km from the release point (Figure 9).

The proportion of tagged and untagged spotted bass tagged in spring 2005 were heterogenous among 1 km distance zones out to 10 km from the release site for fish collected in spring 2005 (Maximum Likelihood Ratio P^2 = 34.67; P < 0.01). Excluding the only spotted bass collected at 2-3 km from the release site which was tagged, the proportion of spotted bass tagged in spring 2005 decreased with distance from 65% within 1 km from the release site to 25% at 4-5 km from the release site (Figure 8). No spotted bass tagged in spring 2005 were collected greater than 4 km from the release site. Recapture probability of spotted bass tagged spring 2005 declined with distance from the release site (Wald P^2 = 11.63; P < 0.01). The model estimated the recapture probability of tournament-caught spotted bass tagged in spring 2005 decreased with distance from 72% at 0.24 km from the release point to 1.3% at a distance of 9.12 km from the release site (Figure 9).

Short-term dispersion after a single tournament event

During two tournaments on February 12-13, 2005, 420 tournament-caught largemouth bass and 811 tournament-caught spotted bass were coded wire tagged, and released at the boat ramp at WCSP(Figure 1, circle). There were significant differences in the ratio of tagged and untagged largemouth bass collected with electrofishing among the 0-1, 1-2 and 2-3 km distances from WCSP at two (P^2 = 26.92; P < 0.01) and seven days at large (P^2 = 13.01; P < 0.01). The proportion of tagged largemouth bass 0-1 km from the release site decreased with time from 49% two days after release to 11% forty-two days after the tournament (Figure 10). Tagged largemouth bass were collected at 1-2 km away from WCSP at 7, 14, 28, and 42 days after release. At this distance from WCSP, the proportion of tagged largemouth bass increased from 8% to 33% between 7 and 14 days after release, then decreased at 28 (10%)

and 42 days (7%) after being released (Figure 10). The proportion of tagged largemouth bass 2-3 km from WCSP decreased from 17% at 14 days at large to 7% at 28 days at large. At this distance, no tagged largemouth bass were collected prior to or after these times (Figure 10).

The proportions of tagged and untagged spotted bass collected with electrofishing were heterogeneous among the 0-1, 1-2 and 2-3 km distances from WCSP 2 days after release ($P^2 = 22.47$; $P < 0.01$). The proportion of tagged spotted bass within 0-1 km from the release site decreased with time from 72% to 10% over the 42-day period after release (Figure 11). The proportion of tagged spotted bass 1-2 km from the release site increased from 21% at two days to 55% at seven days, then decreased to 8% at 14 days, then increased to 19% at 28 days post release. No tagged spotted bass were collected 42 days after release at this distance from WCSP. At 2-3 km from the release site 18% were tagged fish after 7 days, which decreased to 8% after 14 days, while no tagged spotted bass were collected at 2, 28, and 42 days at large (Figure 11).

Distance from the release site (km), time after release (days), and the distance by time interaction were all significant regressors ($P < 0.05$) to predict probability of recapturing tagged largemouth bass (Wald $P^2 = 70.48$; $P < 0.01$; c = 0.762) and spotted bass (Wald $P^2 = 59.71$; $P < 0.01$; c = 0.771).

$$P_{LMB} = -0.3576\, e^{(1.4479\text{Distance} + 0.058\text{Time} - 0.0.0256\text{Interaction})}$$

$$P_{SPB} = -1.1576\ e^{(1.3349\text{Distance} + 1.3349\text{Time} - 0.0436\text{Interaction})}$$

The significant interaction effect indicated the probability of recapture at distance from the release site were not consistent over the time the fish were at large (Figure 12 and 13).

The probability of recapture of tagged tournament-caught largemouth bass declined with distance from the release site at 2 days (Wald $P^2 = 12.59$; $P < 0.01$), 7 days (Wald $P^2 = 9.91$; $P < 0.01$), and 28 days (Wald $P^2 = 4.98$; $P < 0.1$) after release (Figure 12). Trends were similar at 14 and 42 days after release, but not significant ($P > 0.1$; Figure 12). The model estimated tournament-caught largemouth bass contributed to about 60% of the fish collected at the release site at WCSP immediately after the tournament which decreased to 13% of all fish collected 42 days after release. At distances of 1 to 3.5 km from the release site tournament-caught largemouth bass contributed to less than 8% of the total number of largemouth bass collected after 42 days.

The probability of recapture of tagged spotted bass deceased with distance from the release site 2 days (Wald $P^2 = 17.62$; $P < 0.01$) and 7 days (Wald $P^2 = 3.07$; $P < 0.1$) after release (Figure 13). Although not significant, a similar downward trend was evident 28 days after release, no patterns were apparent 14 days after release, but 42 days after release tagged spotted bass appeared to increase with distance ($P > 0.1$; Figure 13). Tournament caught spotted bass at the release site at WCSP declined from 80% to less than 10% after 42 days from release. Few spotted bass were collected after being at large for more than 14 days at distances greater that 1 km from WCSP, although sample sizes were low.

For tournament caught largemouth bass collected with electrofishing within 0-1 km of the release site the probability of recapture decreased after release (Wald χ^2 = 29.95; $P < 0.01$), however for 1-2 and 2-3 km from the release site the probability of recapture remained constant over time after being released ($P > 0.1$; Figure 14). Similarly, the probability of recapturing a tagged spotted bass with electrofishing decreased nearly seven-fold over time for fish collected within 0-1 km of the release site (Wald χ^2 = 36.28; $P < 0.01$). A declining trend between recapture probability and time appeared at 1-2 and 2-3 km from WCSP, however these relationships were not significant ($P > 0.1$; Figure 15)

Trends in tournament recapture rates over time

From October 2003 to April 2005, 7% of tagged tournament-caught largemouth bass and 3% of tagged tournament-caught spotted bass were recaptured by tournament anglers. Tournament recapture rates of previously angler-caught largemouth bass and spotted bass remained constant over time ($P > 0.1$; Figure 16). Similarly, tournament-caught largemouth bass and spotted bass tagged in fall 2004 expressed no trend in tournament recapture rates over time from fall 2004 to spring 2005 ($P > 0.1$; Figure 17). Angler recapture rates of previously caught largemouth bass that were tagged in spring 2005 increased over time during spring 2005 tournaments ($P < 0.05$; $r^2 = 0.40$; Figure 18). No trend appeared evident for tournament-caught spotted bass tagged in spring 2005 and recaptured by anglers during spring 2005 tournaments (($P > 0.1$; Figure 18).

The relation between catch rates and distance away from the release point

For the release point 0.56 km southeast of the mouth of Wind Creek, analysis of variance indicated catch-per-hour of largemouth bass greater than 300 mm TL was not significantly different ($P > 0.1$) across one-km distance zones out to 7 km from the release point in fall 2003. However in spring 2005, catch-per-hour of largemouth bass varied ($P < 0.01$) across one-km distance zones out to 8 km from the release point. In fall 2004, analysis of variance indicated that catch-per-hour of spotted bass greater than 300 mm TL were not significantly different ($P > 0.1$) among one-km distance zones out to 7 km from the release point, but varied ($P < 0.05$) among one-km distance zones out to 8 km from the release point in spring 2005. For both largemouth bass and spotted bass differences in catch-per-hour were not related to the distances from the release site.

For the release point 0.86 km from the boat ramp at WCSP, analysis of variance indicated that catch-per-hour of largemouth bass greater than 300 mm TL among one-km distance zones out to 8 km from the release point were similar ($P > 0.1$) in fall 2004. However in spring 2005, differences ($P < 0.01$) were evident between catch-per-hour of largemouth bass among one-km distance zones out to 10 km from the release point. Catch-per-hour of largemouth bass were similar between 0-1 km and 1-2 km from the release point, but were consistently less at distances greater then 2 km from the release site compared to catches less the 1 km from the release site (Figure 19). In fall 2004, catch-per-hour of spotted bass greater than 300 mm TL were not significantly different ($P > 0.1$) among one-km distance zones out to 8 km from the release point. However in spring 2005, catch-per-hour of spotted bass greater than 300 mm TL varried (P < 0.01) among one-km distance zones out to 10 km, but a consistent pattern with respect to distance from WCSP was not evidnet (Figure 20).

Catch-per-hour of largemouth bass over the short-term 42-day period indicated relative abundances of largemouth bass greater than 300 mm TL were different (two-way ANOVA; P < 0.01) among one-km distance zones from 0 to 3 km from the release point 2, 7, and 14 days after release, and 0 to 4 km from the release point 28 and 42 days after release (Figure 21). No differences in catch-per-hour of largemouth bass over time after release (P > 0.1) or distance from the release point by time interaction (P > 0.1) were evident. Forty-two days after release, the catch-per-hour of largemouth bass was higher (P < 0.05) at the 0-1 km distance zone than the 1-2, 2-3, and 3-4 km distance zones (Figure 21).

For the short-term analysis over a 42-day period , two-way analysis of variance indicated catch-per-hour of spotted bass greater than 300 mm TL was different (P < 0.01) among one-km distance zones from 0 to 3 km from the release point 2, 7, and 14 days after release, and 0 to 4 km from the release point 28 and 42 days after release (Figure 22). No differences were detected in catch-per-hour of spotted bass over time after release (P > 0.1) or distance by time interaction (P > 0.1). Forty-two days after release, catch-per-hour of spotted bass was higher at the 0-1 km distance zone compared to greater distances (Figure 22). Catch-per-effort was significantly lower at 2-3 km after 42 day at large (ANOVA, P < 0.1) One-way analysis of variance indicated a decline (P < 0.1) in catch-per-effort at 2-3 km from the release point after 42 days at large.

The relation between relative weight and tournament capture

Relative weights of tournament-caught largemouth bass were less than ($P < 0.05$) untagged largemouth bass in fall 2004 for quality length and statistically similar for preferred-length fish ($P > 0.05$; Figure 23). In spring 2005, no differences ($P > 0.1$) in relative weights were detected between tagged and untagged largemouth bass for quality and preferred lengths (Figure 23).

Relative weights of preferred-length tagged spotted bass were less than untagged spotted bass ($P < 0.1$) in spring 2005 (Figure 24). Average relative weight was about 7 units lower for tournament-caught fish. For quality-length spotted bass, relative weights were similar between tournament-caught and untagged fish in spring 2005 ($P > 0.1$; Figure 24). Insufficient numbers of tournament caught spotted bass ($N = 4$) were collected in fall 2004 to compare to untagged fish collected with electrofishing.

Two-way analysis of variance indicated that relative weights were statistically different ($P < 0.05$) between tournament-caught and untagged largemouth bass at quality-length for fish that were released from tournaments during February 12-13, 2005. No significant differences ($P > 0.1$) were detected in relative weights over time or interaction between tag and time for quality-length largemouth bass. Relative weights were lower for quality-length tournament-caught largemouth bass than for untagged fish at 7 days after release ($P < 0.02$). At 2, 14, 28, and 42 days at large, relative weights of tournament-caught fish tended to be similar or lower than untagged largemouth bass at quality-lengths, however differences were not statistically significant ($P > 0.02$ Bonferroni correction; Figure 25). Although not significant, relative weights of preferred-largemouth bass appeared lower for tournament caught fish, compared to untagged fish ($P > 0.1$) over the 42-day release period. No interaction effects were detected between tag and time in relative weight ($P > 0.1$).

For fish that were released from tournaments during February 12-13, 2005, two-way analysis of variance indicated that relative weights varied ($P < 0.1$) between tournament-caught and untagged spotted bass at quality-length. No differences ($P > 0.1$) in relative weights over time after release or the interaction between tag and time were evident for quality-length spotted bass. Bonferroni corrected t-tests ($P = 0.02$) indicated no differences in relative weights of quality-length tagged spotted bass compared to untagged fish at 2, 7, and 28 days after release on February 12 - 13, 2005 ($P > 0.02$). However, relative weights were marginally statistically similar ($P = 0.0205$) for quality-length spotted bass compared to untagged fish 28 days after release (Figure 26). Two-way analysis of variance indicated relative weights varied ($P < 0.1$) between tournament-caught and untagged spotted bass, time after release ($P < 0.1$), and a significant ($P < 0.01$) interaction was evident between tag and time after release, for preferred-length spotted bass. Relative weights were higher, but not statistically significant ($P > 0.02$), for preferred-length tournament-caught spotted bass compared to untagged fish 2 days after release, but less than untagged spotted bass 28 days after release ($P < 0.02$; Figure 26). Two-way analysis of variance indicated relative weights were not statistically different ($P > 0.1$) between tournament caught and untagged spotted bass, over time after release, and an interaction between tag and time after release was not evident, for memorable-length spotted bass. However, 2 days after release, tournament-caught spotted bass relative weights were lower, but not statistically different ($P < 0.02$) from untagged spotted bass for fish of memorable length (Figure 26). Low sample sizes of memorable length spotted bass hindered analysis.

Tournament mortality of black bass

Reservoir water temperature (Temp) was the significant regressor to predict initial mortality of tournament-caught largemouth bass ($R^2 = 0.46$; $P < 0.01$). and spotted bass ($R^2 = 0.56$; $P < 0.01$).

$$IM_{\text{Largemouth bass}} = 0.102e^{(0.213*\text{Temp})}$$

$$IM_{\text{Spotted bass}} = 0.016e^{(0.302*\text{Temp})}$$

The model estimated that tournament-caught largemouth bass initial mortality (including fish that died on the release boat) increased from less than 1% at 9.6°C to 44% at 28.5°C (Figure 27), and tournament-caught spotted bass initial mortality increased from less than 1% at 9.6°C to 88% at 28.5 (Figure 28).

Delayed mortality of tournament-caught spotted bass increased with reservoir water temperature and decreased with the number of days after release (Wald $P^2 = 10.72$; $P < 0.01$; Wald $P^2 = 2.94$; $P < 0.1$). The model estimated that tournament related delayed mortality of spotted bass increased from 5% at 13°C to 70% at 30.6°C (Figure 29) The probability of delayed mortality for spotted bass decreased from 58% at 2 days at large to 8% at 24 days at large. . Although non-significant, ($P > 0.5$), delayed tournament mortality of largemouth bass also showed an increasing trend with temperature (Figure 29). The equations to predict delayed mortality (DM) for largemouth bass and spotted bass were:

$$DM_{\text{Largemouth bass}} = 11.619e^{(0.0272*\text{Temp})}$$

$$DM_{\text{Spotted bass}} = 0.707e^{(0.151*\text{Temp})}$$

Other variables such as fish weight, livewell water temperature and dissolved oxygen, reservoir dissolved oxygen, and number of fish in livewell were not significant ($P > 0.1$) predictors of delayed mortality for largemouth bass or spotted bass.

Non-linear regressions to predict initial and delayed mortality were summed and provided estimates of total mortality over a range of temperatures (Figure 30). The equations to predict total mortality (TM) for largemouth bass and spotted bass were:

$$TM_{\text{Largemouth bass}} = [0.102e^{(0.213*\text{Temp})}] + [11.619e^{(0.0272*\text{Temp})}]$$

$$TM_{\text{Spotted bass}} = [0.016e^{(0.302*\text{Temp})}] + [0.707e^{(0.151*\text{Temp})}]$$

At water temperatures over 26°C, at least 50% of the black bass died from tournament handling. However, low sample sizes for largemouth bass and spotted bass for delayed mortality estimates may have hindered the accuracy of this model. Furthermore, tournament-caught largemouth bass regression for delayed mortality to temperature relation was not statistically significant ($P > 0.1$).

DISCUSSION

Movement of black bass after tournament capture and effect on relative abundance

A high proportion (> 50%) of tournament-caught largemouth bass remained within 3 km from the release site up to 3 months after release in Lake Martin. However, after 3 months, proportions of tagged largemouth bass within 7 km decreased from 7% in 2004 to 4% in 2005 for fish tagged in fall 2003 and spring 2004 and within 8 km of the release site decreased from 11% in 2004 to 3% in 2005 for fish tagged in fall 2004. Thus, this long-term reduction in the proportion of tournament-caught largemouth bass suggested these fish dispersed from the release points. In addition, the percentage of released tournament-caught largemouth bass recaptured by tournament anglers after three months did not increase where I observed many anglers fishing in the northern portion of Lake Martin.

Large scale movements after displacement have also been observed in the Chesapeake Bay where 33% of largemouth bass displaced 15 to 21 km returned to the site of capture (Richardson-Heft et al. 2000). However, most black bass do not return to the site of recapture (Stang et al. 1996; Pearson 2002; Wilde and Paulson 2003). In Rideau Lake, Ontario, largemouth bass displaced over 8 km did not return to the capture site (Ridgway 2002). Contrary to my results, Stang et al. (1996) found largemouth bass and smallmouth bass had limited dispersal with 29% of the fish moving less than 1 km and 57% dispersing less than 3 km with few fish moving greater than 6 km after release within a year of release. Gilliland (1999) and found 64% of recaptured tournament-caught largemouth bass within 1.6 km of the release site.

In Lake Martin, over a 42-day period, the proportion of tournament-caught largemouth bass less than 1 km from the release site decreased from 48% to 11%. At 2 km from the release site, about 25% of the largemouth bass captured were tournament caught fish 14 days after release, but after 42 days at large there were few tournament caught fish in the study area. Ridgway (2002) reported tournament-caught largemouth bass on average moved only 0.5 km from the release site after 15 days at large. Over a 43-day period in Lake Mead, Arizona-Nevada, 63% of largemouth bass moved less than 1 km and 83% moved less than 2 km from the release site (Wilde and Paulson 2003). Bunt et al. (2002) observed over 1 to 11 months that 55% smallmouth bass dispersed or returned to their site of capture while 44% of smallmouth bass remained at the release site for 11 months. Richardson-Heft et al. (2000) observed 95% of largemouth bass had moved greater than 0.5 km from the release point less than seven days after release.

In Lake Martin, spotted bass appeared to disperse at a higher rate than largemouth bass after being caught by anglers and displaced. Evidence of dispersal existed as proportions of tagged tournament-caught spotted bass within 6 km of the release site were low in 2004 (3% for fish tagged in fall 2003 and spring 2004 and 5% for fish tagged in fall 2004) and decreased to 0% in 2005. Furthermore, unlike tournament-caught largemouth bass, I observed the probability of spotted bass recapture tended to remain constant with distance from the release point. Small numbers of recaptured tournament-caught fish across all distances hindered the analysis. Spotted bass, however, appeared to suffer higher delayed mortality at water temperatures greater than 21°C, than largemouth bass which could have affected recapture rates. Spotted bass dispersion after tournament capture has not been previously reported.

The proportion of tournament-caught spotted bass collected less than 1 km from the release site decreased from about 70% to less than 10% over a 42-day period, similar to observations for tournament caught largemouth bass. Forty-two days after release, very few tournament-caught spotted bass were collected with in 4 km for the release site (< 10%).

In Lake Martin, 7% of released tournament-caught largemouth bass and 3% of released tournament-caught spotted bass were recaptured by tournament anglers. Recapture rates by anglers in Lake Martin were low and less than observed by Gilliand (1999), Bunt et al. (2002), and Wilde (2003). Wilde’s (2003) review of past studies observed 22% of largemouth bass and 15% of smallmouth bass caught in tournaments were recaptured by anglers. Gilliand (1999) observed a 46% recapture rate of tournament-caught and tagged largemouth bass. Bunt et al. (2002) found 12% angler recapture rate of previously tournament-caught smallmouth bass.

I observed consistent tournament recapture rates over time with the exception of largemouth bass tagged in spring 2005 for tournaments conducted during this time. Although I observed a high amount of the angler tournament effort near the release site, black bass dispersion from the Wind Creek area was likely high enough to reduce angler recaptures of the previously caught fish after about 3 to 6 months after previously being caught by anglers.

Catch rates and accumulation

Long-term accumulations of largemouth bass or spotted bass near the Wind Creek release site were not evident in fall 2003 as catch rates were constant across all distances away from the release site. However in spring 2005, accumulations occurred near the release site as indicated by high catch rates of largemouth bass catch rates at distances less than 2 km from the release site. Spotted bass catch rates in spring 2005 were lower at intermediate distances than at less than 2 km and greater than 8 km from the release point. This suggested that some spotted bass accumulated near the release site, however movement from Wind Creek did occur. Spotted bass catch rates were lower than largemouth bass and suggested that they dispersed at a faster rate than largemouth bass. However, over a 42-day period after release, I observed higher catch rates of largemouth bass and spotted bass within 1 km of the release site at all times sampled, and suggested that short-term accumulation of these fish may have occurred. Also, spotted bass catch rates were lower than largemouth bass which suggested that spotted bass may have dispersed from the release site at a faster rate than largemouth bass or potentially suffered higher rates of tournament mortality. Some studies observed that tournament-caught largemouth bass that accumulated near the release site rendered these fish more venerable to angler capture (Stang et al. 1996; Gilliland 1999).

Relative weight of tournament caught fish

For three sampling events, largemouth bass expressed either similar or lower relative weights than non-tournament fish. Pearson (2002) suggested in addition to handling stress, tournament fish released greater distances from their capture site may expend energy attempting to return to the capture site, searching for forage, or occupying new territory which may contribute to lower body condition. Fish generally make a full recovery from physiological disturbances of angling within 24 hours (Gustaveson and Wydoski 1991; Cooke et al. 2004). However, my observations suggested that tournaments may have longer lasting physiological effects that at times, resulted in reduced body condition.

Multiple studies have investigated the effects of angling and tournament procedures on physiological effects of tournaments (Williamson and Carmichael 1986; Plumb et al. 1988; Gustaveson and Wydoski 1991; Hartley and Moring 1993; Hayes et al. 1995; Kieffer et al. 1995; Philipp et al. 1997; Furimsky et al. 2003; Morrissey et al. 2005; Suski et al. 2003; Cooke et al. 2004; Suski et al. 2004). However, to date no studies have examined the effects of tournaments on relative weight of black bass. Large-scale angler movement of largemouth bass in water bodies which have numerous tournaments such as Lake Martin, could have negative effects on growth, survival, and reproduction due to the large numbers of fish accumulating in an area (Stang et al. 1996).

Tournament mortality

Reservoir water temperature was significantly correlated with initial mortality of tournament caught black bass, similar to past studies (Holbrook 1975; Schramm et al. 1987; Plumb et al. 1988; Steeger et al. 1994; Hartley and Moring 1995; Weathers and Newman 1997; Wilde 1998; Ostrand et al. 1999; Gilliland 2002). Initial mortality increased exponentially with water temperature and at higher water temperatures initial mortality for largemouth bass and spotted bass was greater than data presented by Wilde (1998). I observed a much higher percentage of dead fish when released from the WCSP release boat than at the tournament weigh-in. For example, Wilde (1998) predicted 7% of all black bass initially died after tournaments at 28°C compared to 40 and 70% which my model estimated for largemouth bass and spotted bass at this temperature. Fish dying in the release boat undoubtedly increased my initial mortality estimated when compared to those compiled by Wilde (1998).

Similar to initial mortality, delayed mortality was positively related to reservoir temperature for tournament caught spotted bass. A trend of increasing delayed mortality of largemouth bass with temperature was evident, although not significant in this study, has been observed in other studies (Schramm et al. 1987; Hartley and Moring 1995).

Tournament-caught spotted bass delayed mortality (62%) was almost twice as high as largemouth bass delayed mortality (33%) within 10 days of release, but after this initial stress period, spotted bass mortality decreased. Schramm et al. (1987) observed 83% of largemouth bass delayed mortality occurred within 6 days. Conversely, Archer and Loyacano (1975) observed that mortalities of largemouth bass to be variable until 8 days after the tournament where mortality became more steady throughout the study.

At higher water temperature, tournament-caught spotted bass experienced higher initial, delayed, and total mortalities than largemouth bass. Spotted bass are found at deeper depths and in closer association to the bottom than largemouth bass (Vogele 1975), which could contribute to these higher mortality rates. I observed spotted bass delayed and total mortality at temperatures above 21 and 22°C to increase above largemouth bass delayed and total mortality. In addition, spotted bass may be more susceptible to handling stress. Hartley and Moring (1995) suggested that largemouth bass may be less susceptible to handling and livewell confinement than smallmouth bass because largemouth bass inhabit shallower and warmer waters than smallmouth bass. Thus, these fish may be more vulnerable to decompression stress. Decompression can cause hemorrhaging within the mouth, swim bladder, or from the caudal fin (Feathers and Knable 1983; Morrissey et al. 2005). Decompression has also been shown to affect initial and delayed mortality of largemouth bass caught at depths greater than 6 m (Feathers and Knable 1983; Shasteen and Sheehan 1997).

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Black bass generally dispersed away from the WCSP area of Lake Martin, but some fish remained near the release site for 3 to 6 months. Short-term accumulation of black bass occurred in the area near the WCSP boat ramp, but after 3 months, most had dispersed. Overall recapture rates by anglers of previously caught fish was low.

Black bass caught in tournaments expressed either lower or similar relative weights than black bass not caught in tournaments. Lower relative weights of tournament-caught fish may affect growth and demonstrated tournament handling does negatively effect physiological condition.

Tournament-associated mortality was higher for spotted bass than largemouth bass. Tournament mortality of both largemouth and spotted bass was positively related to water temperature. Special measures should be taken including reducing weigh-in time, reducing livewell water temperature, continual aeration, and adding commercial water treatment agents (salts, antibiotics, and mild anesthetics) to angler live wells (Plumb et al. 1988) and the release boat holding tanks especially during periods were water temperature is greater than 21°C. Estimates of mortality for both largemouth bass and spotted bass were generally higher on Lake Martin than other in studies. The use of the WCSP release boat is likely the source of high initial mortality and its use should be discontinued at warm water temperatures as over time, black bass disperse from the WCSP area and Wind Creek.

TABLES

Table 1. - Number of black bass coded wire tagged, tag location, and recaptured in tournaments from October 2003 to April 2005. CWT is the number of fish coded wire tagged. RC is the number of previously tagged and released fish that were recaptured in tournaments.

		Species			
		Largemouth bass		Spotted bass	
Time period	Tag Location	CWT	RC	CWT	RC
10/2003 - 04/2004	Right Cheek	1036	26	2158	32
09/2004 - 11/2004	Left Cheek	735	36	2287	49
02/2005 - 04/2005	Dorsal/Anal	1192	139	2343	153
Total		2963	201	6787	234

FIGURES

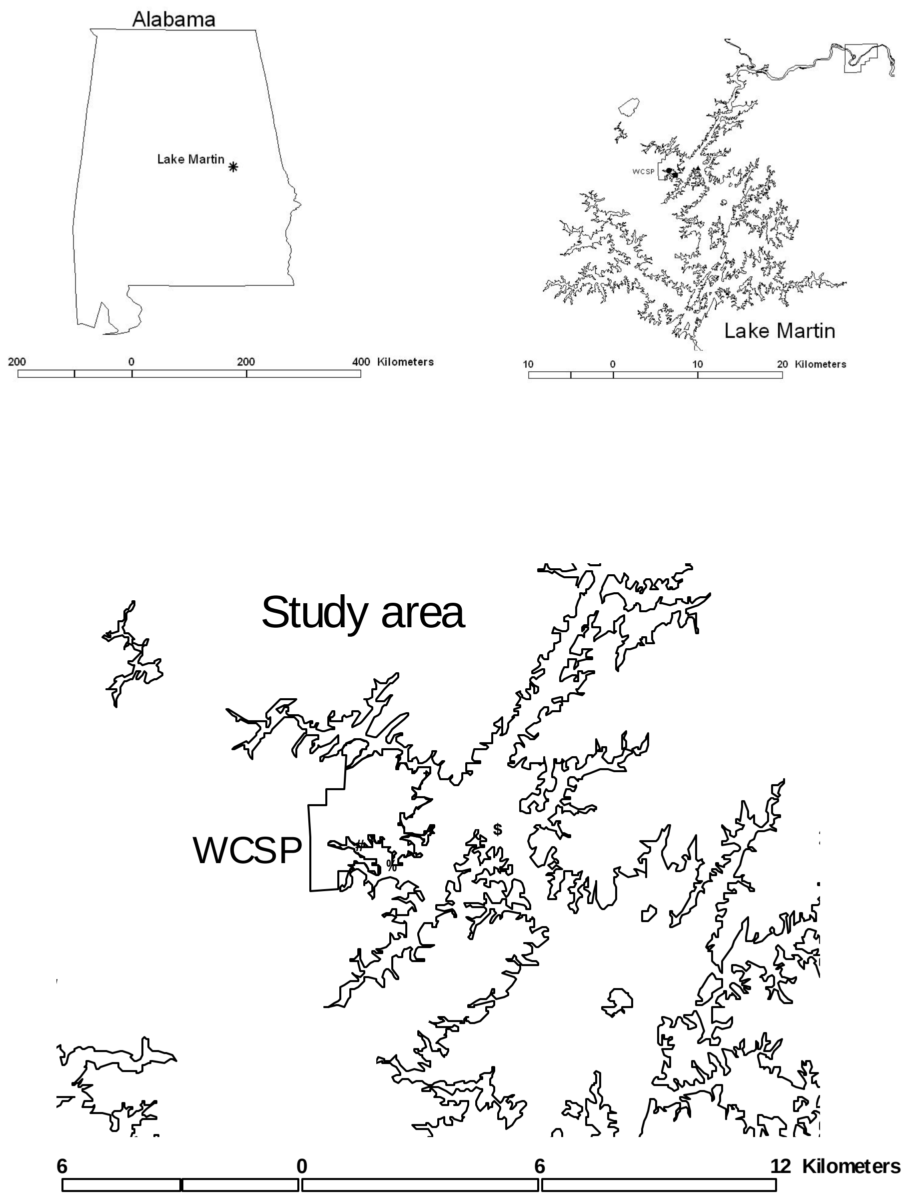

Figure 1. - Lake Martin, Alabama, with the location of Wind Creek State Park (WCSP) and the release sites of tournament-caught largemouth bass and spotted bass. The circle represents the boat ramp and release site for fish during February 12-13, 2005. The square represents the release point for fish tagged from fall 2004 to spring 2005. The triangle represents the mid-point of fish release in fall 2003 and spring 2004.

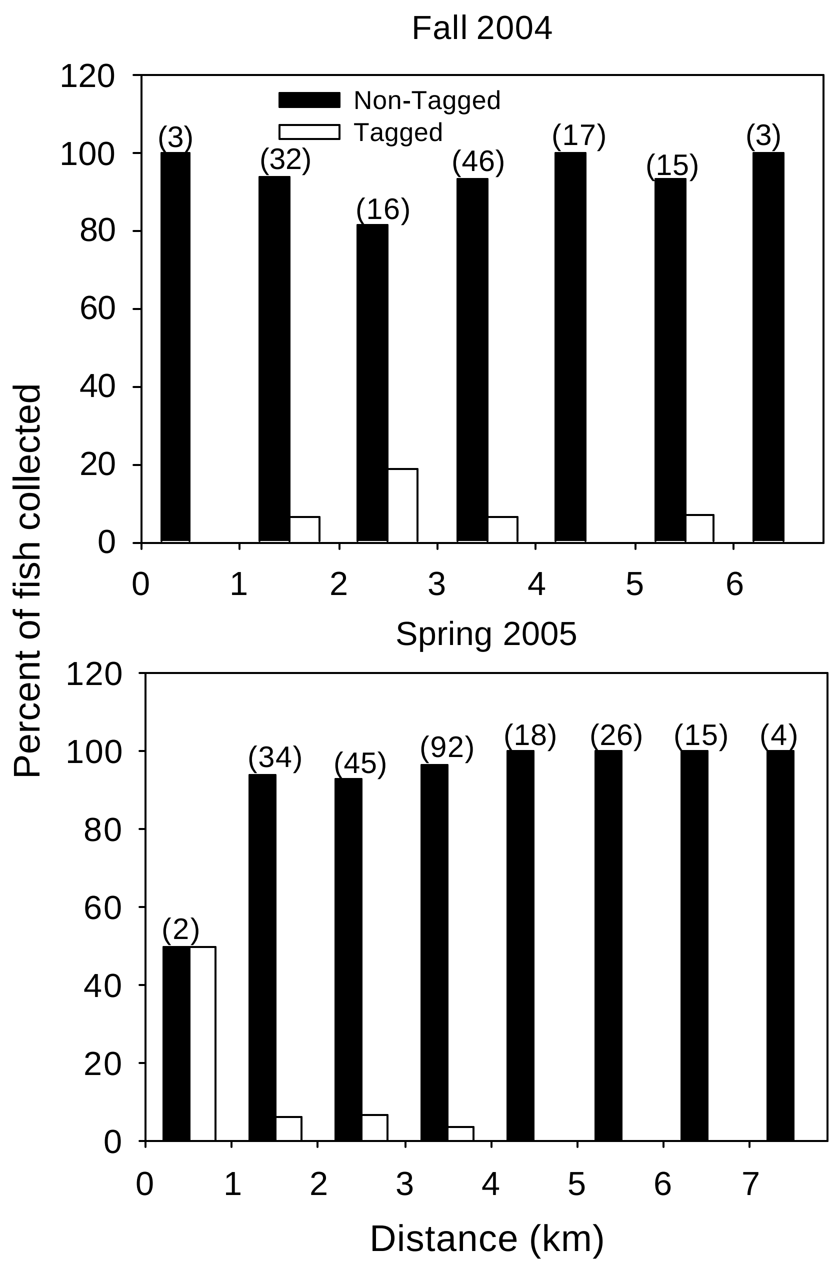

Figure 2. - The percentage of tagged tournament-caught and untagged largemouth bass collected with electrofishing gear at 1 km out to 8 km (distance zones) from the release site in fall 2004 and spring 2005. Fish were coded wire tagged in fall 2003 and spring 2004. Number in parenthesis represents sample size.

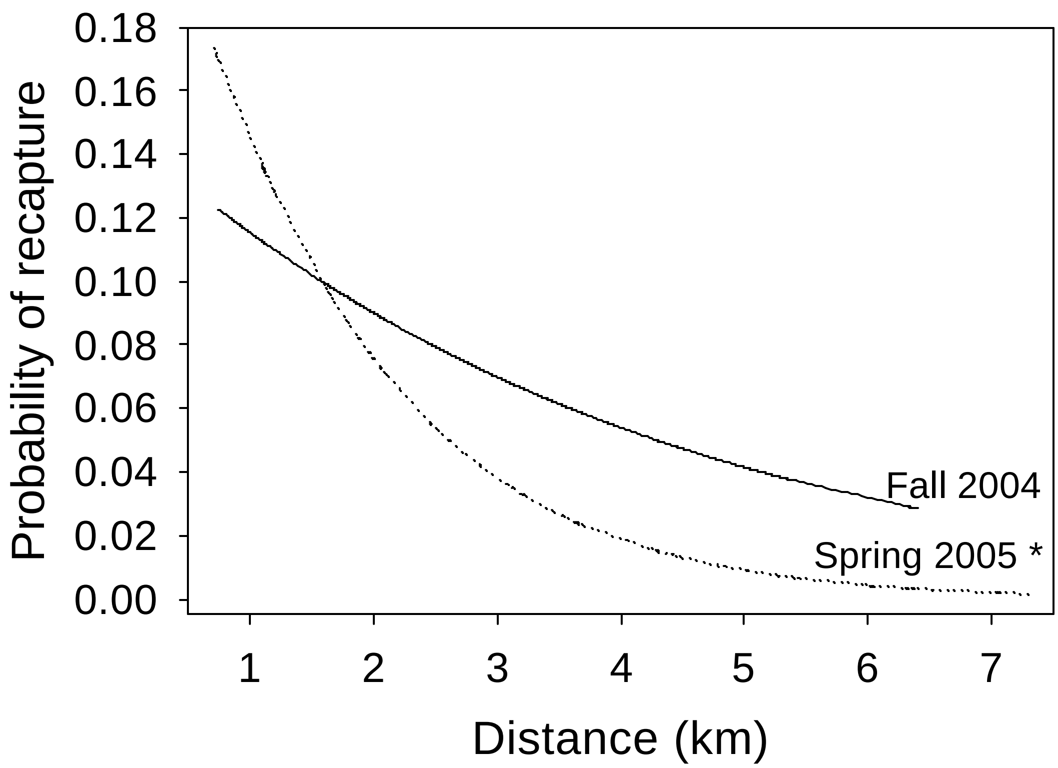

Figure 3. - The predicted recapture probabilities of tagged tournament-caught largemouth bass collected 0 to 7 km from the release site in fall 2004 and 0 to 8 km from the release site in spring 2005. Largemouth bass were coded wire tagged fall 2003 and spring 2004. The asterisk represents a significant relationship ($P < 0.05$).

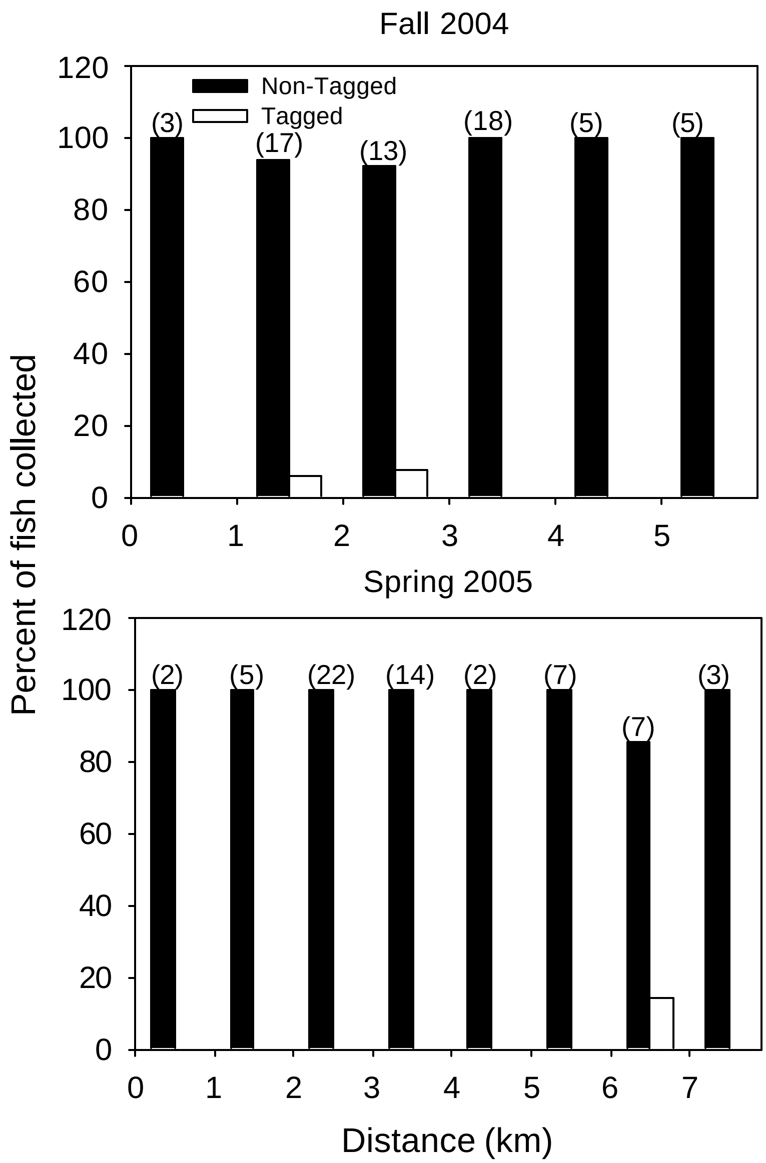

Figure 4. - The percentage of tagged tournament-caught and untagged spotted bass collected with electrofishing gear from 0 to 6 km and 8 km (distance zones) from the release site in fall 2004 and spring 2005. Fish were coded wire tagged in fall 2003 and in spring 2004. Number in parenthesis represents sample size.

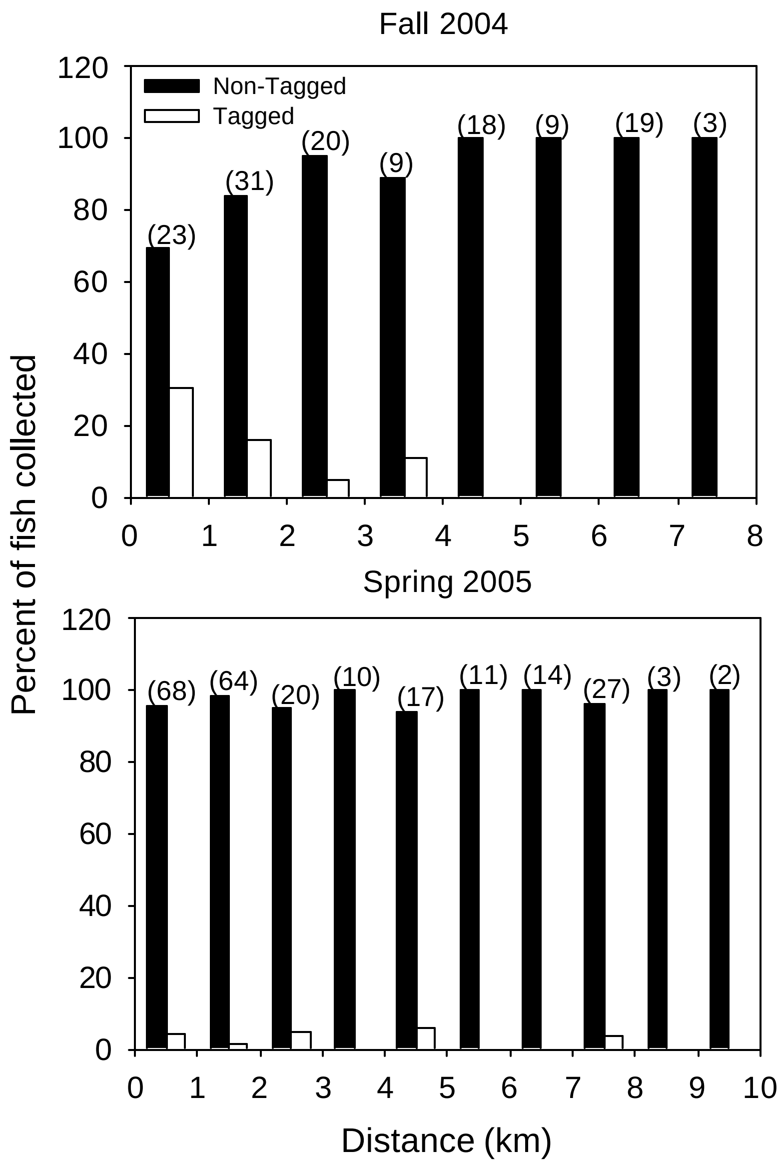

Figure 5. - The percentage of tagged tournament-caught and untagged largemouth bass collected with electrofishing gear from 0 to 8 km (distance zones) from the release site in fall 2004 and from 0 to 10 km (distance zones) from the release site in spring 2005. Fish were coded wire tagged fall 2004. Number in parenthesis represents sample size.

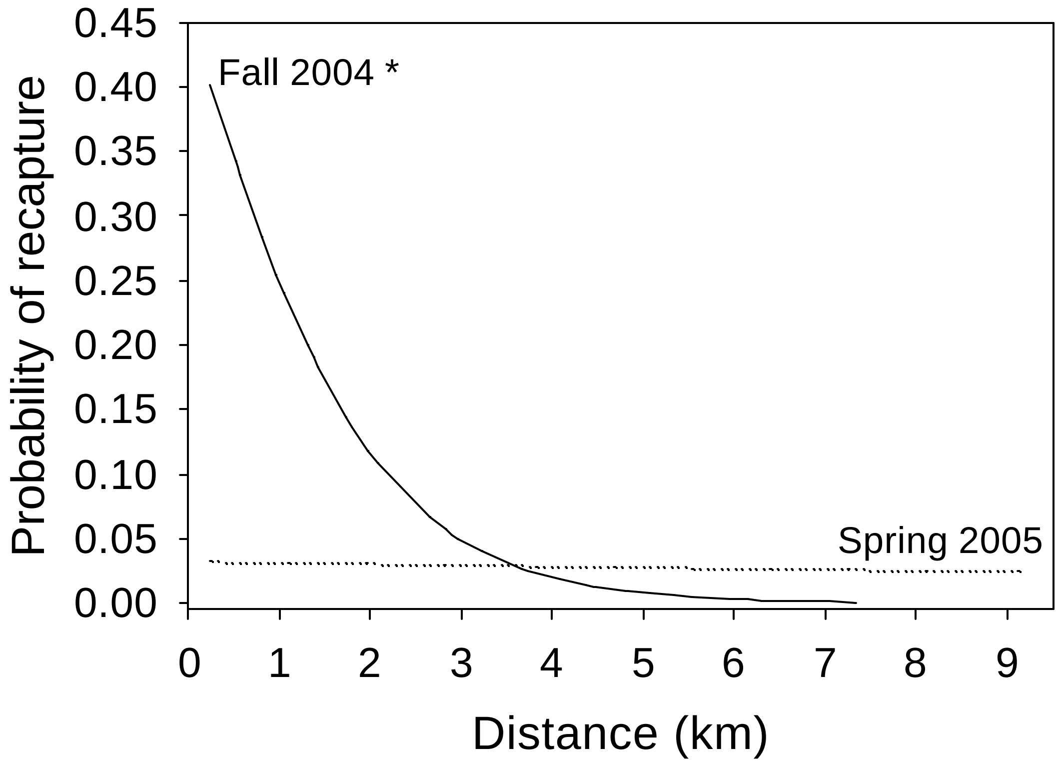

Figure 6. - The predicted recapture probabilities of tagged tournament-caught largemouth bass collected 0 to 8 km from the release site in fall 2004 and 0 to 10 km from the release site in spring 2005. Largemouth bass were coded wire tagged fall 2004. The asterisk represents a significant relationship ($P < 0.05$).

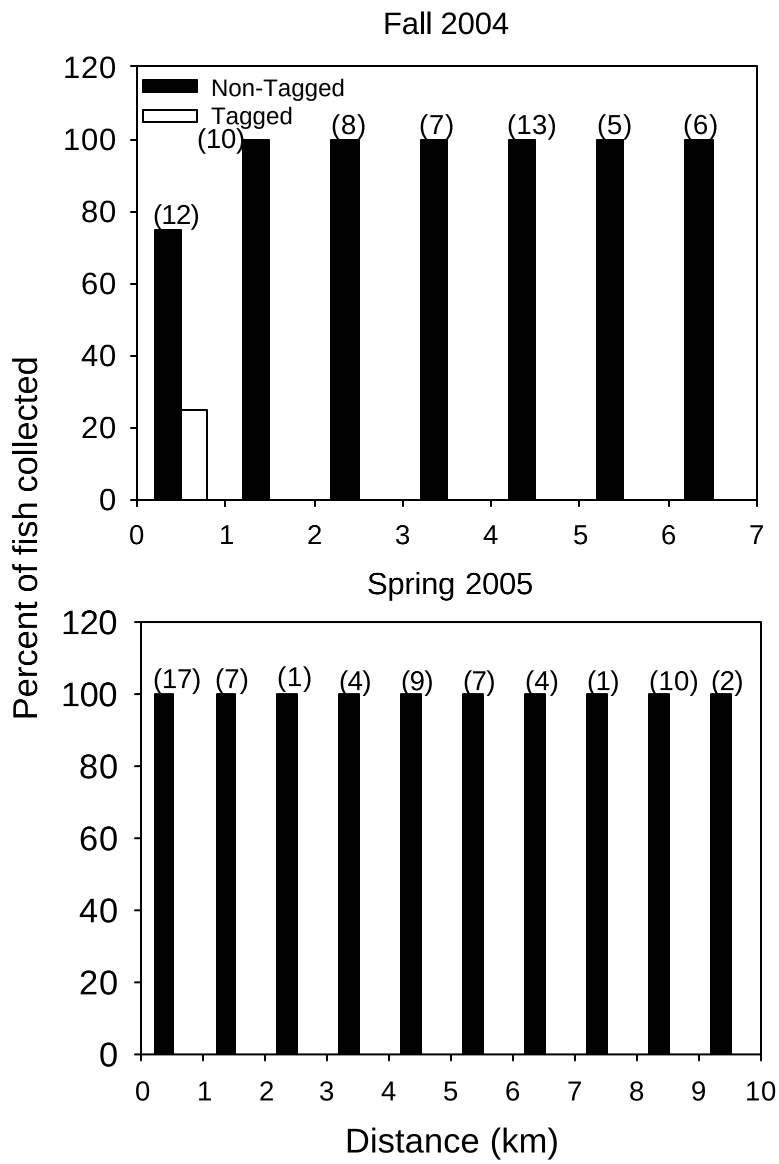

Figure 7. - The percentage of tagged tournament-caught and untagged spotted bass collected with electrofishing gear at 0 to 7 km (distance zones) from the release site in fall 2004 and 0 to 10 km from the release site in spring 2005. Fish were coded wire tagged fall 2004. Number in parenthesis represents sample size.

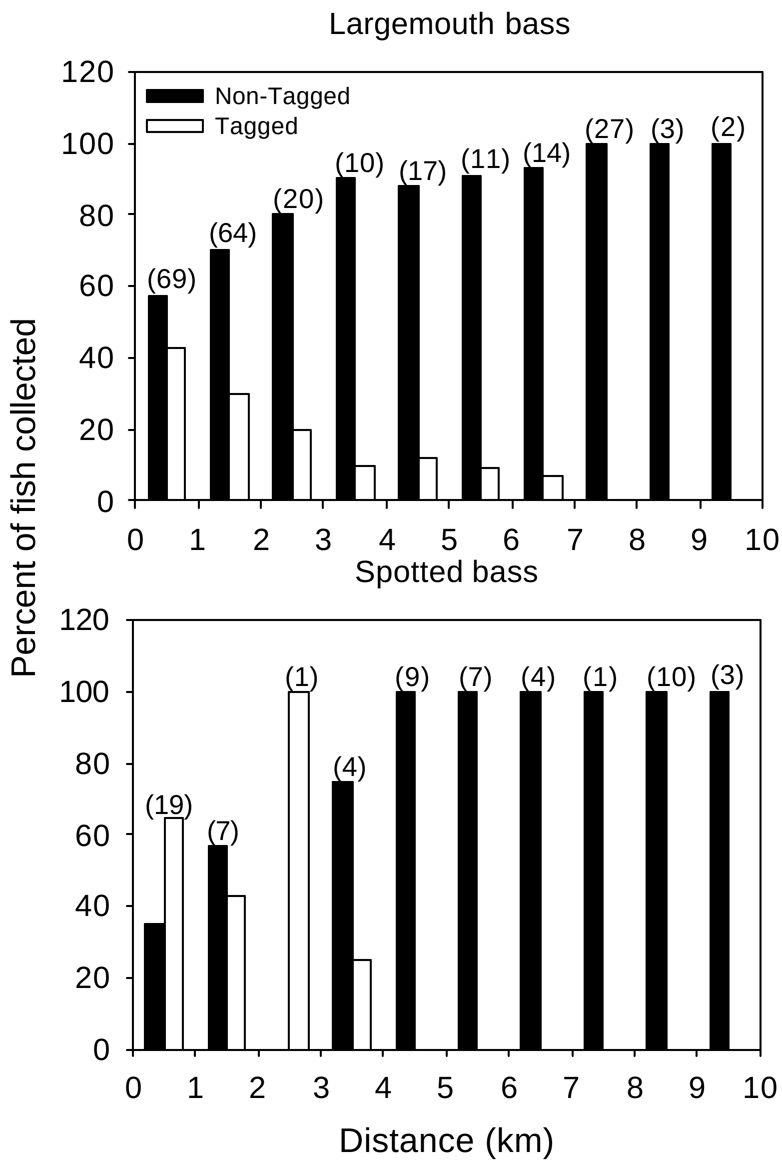

Figure 8. - The percentage of tagged tournament-caught and untagged largemouth bass and spotted bass collected with electrofishing gear at 0 to 10 km (distance zones) from the release site in spring 2005. Fish were coded wire tagged spring 2005. Numbers in parenthesis represents sample size.

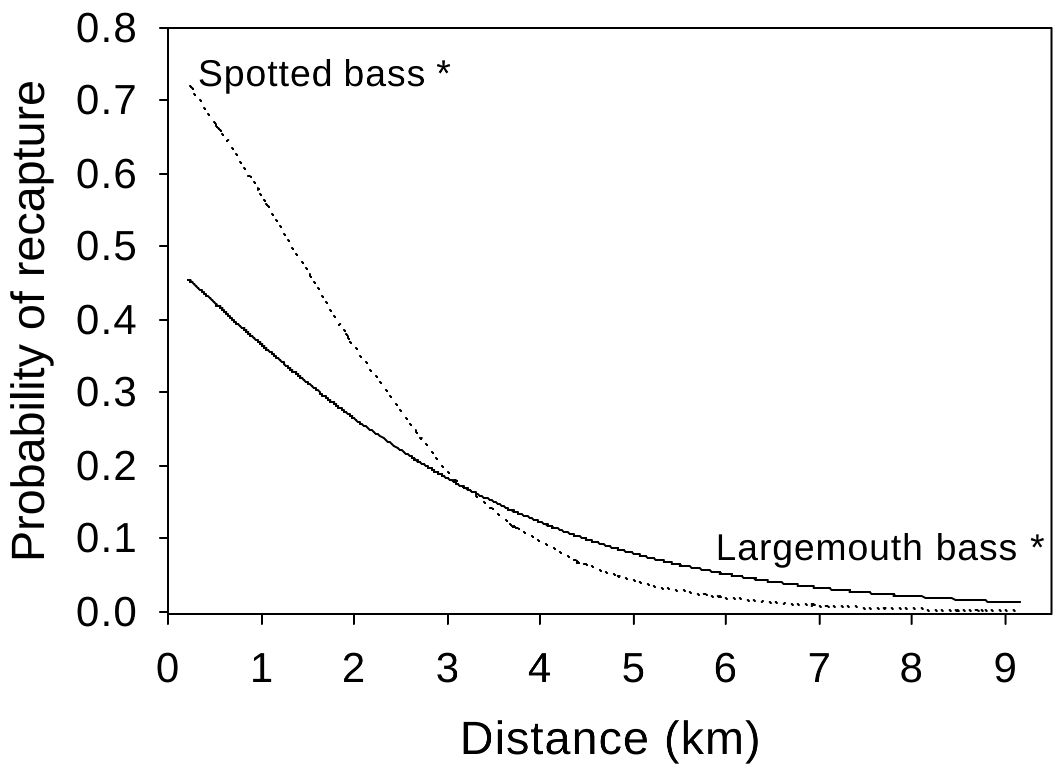

Figure 9. - The predicted recapture probabilities of a tagged tournament caught largemouth bass and spotted bass 0 to 10 km from the release site in Wind Creek in May 2005. Fish were tagged spring 2005. The asterisk represents a significant relationship (P < 0.05).

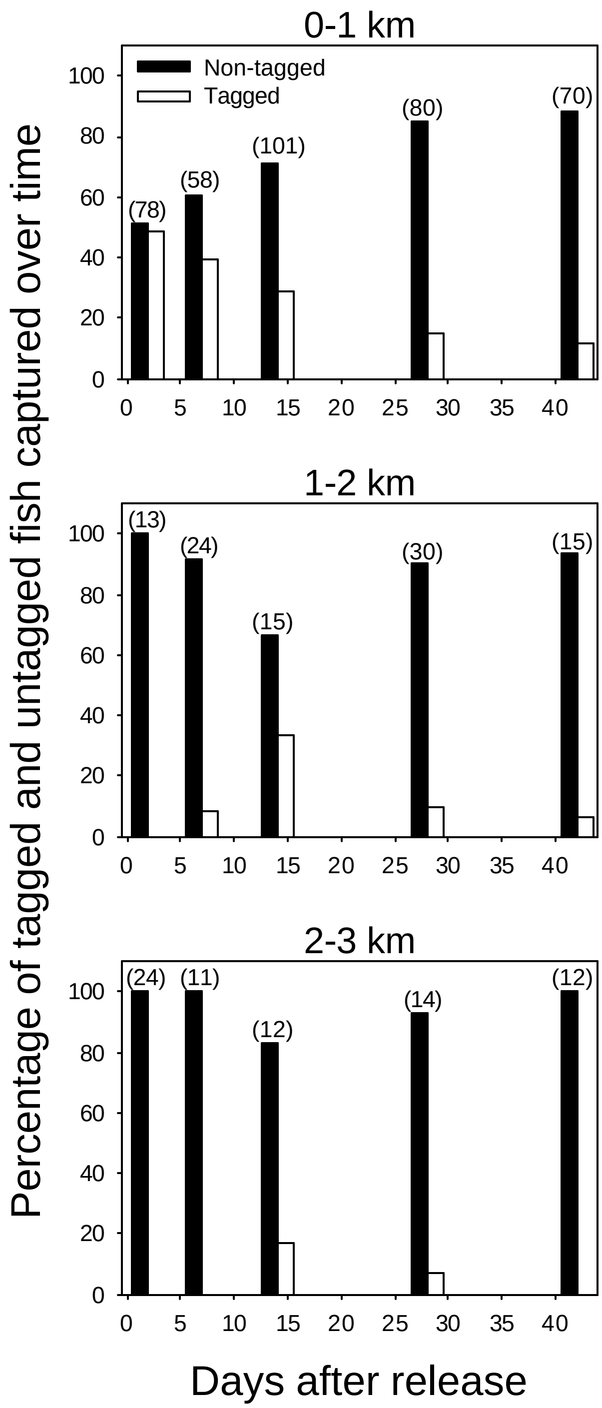

Figure 10. - The percentage of tagged tournament-caught and untagged largemouth bass collected with electrofishing at three distance zones from the release site at WCSP. Fish were sampled over a forty-two day period after release. Tournament fish were tagged February 12 - 13, 2005. Number in parenthesis represents sample size.

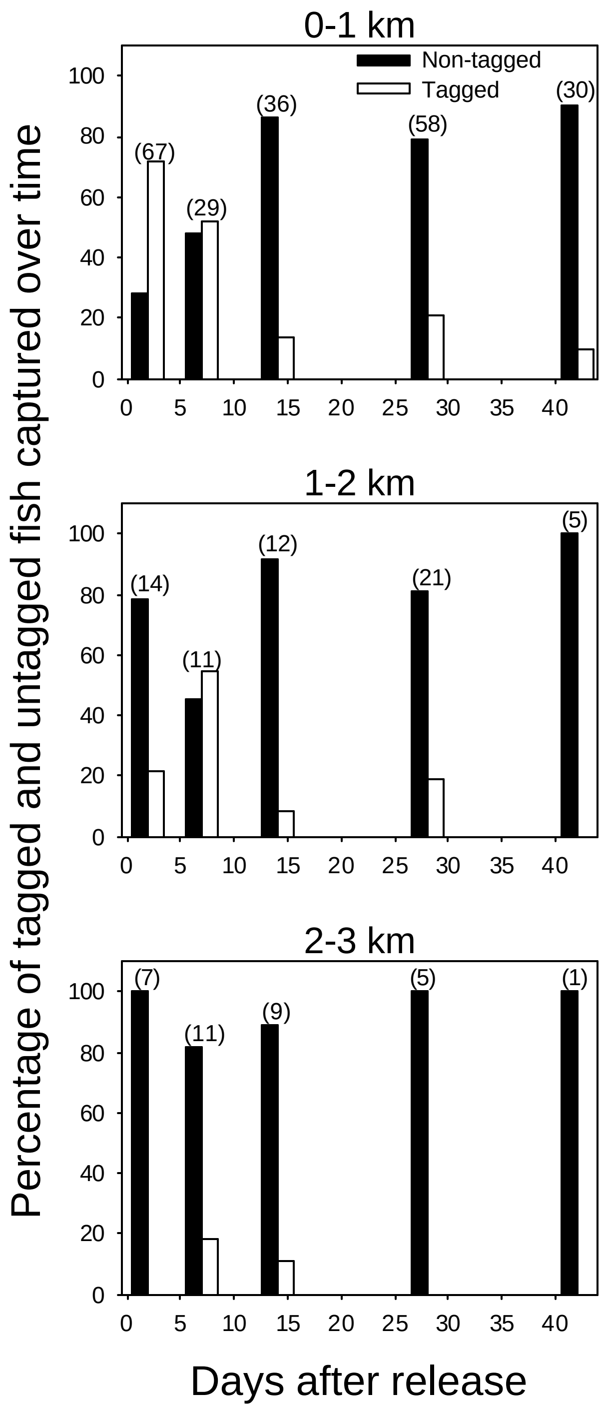

Figure 11. - The percentage of tagged tournament-caught and untagged spotted bass collected with electrofishing at three distance zones from the release site at WCSP. Fish were sampled over a forty-two day period after release. Tournament fish were tagged February 12 - 13, 2005. Number in parenthesis represents sample size.

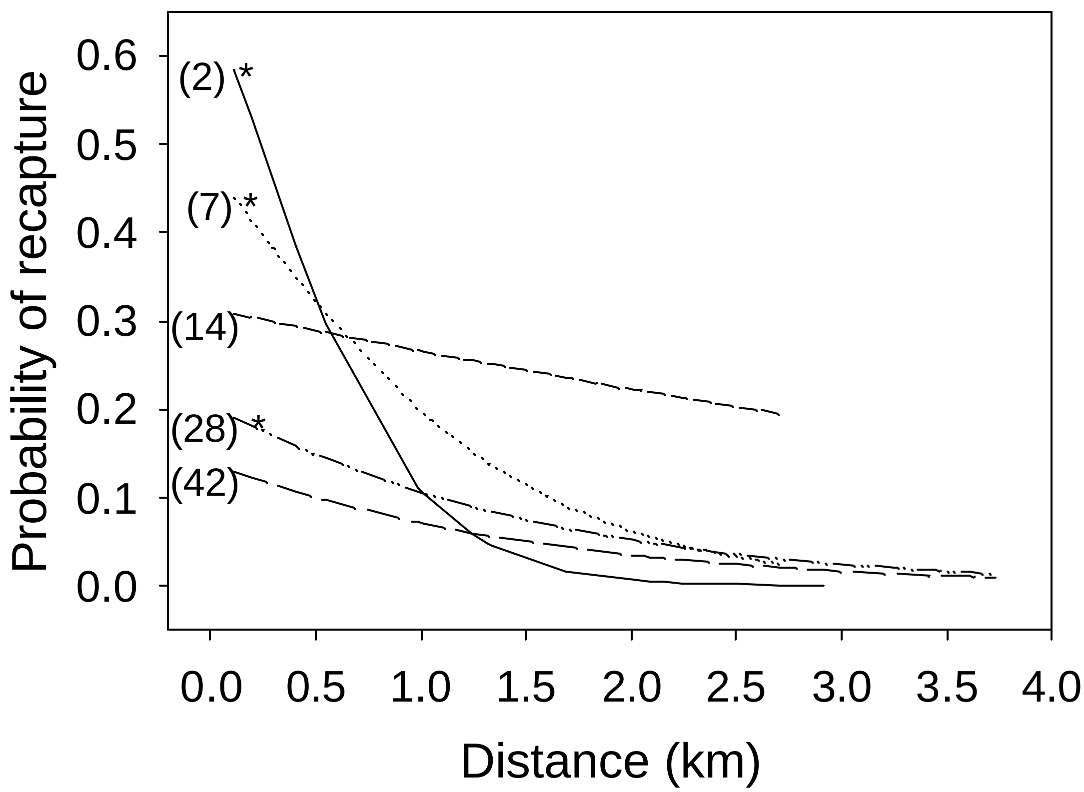

Figure 12. - The predicted recapture probabilities of tagged tournament-caught largemouth bass two to forty-two days after release at 0 to 3.5 km from the release site at WCSP. Number in parentheses represents days after release. The asterisk represents a significant relationship (P < 0.05).

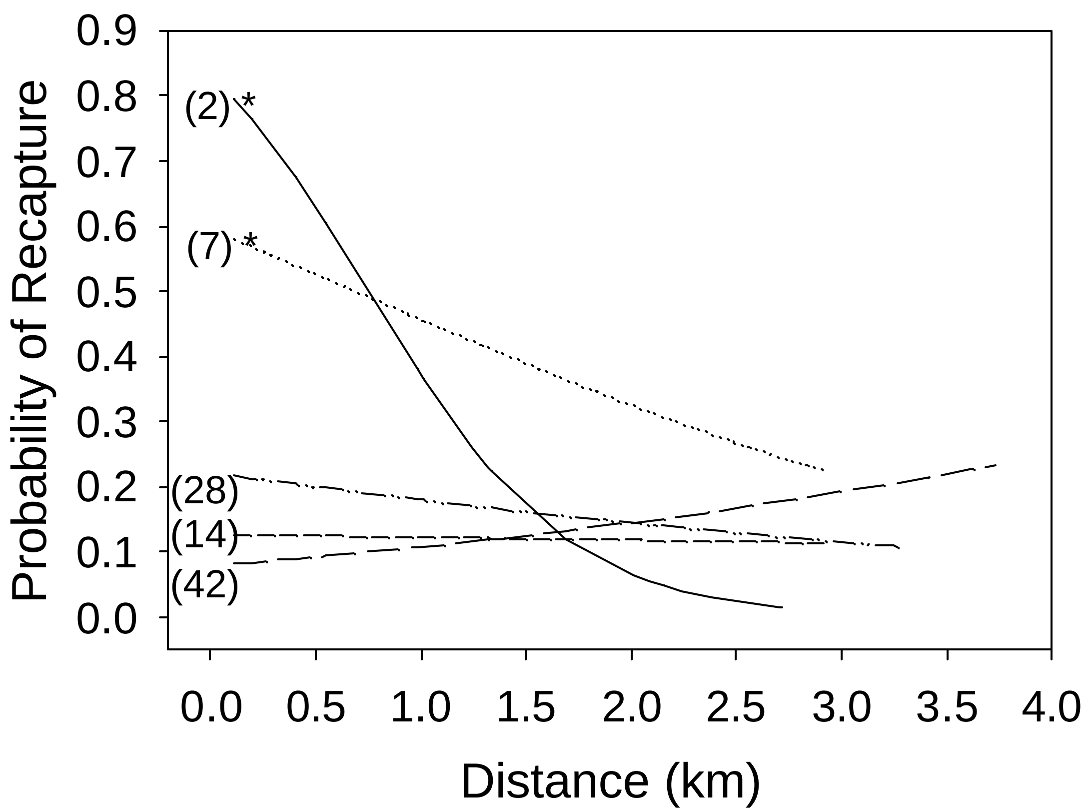

Figure 13. - The predicted recapture probabilities of tagged tournament-caught spotted bass two to forty-two days after release at 0 to 3.5 km from the release site at WCSP. Number in parentheses represents days after release. The asterisk represents a significant relationship ($P < 0.05$).

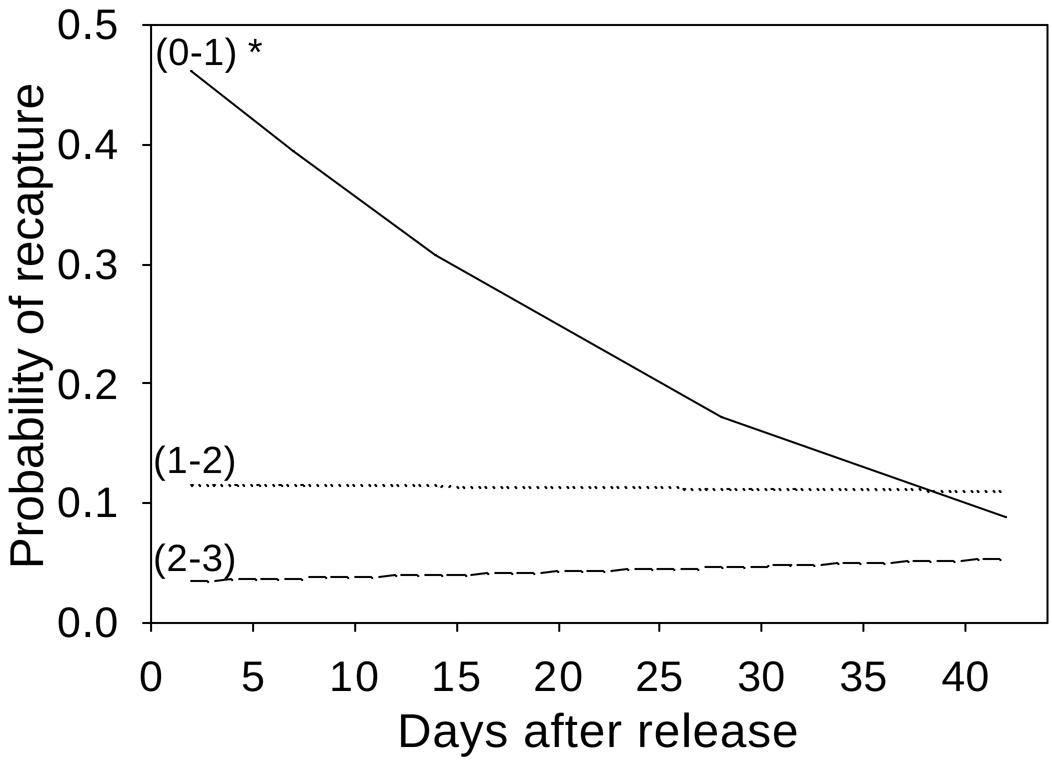

Figure 14. - The predicted recapture probabilities of tagged tournament-caught largemouth bass over time (after release) at three distinct distance zones from the release site at WCSP. Number in parentheses represents one-km distance zones. The asterisk represents a significant relationship ($P < 0.05$).

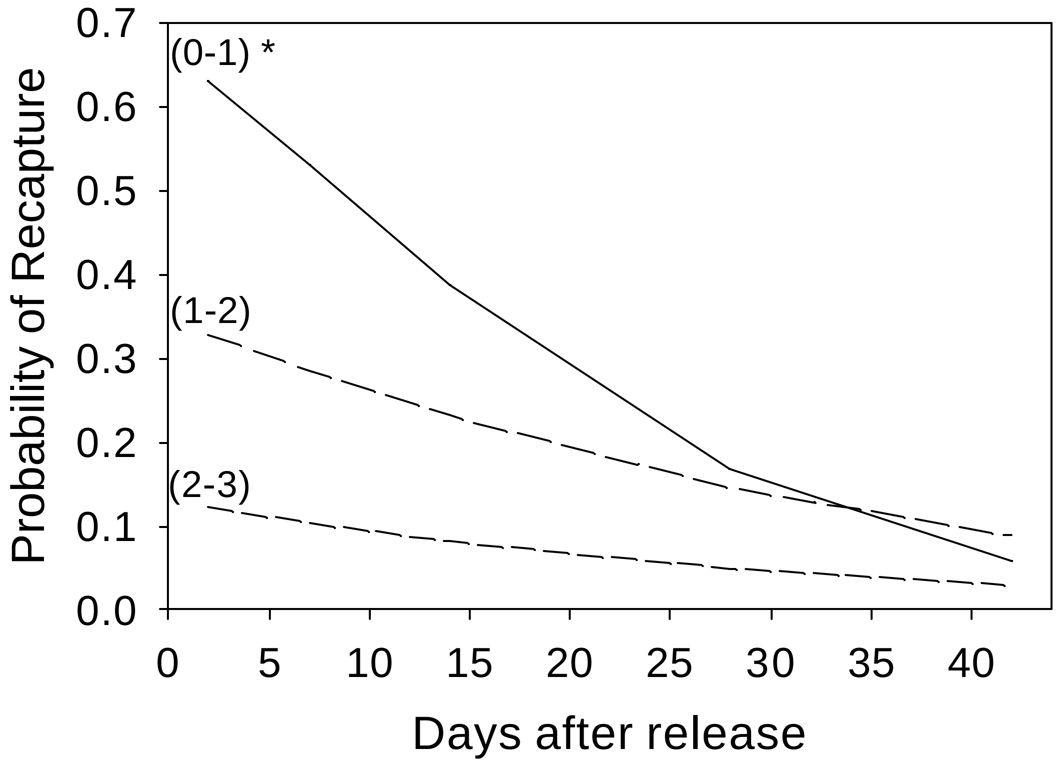

Figure 15. - The predicted recapture probabilities of tagged tournament-caught spotted bass over time (after release) at three distinct distance zones from the release site at WCSP. Number in parentheses represents one-km distance zones. The asterisk represents a significant relationship ($P < 0.05$).

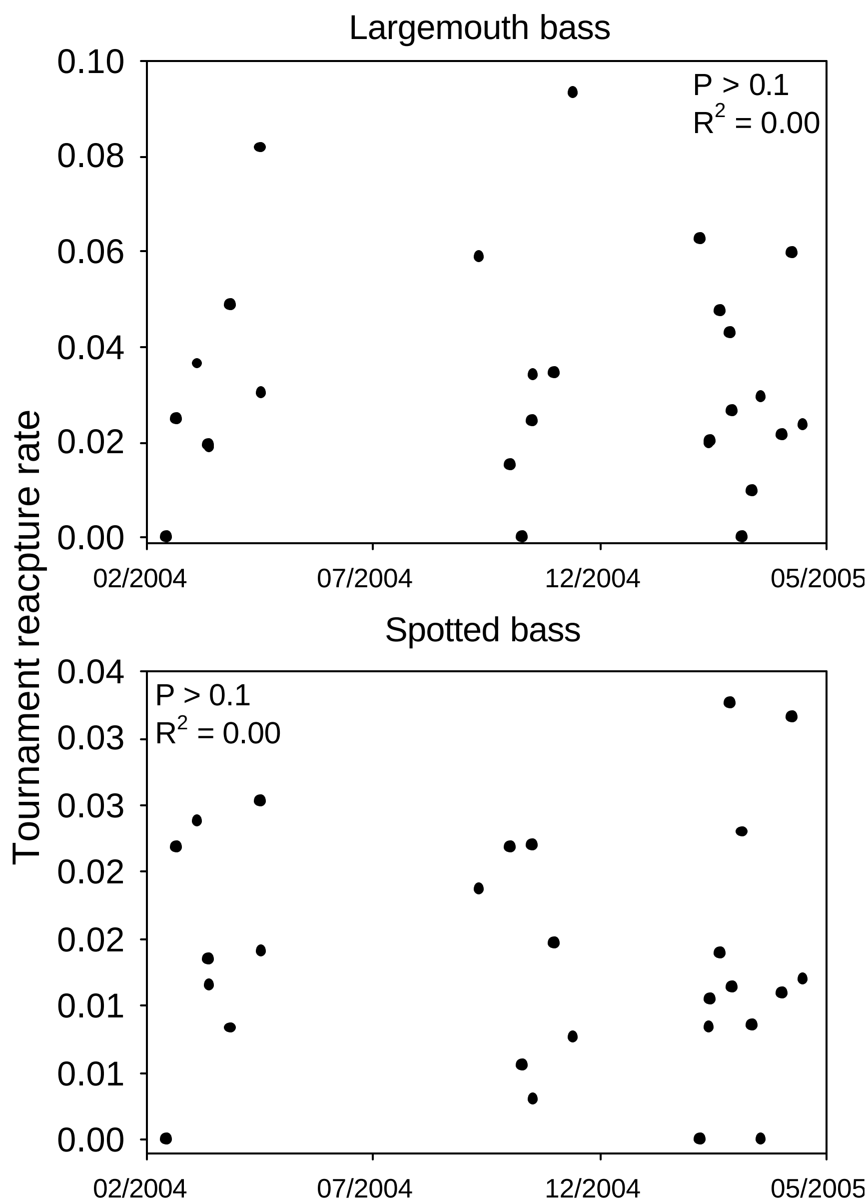

Figure 16. - The tournament recapture rates of black bass tagged in fall 2003 to spring 2004 versus time from spring 2004 to spring 2005.

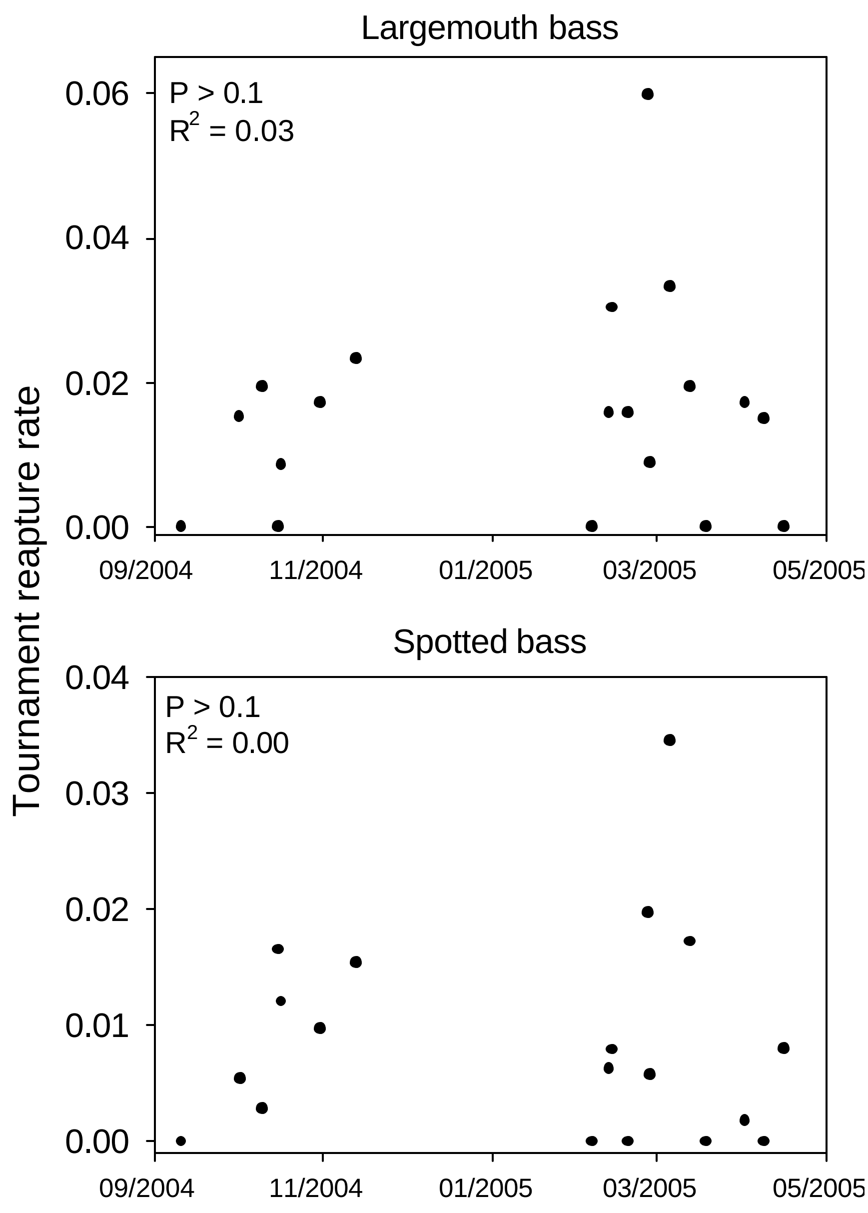

Figure 17. - The tournament recapture rates of black bass tagged in fall 2004 versus time from fall 2004 to spring 2005.

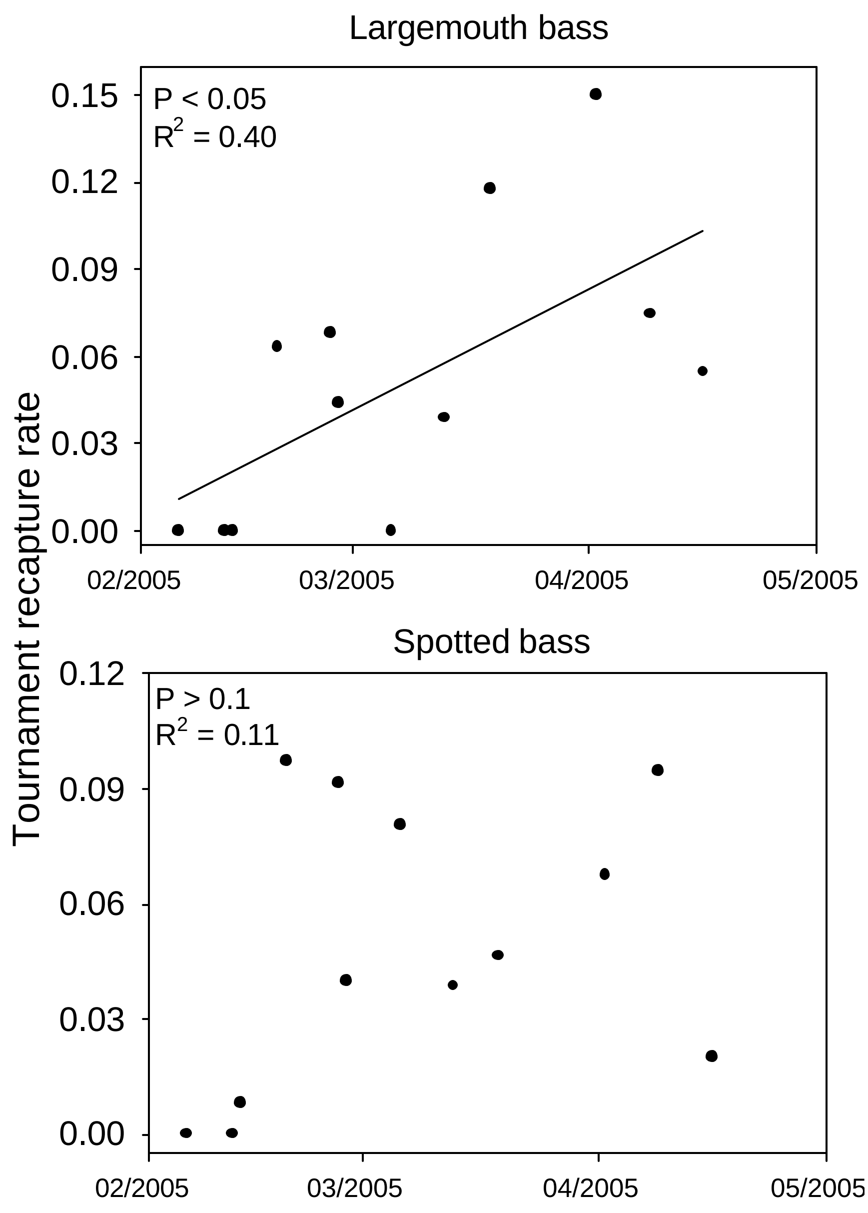

Figure 18. - The tournament recapture rates of black bass tagged in spring 2005 versus time in spring 2005.

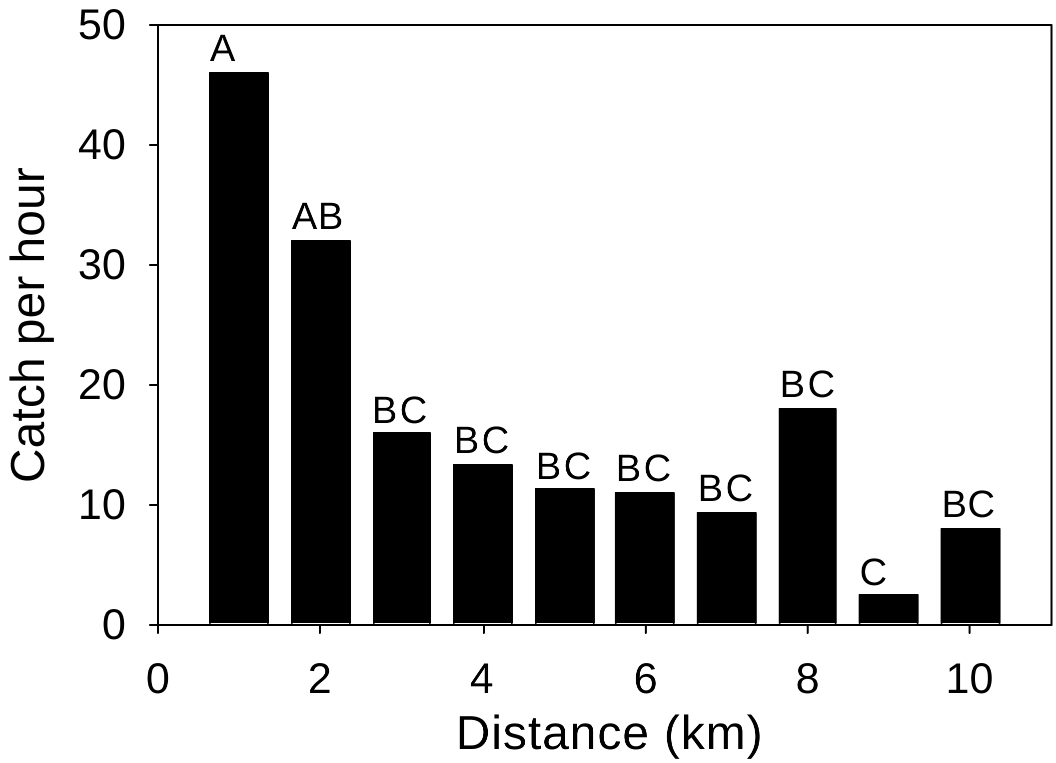

Figure 19. - The mean catch-per-hour of largemouth bass at one-km distance zones collected out to 10 km from the release point. Fish were collected in spring 2005. Mean values followed by the same letter were not significantly different (P > 0.05).

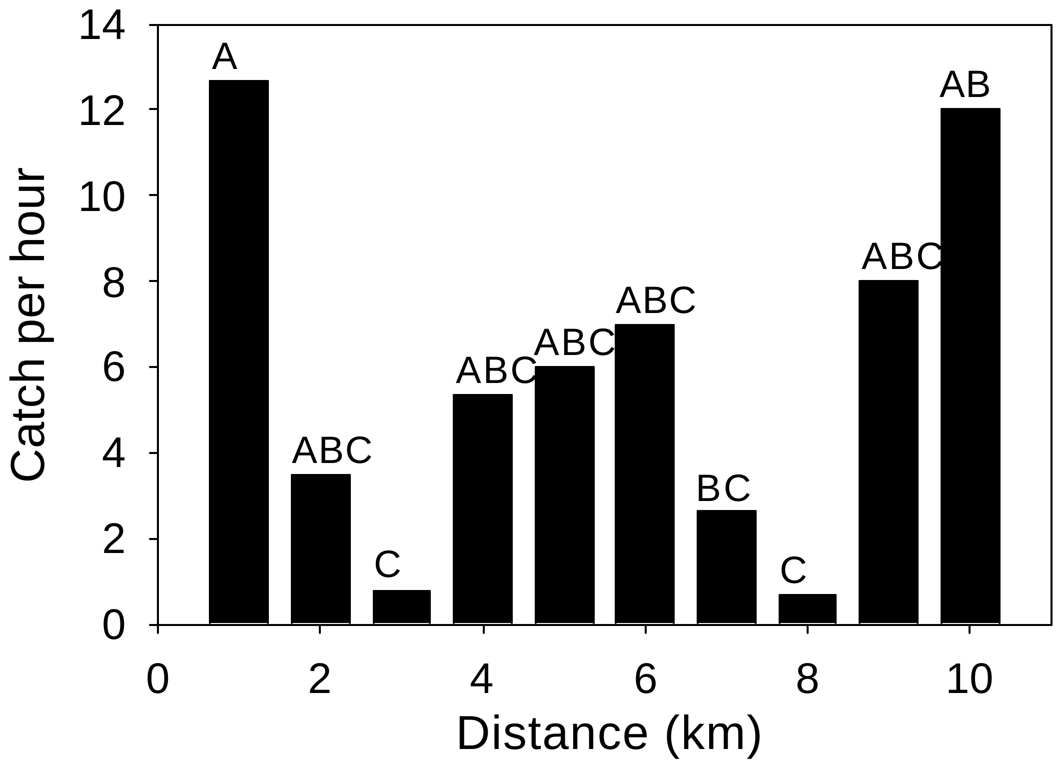

Figure 20. - The mean catch-per-hour of spotted bass at one-km distance zones collected out to 10 km from the release point. Fish were collected in spring 2005. Mean values followed by the same letter were not significantly different (P > 0.05).

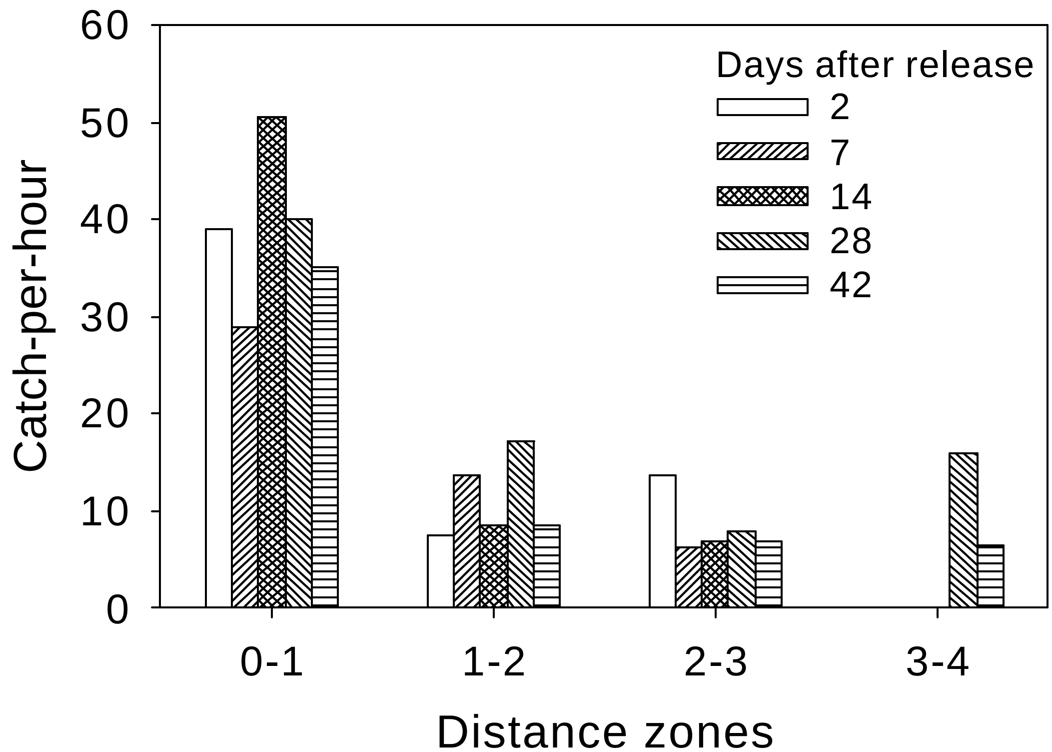

Figure 21. - The mean catch-per-hour of largemouth bass at one-km distance zones collected out to 4 km from the release point. Fish were collected at 2, 7, 14, 28, and 42 days after release.

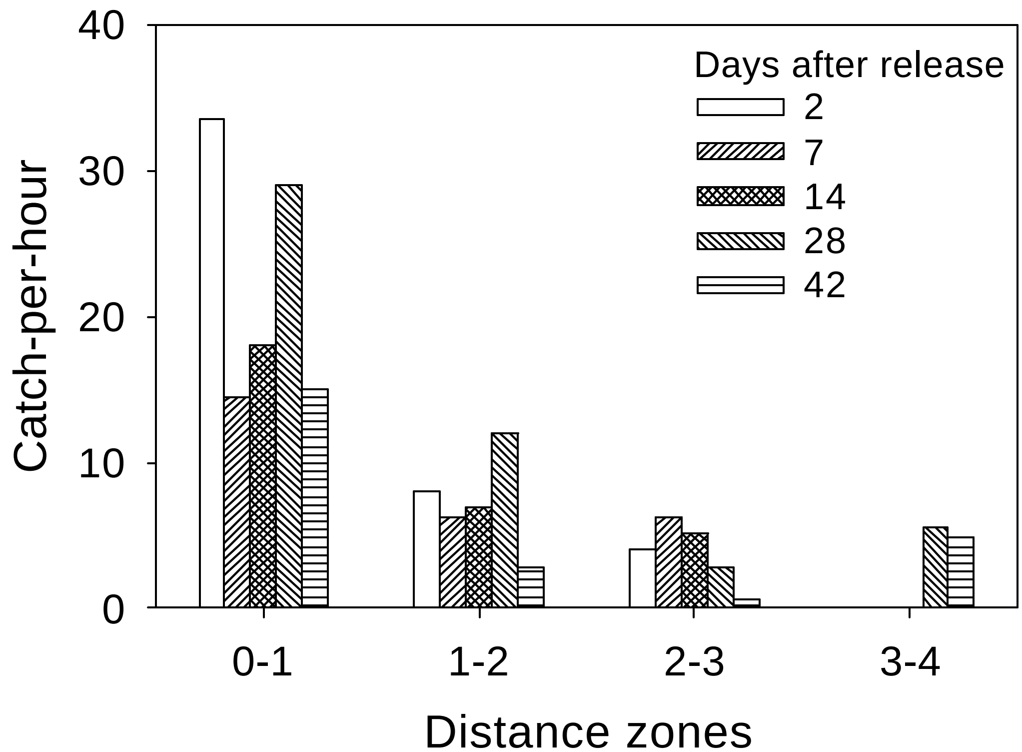

Figure 22. - The mean catch-per-hour of spotted bass at one-km distance zones collected out to 4 km from the release point. Fish were collected at 2, 7, 14, 28, and 42 days after release.

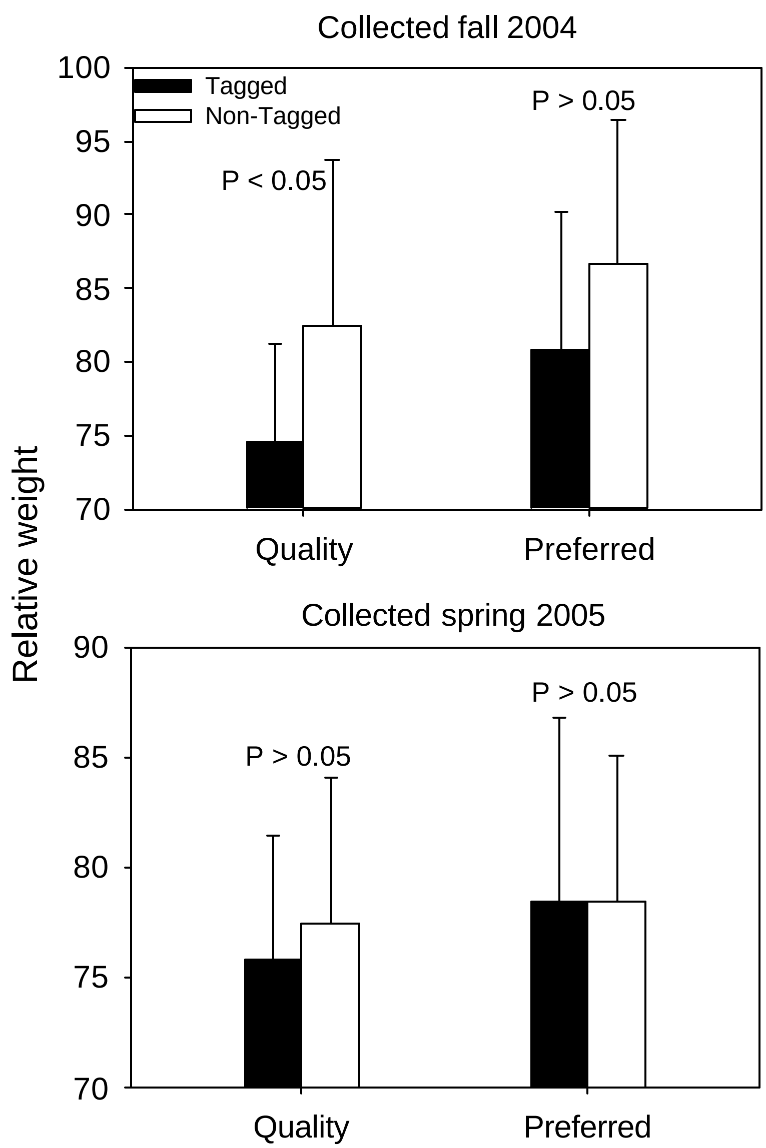

Figure 23. - The mean relative weights of tagged tournament-caught and untagged largemouth bass for quality and preferred lengths collected with electrofishing gear in fall 2004 and spring 2005. Fish were tagged from fall 2003 to spring 2005. Probabilities (P) are given to test for differences in relative weights. Error bars represents standard deviation.

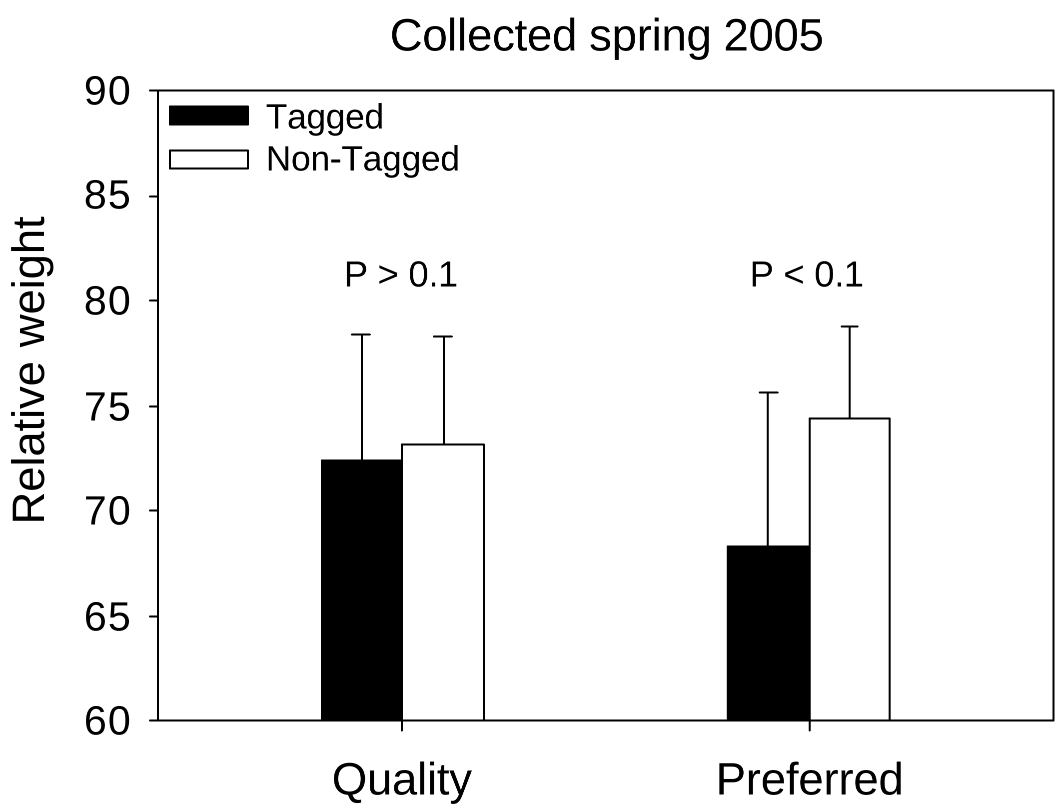

Figure 24. - The mean relative weights of tagged tournament-caught and untagged spotted bass for quality and preferred lengths collected with electrofishing gear in spring 2005. Fish were tagged from fall 2003 to spring 2005. Probabilities (P) are given to test for differences in relative weights. Error bars represents standard deviation.

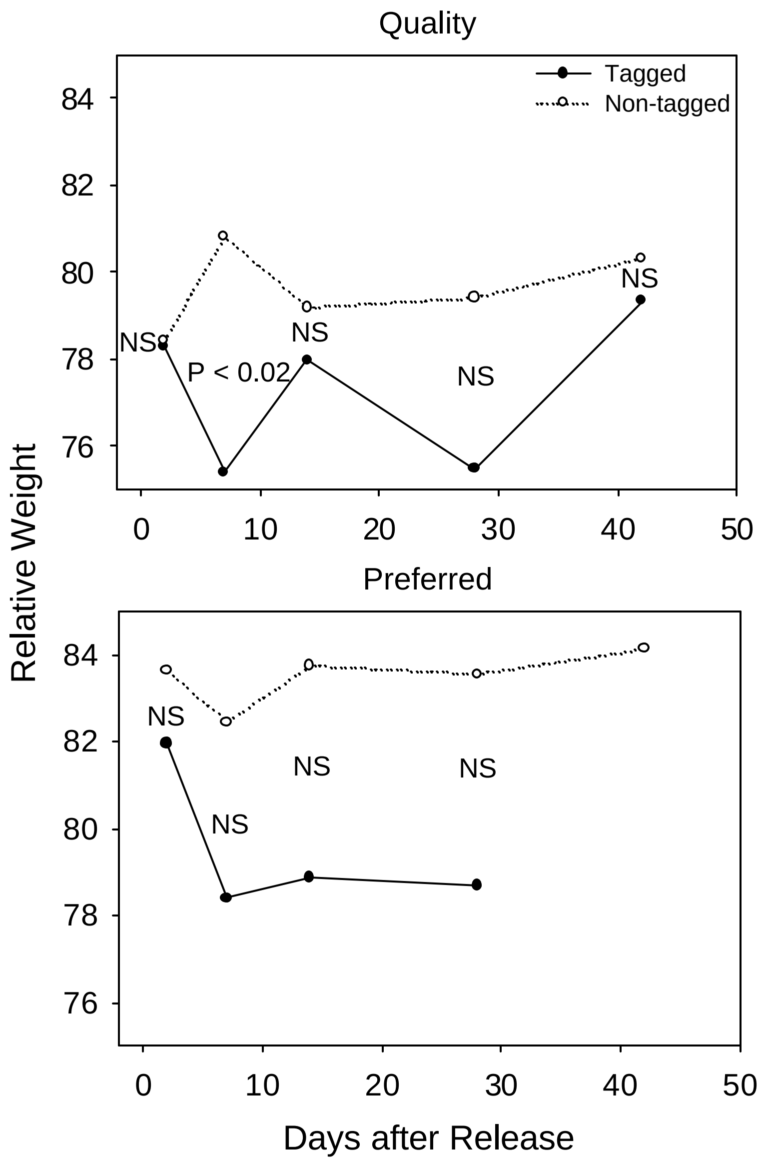

Figure 25. - The mean relative weights tagged of tournament-caught and untagged largemouth bass for quality and preferred lengths collected with electrofishing gear over a forty-two day period after release. Tournament fish were tagged February 12 - 13, 2005. NS represents non-significance. Probabilities (P) are given to test for differences in relative weights.

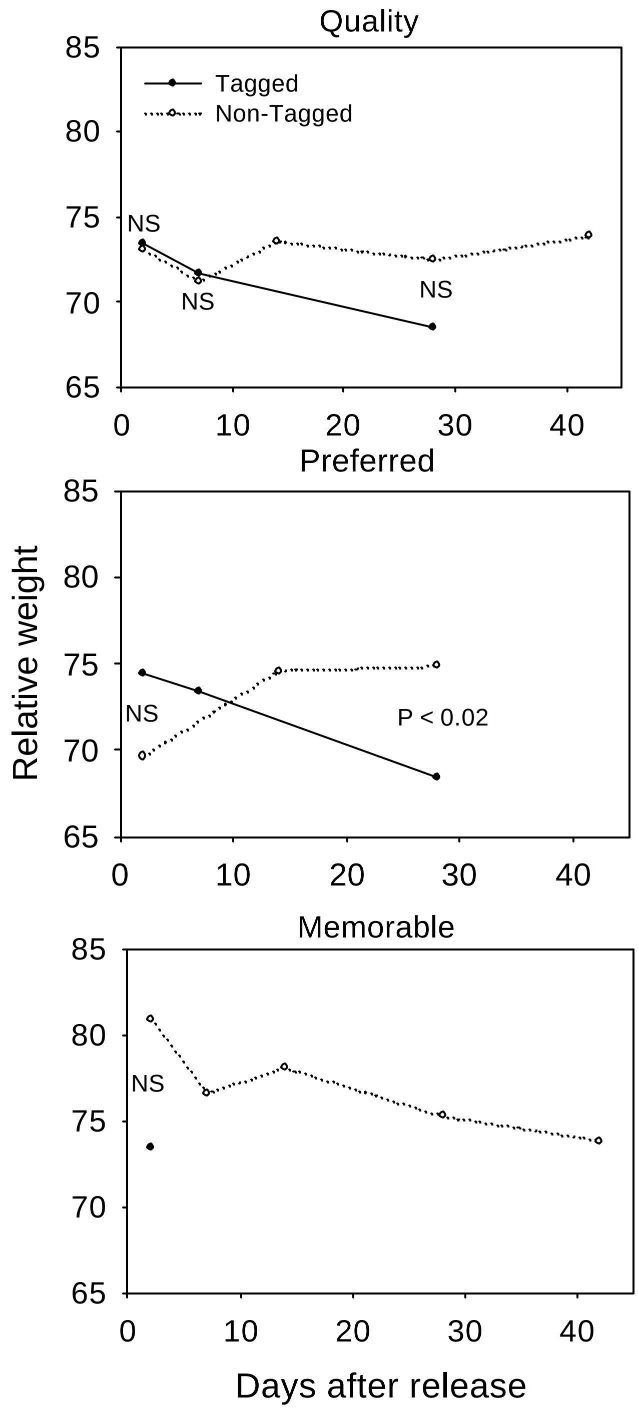

Figure 26. - The mean relative weights of tagged tournament-caught and untagged spotted bass for quality and preferred lengths collected with electrofishing gear over a forty-two day period after release. Tournament fish were tagged February 12 - 13, 2005. NS represents non-significance. Probabilities (P) are given to test for differences in relative weights.

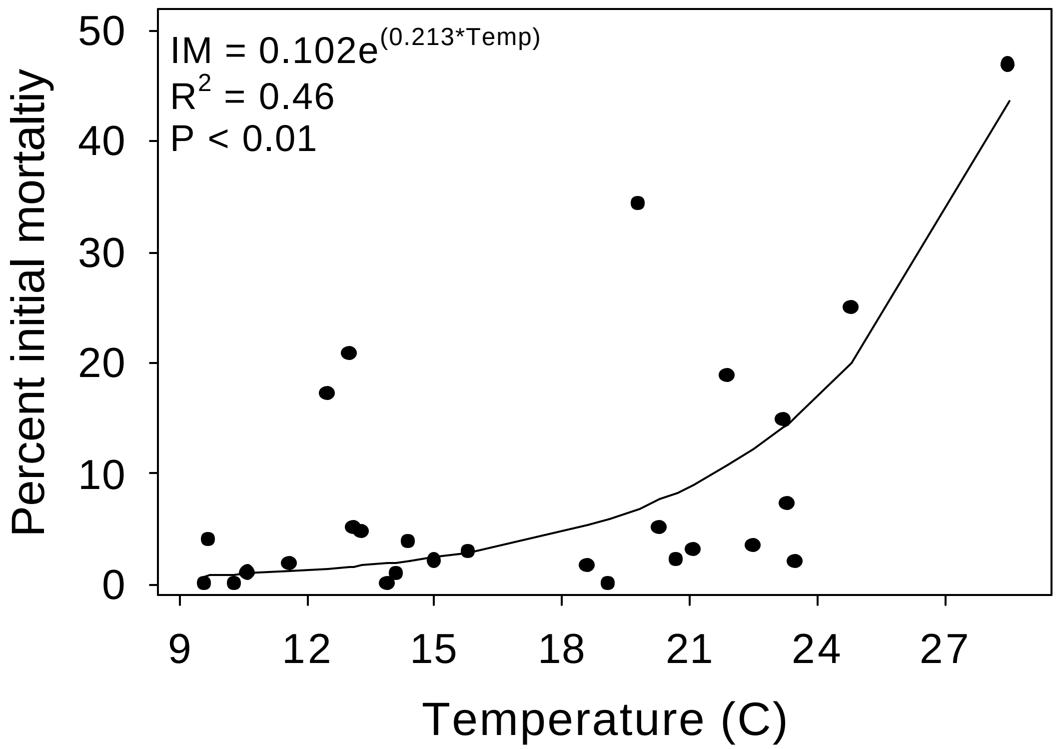

Figure 27. - Predicted and observed percent initial mortality of tournament caught largemouth bass versus temperature during black bass tournaments held fall 2003 to spring 2005.

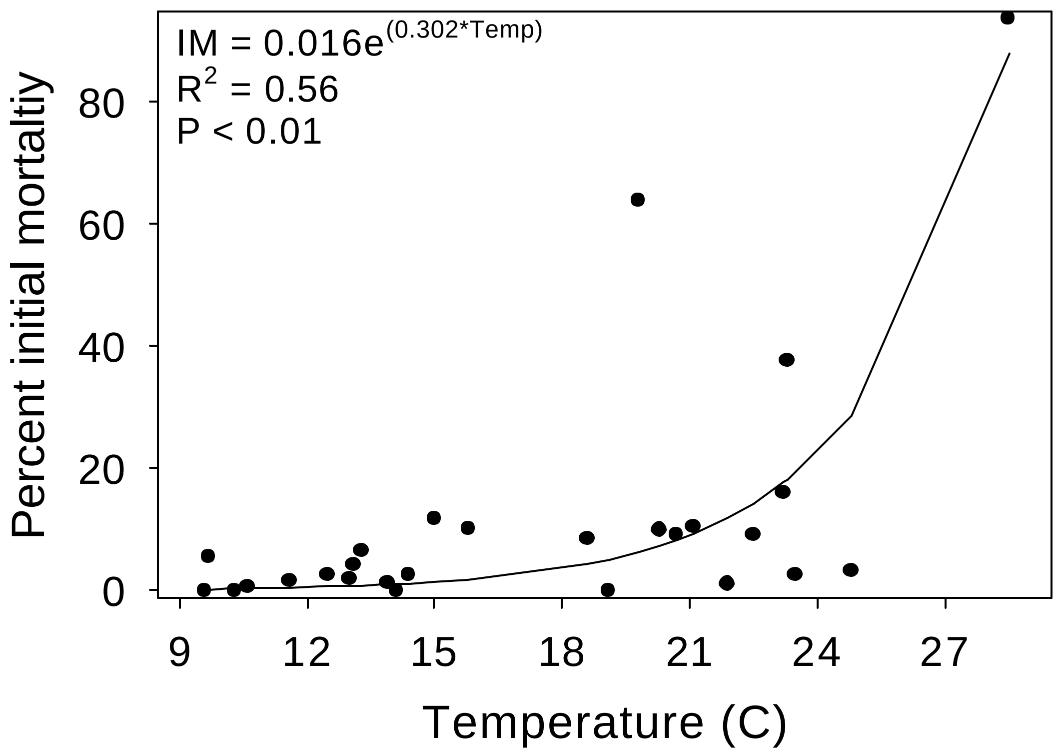

Figure 28. - Predicted and observed percent initial mortality of tournament-caught spotted bass versus temperature during black bass tournaments held fall 2003 to spring 2005.

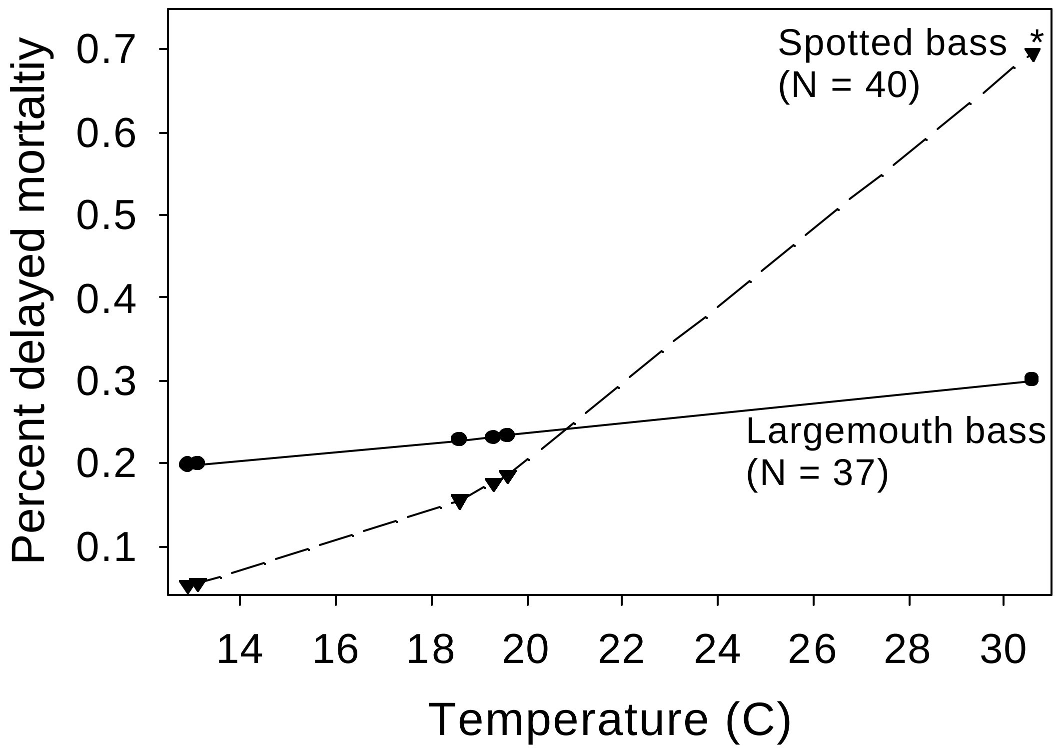

Figure 29. - Predicted percent delayed mortality of tournament-caught largemouth and spotted bass versus temperature during black bass tournaments held in spring and fall 2005. The asterisk represents a significant relationship ($P < 0.05$).

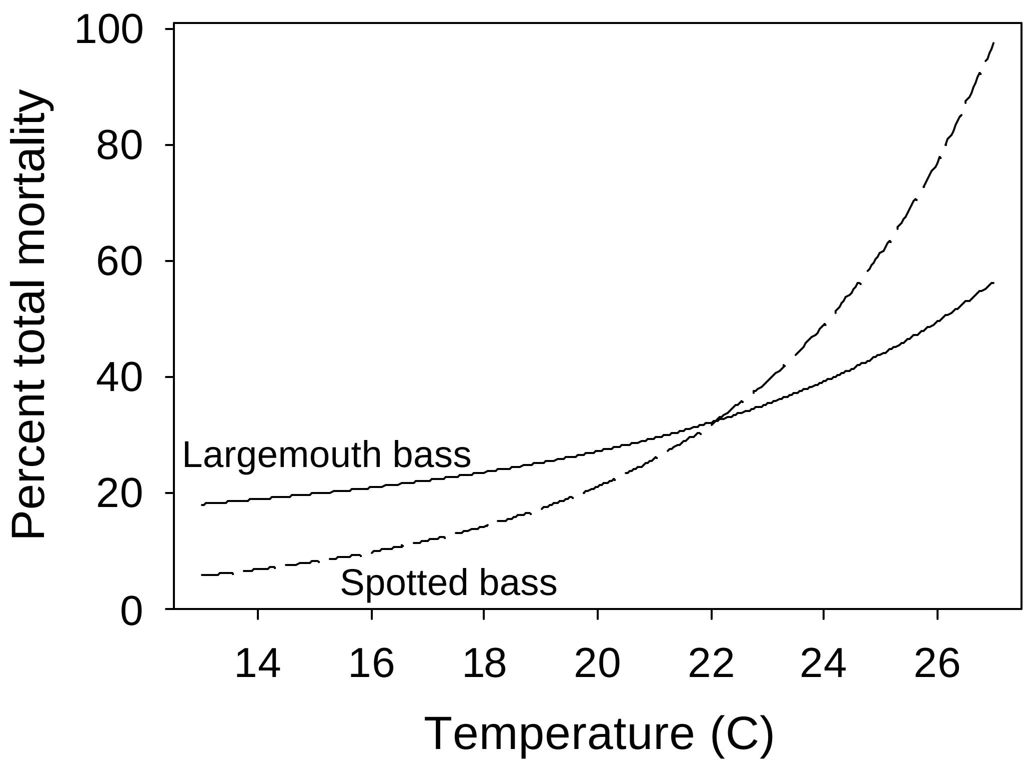

Figure 30. - Predicted percent total mortality of tournament caught largemouth and spotted bass versus temperature during black bass tournaments held fall in Lake Martin.

LITERATURE CITED

Anderson, R. O. and R. M. Neuman. 1996. Length, weight, and associated structural indices. Pages 477-482 in B. R. Murphy and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Archer, D. L. and H. A. Loyacano. 1975. Initial and delayed mortalities of largemouth bass captured in the 1973 national Keowee B.A.S.S. tournament. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 28: 90-96.

Bryan H. 1995. Social and economic impact assessment of the 1993-1994 Bassmasters trail. Final report to Bass Anglers Sportsman Society, Montgomery, Alabama.

Bunt, C. M. S. J. Cooke, and D. P. Philipp. 2002. Mobility of riverine smallmouth bass related to tournament displacement and seasonal habitat use. Pages 545-552 in D. P. Phillip and M. S. Ridgway, editors. Black bass: ecology, conservation and management. American Fisheries Society Symposium 31.

Chapman, P. and W. Fish. 1985. Largemouth bass tournament catch results in Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 37: 495-505.

Cooke, S. J., C. M. Bunt, K. G. Ostrand, D. P. Phillip, and D. H. Wahl. 2004. Angling-induced cardiac disturbance of free-swimming largemouth bass (Micropterus salmoides) monitored with heart rate telemetry. Journal of Applied Ichthyology 20: 28-36.

Edwards, G. P., R. M. Neumann, R. P. Jacobs, and E. B. O'Donnell. 2004. Factors related to mortality of black bass caught during small club tournaments in Connecticut. North American Journal of Fisheries Management 24: 801-810.

Feathers, M. G. and A. E. Knable. 1983. Effects of depressurization upon largemouth bass. North American Journal of Fisheries Management 3: 86-90.

Furimsky, M, S. J. Cooke, C. D. Suski, Y. Wang, and B. L. Tufts. 2003. Respiratory and circulatory responses to hypoxia in largemouth bass and smallmouth bass: Implications for "live-release" angling tournaments. Transactions of the American Fisheries Society 123: 1065-1075.

Gilland, E. R. 1999. Dispersal of black bass following tournament release in an Oklahoma reservoir. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 53:144-149.

Gilland, E. R. 2002. Live well operation procedures to reduce mortality of black bass during summer tournaments. Pages 477-487 in D. P. Phillip and M. S. Ridgway, editors. Black bass: ecology, conservation and management. American Fisheries Society Symposium 31.

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

Hartley, R. A. and J. R. Moring. 1993. Observation of black bass (Centrarchidae) confined during angling tournaments: a cautionary note concerning dissolved oxygen. Aquaculture and Fisheries Management 24: 575-579.

Hartley, R. A. and J. R. Moring. 1995. Differences in mortality between largemouth and smallmouth bass caught in tournaments. North American Journal of Fisheries Management 15:666-670.

Hayes, D. B., W. W. Taylor, and H. L. Schramm. 1995. Predicting the biological impact of competitive fishing. North American Journal of Fisheries Management 15: 457-472.

Holbrook, J. A., II. 1975 Bass fishing tournaments, Pages 408-414 in R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, DC.

Horton, H. F. 1956. An evaluation of some physical and mechanical factors important in reducing delayed mortality of hatchery-reared rainbow trout. Progressive Fish-Culturist 18: 3-14.

Jenkins, R. M. and D. I. Morais. 1971. Reservoir sportfishing effort and harvest in relation to environmental variables. Pages 371-384. in G. E. Hall, editors. Reservoir Fisheries and Limnology. American Fisheries Society Special Publication. No. 8. 511 pp.

Kerr, S. J. and K. K. Kamke. 2003. Competitive fishing in freshwaters of North America: A survey of Canadian and U. S. jurisdiction. Fisheries 28(3): 26-31.

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

Kwak. T. J. and M. G. Henry. 1995. Largemouth bass mortality and related causal factors during live-release fishing tournaments on a large Minnesota lake. North American Journal of Fisheries Management 15:621-630.

May, B. E. 1972. Evaluation of largescale release programs with special reference to bass fishing tournaments. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 26:325-329.

Meals K. O. and L. E. Miranda. 1994. Size-related mortality of tournament-caught largemouth bass. North American Journal of Fisheries Management 14:460-463.

Morrissey, M. B. C. D. Suski, K. R. Esseltine, and B. L. Tufts. 2005. Incidence and physiological consequences of decompression in smallmouth bass after live-release angling tournaments. Transactions of the American Fisheries Society 134: 1038-1047.

Osborne, R. and P. W. Bettoli. 1995. A reusable ultrasonic tag and float assembly for use with large pelagic fish. North America Journal of Fisheries Management 15:512-514.

Ostrand K. O., G. R. Wilde, D. W. Strickland, and M. I. Muoneke. 1999. Initial mortality in Texas black bass fishing tournaments. North America Journal of Fisheries Management 19:1124-1128.

Pearson, J. 2002. Movements of displaced largemouth bass in two Indiana natural lakes. Lake and Reservoir Management 18:257-262.

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

Plumb, J. A, J. M. Grizzle, and W. A. Brono. 1985. Survival of caught and released largemouth bass after confinement in livewells. North American Journal of Fisheries Management 8:324-328.

Richardson-Heft, C. A., A. A. Heft, L. Fewlass, and S. B. Brandt. 2000. Movements of largemouth bass in the northern Chesapeake Bay: Relevance to sportfishing tournaments. North American Journal of Fisheries Management 20: 493-501.

Ridgway, M. S. 2002. Movements, homerange, and survival estimation of largemouth bass following displacement. Pages 525-533 in D. P. Phillip and M. S. Ridgway, editors. Black bass: ecology, conservation and management. American Fisheries Society Symposium 31.

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

Schramm, H. L., P. J. Haydt, and N. A. Bruno. 1985. Survival of tournament-caught largemouth bass in two Florida lakes. North American Journal of Fisheries Management 5:606-611.

Schramm, H. L., Jr. P. J. Haydt, and N. A. Bruno. 1987. Evaluation of prerelease, postrelease, and total mortality of largemouth bass caught during tournaments in two Florida lakes. North American Journal of Fisheries Management 7:394-402.

Schramm, H. L., Jr and seven co-authors. 1991. The status of competitive fishing in North America. Fisheries 16(3):4-12.

Schupp, B. R. 2002. The B.A.S.S. perspective on bass tournaments: A 21st century opportunity for progressive resource managers. Pages 715-716 in D. P. Phillip and M. S. Ridgway, editors. Black bass: ecology, conservation and management. American Fisheries Society Symposium 31.

Seidensticker, E. P. 1974. Mortaltiy of largemouth bass for two tournaments utilizing a "don't kill your catch" program. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 28:83-86.

Shasteen, S. P., and R. J. Sheehan. 1997. Laboratory evaluation of artificial swim bladder deflation in largemouth bass: Potential benefits for catch-and-release fisheries. North American Journal of Fisheries Management 17: 32-37.

Stang, D. L., D. M. Green, R. M. Klindt, T. L. Chiotti, W. W. Miller. 1996. Black Bass movements after release from fishing tournaments in four New York. Pages 163-171 in L. E. Miranda and D. R. DeVries, editors. Multidimensional Approaches to Reservoir Fisheries Management. American Fisheries Society Symposium 16.

Steeger, T. M., J. M. Grizzle, K. C. Weathers, and M. Newman. 1994. Bacterial diseases and mortality of angler-caught largemouth bass released after tournaments on Walter F. George Reservoir, Alabama-Georgia. North American Journal of Fisheries Management 14: 435-441.

Suski, C. D., S. S. Killen, S. J. Cooke, J. D. Keiffer, D. P. Philipp, and B. L. Tufts. 2004. Physiological significance of the weigh-in during live-release angling tournaments for largemouth bass. Transactions of the American Fisheries Society 133: 1291-1303.

Suski, C. D., S. S. Killen, M. B. Morrissey, S. G. Lund, and B. L. Tufts. 2003. Physiological changes in largemouth bass caused by live-release angling tournaments in southeastern Ontario. North American Journal of Fisheries Management 23: 760-769.

Weathers, K. C. and M. J. Newman. 1997. Effects of organizational procedures on mortality of largemouth bass during summer tournaments. North American Journal of Fisheries Management 17:131-135.

Wilde, G. R. 1998. Tournament-associated mortality in black bass. Fisheries 23(10):12-22.

Wilde, G. R. 2003. Dispersal of tournament-caught black bass. Fisheries 27(7): 10-17.

Wilde, G. R. and L. J. Paulson. 2003. Movement and dispersal of tournament-caught largemouth bass in Lake Mead, Arizona-Nevada. Journal of Freshwater Ecology 18: 399-342.

Wilde, G. R.. C. E. Shavilk, and K. L. Pope. 2002. Initial mortality of black bass in B.A.S.S. Fishing Tournaments. North American Journal of Fisheries Management 22:950-954.

Williamson, J. H. and G. J. Carmichael. 1986. Differential response to handling stress by Florida, northern, and hybrid largemouth bass. Transactions of the American Fisheries Society 115:756-761.

Winter, J. D. 1996. Advances in underwater telemetry. Pages 555-590 in B. R. Murphy and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Vogele, L. E. 1975. Spotted bass. Pages 34-45 in R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, DC.