Fisheries Report 05-12

BLACK BASS TOURNAMENT ACTIVITY AND INITIAL MORTALITY ON MIDDLE TENNESSEE RESERVOIRS

A Final Report Submitted To

Tennessee Wildlife Resources Agency
Nashville, Tennessee

By

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FOREWORD

This final report is based on a thesis prepared by the first author in partial fulfillment of the requirements for the Master of Science degree at Tennessee Technological University.

TABLE OF CONTENTS

Chapter I

Tournament Activity and Initial Mortality of Black Bass on Center Hill and Percy Priest Reservoirs, Tennessee

Abstract.- Black bass tournament activity and initial mortality of largemouth bass *Micropterus salmoides,* spotted bass *M. punctulatus*, and smallmouth bass *M. dolomieu* were estimated on two middle Tennessee reservoirs during the 2004 calendar year. At least 471 tournaments were held on J. Percy Priest Reservoir and at least 166 were held on Center Hill Reservoir. On a per-area basis, annual tournament activity was more than three times higher on J. Percy Priest Reservoir (62 per 1,00 hectares) than on Center Hill Reservoir (18 per 1,000 hectares). Between 17 and 22 tournament weigh-ins were monitored at each reservoir throughout 2004 to estimate initial mortality. Most (79%) of the black bass weighed-in at J. Percy Priest Reservoir were largemouth bass; spotted bass were the most common (65%) species weighed-in at Center Hill Reservoir. Pooled mortality rates (all species combined) at each tournament ranged from 0-16% at Center Hill Reservoir Reservoirs and 0- 23% at J. Percy Priest Reservoir at water temperatures ranging from 8 to 29 ºC. At each reservoir, the estimated total number of fish brought to weigh-ins was less than the number of black bass harvested by anglers in 2004. Initial mortality did not vary among species during the summer months. Water and air temperature were significant predictors of initial mortality rates; however, a logistic model provided a poor fit to the data.

INTRODUCTION

According to the US Fish and Wildlife Service (USFWS 2002), nearly $20 billion is spent annually on freshwater fishing by some 28 million anglers in the US. These anglers ranked black bass (i.e., largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieu*, and spotted bass *M. punctulatus*) the most desirable freshwater species (USFWS 2002). An estimated 460,000 anglers fished for black bass in Tennessee in 2001 and their annual expenditures exceeded $400 million in 2001 (USFWS 2005). It is estimated that about

25% of reservoir bass anglers in Tennessee participated in fishing tournaments in 2000 and 2001 (Tim Churchill; Tennessee Wildlife Resources Agency; personal communication).

A survey in the early 1990s reported that 78% of competitive inland fishing events in North America targeted black bass (Schramm et al. 1991). The number of black bass tournaments has continued to increase due to growing popularity and more media coverage. Concerns regarding the impact of tournaments on black bass fisheries led to the implementation of live-release tournaments (i.e., tournaments in which all live fish must be released post weigh-in). Large tournament circuits, specifically Bass Anglers Sportsman Society (B.A.S.S.), impose specific weigh-in regulations in an attempt to keep tournament mortality to a minimum (Wilde et al. 2002b).

Previous studies have documented a variety of variables that cause black bass tournament mortality. Wilde (1998) performed a meta-analysis and found a positive relationship between water temperature and tournament mortality. Carmichael et al. (1984a, b) and Plumb et al. (1988) were some of the first authors to note that increased water temperatures are more likely to stress and kill fish. Prolonged livewell confinement can subject bass to low dissolved oxygen concentrations, elevated ammonia concentrations, and high temperatures, which can lead to infection, injury, and physiological stress (Plumb et al.1988; Kwak and Henry 1995). Inefficient weigh-in procedures as well as mishandling fish contribute to tournament mortality (Hartley and Moring 1995; Weathers and Neuman 1997; Wilde 2002a). Other factors such as fish size (Weathers and Newman 1997), tournament size, fishing day length, and tournament exemptions (Edwards et al. 2004) also have been related to tournament mortality.

Total tournament mortality is a combination of initial mortality and delayed mortality. Initial mortality is represented as a fish that is dead at weigh-in and delayed mortality is represented as a fish that dies after it is released (Hartley and Moring 1995; Wilde et al. 2002a). Numerous studies have investigated initial and delayed tournament mortality of black bass (e.g., Meals and Miranda 1994; Gilliland 1997; Ostrand et al. 1999). Total tournament mortality rates less than 14% have been characterized as “low” (Schramm et al. 1985; Kwak and Henry 1995); total mortality rates that exceeded 26% were deemed “high” (Schramm et al. 1987; Wilde 1998).

Data on the number of tournaments and initial tournament mortality would give reservoir managers a better understanding of the potential effects tournaments may have on bass populations. Identifying major factors contributing to tournament mortality would allow refinement of tournament techniques to minimize bass mortality. Thus, the general objectives of this study were: (1) estimate annual black bass tournament activity on two middle Tennessee reservoirs, Center Hill and J. Percy Priest Reservoirs; (2) characterize the catches of black bass caught by tournament anglers at both reservoirs; and (3) estimate initial tournament mortality of black bass on Center Hill and J. Percy Priest Reservoirs.

STUDY AREA

Center Hill and J. J. Percy Priest Reservoirs were selected for this study due to suspected heavy tournament activity on these reservoirs. The US Army Corp of Engineers constructed these tributary impoundments in the Cumberland River watershed primarily for flood control and power generation.

Center Hill Reservoir was formed by the impoundment of the Caney Fork River in 1948. This reservoir covers 9,332 hectares (ha) at full pool, is approximately 103 km long, and has 724 km of shoreline at summer pool. Center Hill has a mean depth of 22 m and the main channel is mesotrophic, but the embayments are eutrophic (Pucker 1989).

J. Percy Priest Reservoir was formed by the impoundment of the Stones River in 1968. This reservoir covers 7,630 ha at full pool, is approximately 68 km long, and has 343 km of shoreline. J. Percy Priest has a mean depth of 9 m and is a eutrophic system.

Both reservoirs have the same species of black bass (largemouth bass, smallmouth bass, and spotted bass) and the same regulations. Anglers are limited to harvesting a total of five black bass per day. There is a 381 mm total length (TL) minimum length regulation on largemouth bass and smallmouth bass on both reservoirs. There is no minimum length limit for spotted bass; however, most clubs impose a minimum length of 305 mm TL for that species.

METHODS

Tournament Activity

Black bass tournament activity (i.e., dates and approximate number of participants) was estimated for the 2004 calendar year by repeatedly surveying Center Hill and J. Percy Priest Reservoirs. Information was obtained by personally meeting with bass clubs, onsite visits to marinas and boat ramps, internet searches, and querying tournament participants. Additional tournament information was solicited by posting fliers at area marinas, bait shops, and boat ramps.

Data Collection

A subsample of tournament weigh-ins was attended each month during 2004 on each reservoir. The subsample of weigh-ins encompassed dates, time-of-day, tournament durations, and sizes that were common to tournaments on these two reservoirs. The number of weigh-ins attended varied some months due to low numbers of tournaments and logistics. Variables such as air and surface water temperatures and dissolved oxygen concentrations, tournament duration, handling time (i.e., duration of weigh-in), number of boats, and bag limit were recorded. Following the tournament weigh-in, all black bass were identified to species, measured for TL (mm), and scored as dead or alive. A live fish was any fish that displayed movement. A subsample of black bass at each reservoir was weighed in order to describe the relationship between their lengths and weights in each reservoir. Annual estimates of black bass harvest and catch rates by all anglers on each reservoir were obtained from TWRA creel survey reports.

Data Analysis

Chi-square contingency tables were used to compare species composition within each system and between reservoirs. The minimum number of bass caught and weighed-in at tournaments was estimated by multiplying the number of tournaments known to occur at each reservoir by the mean number of bass weighed-in per tournament. The ratio of the total number of black bass caught in tournaments (TC) over the number of bass harvested by Anglers (HARV) in 2004 was calculated for each reservoir to provide a preliminary assessment of the impact of tournaments on their respective bass populations (Allen et al. 2005). Extreme TC/HARV ratios (i.e., TC/HARV > 3.0) would suggest a strong potential for tournament activity to increase rates of fishing mortality.

Analysis of covariance (ANCOVA) was used to test for between-reservoir differences in robustness (i.e., body mass at a specific length) of largemouth bass and spotted bass. Before adjusted mean weights were compared, data on the smallest and largest fish were excluded from the analysis (if necessary) to achieve homogeneity of slopes (P > 0.05) of the $\log_{10}$ length- $\log_{10}$weight regression lines for each species. Chi-square contingency tables were used to test for differences between relative abundance of black bass species caught in tournaments and those caught and reported in creel surveys (Malvestuto and Black 2004) for each reservoir. The relative abundances of black bass species caught in tournaments and captured in TWRA's 2003 electrofishing survey were compared in Center Hill Reservoir. Only tournament-size largemouth bass (> 381 mm), smallmouth bass (> 381 mm), and spotted bass (> 320 mm) in the electrofishing database were included in this analysis. No tournament-size smallmouth bass or spotted bass from J. Percy Priest Reservoir were captured in the 2003 electrofishing survey; therefore, the relative abundances of tournament-caught and electrofished black bass species were not compared.

Initial mortality of each species and pooled (i.e., all species) initial mortality was calculated for each tournament. Logistic regression was used to test for relationships between individual fish status (live or dead) and water temperature, air temperature, dissolved oxygen, number of boats, species, and TL. Observations were pooled from both reservoirs. Significant variables ($P < 0.05$) were identified and entered into the model using forward selection criteria and model fit was tested with Hosmer and Lemeshow's Goodness of Fit test. Interspecific differences in initial mortality for tournaments held in July, August, and September (i.e., summer) were compared using a contingency table and the chi-square test statistic.

Observed initial mortality rates were compared to those predicted from a regression model (Wilde 1998) based on water temperatures at each tournament:

$$\text{Initial Mortality} = 0.0019 * Temp^{2.4569} \qquad \text{Equation 1.}$$

Statistical Analysis System software (SAS Institute 1999) was used to perform all statistical analyses. All tests were considered significant at $\alpha = 0.05$.

RESULTS

Tournament Activity

Nearly three times as many tournaments were held on J. Percy Priest Reservoir than on Center Hill Reservoir in 2004. At least 471 tournaments were known to have occurred on J. Percy Priest Reservoir (Table 1). On a per-unit-area basis, tournament activity was much higher on J. Percy Priest Reservoir (62/1,000 ha) than on Center Hill Reservoir (18/1,000 ha). Most tournaments were held during summer; the fewest tournaments were held during winter. Twenty bass fishing clubs were known to fish Center Hill; five of those clubs held weekly tournaments from May to October. Forty-three clubs fished J. Percy Priest; nine clubs held weekly tournaments from April to December, and three clubs held weekly tournaments year round. The remaining clubs held tournaments sporadically throughout the year.

Tournament start times and tournament duration varied greatly. Tournament durations ranged from 4 to 12 h (mean = 7.5 h; SE = 0.02), and weigh-in start times ranged from 0200 to 2400 h. Most summer tournaments were held at night, with weigh-ins between 0200 and 0700 hours. Most winter tournaments were held during the daylight, starting in the early morning, with weigh-ins between 1400 and 1600 h.

Catch Description

Seventeen tournaments were monitored on Center Hill Reservoir, and 2,561 black bass were observed at the weigh-ins. Most of the fish were spotted bass (n = 1,656), followed by largemouth bass (n = 644) and smallmouth bass (n = 261; Figure 1). Spotted bass represented a significantly greater percentage of the catch ($X^2 = 528$; df = 2; $P < 0.0001$) than the other two species. The average number of fish weighed-in at each tournament was 152 (SE = 687). The average percent contribution to the catch by spotted bass was 65%.

Twenty-two tournaments were monitored on J. Percy Priest Reservoir and 454 black bass were observed. Species composition of the catch varied significantly between reservoirs (X^2 = 1,219; df = 2; $P < 0.0001$). Most of the black bass caught at J. Percy Priest were largemouth bass (n = 361), followed by spotted bass (n = 59) and smallmouth bass (n = 34; Figure 2). Largemouth bass represented a significantly greater percentage of the catch (X^2 = 438.2; df = 2; $P < 0.0001$) than the other two species. The average number of fish weighed-in at each tournament was 21 (SE = 5) and the average percent contribution to the catch by largemouth bass was 79%.

The estimated number of fish caught in tournaments at Center Hill Reservoir (n = 25,232 fish) was less than the number of fish harvested by all anglers in 2004 (n = 39,834); the TC/HARV ratio was 0.64. Similarly, the estimated number of fish caught in tournaments at Percy Priest (9,891) was lower than the number of fish harvested by all anglers in 2004 (n = 12,846) and the TC/HARV ratio was 0.77. Substantially more tournaments in a smaller system did not translate into substantially bigger potential impacts on the resident bass populations in Percy Priest Reservoir.

Largemouth bass contributed more and spotted bass contributed less to the tournament catch than in the reservoir-wide recreational catch on Center Hill Reservoir (X^2 = 6.02; df = 2; P = 0.0492; Table 3). Conversely, largemouth bass contributed less and spotted bass contributed more to the tournament catch than to the recreational catch on J. Percy Priest Reservoir (X^2 = 6.8; df = 2; P = 0.0334; Table 3).

The relative abundance of spotted bass also differed between the electrofishing samples and tournament weigh-ins at Center Hill Reservoir (X^2 = 15.5; df = 2; P = 0.0004). Spotted bass represented 74% of the black bass catch in the electrofishing samples, but only 65% of the tournament catch (Table 4).

Despite state and tournament regulations, some illegal fish were brought to the scales on Center Hill and J. Percy Priest Reservoirs (n = 424 fish, or 14%). Some bass clubs penalized anglers for illegal fish; whereas, others simply did not weigh illegal bass. Most of the illegal fish brought to the scales at Center Hill Reservoir were largemouth bass and most of the "illegal" fish at J. Percy Priest were spotted bass (i.e., they were shorter than the 305 mm TL limit imposed by most clubs). Few illegal smallmouth bass were brought to the scales at either reservoir.

Largemouth bass and spotted bass weighed-in at Center Hill Reservoir were more robust than those weighed-in at J. Percy Priest Reservoir (*P* < 0.0001; Figure 3). The slopes of the $\log_{10}$length- $\log_{10}$weight regressions for largemouth bass on each reservoir were similar (*P* = 0.2020) after excluding largemouth bass greater than 457 mm TL and less than 363 mm TL. The slopes of the $\log_{10}$length- $\log_{10}$weight regression for spotted bass on each reservoir were similar (*P* = 0.3113) and the adjusted mean weights differed (*P* < 0.0001; Figure 4). At any given length, largemouth bass and spotted bass weighed-in at Center Hill Reservoir were 15% more robust than those weighed-in at J. Percy Priest Reservoir.

Initial Mortality

Surface water temperatures at Center Hill Reservoir weigh-ins ranged from 12 to 29 °C (mean = 21°C; SE = 2.3). Average initial mortality for all species combined was only 3% (range = 0-16%). Initial mortality averaged 2, 4, and 6% for spotted, largemouth, and smallmouth bass, respectively (Table 2). Water temperatures at J. Percy Priest Reservoir ranged from 8 to 29 °C (mean = 24°C; SE = 1.3), and average initial mortality for all species combined was similarly low (6%; range = 0-23%). Initial mortality averaged 1, 6, and 2% for spotted, largemouth, and smallmouth bass, respectively (Table 2).

Water temperature and air temperature were significant predictors of initial mortality (*P* < 0.0041). Although the full model was significant (X^2 = 58.5, df = 2, *P* < 0.0001), it failed the Hosmer and Lemeshow's Goodness of Fit test (X^2 = 26.8, df = 8, *P* = 0.0008), indicating a poor fit of the model to the data. Therefore, this model was not used to predict initial mortality.

Observed initial mortality did not vary among species in summer. Pooled mortality rates were similarly low among species at Center Hill Reservoir (X^2 = 5.23, df = 2, *P* = 0.0730) and J. Percy Priest Reservoir (X^2 = 1.12, df = 2, *P* = 0.5724). Initial mortality predicted by Equation 1 from Wilde (1998) varied widely from observed initial mortality (Table 5). Although predicted values corresponded to observed values at lower water temperatures, at water temperatures exceeding 20°C the model failed to accurately predict initial mortality in middle Tennessee reservoirs.

DISCUSSION

The most likely explanation of why tournament activity was nearly three times greater on J. Percy Priest Reservoir compared to Center Hill Reservoir is because it is located adjacent to the Nashville metropolitan area. Both reservoirs are highly accessible, offering a variety of public boat ramps and marina access, and J. Percy Priest is smaller. However, J. Percy Priest Reservoir's urban location attracts more anglers, including national tournament circuits, because the surrounding area can accommodate large groups.

Illegal bass were observed at the weighed-ins on both reservoirs; invariably, "illegal" largemouth bass were misidentified as "legal" spotted bass. Spotted bass are distinguished from largemouth bass by the size of their mouth, presence of a toothy tongue patch, and a spotted ventral surface (Etnier and Starnes 1993). However, these characteristics are not always obvious to untrained observers.

Initial tournament mortality was low, which has been observed in other studies (Hartley and Moring 1991; Gilliland 1997; Wilde 2002a) and initial mortality was influenced by water temperature and air temperature. Similar to tournaments in Maine, initial mortality in Tennessee reservoirs was highest at water temperatures exceeding 24°C (Edwards et al. 2004).

Hartley and Moring (1995) suggested that factors other than temperature also contribute to initial mortality because of its variability at temperatures exceeding 25°C. Dissolved oxygen decreases with increasing water temperature and low dissolved oxygen can be lethal in boat livewells (Hartley and Moring 1991; Gilliland 1997; Edwards et al. 2004). Suski et al. (2004) argued that hypoxia due to transfer bag confinement can be more lethal than factors associated with livewell confinement. Poor water quality has been observed in water-filled bags used during the weigh-in process (Edwards et al. 2004). Increased bass densities and elevated water temperatures in transfer bags can rapidly cause hypoxia, resulting in mortality (Suski et al. 2004).

Observed initial mortality was 2X – 4X higher than values predicted using Equation 1 at six tournaments, all of which were at temperatures above 20°C. One explanation is that the observations used to build the predictive model were from large organized tournaments; whereas, our observations were gathered at relatively small, unorganized tournaments, where techniques to reduce stress at the weigh-ins were often rudimentary, at best. Unorganized tournaments can prolong the exposure of fish to harsh conditions (e.g., hypoxia; increased densities). Some tournaments begin to weigh fish when the first angler arrives; whereas, other clubs wait until all anglers have checked in. Similar to observations made by Edwards et al. (2004), some of the Tennessee tournament officials themselves participated in the tournaments, sometimes delaying the weigh-in and prolonging livewell confinement times.

Live-release practices varied among bass clubs. Generally, fish were returned to the angler after they were weighed and each individual was responsible for releasing his or her catch. However, some tournament organizers provided a basin to hold all the weighed fish until the weigh-in was over. Basins ranged from well-aerated tanks to a boat hull filled with poorly aerated water. After the weigh-in, it was then the organizer's responsibility to release the fish. Release methods varied from carrying fish away from the weigh-in site using a release boat to manually hauling fish over 100 m to the lake in a large landing net. The large differences in how fish were released would undoubtedly contribute to variation in subsequent delayed mortality rates.

Initial mortality is not a realistic indicator of how tournaments affect bass populations (Gilliland 1997). Initial mortality only accounts for fish that are dead at the time of weigh-in and does not account for fish that die after they are released. Fish were observed in a variety of conditions as they were brought to the scales. Several fish had lures lodged in their esophagus and others were bleeding from a variety of wounds. Depressurization was evident in a number of fish, particularly in late summer and fall, similar to observations made by Wilde (2002a).

According to Edwards et al. (2004), re-circulating livewells or constant aeration and the replacement of livewell water during a tournament should increase survival. Other researchers recommend adding salt and ice during summer tournaments to reduce stress to fish during confinement (Gilliland 1997). Weathers and Newman (1997) believe total tournament mortality can be kept below 25% during summer months if tournament organizers follow proper handling procedures.

Canadian researchers have developed a new method of weighing bass called a "water weigh-in." This method reduces the time fish are spent out of water during the weigh-in by holding fish in aerated water troughs while anglers wait for their catch to be weighed, and weighing fish in water. Suski et al. (2004) reported that largemouth bass exposed to air during weigh-in suffered greater physiological disturbances than those kept in water throughout the weigh-in process. Small clubs may be hesitant to adopt this method because of the time and effort needed for set-up. However, it would be in the best interest of larger clubs with longer weigh-ins to reduce the time fish are kept in hypoxic water and exposed to air (Suski et al. 2004). This method would probably reduce mortality and improve the public's perception of bass clubs and tournaments by demonstrating a willingness by bass clubs to take meaningful steps to reduce tournament mortality.

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Table 1. Minimum number of tournaments held on Center Hill and Percy Priest Reservoirs, Tennessee, 2004.

Lake	Winter Dec-Feb	Spring Mar-May	Summer Jun-Aug	Fall Sept-Nov	Total
Center Hill	6	33	75	52	166
Percy Priest	52	132	169	118	471

Table 2. Species caught and initial mortality at tournaments held on Center Hill (CH) and Percy Priest (PP) Reservoirs, Tennessee, 2004.

								Initial Mortality (%)			
Date	Lake	Air Temperature (°C)	Water Temperature (°C)	Number of Fish	Spotted Bass (%)	Largemouth Bass (%)	Smallmouth Bass (%)	Spotted Bass	Largemouth Bass	Smallmouth Bass	Pooled
1-Feb-04	Percy Priest	14	8	31	48	52	0	7	0	.	3
13-Mar-04	Center Hill	14	12	203	70	24	6	0	0	0	0
7-Mar-04	Percy Priest	16	15	29	21	72	7	0	0	0	0
3-Apr-04	Center Hill	17	14	8	100	0	0	0	.	.	0
18-Apr-04	Center Hill	29	17	239	67	31	2	1	0	0	<1
25-Apr-04	Percy Priest	23	20	21	14	81	5	0	0	0	0
9-May-04	Percy Priest	30	25	21	0	100	0	.	10	.	10
16-May-04	Center Hill	26	24	182	59	36	5	2	0	0	1
22-May-04	Percy Priest	28	27	39	0	99	1	.	24	0	23
5-Jun-04	Percy Priest	22	26	26	4	85	11	0	0	0	0
5-Jun-04	Center Hill	22	26	9	78	11	11	0	0	0	0
13-Jun-04	Center Hill	23	27	294	59	27	14	4	3	2	3
26-Jun-04	Center Hill	24	22	22	0	95	5	.	5	0	5
27-Jun-04	Percy Priest	29	26	11	18	55	27	0	17	0	9
10-Jul-04	Center Hill	25	29	95	57	12	32	4	18	17	10
10-Jul-04	Center Hill	25	28	243	56	27	16	1	3	3	2
18-Jul-04	Percy Priest	30	29	21	9.5	81	9.5	0	0	0	0
28-Jul-04	Percy Priest	25	27	21	5	90	5	0	0	0	0
31-Jul-04	Center Hill	26	28	63	70	24	6	14	13	50	16
1-Aug-04	Percy Priest	28	29	26	61	30	9	0	0	0	0
14-Aug-04	Center Hill	22	25	244	50	30	20	3	10	6	6
22-Aug-04	Percy Priest	26	26	9	0	89	11	.	0	0	0
2-Sep-04	Percy Priest	24	27	10	0	100	0	.	10	.	10
3-Sep-04	Percy Priest	26	27	28	0	89	11	.	8	0	7

Table 2. Continued.

Date	Lake	Air Temperature (°C)	Water Temperature (°C)	Number of Fish	Spotted Bass (%)	Largemouth Bass (%)	Smallmouth Bass (%)	Initial Mortality (%) Spotted Bass	Initial Mortality (%) Largemouth Bass	Initial Mortality (%) Smallmouth Bass	Initial Mortality (%) Pooled
5-Sep-04	PP	26	27	15	0	80	20	.	8	0	7
9-Sep-04	PP	28	25	21	0	86	14	.	11	33	14
9-Sep-04	PP	28	26	6	17	83	0	0	20	.	17
9-Sep-04	PP	28	22	6	0	83	17	.	20	0	17
10-Sep-04	PP	29	27	21	0	86	14	.	6	0	5
11-Sep-04	PP	29	28	11	9	64	27	0	0	0	0
12-Sep-04	CH	18	26	259	58	30	12	<1	1	0	<1
26-Sep-04	PP	27	27	15	0	93	7	.	0	0	0
10-Oct-04	CH	19	22	142	54	32	13	0	0	0	0
25-Oct-04	PP	26	20	27	48	48	4	0	0	0	0
14-Nov-04	CH	17	19	317	87	9	4	0	4	0	<1
21-Nov-04	PP	16	14	47	0	96	4	.	0	0	0
27-Nov-04	CH	8	13	28	11	89	0	0	0	.	0
4-Dec-04	CH	1	14	36	83	17	0	0	0	.	0
12-Dec-04	CH	2	12	198	88	7	5	0	0	0	0

Table 3. Percent species composition of black bass caught in 2003 by anglers and weigh-ed in at tournaments in 2004 at Center Hill and Percy Priest Reservoirs, Tennessee.

Database	Largemouth Bass	Smallmouth Bass	Spotted Bass
		Center Hill	
Tournament	25	10	65
Creel	13	10	77
		Percy Priest	
Tournament	79	8	13
Creel	89	5	6

Table 4. Percent species composition of black bass in electrofishing samples collected in 2003 and weighed-in at tournaments in 2004 at Center Hill Reservoir, Tennessee.

Database	Largemouth Bass	Smallmouth Bass	Spotted Bass
Tournament	25	10	65
Electrofishing	23	3	74

Table 5. Observed and predicted mortality of black bass for tournaments observed on Center Hill and Percy Priest Reservoirs, Tennessee, 2004.

Lake	Water Temperature (°C)	Initial Mortality (%) Observed	Initial Mortality (%) Predicted
Percy Priest	8	3	0
Center Hill	12	0	1
Percy Priest	15	0	1
Center Hill	14	0	1
Center Hill	17	<1	2
Percy Priest	20	0	3
Percy Priest	25	10	5
Center Hill	24	1	5
Percy Priest	27	23	6
Percy Priest	26	0	6
Center Hill	26	0	6
Center Hill	27	3	6
Center Hill	22	5	4
Percy Priest	26	9	6
Center Hill	29	10	7
Center Hill	28	2	7
Percy Priest	29	0	7
Percy Priest	27	0	6
Center Hill	28	16	7
Percy Priest	29	0	7
Center Hill	25	6	5
Percy Priest	26	0	6
Percy Priest	27	10	6
Percy Priest	27	7	6
Percy Priest	27	13	6
Percy Priest	25	14	5
Percy Priest	26	17	6
Percy Priest	22	17	4
Percy Priest	27	5	6
Percy Priest	28	0	7
Center Hill	26	<1	6
Percy Priest	27	0	6
Center Hill	22	0	4
Percy Priest	20	0	3
Center Hill	19	<1	3
Percy Priest	14	0	1
Center Hill	13	0	1
Center Hill	14	0	1
Center Hill	12	0	1

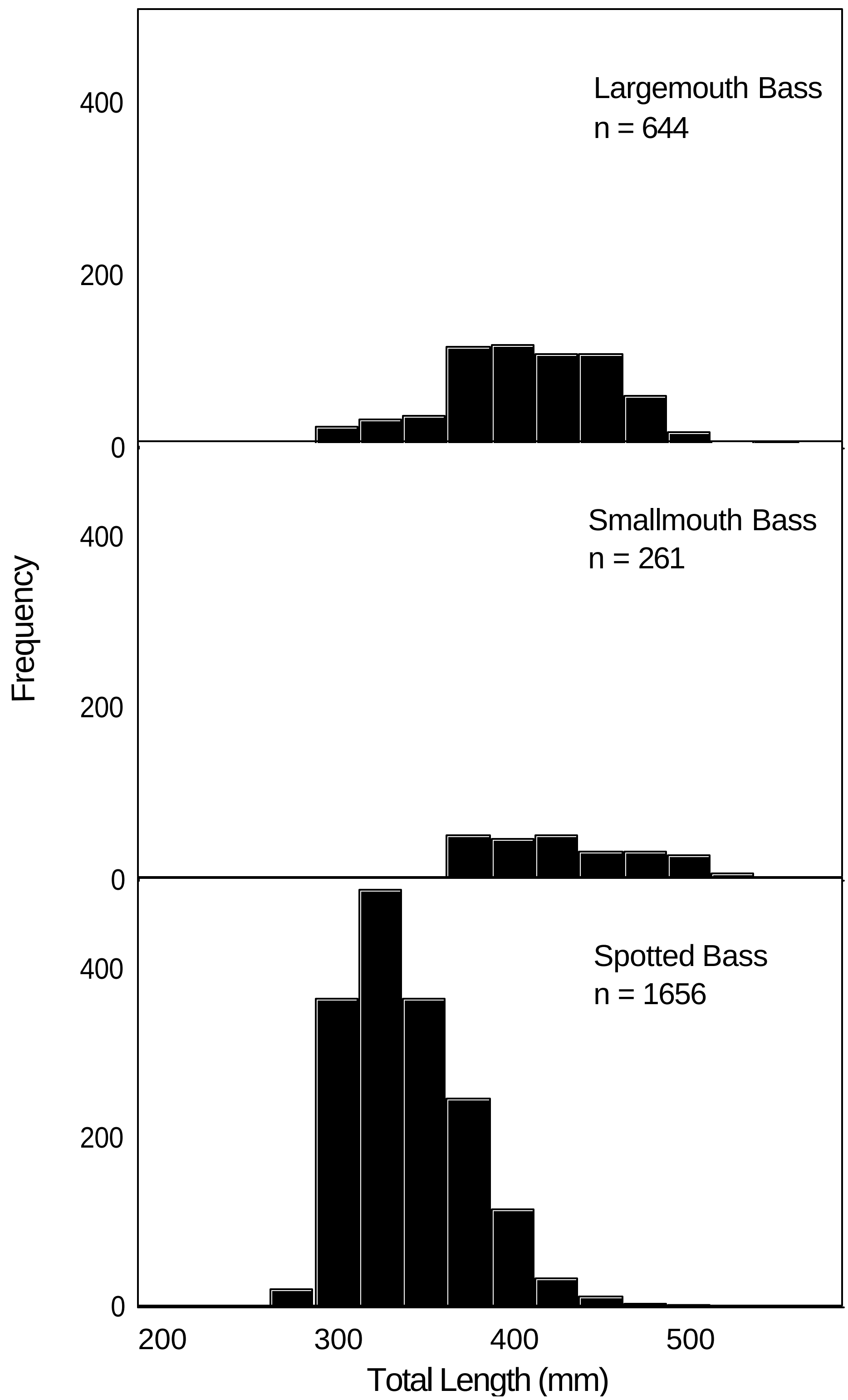

Figure 1. Length frequency distribution for tournament caught black bass in Center Hill Reservoir, Tennessee, 2004.

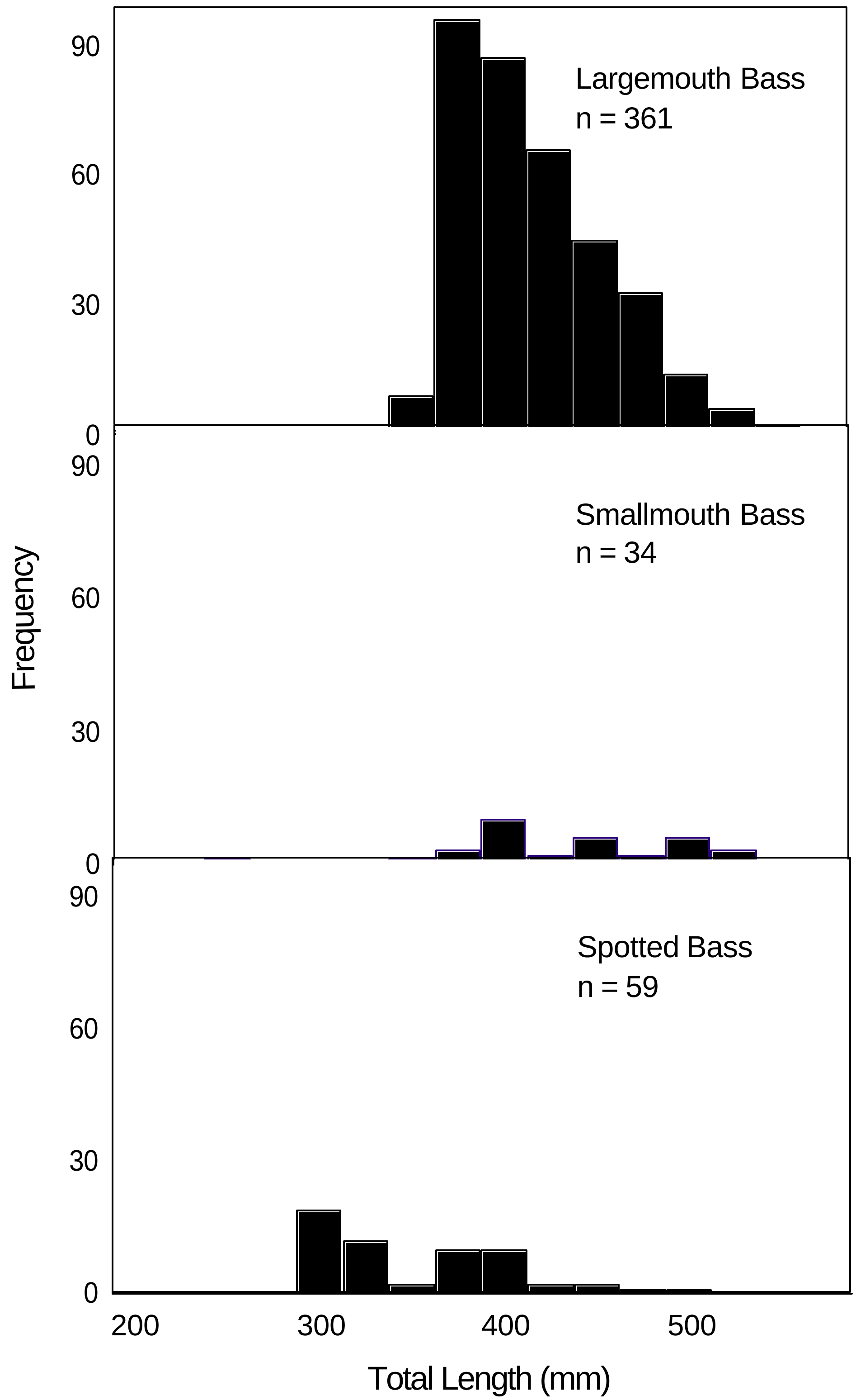

Figure 2. Length frequency distribution for tournament caught black bass in Percy Priest Reservoir, Tennessee, 2004.

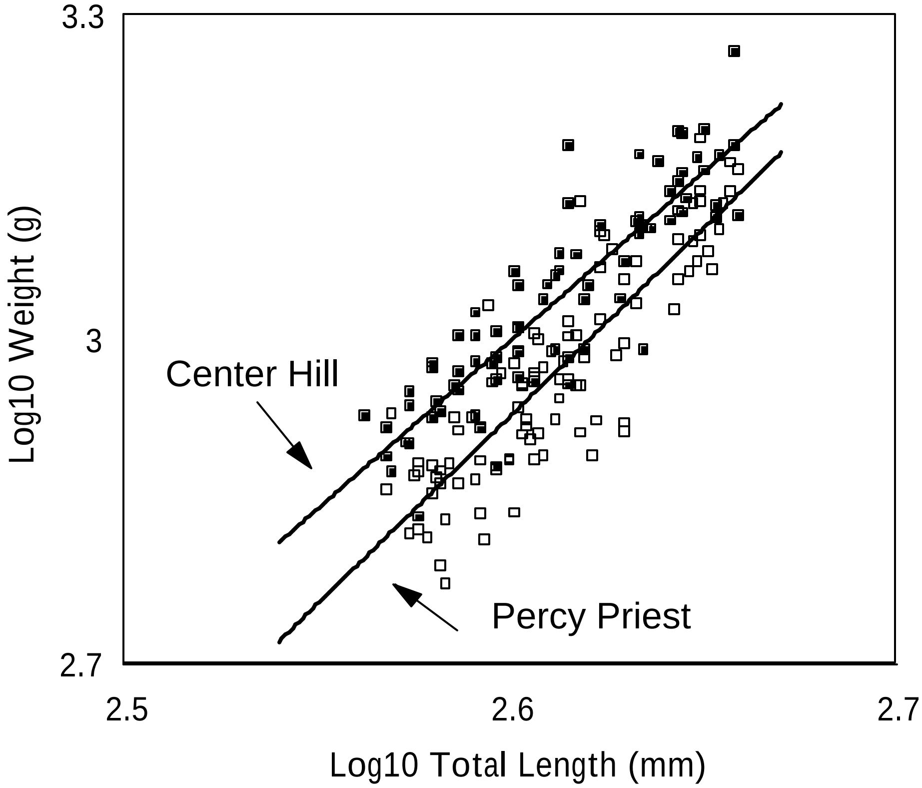

Figure 3. Log_{10}weight-log_{10}length relationships for tournament caught largemouth bass in Center Hill Reservoir (filled squares) and Percy Priest Reservoir (open squares), Tennessee. Fish greater than 457 mm and less than 363 mm total length were excluded from analysis in order to achieve homogeneity of slopes ($P = 0.2020$). The adjusted mean weights differed ($P < 0.0001$).

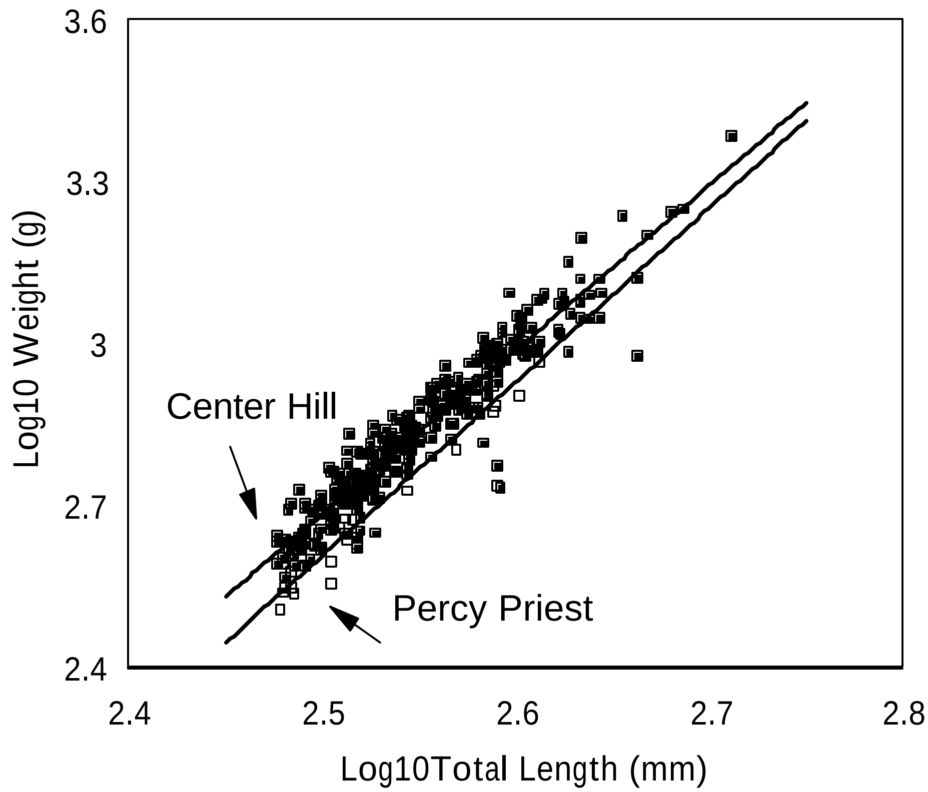

Figure 4. Log_{10}weight-log_{10}length relationships for tournament caught spotted bass in Center Hill Reservoir (filled squares) and Percy Priest Reservoir (open squares), Tennessee. The slopes were homogenous ($P = 0.3113$) and the adjusted mean weights differed ($P < 0.0001$).

Chapter II

Delayed Mortality and Dispersal of Smallmouth Bass Surviving Simulated Fishing Tournaments on Dale Hollow Reservoir, Tennessee

Abstract.- Smallmouth bass are thought to be more susceptible to tournament mortality than other black bass species. In Dale Hollow Reservoir, simulated smallmouth bass fishing tournaments were staged between March 2004 and February 2005 in order to investigate initial and delayed tournament mortality. Smallmouth bass were captured with conventional hook-and-line tackle, placed in livewells, and subjected to weigh-in procedures before being placed into a large net pen (1.8 x 3.1 x 12 m) for observation (n = 8), or externally tagged with an ultrasonic tag and released (n = 54). On average, smallmouth bass spent 2.8 hours in livewells before they were weighed. Water temperatures ranged from 7.4 to 29.3 ^{o}C and no fish were dead at weigh-in (i.e., initial mortality was zero). Delayed mortality of smallmouth bass confined in the net pen in July 2004 was 38%; fish that were tagged and released in other months suffered 19% mortality and the pooled mortality rate was 21%. Logistic regression analyses indicated that mortality was negatively related to total length and positively related to water temperature. Smallmouth bass dispersed rapidly out of the embayment where they were tagged and released; within 5 days, the average distance traversed by survivors was 2.75 km. Relatively few tournaments are held on Dale Hollow Reservoir because there is a protected slot limit (406 mm – 533 mm total length) for smallmouth bass and anglers must immediately release any smallmouth bass that falls within that slot limit. However, delayed mortality of smallmouth bass may be problematic in systems that experience heavier tournament activity, particularly during summer months.

INTRODUCTION

Disregarding delayed tournament mortality leads to the common misconception that tournament mortality is relatively low (Schreer et al. 2001). Delayed mortality refers to a fish that is alive at weigh-in, but dies post-release. Effects from hooking and poor livewell conditions can be evident when bass are brought to the scales (Carmichael et al. 1984; Kwak and Henry 1995); however, unorganized tournaments and poor weigh-in conditions can increase stress that may not be apparent prior to release (Hartley and Moring 1991). Researchers have defined several discrete periods during which delayed mortality might occur. In general, delayed mortality occurs within 6 days (Plumb et al. 1974; Schramm et al. 1987). Several authors estimate that 3 to 20% of tournament fish die post release (Schramm et al. 1985, 1987; Bennett et al. 1989; Hartley and Moring 1991).

Similar to initial mortality, delayed mortality is strongly influenced by water temperature (Schramm et al. 1987; Bennett et al. 1989; Taylor 1990; Neal and Lopez-Clayton 2001; Edwards et al. 2004). Warmer water temperatures extend the period of physiological recovery after exposure to stress. Schreer et al. (2001) studied the cardiac response of smallmouth bass *M. dolomieu* to simulated angling and noted that their recovery from stress was fastest at intermediate (~16 ºC) temperatures.

The most common method of measuring delayed mortality is direct observation of confined fish (Schramm et al. 1987; Hartley and Moring 1995; Gilliland 1997; Wilde et al. 2002). However, poorly designed and deployed net pens can induce mortality. Shallow net pens will not allow fish to reach the thermocline in warmer months; whereas, repeatedly raising a net pen to count and remove dead fish could inflict additional stress on confined fish. In recent studies, raceways have been used to confine fish for observation and decrease the density of captive fish (Schramm et al. 2004).

Telemetry has been used to monitor hooking mortality of free-ranging striped bass (Bettoli and Osborne 1998). Attaching transmitters to fish to measure delayed tournament mortality would eliminate concerns over confinement, artificially high fish densities in pens, or exposure to elevated temperatures. Telemetry would also provide additional data such as the dispersal rate of tournament caught bass.

Most tournament mortality studies do not distinguish among black bass species (Gilliland 1997; Wilde 1998; Ostrand et al. 1999); however, each species may respond differently to tournament angling (Hartley and Moring 1995). Smallmouth bass prefer colder water and are less eurythermal than largemouth bass (Bevelhimer 1996), which may translate into increased susceptibility to handling stress. In a 1989 study, smallmouth bass were three times more likely to die than largemouth bass in tournaments (Hartley and Moring 1991). Similarly, initial mortality was significantly greater for smallmouth bass (4.8%) than largemouth bass (2.2%) in a recent Connecticut study (Edwards et al. 2004). It was also reported that initial mortality was higher for smallmouth bass, but delayed mortality was greater for largemouth bass (Hartley and Moring 1991).

Tournament activity that displaces significant numbers of smallmouth bass could have ecological effects and management implications for reservoir populations (Wilde 2003). Ridgway (2002) noted that smallmouth bass released at a tournament tended to stay near the release site for several days; thus, artificially increasing smallmouth bass density and possibly increasing exploitation of released fish. There is little information on smallmouth bass tournament mortality, and no such information exists for Tennessee reservoir populations. The objectives for this study were to: (1) describe delayed tournament mortality of smallmouth bass on Dale Hollow Reservoir as a function of air and water temperature, fish size, livewell duration, and dissolved oxygen concentrations; and (2) measure smallmouth bass dispersion from the release site.

STUDY AREA

Dale Hollow Reservoir is an impoundment on the Obey and Wolf Rivers that was constructed in 1943. It has a surface area of 12,396 ha, is approximately 92 km long, and has 1,000 km of shoreline. The reservoir has a mean depth of 15 m and is an oligo-mesotrophic system.

Dale Hollow Reservoir harbors largemouth bass, smallmouth bass, and spotted bass. Anglers are limited to five black bass a day and each species is managed with a different size limit regulation. There is a 381 mm minimum total length (TL) limit on largemouth bass and no size limit for spotted bass. There is a protected slot limit (406 to 533 mm TL) for smallmouth bass. Anglers are allowed to keep one smallmouth bass under 406 mm TL and one over 533 mm TL per day..

METHODS

Delayed mortality was assessed through simulated bass tournaments on Dale Hollow Reservoir. The simulated tournaments were held from March 2004 through February 2005 at water temperatures between 8 and 27 ^{o}C. With the assistance of experienced anglers and guides, fish were captured using artificial lures. Each angler operated their livewell independently as if they were fishing in a tournament. An observer accompanied each volunteer angler to record data. Captured fish were marked with a T-bar numbered Floy© tag or a hole punch in a specific fin to identify the order in which they were caught. Time caught, handling time (i.e., time elapsed between hooking and placing in livewell), geographic location (when possible), lure type, hook location, fish length (TL), and general condition were recorded. Once a fish was added to the livewell, the water temperature, dissolved oxygen concentration, ammonia level, and the number of fish present were recorded every hour. A simulated weigh-in followed most tournaments. Each boat brought their fish to the scales in a standard black plastic "weigh-in" bag filled with lake water. Fish were then placed into a large plastic container with drain holes and weighed. Occasionally, fish were not weighed; however, those fish were handled and transferred between boats to simulate the other handling procedures a fish would experience during a weigh-in. After weighing, fish were either released into a net pen and held for three days (Wilde et al. 2002) or an ultrasonic tag and float assembly was externally attached and fish were immediately released. All tagged fish were released from Horse Creek Marina located at the southernmost point of Horse Creek on Dale Hollow Reservoir, Tennessee.

Net Pen Confinement

The net pen was 1.8 m wide, 3.1 m long, and 12.2 m deep and was constructed from 6.4 mm nylon mesh. There were five supporting frames; a top and bottom frame built with 51-mm polyvinyl chloride (PVC) pipe, and three central frames built with 13-mm PVC pipe. Insulating foam was inserted into the top frame for floatation and holes were drilled into the bottom frame to allow the net to sink. Cable ties were used to hold the 13 mm pipes together and bolts and wing nuts were used to connect the 51 mm pipes. A lid was constructed from 12.7 mm PVC pipe and fastened to the pen. Additional floats were attached to the surface frame for floatation. The net pen was deployed and anchored in a boat slip, where it was monitored daily for dead fish using an Aquaview© camera to avoid additional stress on fish that might be associated with raising the net pen.

Ultrasonic Tags and Tracking

Sonotronics IBT-96-5 ultrasonic transmitters (tags) that were 36 mm long, 13 mm in diameter, weighed 3.2 g in water, and had a maximum range of 500 m were externally attached to most of the fish caught in this study. Each tag had a unique code consisting of a series of pulses allowing the identification of individual tagged fish. Tags were equipped with a small float that was approximately 80 mm long, 13 mm in diameter and made from acrylic tubing with end caps. Each float was labeled with contact information and the words "$25 Reward." Tags were attached in front of the dorsal fin using suture thread inserted into the musculature. A previous study explored various ways of externally attaching ultrasonic tags and found placement in front of the dorsal fin to be the least invasive (MacLean et al. 1982). The suture thread was chromic gut suture (VetCassette® II C, size 1), which would eventually decompose and allow the tag and float assembly to detach from the fish and float to the surface, where the tag could theoretically be recovered and re-attached to another fish (Sutton et al. 2004). A similar float-and-tag system was used successfully to assess catch-and-release mortality of free-ranging striped bass (Osborne and Bettoli 1995).

Smallmouth bass were tracked using a Sonotronics® directional hydrophone and wideband receiver. Tracking was limited to the embayments and open water of the reservoir between the dam and Indian Creek (the embayment to the east of Horse Creek embayment). Tagged fish were usually located once a day for the first 3 days, then on days 10 and 14. Once a fish was located, the geographic location was recorded using a global positioning system receiver (Garmin® GPSMAP 188, Garmin International Inc.). A fish that moved out of the search area (i.e., upstream of Indian Creek) was deemed to have survived; whereas, a fish was considered dead if it remained in the same location for three consecutive fixes.

Data Analysis

Total fishing effort and the catch rate were calculated for the entire study. A t-test was used to test for differences in mean total length for smallmouth bass caught in the summer (June-September) and in winter (October-May). The test was considered significant at a = 0.05. Delayed mortality was calculated separately for smallmouth bass held in the net pen, for smallmouth bass fitted with ultrasonic tags, and all smallmouth bass caught and held, or tagged.

Logistic regression was used to test for relationships between the status (dead or alive) of all the fish caught in this study (tagged or confined in net pen) and water temperature (WTEMP), tournament length (TLENGTH), handling time (HTIME), total length (TL), and livewell confinement time (LWT). Significant ($P < 0.10$) variables were identified and entered into the model using forward selection criteria and model fit was tested with Hosmer and Lemeshow's Goodness of Fit test. Pearson correlation analysis was used to assess multicollinearity *a priori.* SAS was used to perform all statistical analyses (SAS Institute 1999).

ArcView GIS 3.2 was used to measure minimum distances traversed by smallmouth bass away from the release site. The average minimum distances traversed within 3 and 5 days was calculated, as well as the greatest minimum distance traversed by any fish.

RESULTS

Catch per unit effort of smallmouth bass on Dale Hollow Reservoir was very low. Only 66 smallmouth bass were caught during 755 hours of fishing between March 2004 and February 2005. Thus, catch per unit effort was only 0.09 smallmouth bass per hour at water temperatures ranging from 7.4 to 29.3°C (mean = 20°C; SE = 5.1). Tournament durations ranged from 3.1 to 9.0 hours (mean = 6.2 hours; SE = 0.05). Data on four fish were not included in subsequent analyses because they were not tagged and released or held in the net pen.

Smallmouth bass ranged from 330 to 572 mm TL (mean = 447 mm TL; SE = 52.4). Mean total length of smallmouth bass caught in the winter (mean = 461 mm TL; SE = 81) was significantly greater than fish caught in the summer (mean = 429 mm TL; SE = 193; $P = 0.0452$). Handling time ranged from 0.3 minutes to 3.62 minutes (mean = 1.5 minutes; SE = 0.008).

The majority of the fish caught during this study were within the slot limit on Dale Hollow Reservoir. Therefore, these fish could not have been retained during a regular tournament. Most fish were hooked in the lip with a single hook jig. There were no obvious hooking injuries throughout the study and all fish appeared to be in good condition when released. The majority of anglers involved with the study were experienced tournament anglers, which resulted in short handling times. Fish were not played until exhaustion, but retrieved as quickly as possible.

Throughout the study, eighteen different livewells were used to confine smallmouth bass and some were used more than once. Livewell water temperatures ranged from 6.1 to 29.3°C (mean = 17.8°C; SE = 0.57) and dissolved oxygen concentrations ranged from 1.42 to 13.5 ppm (mean = 7.65 ppm; SE = 0.06). Lower concentrations of dissolved oxygen were observed in livewells during summer months (Figure 1); however, only 8% of observations fell below 4 ppm. Ammonia levels were negligible, and livewell confinement ranged from 0.17 to 7.38 h (mean = 2.8 h; SE = 0.06). No smallmouth bass were dead at weigh-in (i.e., initial mortality was zero).

Delayed mortality was high for smallmouth bass confined in the net pen. Eight smallmouth bass were placed in the net pen in July 2004, and three of those fish died (i.e., 38% mortality). One smallmouth bass was found dead on day one, and the other two fish were found dead on day three. Water temperature inside the net pen ranged from 28.3°C at 1 m to 11.8°C at 16 m, and dissolved oxygen concentrations ranged from 8.47 ppm at 1 m to 4.29 ppm at 16 m. Due to subsequent vandalism of the net pen, it was no longer used to assess delayed mortality.

Delayed mortality was lower for smallmouth bass fitted with a tag and float assembly. Fifty-four smallmouth bass were tracked using ultrasonic equipment, and ten of those fish died. Thus, delayed mortality of tagged smallmouth bass over all seasons was 19%. Fish were tagged and released at water temperatures ranging from 7.4 to 29.3°C. Mortality for tagged fish was 11% at water temperatures less than 10°C and 28% at water temperatures greater than 18°C. Delayed mortality for confined and tagged fish was 21% over all samples.

Two anglers reported catching the same smallmouth bass within 4 weeks after it had been tagged and released. The greatest distance any tagged fish was known to have traversed was at least 5.17 km within five days of release. Twenty percent (11 of 54) of the deployed ultrasonic tags were recovered through August 2005.

Multicollinearity existed among the variables examined as mortality predictors. Livewell confinement time (LWT) was excluded from analysis due to its correlation with three other variables ($r \geq 0.3271$; $P \leq 0.0123$). Total length (TL) and water temperature (WTEMP) were also correlated ($r = -0.40712$; $P = 0.0010$); therefore, logistic regression was performed using two separate models. Tournament length (TLENGTH), TL, and handling time (HTIME) were included in the first forward selection procedure. TL was the only significant predictor of delayed mortality ($P = 0.0351$) and the model passed the Hosmer and Lemeshow's Goodness of Fit test ($X^2 = 6.1$, df = 7, $P = 0.5284$). The model was:

$$\text{Probability of Mortality} = \frac{e^{3.77-0.0117(TL)}}{1+e^{3.77-0.0117(TL)}} .$$

Over the range of lengths examined, smaller fish were more likely to die than larger fish (Figure 2).

Only WTEMP and HTIME were included in the second logistic regression model because WTEMP was correlated to TLENGTH ($r = -0.4861$; $P < 0.0001$). WTEMP was the only significant predictor of delayed mortality (P = 0.0588) and the model passed the Hosmer and Lemeshow's Goodness of Fit test (X^2 = 9.3, df = 7, P = 0.2307). The model was

$$\text{Probability of Mortality} = \frac{e^{-2.77+0.0754(WTEMP)}}{1+e^{-2.77+0.0754(WTEMP)}}\ .$$

Over the range of water temperatures examined, smallmouth bass were more likely to die at higher water temperatures (Figure 3).

Smallmouth bass dispersal rates varied among individual fish. Most smallmouth bass dispersed from the release within 3 d (Figure 4). Generally, fish swam up the western shore of Horse Creek and were usually located on points or along cliffs. Fish were usually located near shore and rarely were found in open water. On average, smallmouth bass moved approximately 2 km and seven fish reached the main channel within three days. A few fish crossed the main channel and swam to various creeks within the first day (Figure 4). Within five days, the average distance traversed was 2.75 km and more fish reached the main basin (Figure 5). One fish traversed at least 3.96 km within one day of release and another traversed at least 4.18 km within five days of release. Most (67%) tagged smallmouth left the search area, traveling at least 5.50 km, within two weeks. Only 33% of tagged smallmouth remained in the search area after 14 d (Figure 6). Fish did not congregate after dispersing from the release site; however, some fish appeared to follow similar dispersal patterns. Some fish dispersed slowly with relatively short movements, while others moved large distances quickly. Once fish reached the mouth of Horse Creek they had a choice of moving downlake toward the dam or uplake. Approximately 60% of fish moved towards the dam before dispersing uplake. The other 40% dispersed uplake immediately, occupying various coves and creeks for several days along the way. At least two smallmouth bass displayed homing behavior and returned to within 0.1 km of where they were known to have been caught.

DISCUSSION

Anglers maintained individual livewells in various manners and were not influenced by observers to treat the livewells in any particular way. Some anglers added ice to their livewells to reduce the temperature during warmer months. Adult smallmouth bass prefer water temperatures around 21°C, which is lower than the preferred temperature for largemouth bass (27°C; Edwards et al. 2004). Although cooling the water in a livewell may reduce mortality, cooling water by more than 3 to 4 °C might cause thermal shock when fish are returned to the lake (Schramm et al. 2004). Many anglers did not realize that the ice they added to livewells was chlorinated and chlorine is toxic to fish at even low concentrations. Lowering livewell temperatures will only benefit smallmouth bass if anglers carefully regulate livewell temperatures and use non-chlorinated ice or dechlorination additives.

Some anglers will not add fresh lake water to a livewell to which they have already added ice. In systems with recirculating livewells this is not a problem; however, some systems can only replenish dissolved oxygen by adding fresh water. Therefore, these systems may become hypoxic and perhaps lethal depending on how many fish are present (Hartley and Moring 1991). During summer in the present study, low concentrations of dissolved oxygen were observed in livewells, sometimes falling below 2 ppm; however, dissolved oxygen concentrations rarely fell below 4 ppm. Similar findings were reported by Schramm et al. (2004), who noted that modern bass boats are capable of keeping dissolved oxygen levels adequate for fish survival. Although continuous recirculation of livewell water would be optimal, even sporadic aeration of water increases dissolved oxygen (Edwards et al. 2004). Using more than one livewell when available would also reduce the deleterious effects of high fish densities.

Delayed mortality was high for smallmouth bass confined in the net pen (38%), when fish were confined during the warmest water temperatures experienced during this study. It was assumed that there was no effect from net pen confinement; however, additional research is needed to support that assumption. In addition to the potential deleterious effects of net confinement on smallmouth bass survival (Schramm et al. 2004), biofouling occurred and may have restricted water flow through the net. Dense algae grew on the lid and fouled the net to a depth of 3 m. This problem could have been avoided by removing the net when it was not in use. A variety of prey was observed in the net pen using the underwater camera while the fish were being confined; therefore, food was always available. The submersible camera was suitable for observing dead fish in waters as clear as Dale Hollow Reservoir and the disturbance to live fish was minimized. However, it was impossible to identify individual fish using the camera.

A key assumption in this study was that attaching tags to fish did not influence fish survival or behavior, as Osborne and Bettoli (1995) successfully argued. Fish did not seem to be affected by the tags; every fish that was tagged swam away and was out of sight within seconds, even those that subsequently died. The fact that one fish was caught by anglers, twice, with the tag and float assembly still attached suggests that smallmouth bass behavior (or survival) was not affected by the tags.

Total length of smallmouth bass was a significant predictor of delayed mortality. In the present study, longer fish had a greater chance of survival than shorter fish, contrary to the findings of Hartley and Moring (1991) and Meals and Miranda (1994), who reported higher mortalities for larger, older fish. Schramm et al. (1987) also reported a positive relationship between fish size and delayed tournament mortality; however, it was not a statistically significant relationship. It has been suggested that larger fish require a greater amount of dissolved oxygen and are more susceptible to poor livewell conditions (Weathers and Newman 1997). Anglers were limited to two smallmouth bass, one under 406 mm TL and one over 533 mm TL, per tournament. Tournament anglers cull smaller fish and keep larger fish, which increases their total fish weight. According to the predictive model, the effects of delayed mortality on the population should be low in Dale Hollow Reservoir because anglers can only possess one short smallmouth bass (< 406 mm TL) per tournament.

Similar to most tournament mortality studies, water temperature was a significant predictor of delayed mortality (Schramm et al. 1987; Weathers and Newman 1997; Wilde 1998; Neal and Lopez-Clayton 2001; Wilde et al. 2002; Edwards et al. 2004). Recovery from physiological stress is prolonged for smallmouth bass at temperatures over 16° C (Schreer et al. 2001), which results in increased mortality.

Few studies have examined dispersal patterns of smallmouth bass. In the present study, fish tended to disperse along the western shore of Horse Creek towards the main channel. The western shore is a steep rocky wall; whereas, the eastern shore is a gradual slope with shallower depths. Smallmouth bass prefer rocky points with steep drop offs as opposed to shallow pools (Hubert and Lackey 1980). Similarly, Reeser (1995) noted that smallmouth bass were usually found in or near deep water. Smallmouth bass also displayed an affinity for cover and aquatic vegetation in that study; but that variable was not assessed in the present study.

Peterson and Myhr (1977) reported homing behavior by only one smallmouth bass out of five. In this study, two smallmouth bass displayed homing behavior and returned to within 0.1 km of their capture site. However, the capture sites were located within the search area and less than 5 km from the release site. Reeser (1995) found that smallmouth bass that moved extensively did not display homing behavior; however, in the same study smallmouth bass that displayed little movement remained in the general vicinity of the tagging location. It is possible that other smallmouth bass in the present study displayed homing behavior, but that cannot be assessed properly because some anglers would not allow GPS coordinates to be recorded at capture sites. Many smallmouth bass moved uplake towards remote capture sites, suggesting the possibility of some homing behavior.

There are several management implications that arise from the findings in the present study regarding smallmouth bass tournaments on Dale Hollow Reservoir. Although delayed mortality for tournament-caught smallmouth bass was not negligible, rapid dispersal from the release point alleviated any concern regarding increased fish densities near release sites. The current slot limit that prohibits anglers from retaining average-sized adult smallmouth bass in livewells has resulted in low numbers of bass tournaments on Dale Hollow Reservoir; thus, the impact of tournament fishing activity on the smallmouth bass population probably is negligible. However, delayed mortality of smallmouth bass may be problematic in other lakes and reservoirs that experience heavier tournament activity, particularly during summer months.

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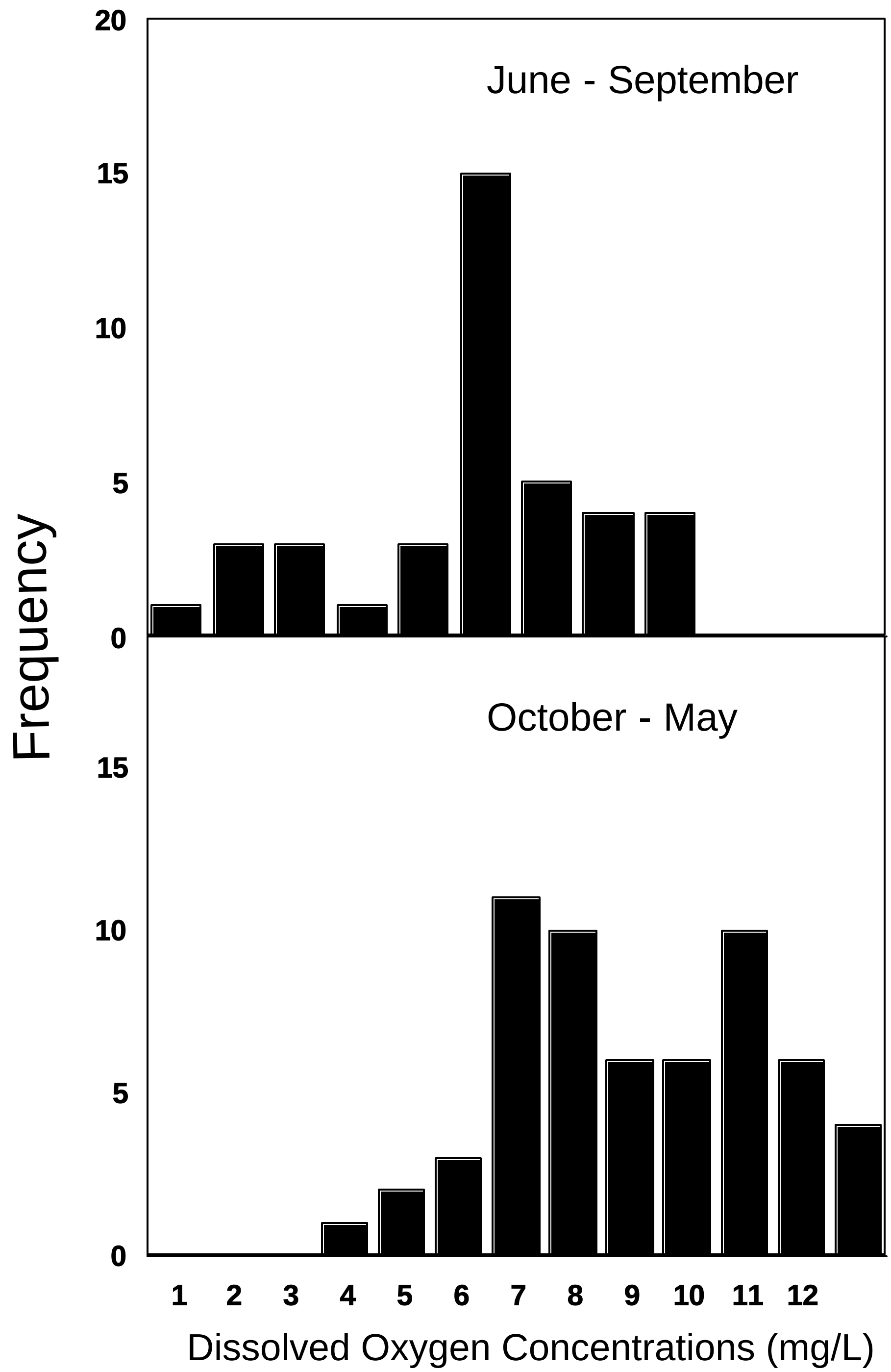

Figure 1. Dissolved oxygen concentrations (mg/L) in boat livewells during simulated tournaments on Dale Hollow Reservoir, Tennessee.

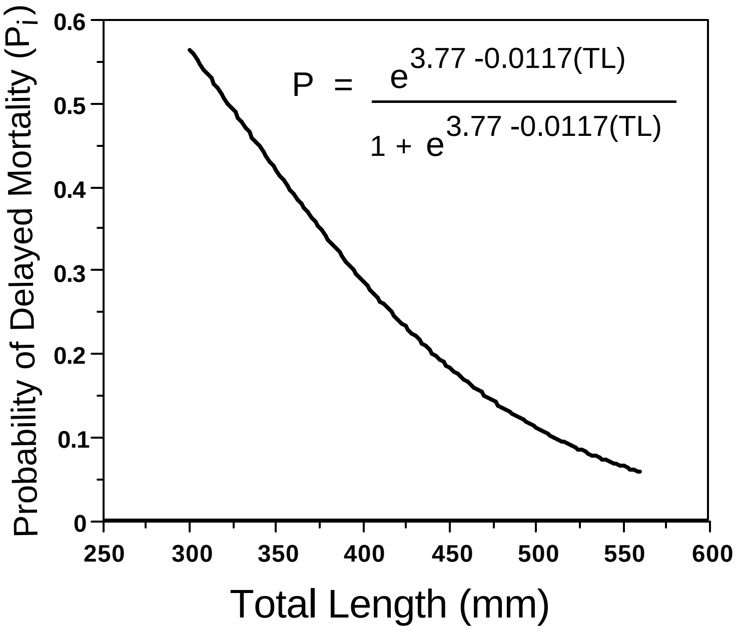

Figure 2. Probability of delayed mortality (Pi) as a function of total length (TL) for tournament caught smallmouth bass on Dale Hollow Reservoir, Tennessee.

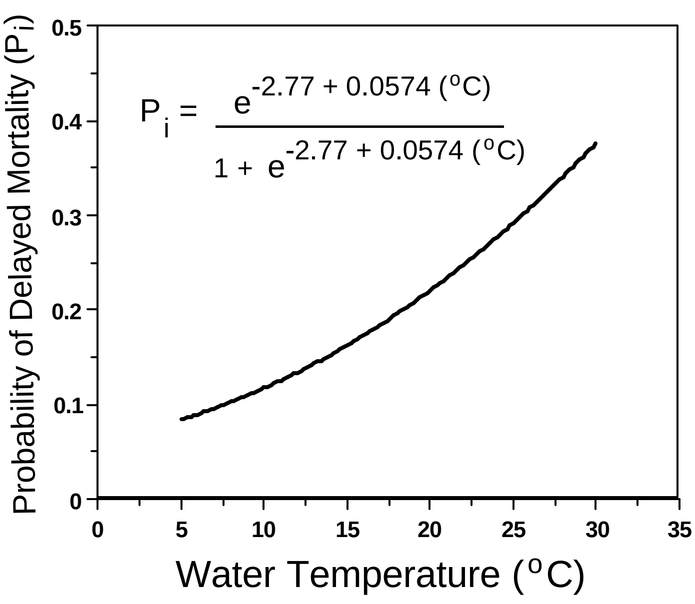

Figure 3. Probability of delayed mortality (Pi) as a function of water temperature (WTEMP) for tournament caught smallmouth bass on Dale Hollow Reservoir, Tennessee.

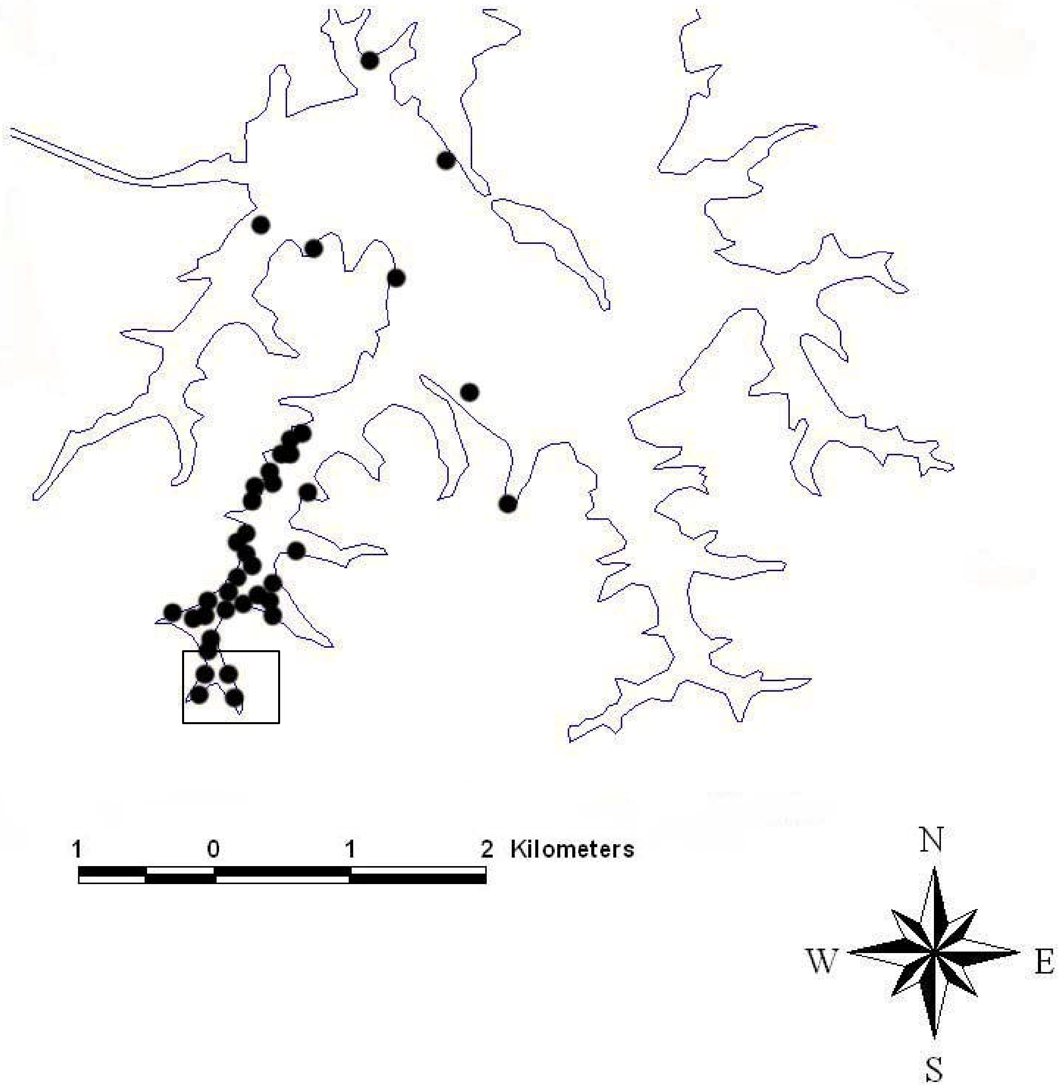

Figure 4. Locations within three days of release of tournament caught smallmouth bass that survived tournament weigh-ins on Dale Hollow Reservoir, Tennessee. The outlined area represents the release point for all fish.

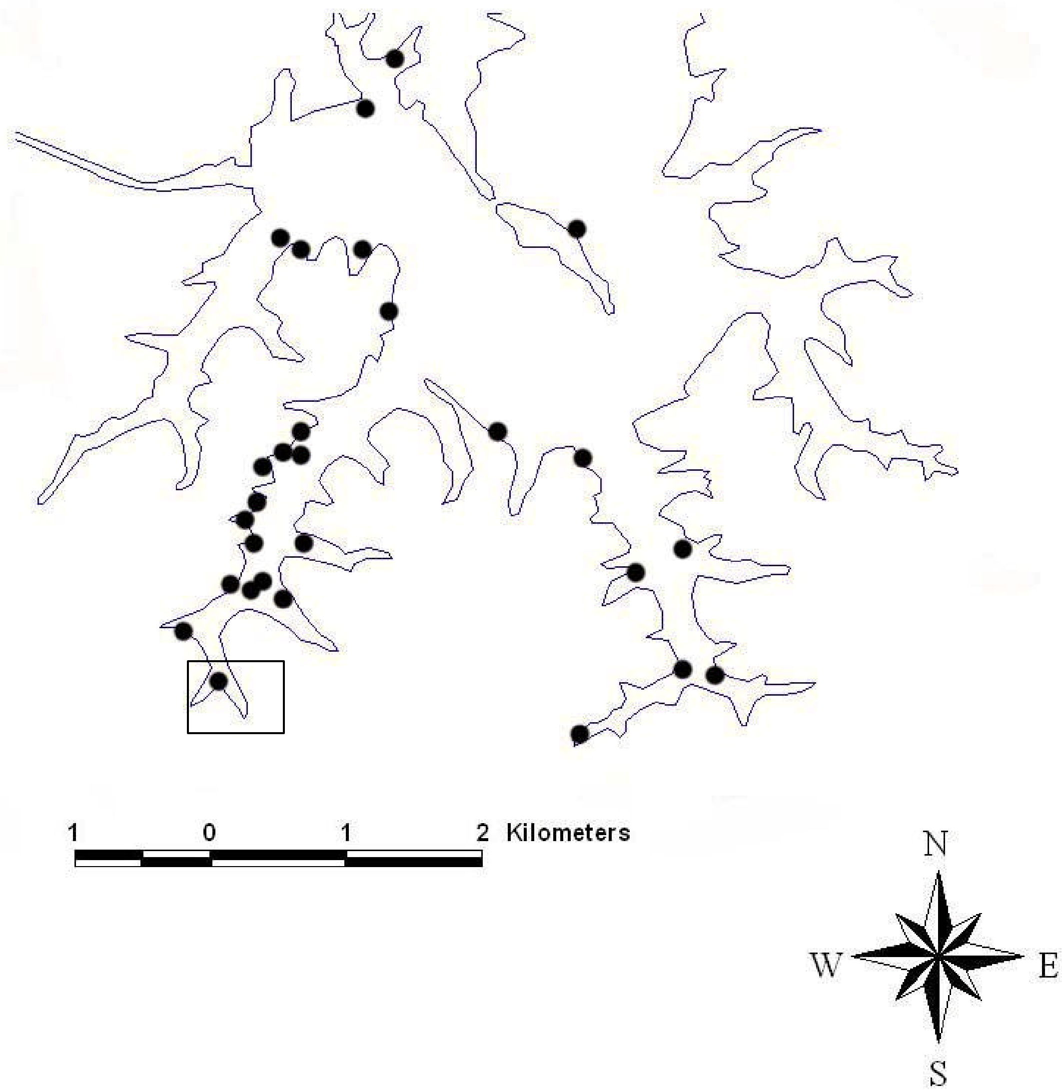

Figure 5. Locations three to five days after release of tournament caught smallmouth bass that survived tournament weigh-ins on Dale Hollow Reservoir, Tennessee. The outlined area represents the release point for all fish.

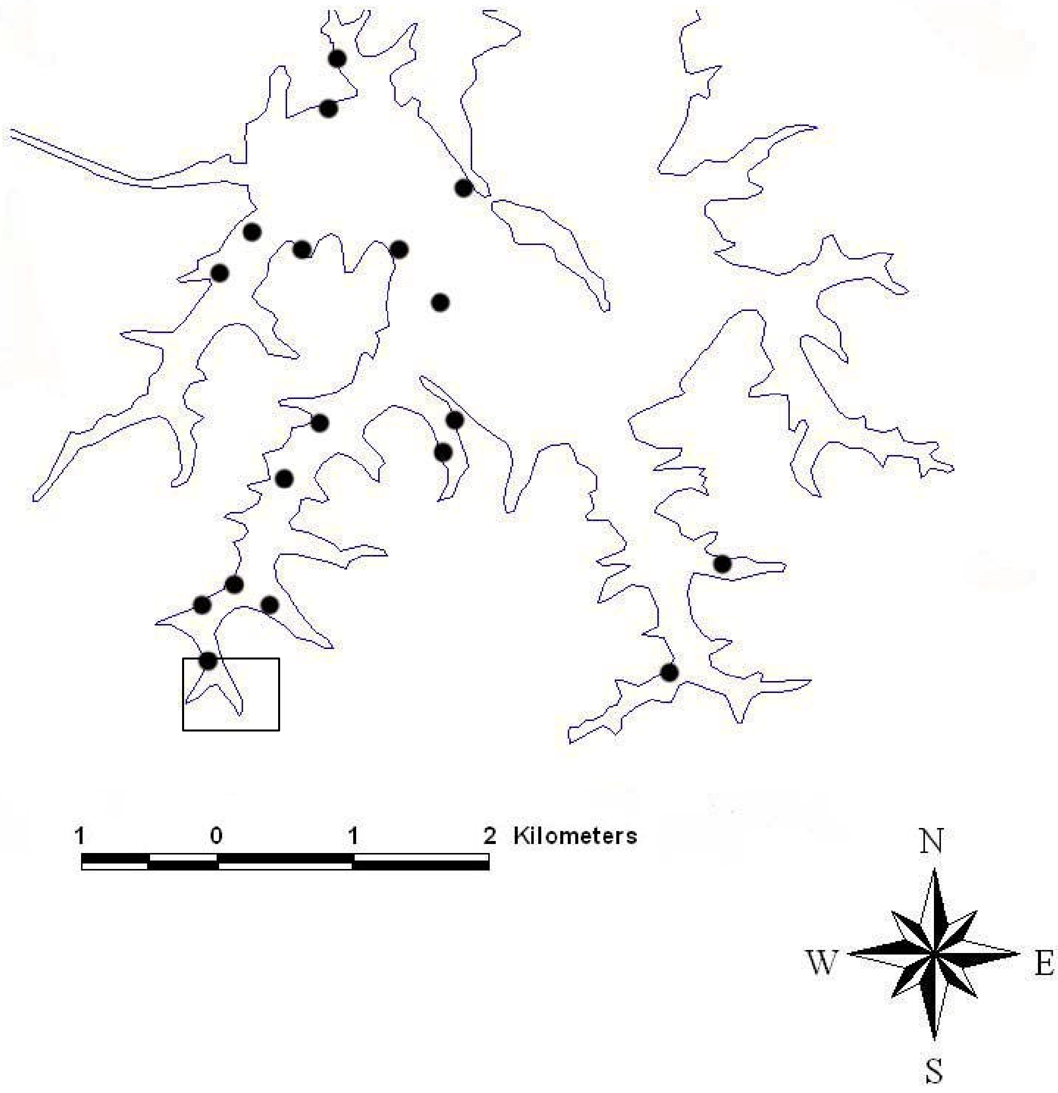

Figure 6. Locations after five days of tournament caught smallmouth bass that survived release on Dale Hollow Reservoir, Tennessee. The outlined area represents the release point for all fish.

APPENDIX

Table 1. Minimum distances traversed by 54 tournament-caught smallmouth bass in Dale Hollow Reservoir, Tennessee.

Tag Number	Date Tagged	TL (mm)	Water Temperature (°C)	Livewell Time (hr)	Fate	Number of Fixes	Minimum Distance Traversed (km)
3-3-4-6	03/17/04	448	9.2	6.42	Live	7	3.35
3-3-5-5	03/17/04	472	9.2	7.38	Live	4	0.32
3-4-4-4	03/17/04	433	9.2	7.32	Live	7	0.8
4-4-4-4	03/17/04	498	9.2	2.37	Live	5	1.95
7-7-7-7	05/06/04	508	18	4.92	Live	4	4.25
3-3-7-5	08/13/04	508	26.2	4.05	Live	2	0.45
3-4-6-6	08/13/04	381	26.2	2.3	Dead	2	0.43
3-4-4-6	08/13/04	356	26.2	2.17	Live	1	1.38
3-3-5-7	08/13/04	483	26.2	1.28	Live	1	3.5
3-4-5-5	08/13/04	337	26.2	4.62	Live	0	.
3-3-6-6	08/13/04	330	26.2	0.3	Dead	4	0.43
6-6-6-6	08/13/04	495	26.2	4.33	Live	1	0.39
3-3-3-7	08/13/04	330	26.2	4	Dead	4	0.13
3-4-5-7	09/14/04	483	26.7	2.88	Live	3	1.21
3-3-4-6	09/14/04	483	26.7	1.5	Live	2	1.42
3-3-6-4	09/14/04	483	26.7	0.33	Dead	3	0.56
3-4-7-5	09/14/04	521	26.9	2.17	Live	1	.
6-6-6-6	09/14/04	426	26.9	1.67	Dead	3	0.39
3-3-3-3	09/14/04	394	27	0.75	Live	1	0.84
3-3-4-4	09/14/04	406	27	0.05	Live	3	0.56
4-4-7	10/07/04	508	23.1	2.33	Live	2	0.84
3-3-5	10/07/04	432	23.1	1.17	Dead	7	0.48
4-4-5	10/07/04	407	23.1	0.42	Live	5	1.75
3-4-6-6	10/07/04	343	23.1	3.17	Live	4	5.13
4-4-6	10/07/04	419	23.1	2.08	Live	2	5.17
3-3-3	10/30/04	400	20.7	3.08	Live	2	3.98
4-5-5	10/30/04	406	20.7	1.47	Live	3	1.67
3-3-6	10/30/04	415	20.7	6.83	Live	4	0.25
3-3-7	10/30/04	357	20.7	4.28	Dead	7	0.28
3-3-4	10/30/04	432	20.7	2.8	Live	5	3.14
2-3-3	01/14/05	381	9.9	4.12	Live	4	3.7
3-4-4	01/28/05	483	7.6	2.83	Live	2	3.74
3-4-5	01/28/05	533	7.6	2.78	Live	3	1.66
4-4-4	01/28/05	508	7.6	2.58	Live	2	2.53
4-4-7	01/28/05	470	7.6	2.17	Live	2	4.02
4-4-5	01/28/05	432	7.6	.	Live	7	2.22
5-5-6	01/28/05	533	7.6	1.42	Live	2	3.04
2-2-5	01/28/05	483	7.6	0.33	Live	2	1.06
5-5-5	01/28/05	521	7.6	0.17	Live	3	3.00

Table 1. Continued.

Tag Number	Date Tagged	TL (mm)	Water Temperature (°C)	Livewell Time (hr)	Fate	Number of Fixes	Minimum Distance Traversed (km)
2-3-4	01/28/05	470	7.6	2.42	Live	2	0.79
2-4-4	01/28/05	495	7.6	.	Dead	7	0.03
3-3-4-4	01/28/05	483	7.6	.	Live	5	2.98
2-2-2	01/28/05	495	7.6	.	Live	2	1.26
2-3-5	02/05/05	445	7.4	7.25	Live	3	2.35
2-4-5	02/05/05	381	7.4	7.15	Dead	5	0.77
3-3-3	02/05/05	419	7.4	0.53	Live	2	3.49
3-3-5	02/05/05	508	7.4	5.65	Dead	4	0.72
2-2-4	02/19/05	457	8	4.08	Live	1	3.31
4-5-5	02/19/05	533	8	4	Live	0	0.29
3-5-5	02/19/05	572	8	3.98	Live	2	0.95
3-3-4	02/19/05	508	8	3	Live	1	2.51
3-3-3	02/19/05	533	8	1.92	Live	2	3.48
2-2-3	02/19/05	483	8	1.5	Live	2	1.90
4-4-4	02/19/05	381	8	1.75	Live	2	0.70