MOVEMENT, DISPERSAL AND HOME RANGES OF TOURNAMENT DISPLACED LARGEMOUTH AND SPOTTED BASS IN LAKE MARTIN, ALABAMA

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MOVEMENT, DISPERSAL AND HOME RANGES OF TOURNAMENT DISPLACED LARGEMOUTH AND SPOTTED BASS IN LAKE MARTIN, ALABAMA

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MOVEMENT, DISPERSAL AND HOME RANGES OF TOURNAMENT

DISPLACED LARGEMOUTH AND SPOTTED BASS

IN LAKE MARTIN, ALABAMA

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VITA

Ryan Wayne Hunter, son of Anthony Hunter and Bonnie (Rhodes) Hunter, was born May 5, 1982 in Dallas, Texas. He graduated from Commerce High School in Commerce, Texas in 2000. He received his Bachelor of Science degree in Marine Biology from Texas A&M University in August, 2004, after studying at the Texas A&M University Galveston branch campus on Galveston Island. In January 2005, he entered the Graduate School at Auburn University in the Department of Fisheries.

THESIS ABSTRACT

MOVEMENT, DISPERSAL AND HOME RANGES OF TOURNAMENT DISPLACED LARGEMOUTH AND SPOTTED BASS IN LAKE MARTIN, ALABAMA

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Anglers fishing in black bass tournaments often displace fish great distances from their site of capture and the effects of tournament displacement on movement and behavior of fish after release have been variable. Accumulation of black bass, which may have negative effects on populations and the fishery, can occur when many tournaments displace large numbers of black bass to a single tournament processing site. Largemouth bass *Micropterus salmoides* and spotted bass *M. punctulatus* were implanted with radio transmitters to observe the effect of tournament displacement on movement and behavior in Lake Martin (16,188 ha), Alabama. In April-May 2005, 10 largemouth bass and 10 spotted bass were collected with electrofishing, radio-tagged, and transported to a popular tournament processing site (Wind Creek State Park; WCSP). In addition, 10 largemouth bass and 9 spotted bass were tagged and released at their capture location to serve as control fish. In November 2005, 7 spotted bass and 8 largemouth bass weighed-in at black bass tournaments were implanted with radio transmitters and released at

WCSP. Both groups of displaced largemouth bass and spotted bass moved farther from the release site than control fish over time. Fish displaced in spring 2005 exhibited higher daily movement than control fish during the spring, summer, and fall 2005. Diel behavior was not significantly different between the two experimental groups. No significant differences were detected between the 50 and 95% kernel home range estimates of control and displaced largemouth bass. However, control spotted bass had smaller 50 and 95% home ranges than control largemouth bass. Displaced largemouth bass set up home ranges 9 to13 km from WCSP, 47 to 85 d after being released. For fish tagged in November 2005, 57% (4 of 7 fish) of the tournament displaced fish remained within 2 km of the WCSP release site for 3 months. All tournament simulated fish moved farther than 2 km from the WCSP release site within 3 months.

Dispersal of black bass from the tournament release site was used to model the increase in biomass of black bass that occurred within 2 km of the release site during the spring 2005. Based on the model and estimates of standing stock biomass from Lake Martin, estimates of black bass biomass possibly doubled within 2 km of WCSP (146 ha) as tournament displaced fish contributed nearly 9 kg/ha during the 3-month tournament season. Behavior of tournament released fish was altered for up to 9 months following release and short-term accumulation of fish at the release site probably occurred.

Most displaced black bass migrated from WCSP within a few months of release, but some remained in the vicinity of WCSP for up to 3-6 months. Short-term accumulation of fish occurred which likely artificially increased black bass abundance near the release site. Simulated tournament fish moved more than control fish for up to 9 months and altered behavior could effect growth, survival, and reproductive output. To negate the effects of tournament displacement additional tournament release sites could be used on Lake Martin and improvement of the “live release” boat could expedite dispersal.

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INTRODUCTION

Since the 1970's, black bass *Micropterus sp.* fishing tournaments have steadily increased in popularity (Schramm et al. 1991). In the past, fisheries managers have primarily examined tournament mortality of black bass (Schramm et al. 1991). Kerr and Kamke (2003) estimated from a survey of competitive fishing activity, that over 25,000 competitive fishing events on freshwater occur each year in North America. In the survey fisheries agencies reported fish relocation was one of the most important biological impacts of fishing tournaments (Kerr and Kamke 2003). Stockpiling of fish occurs when many tournaments release large numbers of fish in the same location. Stockpiling may have an influence on fish health, forage availability, and exploitation (Gilliland 1999; Wilde and Paulson 2003).

Results have varied among studies that have examined tournament displacement (Stang et al. 1996; Gilliland 1999; Richardson-Heft et al. 2000; Pearson 2002; Ridgway 2002; Wilde and Paulson 2003). Stang et al. (1996) found that most displaced black bass move very little after an initial dispersal period in New York. In the St. Lawrence River, 70% largemouth bass *M. salmoides* and smallmouth bass *M. dolomieu* were within 6.4 km of the release site after 9 months, and 60% were located within 2.4 km of the release site (Stang et al. 1996). In Cayuga Lake, 71% of largemouth bass were located within 2 km of the release site 221 d after release (Stang et al. 1996). Similar results were observed in Saratoga Lake and the Hudson River for displaced largemouth bass (Stang et al. 1996).

Gilliland (1999) found that most largemouth bass released following tournaments remain in the vicinity of the release site for a considerable length of time. In a 2,500 ha Oklahoma reservoir, 49 and 64% of tagged bass were recaptured within 0.8 and 1.6 km of the release site during the first year (Gilliland 1999). During the second year, 35 and 46% of recaptures were observed 0.8 and 1.6 km from the release site (Gilliland 1999). Wilde and Paulson (2002) reported 63% of tournament caught largemouth bass were located less than 0.5 km from the release site at the end of a 43-d observation period in Lake Mead, Arizona-Nevada.

Largemouth bass displaced in Rideau Lake, Ontario, moved farther from the release site than control fish moved after 1 month (Ridgway 2002). Black bass displaced 1.5 to 16.5 km returned to their capture site 37% of the time. Once home ranges were established, no difference in home range area was observed between displaced and non-displaced largemouth bass (Ridgway 2002).

In northern Chesapeake Bay, the mean distance between the release site and final location for radio-tagged largemouth bass was greater for displaced than for control fish (Richardson-Heft et al. 2000). By the end of the study, 95% of displaced and control largemouth bass were farther than 0.5 km from the release site (Richardson-Heft et al. 2000). Largemouth bass displaced up to 21 km tended to return to the site of capture (Richardson-Heft et al. 2000). However, 36% of released largemouth bass were still within 0.5 km of the release site after one week (Richardson-Heft et al. 2000).

Pearson (2002) used ultrasonic tags to observe the ability of largemouth bass to return to a capture site from interconnected lakes, and reported one of five experimental fish returned to its lake of origin. In two Florida lakes, 88% largemouth bass returned to their capture sites 3-69 d after being displaced 2.6-4.7 km (Mesing and Wicker 1986).

Most studies that have assessed the effects of tournament displacement have examined largemouth bass and smallmouth bass, while little information exists about the effects of displacement on spotted bass *M. punctulatus*. In addition, information on movement and behavior of spotted bass is nearly non-existent (Ricks 2006).

Ricks (2006) used mark and recapture techniques to measure the dispersal of tournament caught fish in Lake Martin, Alabama. Ricks (2006) found that tournament caught largemouth bass and spotted bass dispersed from the release site over time, however some fish remained near the release site for up to 6 months. Electrofishing catch rates of black bass were high near the release site indicating that short-term accumulation of black bass may be occurring (Ricks 2006). Ricks (2006) also noted that spotted bass may disperse more quickly from the release site than largemouth bass as electrofishing recapture of previously caught spotted bass were less than for largemouth bass.

In this study, I used radio telemetry to observe the effects of tournament displacement on largemouth and spotted bass in Lake Martin, Alabama. I compared diel and seasonal movement patterns, habitat depths, and home range areas of displaced and control largemouth and spotted bass. The dispersal rates and behaviors of fish displaced to a single tournament processing site on Lake Martin were of special concern because of the implications of accumulation on the fishery and population. Based on dispersal rates and tournament catches of black bass, I attempted to estimate the additional biomass of black bass that accumulated in the vicinity of Wind Creek State Park (WCSP).

STUDY SITE

Lake Martin is a large (16,188 ha) oligo-mesotrophic reservoir impounded in 1926 on the Tallapoosa River (Figure 1). Lake Martin reaches depths in excess of 45 m and has over 1100 km of shoreline. Wind Creek State Park (WCSP) is located in the northern portion of the reservoir (Figure 1) and is the site where nearly every black bass tournament on this reservoir is held. Tournaments are held almost every weekend at WCSP from January to May and from September to November. Black bass caught in these tournaments are potentially displaced up to 45 km. More than half of the surface acreage of Lake Martin is greater than 15 km from WCSP.

METHODS

Twenty largemouth bass and 19 spotted bass from Lake Martin were implanted with radio transmitters in April-May 2005. Fish were captured in portions of the reservoir down river from WCSP (Figures 2 and 3). Fish were collected with 1000 V direct-current electrofishing (Smith Root 7.5 GPP) and were held in a 160 L live-well. Ten largemouth bass and 10 spotted bass were transported to the boat ramp at WCSP to simulate tournament displacement (Table 1, Figure 2). Ten largemouth bass and 9 spotted bass were released at the site of capture and served as controls (Table 2, Figure 3). Fish transported to WCSP were held in the live-well until 3 or 4 fish of the appropriate size (> 1145 g) were captured and then the fish were moved, tagged, and released. Control fish were tagged and released immediately upon being captured.

Body implant radio transmitters (ATS model F1845, 22.9g) with a one year battery life were implanted using procedures similar to those described by Winter (1996). Only fish greater than 1,145 g were sought for implantation, so transmitters would be less than 2% of the fish's body weight, in an attempt to avoid altering behavior (Winter 1996). However, five fish smaller than the target minimum weight, but greater than 1008 g (< 2.3% of fish's body weight, Tables 1 and 2) were tagged due to difficulty capturing spotted bass over 1,145g. Each fish was placed in a 150 mg/L solution of MS-222 until the fish was unable to right itself in the water. Total length (mm), weight (g), and sex, if it could easily be determined, were recorded. Fish were placed in a cradle surrounded by a wet towel to prevent movement during surgery. A 3 cm incision was made on the ventral side of the fish just posterior to the pelvic girdle. The transmitter's antenna was pulled through the body wall from inside using a cruciate needle 2 cm posterior to the incision. Once the transmitter was placed inside the body cavity, the incision was closed with 3 to 4 sutures and iodine disinfectant was rubbed on the outside of the incision. The surgical procedure lasted less than 3 minutes. Fish were returned to the holding tank until they recovered and then were released.

Fish with internal tags were located every 3 to 4 d for the first 2 weeks and about every 10 d there after. About every 25 d fish were located every 4 h over a 24-h period to observe diurnal movement. Fish locations were determined with an ATS R2000 scanner and a directional yagi antenna. The location of each fish was recorded when the signal was strongest directly below the boat with a handheld global positioning system (GPS, Lowrance, *I* Finder Pro with WAAS receiver). GPS waypoint and coordinates, time, depth, and a brief description of the habitat were recorded for every location. Fish were tracked until they died, shed the transmitter, or the study was completed.

Eight largemouth bass and 7 spotted bass caught in tournaments were implanted with recovered transmitters on 13 November 2005 and released at the boat ramp at WCSP (Table 3). Fish implanted with recovered transmitters were tracked following the same schedule as the original 39 fish and were tracked for about 5 months. These fish provided additional information on short and long-term movement and behavior of tournament-caught black bass. These tournament caught fish were compared to the control fish tagged in April-May 2005 using data collected after 13 November 2005.

Individual fish positions determined every 20 d were combined with the first position from each diel track to estimate movement and behavior of fish over longer periods of time (> 1 d). Locations recorded on a 10-day interval were used to describe the dispersal of fish away from release sites, and determine kernel home ranges. For the purpose of this study, single locations on a 10-d cycle were referred to as single locations and locations from 24-h tracking were referred to as diel locations. Diel locations were used to describe movement and behavior over the course of a single day. Movement determined from single location data was calculated in meters moved per day (m/d):

$$\text{Movement (m/d)} = \frac{\text{distance moved since last location (m)}}{\text{days lapsed (d)}}$$

All movement recorded was the minimum distance traveled since the last location. Diel movement was calculated as meters moved per hour (m/h) and is also minimum movement during that time period:

$$\text{Diel movement (m/h)} = \frac{\text{distance moved since last diel location (m)}}{\text{hours lapsed (h)}}$$

Dispersal from the release site was the minimum straight line distance over water of each single location from the location where that fish was released, i.e. the site of capture for control fish and WCSP for displaced fish. The rate of dispersal was estimated as:

$$\text{Dispersal rate (m/d)} = \frac{DFR_1\text{(m)} - DFR_2\text{(m)}}{\text{days lapsed (d)}}$$

where DFR_1 was the distance of the previous location from the release site and DFR_2 was distance of the location from the release site. Negative rates of dispersal correspond with movement to a location closer to the release site than the previous location.

To describe dispersal rates and movement following tournament displacement, the first 70 d after release was divided into five, 14 d periods. Mean movement during each period was calculated for each fish to compensate for an unequal number of locations for some fish during some periods.

Movement was quantified seasonally for both single and diel locations. Seasonal movement patterns were compared among 4 seasonal time periods; 1) spring 2005; 2) summer 2005; 3) fall 2005; and 4) winter 2005-2006. In addition to seasonal movement, diel movement was compared over monthly time periods. Diel movement was also separated into day and night for comparison.

Differences in dispersal, seasonal movement, and diel movement among the species, experimental groups, and time periods were tested with a repeated measures analysis of variance (ANOVA) with random and fixed effects included in the model. Restricted maximum likelihood (REML) was used to estimate variance components in Proc MIXED (SAS 2003) by minimizing the likelihood of residuals from fitting the fixed effects portion of the model (Littell et al. 2006). First-order autoregressive (AR(1)) covariance structure was specified for this analysis because it was assumed observations taken closer together in time were more highly correlated than observations taken farther apart in time and AR(1) adequately described this correlation. When differences were detected by the repeated measured ANOVA, a least squares means procedure with a Bonferroni correction (alpha = 0.05 / N tests) to control the Type I error rates associated with simultaneous inferences, was used to detect individual differences. When group differences were detected among periods, F-protected t-tests were used to determine during what time periods these differences occurred. Kolmogorov-Smirnov tests were conducted to compare depth distributions between species and for control and displaced fish.

For fish radio tagged in April-May 2005, kernel home range estimates were calculated using the Animal Movement Analysis Extension (Hooge et al. 1997) for ARC View GIS 3.2 (ESRI 1992). Kernel estimates are considered the least bias estimate of home range (Seamen and Powell 1996) and 95% and 50% contours were used in this analysis so results could be compared with other studies. Ninety-five percent kernel home ranges were considered the area the fish actually used while 50% kernel home ranges were considered the area of core activity (Hooge et al 2001). Site fidelity was tested using Monte Carlo random walk test developed by Spencer et al. (1990) and modified by Hooge et al. (1997) to use actual distances traveled by an individual fish. Site fidelity was tested for displaced fish using the release site as the point of origin and then again using only observations taken after 90 d, using the first location after 90 d as the point of origin. Wilcoxon rank-sum test was used to test for differences in 50% and 95% home range area between species and groups. The Wilcox rank sum test was chosen because sample sizes were low and distributions of home range sizes were not normal. Sufficient data were collected to estimate home range for 7 control largemouth bass, 3 displaced largemouth bass, and 4 control spotted bass.

Estimates of the number and biomass of black bass transported to WCSP, and the additive effect of fish released from many tournaments during 2005 were modeled using tournament data. The total numbers of fish weighed-in and released from black bass fishing tournaments held at WCSP between February and April 2005 were obtained (Ricks 2006). The percentage of displaced fish located < 1 km, 1-2 km, and > 2 km from WCSP for tournament simulated and tournament displaced fish was determined for 2 week, 1 month, 2 month, and 3 month periods after release. I defined and mapped the area of potential accumulation as the area within 2 km of the release site using ArcView 3.2 (Figure 4). Two kilometers was approximately the distance that a fish must travel to leave the embayment where WCSP is located. Weight of accumulated black bass was estimated by multiplying 0.59 kg (Haffner 2004) by the number of black bass remaining within 2 km of WCSP. By estimating the number and percentage of displaced fish remaining within 2 km of WCSP and multiplying this value by the number of fish weighed-in during spring 2005, the additional number and biomass of tournament caught fish following tournament displacement was calculated for up to 3 months. For this model, I did not include loss due to tournament mortality. Water temperatures were less than 21°C during spring 2005, and Ricks (2006) predicted black bass total mortality was less than 20%. In addition, not all fish were processed by Ricks (2006) during the spring 2005 tournament season. Fish from smaller tournaments were not estimated in the spring 2006.

RESULTS

Short-term dispersal and daily movement

For both species pooled, displaced fish moved farther from WCSP than control fish moved from their respective capture sites during the first 70 d after release ($F_{1,16}$ = 21.52, $P < 0.001$). However, a treatment x time-period interaction was detected ($F_{1,84}$ = 12.21, $P < 0.001$) which indicated that control and displaced fish movement was not consistent over time. Displaced fish moved an average of 1.29 km from their release site during the first 2 weeks after release, while control fish moved an average of 0.54 km away from their release site (t = 3.00, P = 0.009; Figure 5). After 14 d, displaced black bass steadily moved farther from the release site and traveled an average of 1.8, 2.3, and 2.9 km over the 2nd (15-28 d, t = 2.40, P = 0.03), 3rd (29-42 d, t = 3.69, P = 0.002), and 4th (43-56 d, t = 2.59, P = 0.033) time periods, while control fish remained within an average of 0.6, 0.6, 0.8 km from the release sites over the same time periods (Figure 5). During period 5 (57-70 d), displaced fish were on average 7.0 km from the WCSP release site while control fish averaged 1.3 km (t = 4.12, P = 0.002) from their respective release sites.

For a mixed model that examined species, time period, and treatment effects during the first 70 d after release, largemouth bass dispersed greater distances than spotted bass ($F_{1,76}$ = 5.45, P = 0.022) as average distance moved was 2.4 and 1.4 km for each species (Figure 5). Accounting for species differences in movement, displaced fish (mean = 3.06 km) moved farther away from the release site than control fish (mean = 0.77 km, $F_{1,29}$ = 26.71, P < 0.001) similar to the previous analysis for both species pooled. Within species, displaced largemouth bass moved farther from the release site than control largemouth bass (t = 4.70, Bonferroni adjusted P < 0.001) and displaced spotted bass moved farther from the release site than control spotted bass (t = 2.90, Bonferroni adjusted P = 0.03). The temporal movement responses of control and displaced largemouth bass and spotted bass showed no significant interaction ($F_{1,76}$ = 0.35, P = 0.6). Dispersal was variable among individual fish over the first 70 d after release (Figure 6).

Two weeks after release, 69% of the largemouth bass and spotted bass displaced to WCSP were located less than 2 km from the release site at WCSP (Table 5) and after one month, 58% of the displaced fish were within 2 km of the release site. After 2 months, 20% of the fish remained within 2 km of WCSP. Three months after release, none of the fish displaced in spring 2005 remained within 2 km of WCSP.

No differences in dispersal rates were detected between species for displaced (t = 0.35, P = 0.7) and control fish (t = 0.39, P = 0.7) during the initial 70 d after release. Thus, data for both species were pooled. A treatment x time-period interaction was detected ($F_{4,84}$ = 2.39, P = 0.06), as dispersal rates for control and displaced fish varied over time. Displaced fish moved away from WCSP at greater rates than control fish during 1-14 d (means = 246 and 38 m/d, t = 3.87, P = 0.003) and 29-41 d (means = 92 and 3 m/d, t = 2.20, P = 0.04). However, dispersal rates were similar during 15-28 d and

42-70 d (Figure 7).

Largemouth bass and spotted bass displaced to WCSP ($t = 0.91$, $P = 0.4$) and control fish ($t = 0.51$. $P = 0.6$) had similar minimum daily movement rates within their respective treatment groups. Thus these two species were pooled for analysis of minimum movement during the 10 weeks following release. A significant treatment x time-period interaction was detected ($F_{4,90} = 2.73$, $P = 0.03$; Figure 8). Displaced fish movement rates were higher than control fish movement rates during 1-14 d (means = 433 and 69 m/d, $t = 2.79$, $P = 0.02$), 15-28 d (means = 387 and 96 m/d, $t = 2.46$, $P = 0.03$), 29-42 d (means = 143 and 35 m/d, $t = 2.96$, $P = 0.01$), and 57-70 d (means = 259 and 57 m/d, $t = 3.94$, $P = 0.005$) but minimum movement was similar between the two groups during 43-56 d (Figure 8).

Seasonal and diel movement

Fish (species pooled) displaced to WCSP had different seasonal movement than control fish ($F_{1,31} = 6.65$, $P < 0.015$) and a treatment x time interaction was detected ($F_{3,225} = 12.61$, $P < 0.001$; Figure 9). Displaced fish moved more than control fish during spring 2005 (means = 278 and 78 m/d, $t = 3.41$, $P = 0.002$), summer 2005 (means = 159 and 67 m/d, $t = 4.07$, $P < 0.001$), and fall 2005 (means = 95 and 50 m/d, $t = 2.39$, $P = 0.02$). In contrast, control fish (18 m/d) moved more than displaced fish (7 m/d) during the winter 2005-2006 ($t = 2.23$, $P = 0.03$). Control largemouth and spotted bass had similar ($F_{1,162} = 2.96$, $P = 0.9$) movement patterns throughout the study (Figure 10). However, movement was variable among the four seasons ($F_{3,162} = 4.28$, $P = 0.006$). Control fish (species pooled) moved less during winter 2005-2006 (mean = 25 m/d) than during the spring (mean = 75 m/d, $t = 3.22$, $P = 0.009$) and summer (mean = 61 m/d, $t = 2.96$, $P = 0.02$), but movement was similar among the other seasons.

Control largemouth bass moved more (mean = 52 m/h) based on 24 h tracking than control spotted bass (mean = 25 m/h, $F_{1,78} = 4.4$, $P = 0.04$) over the11-month tracking period (Figure 11). No difference ($F_{1,16} = 0.1$, $P = 0.8$) was detected in hourly movement between control and displaced largemouth bass (Figure 11). During the first 2 months (May and June 2005), average diel movement was 75 m/h for displaced largemouth bass and 63 m/h for control largemouth bass. Displaced spotted bass moved an average of 52 m/h while control spotted bass moved an average of 39 m/h during the first two diel tracking periods. No differences ($F_{1,211} = 0.33$, $P = 0.6$) in diurnal and nocturnal movement were detected.

Frequency distributions of depth were dissimilar between spotted bass displaced to WCSP and control spotted bass (Kolmogorov-Smirnov Test, Ksa = 2.40, $P < 0.0001$) as control spotted bass were found in deeper water at times (Figure 12). Largemouth bass displaced to WCSP and control largemouth bass inhabited similar ($F_{1,18} = 0.03$, $P <0.001$) depths (mean = 3.0 and 2.9; respectively) throughout the study (Ksa = 0.91, $P = 0.4$). Control spotted bass (mean = 4.9 m) inhabited deeper water on average than control largemouth bass (mean = 2.8 m, $F = 3.7$, $P = 0.06$) during the 11-month study period (Ksa = 1.39, $P = 0.04$; Figure 13).

No difference in 95 and 50% kernel home range areas were detected between control and displaced largemouth bass (one-sided, $Z = 1.14$, $P = 0.13$) based on a Wilcoxon rank-sum test. Largemouth bass kernel home ranges were larger than control spotted bass home ranges (one-sided, Z = -1.98, P = 0.02). Fifty percent kernel home range areas ranged from 0.6-3.6 ha (mean = 2 ha) for control spotted bass, 1.6-94.2 ha (mean = 26 ha) for control largemouth bass, and 21.2-51.9 ha (mean = 35 ha) for displaced largemouth bass (Figure 14). Ninety five percent kernel home range areas ranged from 3.0-26.0 ha (mean = 16 ha) for control spotted bass, 10.2-584.4 ha (mean = 168 ha) for control largemouth bass, and 103.9-602.0 ha (mean = 325 ha) for displaced largemouth bass (Figure 15). Displaced largemouth bass set up home ranges 9-13 km from WCSP, 47-85 d after release.

Tournament displaced fish

During the first 4 months of the study, 15 transmitters were recovered from fish that were caught by anglers, died, or shed their transmitters (Tables 1 and 2). Three transmitters were recovered using SCUBA, 2 transmitters were recovered from fishing tournaments held at WCSP, and 10 transmitters were recovered in shallow water or on the bank. These fifteen transmitters were implanted into tournament caught black bass on 13 November 2005 and were compared with control fish tagged in April-May 2005 and tracked after 13 November 2005. Tournament caught fish moved farther from WCSP (mean = 1.32 km) than control fish moved from their locations (mean = 0.25 km, $F_{1,20}$ = 15.69, P < 0.001) for both species pooled. During individual time periods, tournament displaced fish were located farther from the release site than control fish during 1-19 d (mean = 0.51 and 0.20 km; t = 2.59, P = 0.018), 20-39 d (mean = 1.10 and 2.02 km, t =

2.68, P = 0.02), 40-59 d (mean = 1.81 and 0.23 km, t = 2.81, P = 0.03), 60-79 d (mean = 1.69 and 1.24 km, t = 2.69, P = 0.03), and 100-126 d (mean = 1.89 and 0.56 km, t = 3.07, P = 0.02) after release. However, no difference was detected during 80-99 d (mean = 1.25 and 0.23 km, t = 1.67, P = 0.2; Figure 16).

Fish tagged on 13 November 2005 were compared to control fish based on 20 d tracking periods over 138 d at large. Tournament caught fish (species pooled) moved more (mean = 64 m/d) than control fish (mean = 19 m/d, $F_{1,21}$ = 12.08, P = 0.002) during the 5 months these fish were tracked (Figure 17). During the first 19 d after release, tournament displaced fish moved 134 m/d on average while control fish moved 23 m/d. After 19 d, tournament caught fish appeared to move more than control fish, but differences were not statistically significant (P > 0.05; Figure 17).

Two weeks after release, 75% of the largemouth bass and spotted bass displaced to WCSP were located less than 2 km from the release site (Table 5). One month and 2 months after release 63% of tournament caught fish remained within 2 km of WCSP. Forty percent of tournament caught fish were located within 2 km of WCSP 3 months after release.

No differences in habitat depth frequency distributions of control and tournament displaced spotted bass were evident (Ksa = 0.96, P = 0.3; Figure 17). However, the depth frequency distribution of tournament displaced largemouth bass and control largemouth bass were different (Ksa = 1.39, P = 0.04; Figure 18), as displaced largemouth bass were at times found in deeper water. Habitat depth averaged 3.8 m for control spotted bass and 2.0 m for control largemouth bass after 13 November 2005 while tournament displaced spotted bass habitat depth averaged 2.3 m and displaced largemouth bass habitat depth averaged 2.0 m.

Estimate of black bass accumulation at WCSP

Tournament displaced and tournament simulated movement data were combined and the proportion of live fish within 2 km of WCSP was estimated by the regression:

$$\text{Proportion of fish} < 2\text{ km} = -7.125 * \log_{10}(\text{week}) + 96.167.$$

This model explained 95% of the variation in proportion of black bass within 2 km of WCSP (Figure 19). Between 2 February 2005 and 16 April 2005, at least 3,534 black bass were released from 12 tournaments held at WCSP (Ricks 2006), but Ricks (2006) did not process fish from small tournaments held during this time period. Based on the estimated proportions of displaced radio tagged fish remaining within 2 km of WCSP and the number of fish weighed-in at WCSP, I predicted 1,259 displaced fish were inhabiting the area within 2 km of WCSP after the 2nd week of tournaments in February 2005 (Table 8). The surface area within 2 km of WCSP was 146 ha. The number of displaced fish reached a maximum during week 10 in which 2,184 tournament displaced fish were predicted to be within 2 km of WCSP. During spring 2005 an increase of up to 8.8 kg/ha of black bass occurred in this 146 ha area of Lake Martin (Figure 20). Percent biomass increase was estimated for spring 2005 assuming black bass standing stock biomass in the vicinity of WCSP was 10 and 30 kg/ha. Thus, maximum predicted increases in biomass of black bass near WCSP ranged from 29-88% (Figure 21) .

DISCUSSION

Dispersal, movement, and behavior

Largemouth and spotted bass displaced to WCSP behaved differently than control fish during the first 3-5 months after being released. All of the fish tagged in April-May 2005 moved away from the WCSP release site and although dispersal rates were variable among fish, ultimately no fish remained in close proximity to WCSP. After 343 d, no displaced fish remained within 9 km of the WCSP release site. Ricks (2006) found that tournament caught fish moved away from the release site at WCSP over time. In contrast, Stang et al. (1996) found that 29% of displaced fish moved less than 1 km and 57% moved less than 3 km after 9 months and Gilliland (1999) reported that 64% of angler recaptures occurred within 2 km of the release site up to 6 months after release.

The mean dispersal rate of displaced fish initially increased as all fish moved away from the release site. At first, some fish moved in the opposite direction from the main body of the reservoir, farther into the WCSP embayment where the fish were released. These fish then traveled back towards the release site to reach the main body of the reservoir. This explained the decrease in dispersal rate observed 14-28 days after release. In addition, mean daily movement of displaced fish decreased from 387 m/d to 143 m/d between the 2nd (14-28 d) and 3rd (29-42 d) periods. The fish dispersed immediately after being released (1-28 d) and then movement decreased (29-57 d), possibly while fish recovered from the stress associated with displacement. After about 2 months, fish continued to gradually move away from the release site over time. Movement patterns were unique for each fish. Some displaced fish were consecutively located farther from the release site, while other fish moved back and forth to locations at variable distances, gradually moving away from the WCSP release site.

Control fish were normally located within a few hundred m of their previous location, often in the same cove or nearly in the same location. Some fish were found repeatedly in the same area, but made 1-2 km excursions before returning. Wilde and Paulson (2002) observed similar behavior and located largemouth bass at sites where they were last located 55% of the time. Control fish movement remained consistent between about 25 and 100 m/d during the entire study.

Radio-tagged spotted bass suffered a higher mortality rate than largemouth bass in this study. Spotted bass that were implanted with transmitters and transported to WCSP suffered 80% mortality and 20% were not located after the first 90 d. Thirty percent of largemouth bass transported to WCSP survived the duration of the experiment (343 d), but at least 20% were caught by anglers. Thus, reduced observations limited my analysis of displaced spotted bass. Researchers should consider adding oxygen to holding tanks, using antibiotics, and minimizing transmitter size to maximize survival when surgical procedures are used on black bass in future studies, especially with spotted bass.

Largemouth bass and spotted bass dispersal, daily movement during the first 70 d, seasonal movement and diel behavior were all statistically similar ($P > 0.05$) between the two species. However, spotted bass had smaller kernel home ranges than largemouth bass. Spotted bass were often found in similar locations associated with the same structure (docks, blown down trees, rock piles etc.) successively during and among both diel and 10-d tracking events. Largemouth bass were also often associated with the same locations over time, but generally moved between a small number coves or structures and showed less affinity for a specific structure than spotted bass. Sammons et al. (2003) found that diel movement of largemouth bass averaged 54 m/h similar to the average diel movement for largemouth bass I observed for control and displaced fish.

Displaced fish moved more than control fish during the spring, summer, and fall of 2005 based on minimum daily movement estimates. However, hourly movement estimates indicated that displaced fish were not moving more than control fish. This indicated that displaced fish were not actually moving more on average than control fish, but the movement was more directional than control fish. Thus, displaced fish were traveling more in one direction so the minimum distance traveled appeared to be much greater for displaced fish. Control fish traveled the same distance between 10-d tracking periods, but movement was restricted to within their home range. In this instance, a combination of diel and 10-d tracking data was the optimal method for describing dispersal behavior of fish.

Habitat depth was significantly different between control largemouth and spotted bass. Often spotted bass were located on bluff walls and rocky points in or around much deeper water than largemouth bass, which were consistently located in shallow sandy coves.

Control spotted bass appeared to moved less than largemouth bass between 10-d tracking events although differences were not statistically significant. Largemouth bass moved most during the spring and summer on average, movement decreased during the fall and was lowest during the winter. Spotted bass moved most during the summer and least during the winter. Diel movement was lower for spotted bass then largemouth bass between May and September, but was similar from October to March when movement of both species deceased.

Displaced largemouth bass tended to have larger home ranges than control fish although not highly significant. Ridgway (2002) estimated similar home range areas for displaced and non-displaced largemouth bass in Rideau Lake, Ontario, Canada. The mean home range area of largemouth bass observed in this study was more than 9 times larger the home ranges observed by other studies (Ridgway 2002; Sammons et al. 2003), but were not that different (10%) from home ranges estimated for smallmouth bass (Ridgway and Shuter 1996) using methods similar to mine. I know of no information previous to this study on the home ranges of spotted bass in reservoirs.

<u>Tournament caught black bass</u>

The movement and dispersal of tournament caught fish in November 2005 was different compared to the 19 black bass captured by electro-fishing in April 2005 and transported to WCSP. Distance dispersed from WCSP over time was lower for tournament caught fish than for fish tagged and released in April-May 2005. None of tournament caught fish moved farther than 5 km from the release site during the 5 months after release. Seventeen percent of tournament caught fish remained within 1 km of the release site after 5 months. The dispersal of tournament caught fish tagged in fall 2005 was similar to the findings of other studies, (Stang et al. 1996; Gilliland 1999; Wilde and Paulson 2002; Ricks 2006), as a proportion of tournament displaced fish remain near the release site for a considerable length of time (> 2 months) after release. Mean minimum movement ranged from about 18-60 m/d during the winter months. One spotted bass did not move at all for 3 months during the winter of 2005-2006. The fish was suspected to be dead until an angler caught and harvested the fish 127 d after it was released.

Depth distributions of control and displaced largemouth bass varied. Tournament caught largemouth bass tended to inhabit deeper water than control fish. The differences in habitat depth may be related to tournament fish being displaced after water levels were drawn down, in comparison to control fish that remained in the same coves despite the lower water level. Tournament caught black bass were primarily located on rock piles and blown down trees during the 5 months after release.

Comparison of fish relocated in April-May 2005 and fish displaced by tournament anglers in November 2005

All 19 black bass transported to WCSP to simulate tournament displacement moved away from the release site, died , or were harvested by anglers. Conversely, tournament-caught fish remained within the vicinity of WCSP longer than tournament simulated fish. Possibly, some tournament-caught fish were resident fish and were only displaced a short distance. Mesing and Wicker (1986) and Richardson-Heft et al. (2000) have reported that some displaced fish exhibit homing tendencies. None of the fish displaced from known locations returned to their original site of capture in this study. Fish collected with electrofishing that were transported to simulate tournament displacement were captured at locations 9-19 km from WCSP. Two of the displaced largemouth bass set up home ranges in the same area of the reservoir, 2.4 and 4.0 km from their original site of capture. This supported the suggestion by Richardson-Heft et al. (2000) that movement of displaced fish is influenced by the location in which they were originally captured.

Simulated tournament fish were released in April-May 2005 and seasonal differences may have occurred in movement and behavior as tournament caught fish were released in November 2005. Fish in Lake Martin moved much less during the winter months than during the spring and summer months regardless of whether or not they had been displaced. Richardson-Heft et al. (2000) found that water temperature affects the likelihood, timing, and rate of movement of displaced fish. Seasonal movement and behavior of fish in this study suggested that a seasonal component (likely associated with water temperature) influenced movement of all fish regardless of displacement. Fish displaced in the fall and winter disperse shorter distances at a slower rate than fish displaced in the spring and summer. Spawning and spawning migrations may also have an influence on whether or not a fish remained in an area after displacement.

In addition, a percentage of the original 19 fish might have remained near WCSP if they had not died or been harvested. Rising water temperatures in the spring and summer probably had an impact on initial and delayed tournament mortality (Plumb et al. 1988; Ostrand et al. 1999; Edwards et al. 2004). Possibly, higher angler catch rates related to black bass accumulation lead to increased fishing effort in this area. Two of the original 19 radio tagged bass released at WCSP were caught and weighed-in by tournament anglers 6 and 46 d after release. One tournament displaced fish was harvested by an angler 127 d after release and several other fish were suspected to have been moved to this tournament site or removed from the lake by anglers during the study.

<u>Black bass accumulation model</u>

In Lake Martin, multiple tournaments held consecutively over time probably increased and may have doubled the resident black bass biomass in the vicinity of WCSP over a three-month period. My data predicted that a large percentage of fish (40%) left the release site quickly during the first 4 weeks, but another 25 % left WCSP between 4 and 12 weeks, while 40% of fish either gradually dispersed over time or remained in the area. I predicted a maximum biomass increase of nearly 9 kg/ha within 2 km of WCSP.

Estimates of black bass standing stock biomass in reservoirs were variable. Swingle (1954) estimated 8-9 kg/ha of largemouth bass and spotted bass in coves and open water in Lake Martin. The USA average standing stock biomass of black bass in 171 reservoirs was 11 kg/ha with a maximum of 58 kg/ha (Jenkins 1975). In Lake Normandy, Tennessee, which is an oligo-mesotrophic reservoir that fluctuates 3 m similar to Lake Martin, the biomass of black bass averaged 10 kg/ha (Sammons and Bettoli 1998). In Guntersville Reservoir, Alabama (1983-1994), biomass of largemouth bass ranged 30-36 kg/ha (Wrenn et al. 1996). Lake Martin is an oligo-mesotrophic reservoir (Bayne et al. 1994) and predator sport fish biomass was positively related to trophic state (Ney 1996). Thus, the Swingle (1954) estimate of black bass standing stock biomass appeared realistic for Lake Martin and implied that over a 2-3 month time period, tournament activity could double the biomass of black bass in the vicinity of WCSP. If the standing stock biomass of black bass was 30 kg/ha, which may be unrealistically high in Lake Martin, then tournaments in spring 2005 would increase black bass biomass about 30%.

This large artificial increase in biomass of top predators may have an impact on the population and affect growth, fishing and natural mortality, body condition, and recruitment. My analysis did not account for initial or delayed mortality of tournament fish but tournament associated mortality during the spring 2005 was probably not high. Ricks (2006) found that mortality of tournament caught bass in Lake Martin was low when water temperatures were <21ºC which occurred between February and April 2005, but increased exponentially when water temperatures were greater than 24ºC. Finally, a few more fish were released during the tournament season in spring 2005 than counted by Ricks (2006) as fish from smaller tournaments were not processed.

Management Implications

Most displaced black bass migrated away from the release site at WCSP within a few months of being released. However, the rate of dispersal was variable and some fish remained in the vicinity of WCSP for a considerable time (3-6 months) and significant accumulation of black bass probably occurred during this time. The live release boat at WCSP can transport up to about 250 fish per tournament and can move fish up to 4 km, but mortality associated with the use of this boat appeared high when water temperatures were greater than 24ºC. Ricks (2006) recommended the live-release boat not be used at higher water temperatures. The ideal solution to minimize the risk of accumulation would be to hold tournaments at different locations around the reservoir. I recommend continuing to use the release boat to disperse a portion of tournament displaced black bass at cooler water temperatures. The current release boat at WCSP which can hold about 550 L of water should be upgraded to a much larger holding capacity with a mechanism to release fish without netting to facilitate migration of tournament caught fish from WCSP.

I found simulated tournament released black bass moved more than control fish for up to 9 months. The impact of this altered behavior on growth, body condition, survival, and reproduction is unknown, but could negatively affect these attributes and warrants investigation. A seasonal effect on dispersal of displaced fish may occur, with fish displaced in the spring dispersing farther at higher rates than fish displaced during the fall. If this is the case, limiting the number of large tournaments held in late fall at a single location could be beneficial, however further investigation is necessary to confirm if seasonal differences exist. Largemouth bass established home ranges 47 to 85 d after displacement but moved 9 to 13 km before establishing residency. In addition, 95% kernel home ranges were nearly twice as large for displaced largemouth bass compared to control largemouth bass, which would probably result in greater energetic demand on displaced fish. Ricks (2006) found tournament caught black bass at times expressed lower relative weights than wild fish up to 2 months after being caught by anglers. I found the potential for short-term impacts of high tournament release rates of black bass at WCSP, but after 6 months nearly all fish migrated far enough away to prevent long-term accumulation of tournament displaced fish.

TABLES

Table 1. Tag number, species, sex, total length (mm), weight (g), days at large, and fate of 10 largemouth and 10 spotted bass displaced to Wind Creek State Park in Lake Martin, Alabama.

Displaced Fish						
Tag #	**Species**	**Sex**	**TL (mm)**	**Wt (g)**	**Days at -large**	**Fate**
407	SPB	NA	500	1220	28	Died
416	LMB	M	461	1301	59	Missing
428	LMB	M	475	1266	46	Caught
437	LMB	F	546	2239	12	Caught
447	LMB	F	569	2341	30	Died
457	LMB	F	556	2157	343	Study Ended
465	LMB	F	616	3087	343	Study Ended
477	LMB	M	461	1227	343	Study Ended
486	LMB	F	517	1766	48	Lost
497	LMB	F	568	2259	125	Died
507	LMB	F	509	1796	135	Died
707	SPB	F	455	1063	73	Died
715	SPB	F	449	1019	90	Died
724	SPB	M	440	1042	55	Lost
735	SPB	M	523	1659	26	Died
746	SPB	M	492	1317	55	Died
757	SPB	F	497	1517	73	Died
767	SPB	M	476	1162	26	Died
775	SPB	M	452	1210	26	Died
867	SPB	M	514	1430	56	Lost

Table 2. Tag number, species, sex, total length (mm), weight (g), days at-large, and fate of 10 largemouth and 10 spotted bass released at their capture locations in Lake Martin, Alabama.

Control Fish						
Tag #	**Species**	**Sex**	**TL (mm)**	**Wt (g)**	**Days at -large**	**Fate**
516	LMB	F	469	1386	334	Study Ended
526	LMB	M	495	1286	57	Died
536	LMB	F	535	2101	102	Caught
545	LMB	M	463	1318	334	Study Ended
556	LMB	M	559	2118	334	Study Ended
566	LMB	M	511	1747	334	Study Ended
575	SPB	F	511	1534	14	Died
585	SPB	F	522	1447	33	Lost
597	SPB	F	520	1691	326	Study Ended
617	LMB	F	545	2059	326	Study Ended
625	SPB	F	456	1008	329	Study Ended
658	SPB	M	464	1057	89	Died
666	SPB	NA	472	1116	9	Died
677	SPB	NA	453	1137	329	Study Ended
687	LMB	F	493	1484	46	Died
695	SPB	NA	449	1077	254	Died
815	LMB	M	533	2040	326	Study Ended
826	LMB	M	476	1454	326	Study Ended
836	SPB	F	498	1535	152	Lost

Table 3. Tag number, species, total length (mm), weight (g), days at-large, and fate of 7 largemouth bass and 7 spotted bass implanted with radio transmitters after being displaced to Wind Creek State Park by clack bass tournament anglers on 13 November 2005.

Tournament Displaced Fish					
Tag #	**Species**	**TL (mm)**	**Wt (g)**	**Days at-large**	**Fate**
407	LMB	529	2306	138	Study Ended
428	SPB	463	1253	66	Died
437	SPB	492	1459	127	Harvested
486	LMB	462	1352	138	Study Ended
507	LMB	481	1573	138	Study Ended
526	SPB	419	877	50	Died
575	SPB	526	1937	50	Died
585	SPB	450	1066	9	Died
666	LMB	468	1282	138	Study Ended
735	LMB	454	1152	138	Study Ended
746	SPB	480	1510	9	Died
764	LMB	450	1324	9	Died
776	SPB	480	1469	138	Study Ended
807	LMB	482	1408	9	Died

Table 4. Percentage of displaced fish (species pooled), tagged in April-May 2005, located < 1 km, 1-2 km, and > 2 km from the release site at WCSP, 2 weeks, 1 month, and 2 months following release.

	2 Weeks	1 Month	2 Months	3 Months
< 1 km	50 %	42 %	0 %	0 %
1-2 km	19 %	16 %	20 %	0 %
>2 km	31 %	42 %	80 %	100 %

Table 5. Percentage of tournament displaced fish (species pooled), tagged in November 2005, located < 1 km, 1-2 km, and > 2 km from the release site at WCSP, 2 weeks, 1 month, and 2 months following release.

	2 Weeks	1 Month	2 Months	3 Months
< 1 km	67 %	63 %	50 %	43 %
1-2 km	8 %	0 %	13 %	14 %
>2 km	25 %	47 %	47 %	43 %

Table 6. Percentage of displaced fish (species pooled) located < 1 km, 1-2 km, and > 2 km from the release site at WCSP over time (2 weeks, 1 month, and 2 months after release), for fish tagged in April-May 2005 and November 2005 pooled.

	2 Weeks	1 Month	2 Months	3 Months
< 1 km	57 %	50 %	29 %	20 %
1-2 km	14 %	10 %	14 %	20 %
>2 km	29 %	40 %	57 %	60 %

Table 7. Predicted percentage of tournament displaced fish remaining within 2 km of WCSP 12 weeks after release.

Week	Percent %
1	94.1
2	77.8
3	68.2
4	61.4
5	56.2
6	52.9
7	48.2
8	45.1
9	42.3
10	39.8
11	37.6
12	35.5

Table 8. Estimated number, weight, and biomass of tournament displaced of black bass to WCSP over a 12 week period. Numbers in bold represent the actual numbers of fish released at WCSP during each week. Rows represent the estimated number of fish from each tournament weekend that remain within 2 km over time and columns represent the estimated number of tournament displaced fish remaining within 2 km during that week. Biomass (kg/ha) was calculated as by multiplying the total number of black bass displaced by the mean weight (0.59 kg) of tournament caught fish in Lake Martin.

Week	1	2	3	4	5	6	7	8	9	10	11	12
1	**30**	28	23	20	18	17	16	14	14	13	12	11
2	-	**1231**	1159	958	840	756	692	639	594	555	521	490
3	-	-	**117**	110	91	80	72	66	61	56	53	50
4	-	-	-	**481**	453	374	328	296	270	250	232	217
5	-	-	-	-	**100**	94	78	68	61	56	52	48
6	-	-	-	-	-	**290**	273	226	198	178	163	150
7	-	-	-	-	-	-	**193**	182	150	132	119	108
8	-	-	-	-	-	-	-	**631**	594	491	431	388
9	-	-	-	-	-	-	-	-	**132**	124	103	90
10	-	-	-	-	-	-	-	-	-	**329**	310	256
total num	30	1259	1299	1569	1502	1611	1651	2121	2074	2184	1994	1808
weight (kg)	17.7	742.9	766.4	925.8	886.2	950.7	974.1	1251.3	1223.5	1288.6	1176.5	1067.0
biomass	0.1	5.1	5.5	6.3	6.1	6.5	6.7	8.6	8.4	8.8	8.1	7.3

FIGURES

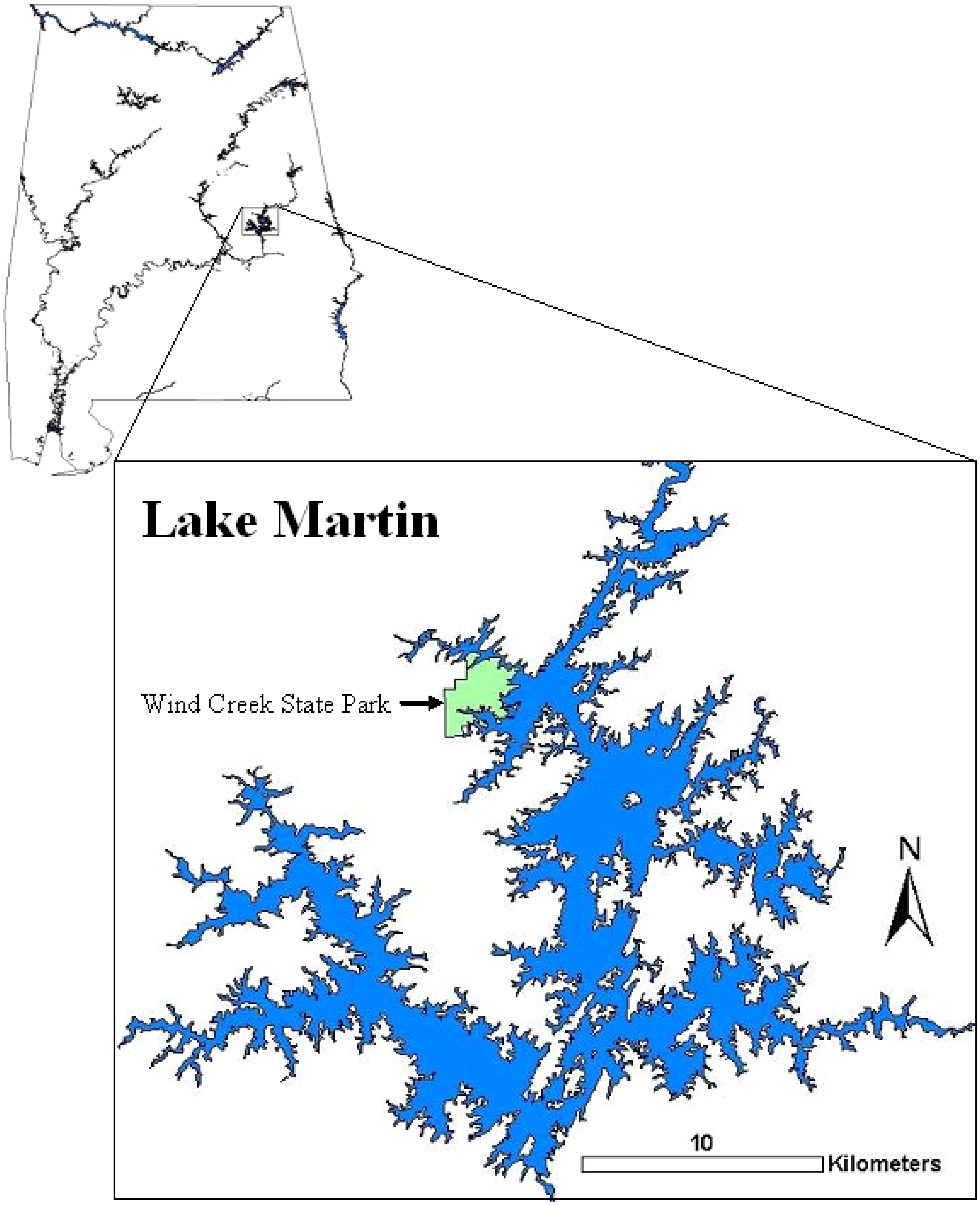

Figure 1. Map of Lake Martin and location of Wind Creek State Park.

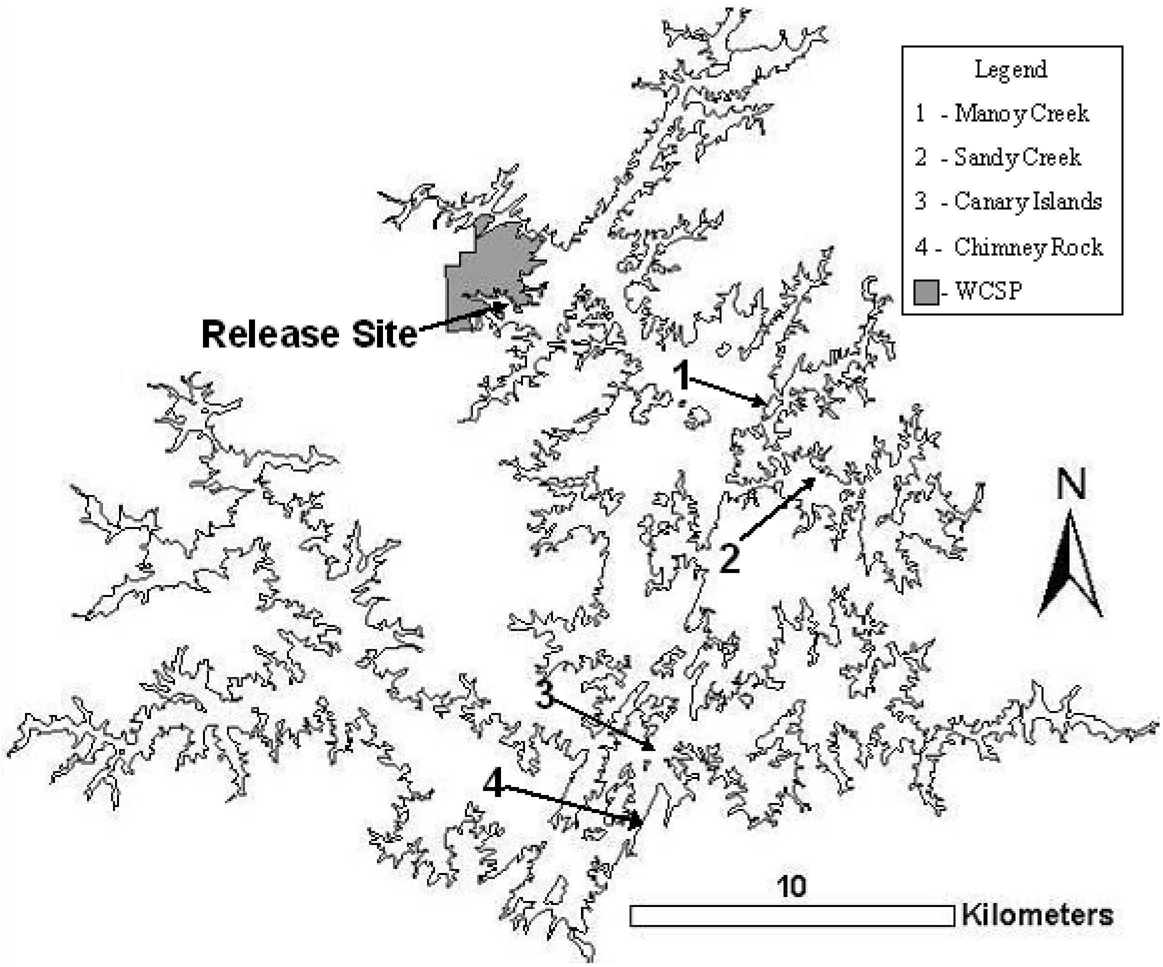

Figure 2 . Capture locations and release site of displaced largemouth and spotted bass in Lake Martin. Five fish were taken from the mouth of Manoy Creek (1). Eleven fish were displaced from Sandy Creek (2). Three fish were taken from water surrounding the Canary Islands (3) and one fish was captured below Chimney Rock (4).

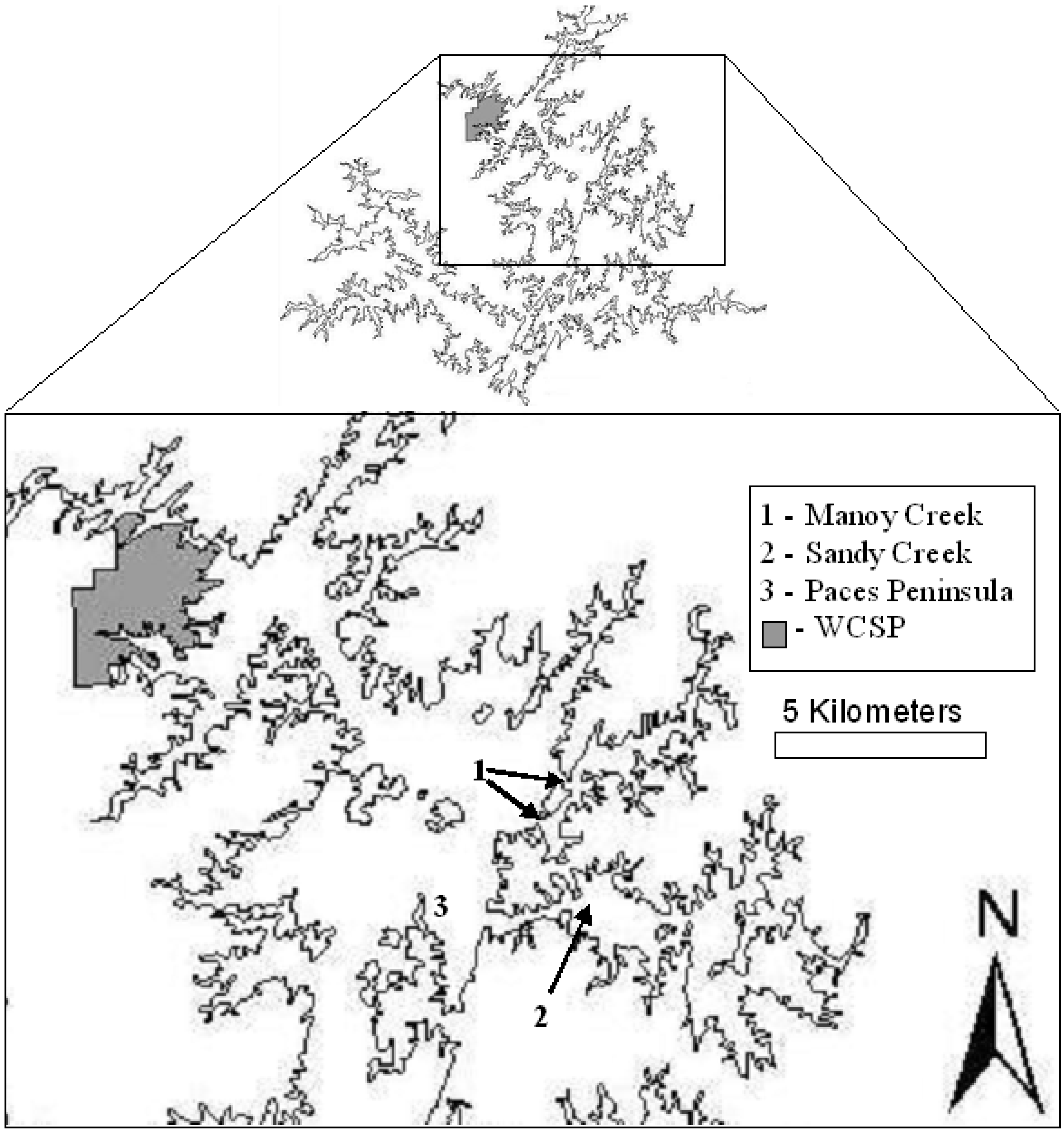

Figure 3. Capture and release sites of control largemouth and spotted bass in Lake Martin. Eight fish were tagged and released in the mouth of Manoy Creek (1). Seven fish were tagged and released in Sandy Creek (2). Four fish were tagged and released on the west side of Paces Peninsula (3).

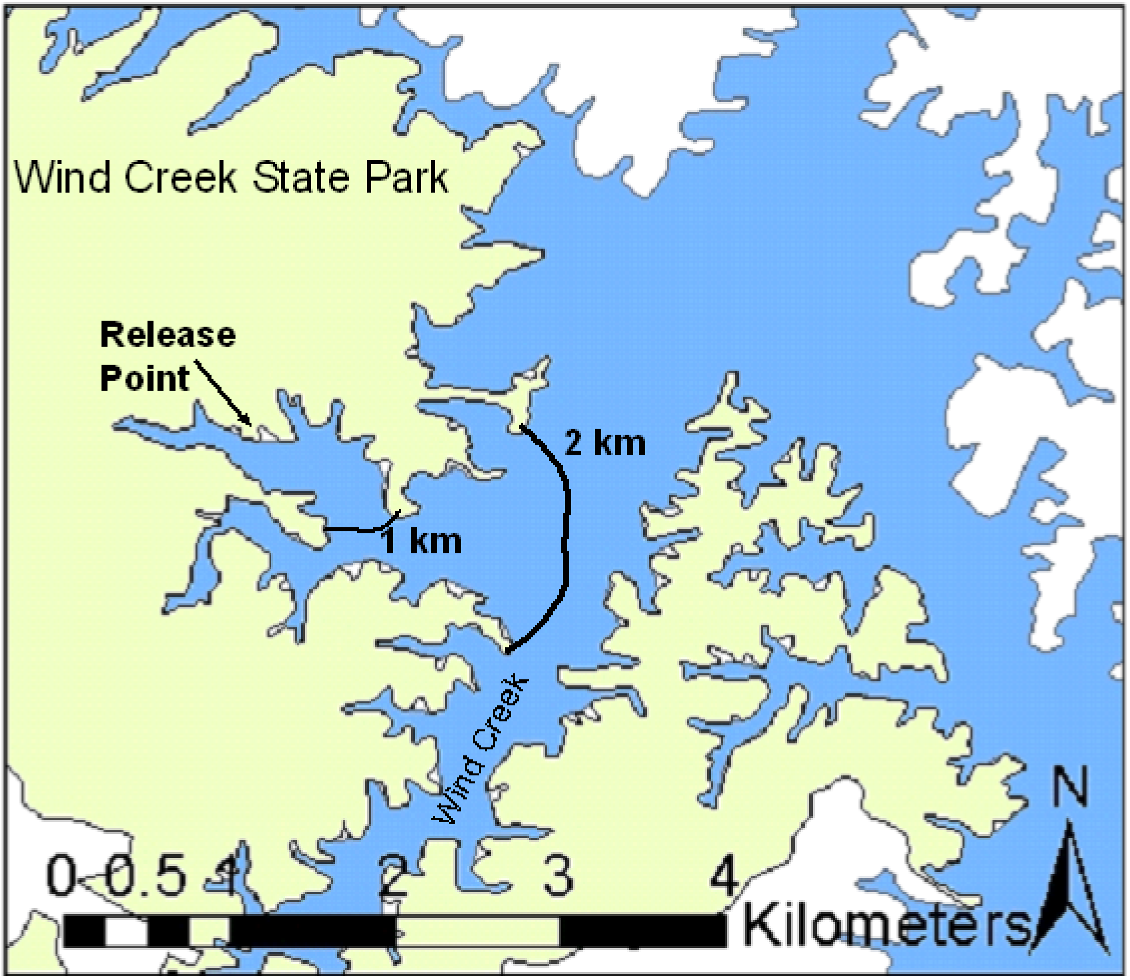

Figure 4. Location of 1 and 2 km distances from the release site relative to the release point at WCSP and Wind Creek.

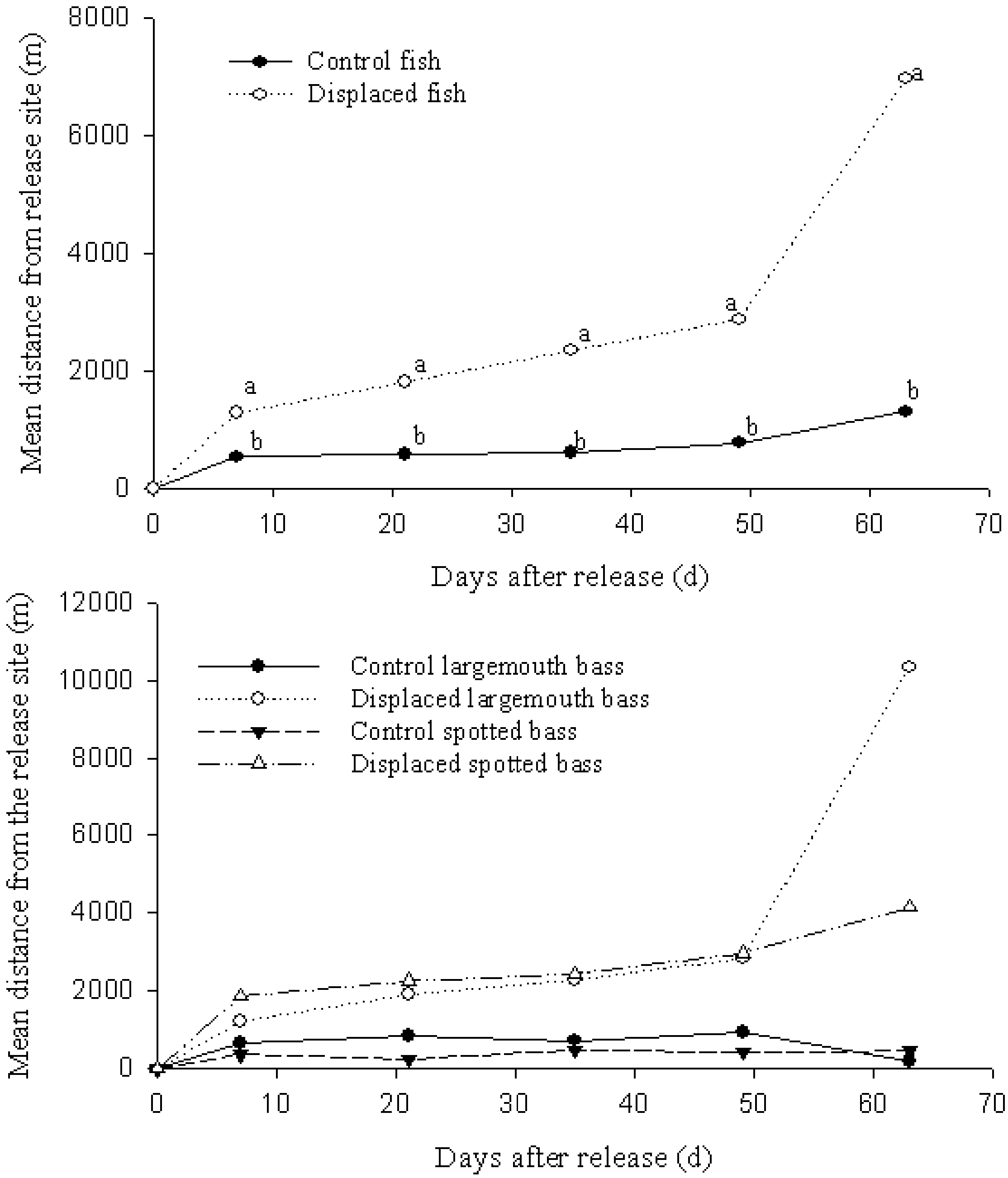

Figure 5. Mean distances from the release sites of displaced and control fish during the first 70 d after release with largemouth bass and spotted bass pooled (top) and with these species separated (bottom). Mean values followed by the same letter were not significantly ($P > 0.05$) different for each time period comparison (top graph).

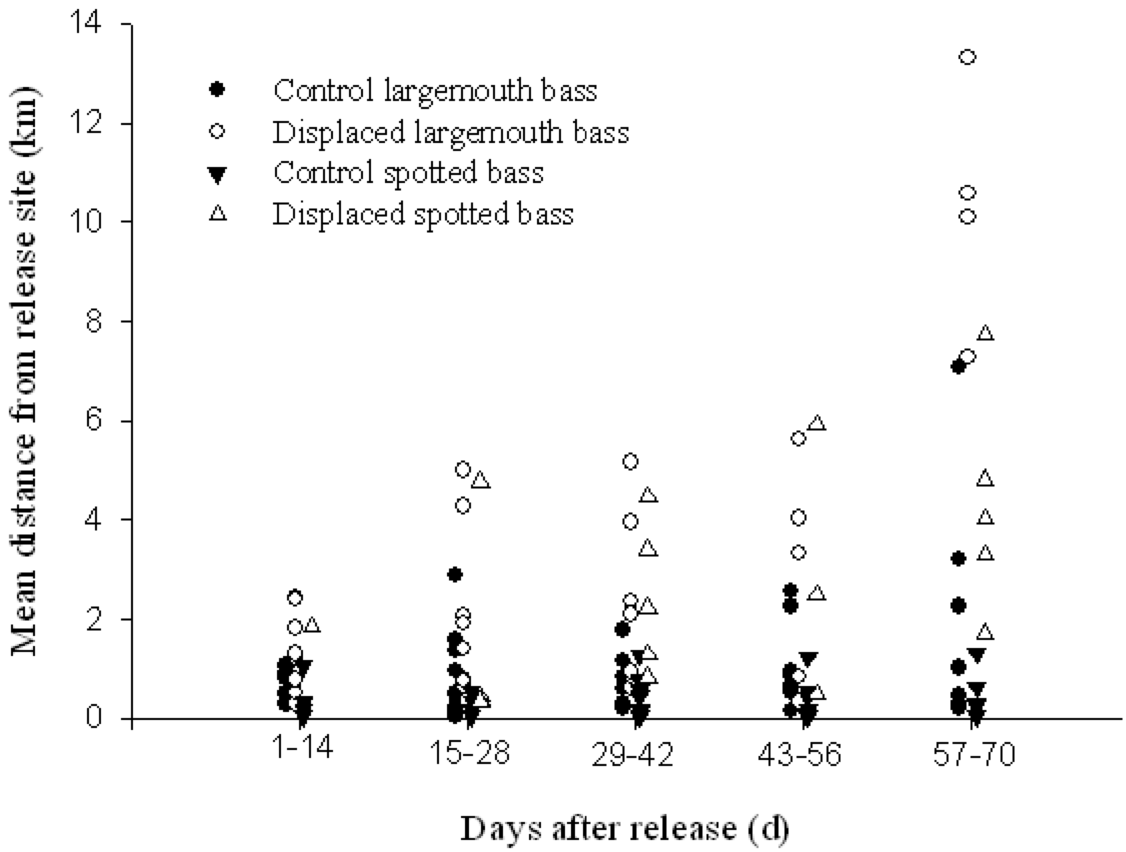

Figure 6. Mean distance moved from the release site (km), for individual fish, during each period. Periods correspond to 14 d intervals after release. Circles represent largemouth bass, triangles represent spotted bass, dark shapes represents control fish, and hollow shapes represent displaced fish.

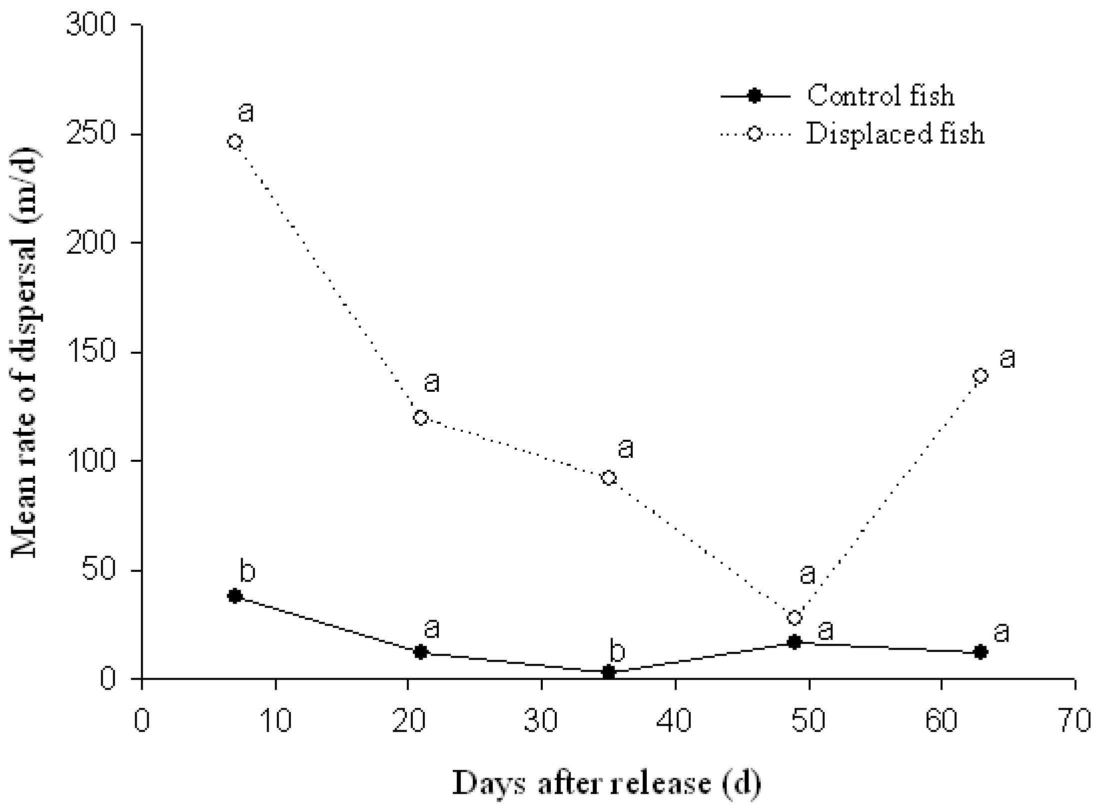

Figure 7. Mean dispersal rates (m/d) of displaced and control largemouth and spotted bass from release sites. Mean values followed by the same letter were not significantly (P > 0.05) different for each time period comparison.

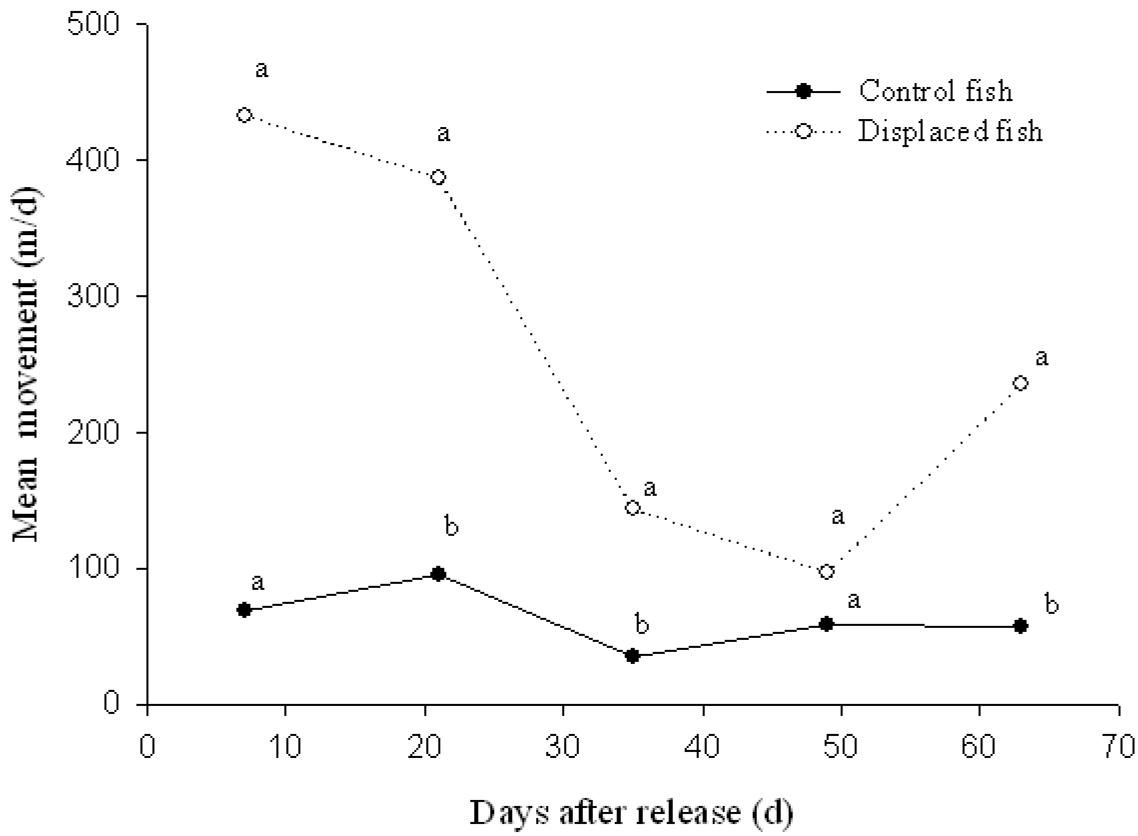

Figure 8. Mean minimum movement (m/d) of control and displaced fish based on single location data during the first 70 d after release. Mean values followed by the same letter were not significantly ($P > 0.05$) different for each time period comparison.

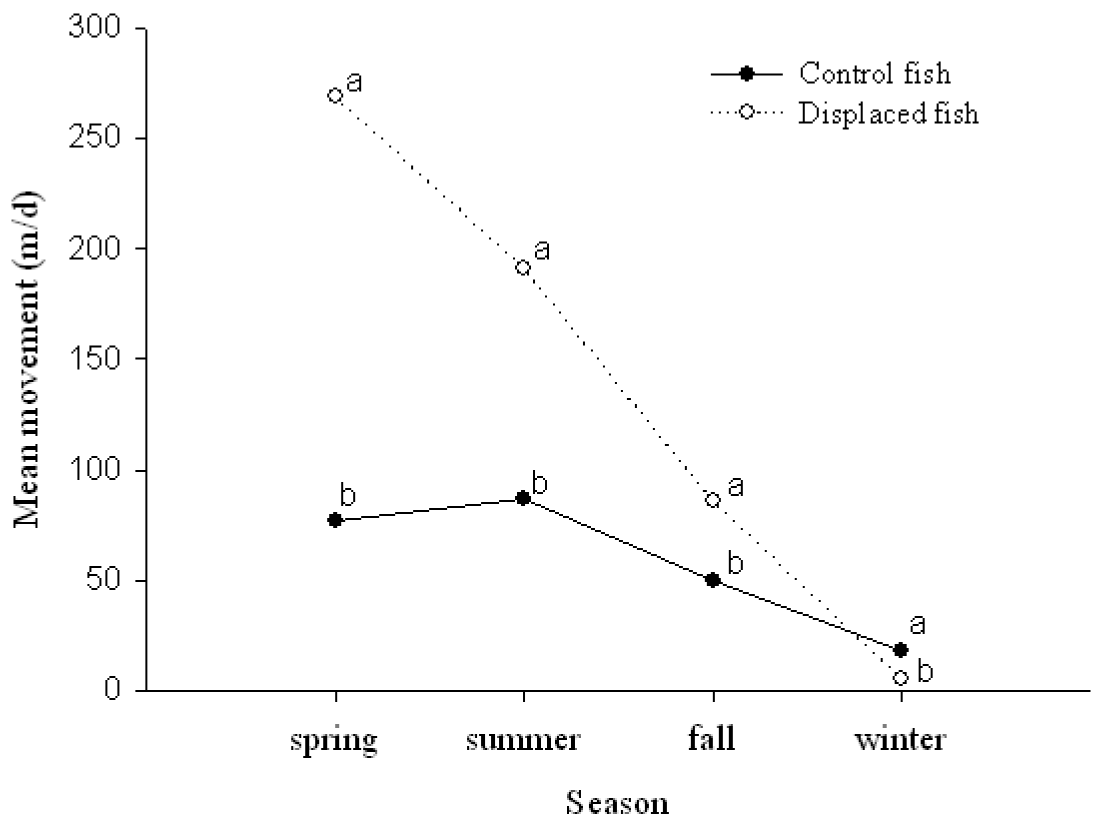

Figure 9. Mean movement (m/d) of control and displaced largemouth and spotted bass (pooled) by season. Mean values followed by the same letter were not significantly ($P > 0.05$) different for each seasonal comparison.

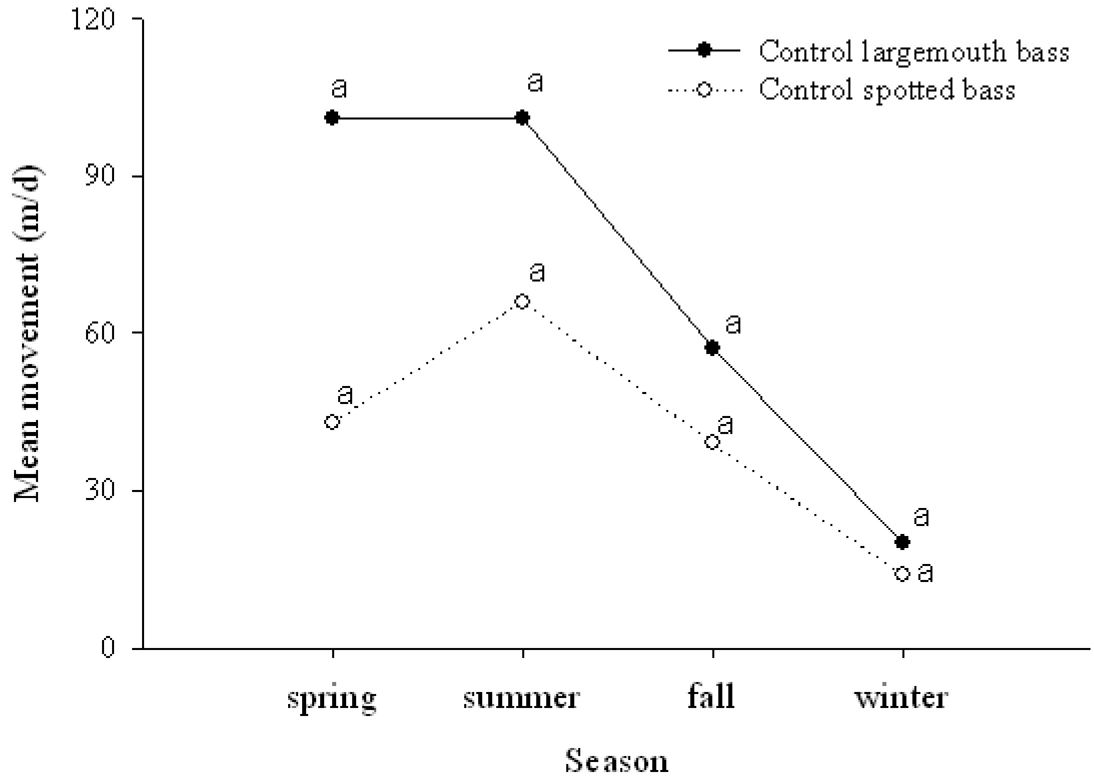

Figure 10. Mean movement (m/d) of control largemouth and spotted bass by season. Mean value followed by the same letter were not significantly ($P > 0.05$) different for each seasonal comparison.

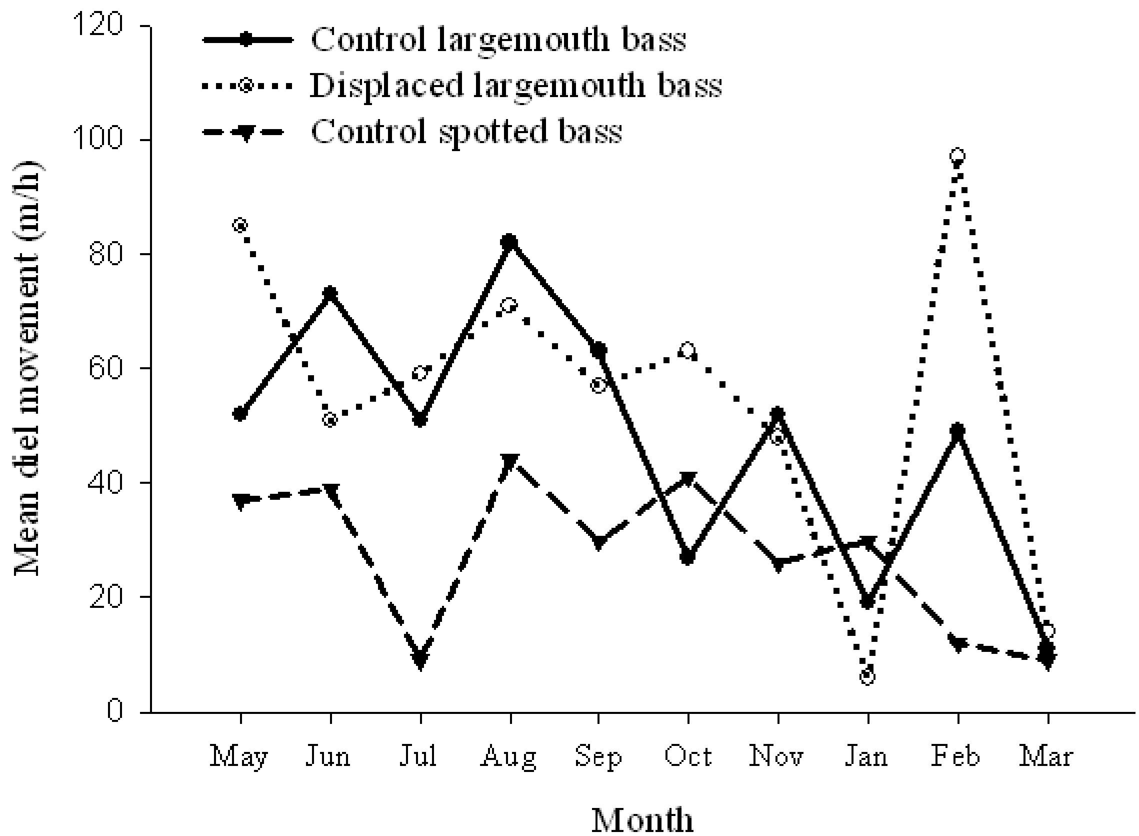

Figure 11. Mean monthly diel movements (m/h) of displaced and control largemouth bass and control spotted bass. No differences($F_{1,16}$ = 0.10, P = 0.8) were detected between control (mean = 52 m/h) and displaced (mean = 58 m/h) largemouth bass hourly movement. Control spotted bass (mean = 25 m/h) moved significantly ($F_{1,78}$ = 4.40, P = 0.04) less than control largemouth bass (mean = 52 m/h) during diel periods.

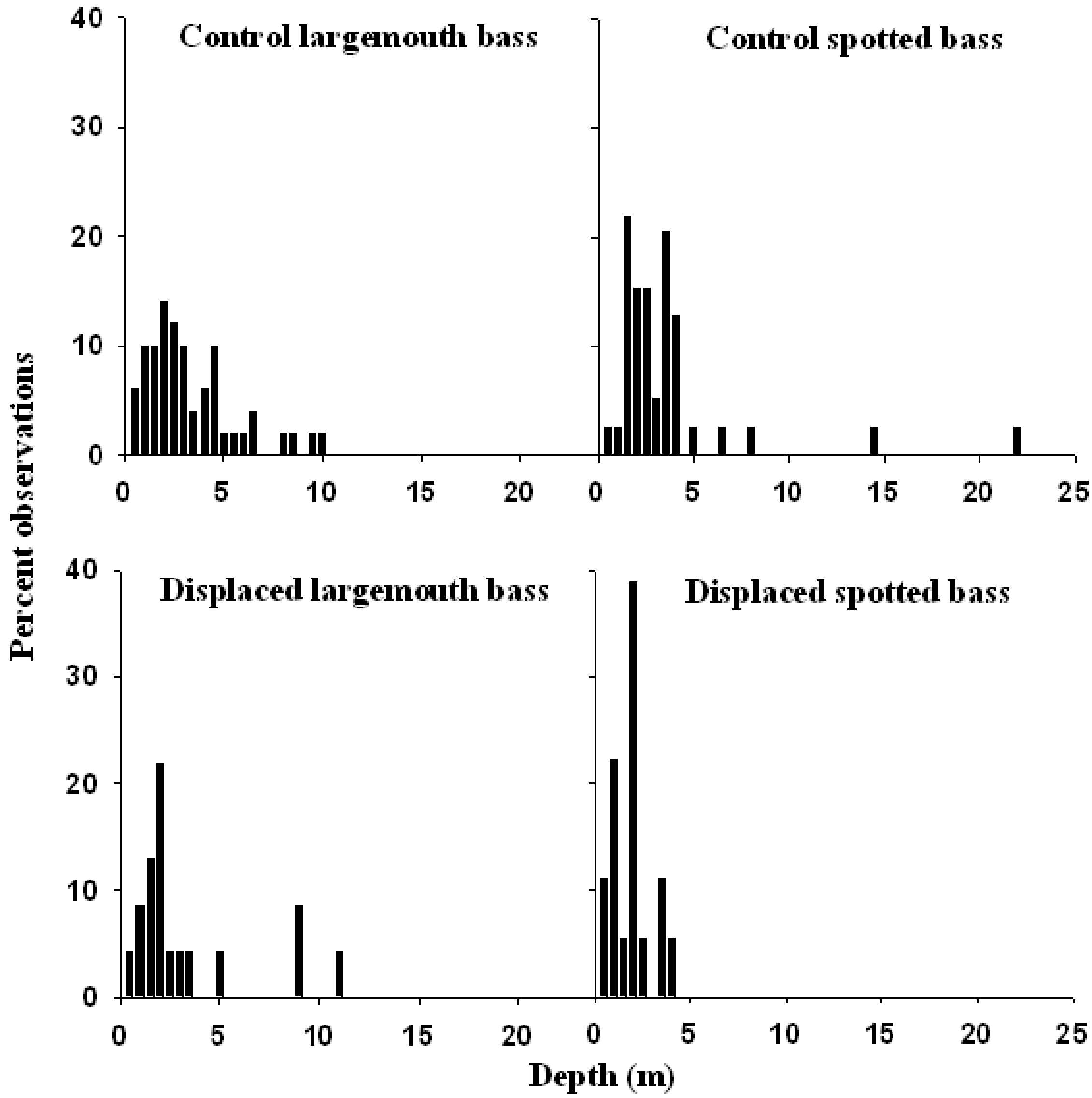

Figure 12. Depth frequency distributions of displaced and control largemouth and spotted bass during the first 70 d after release.

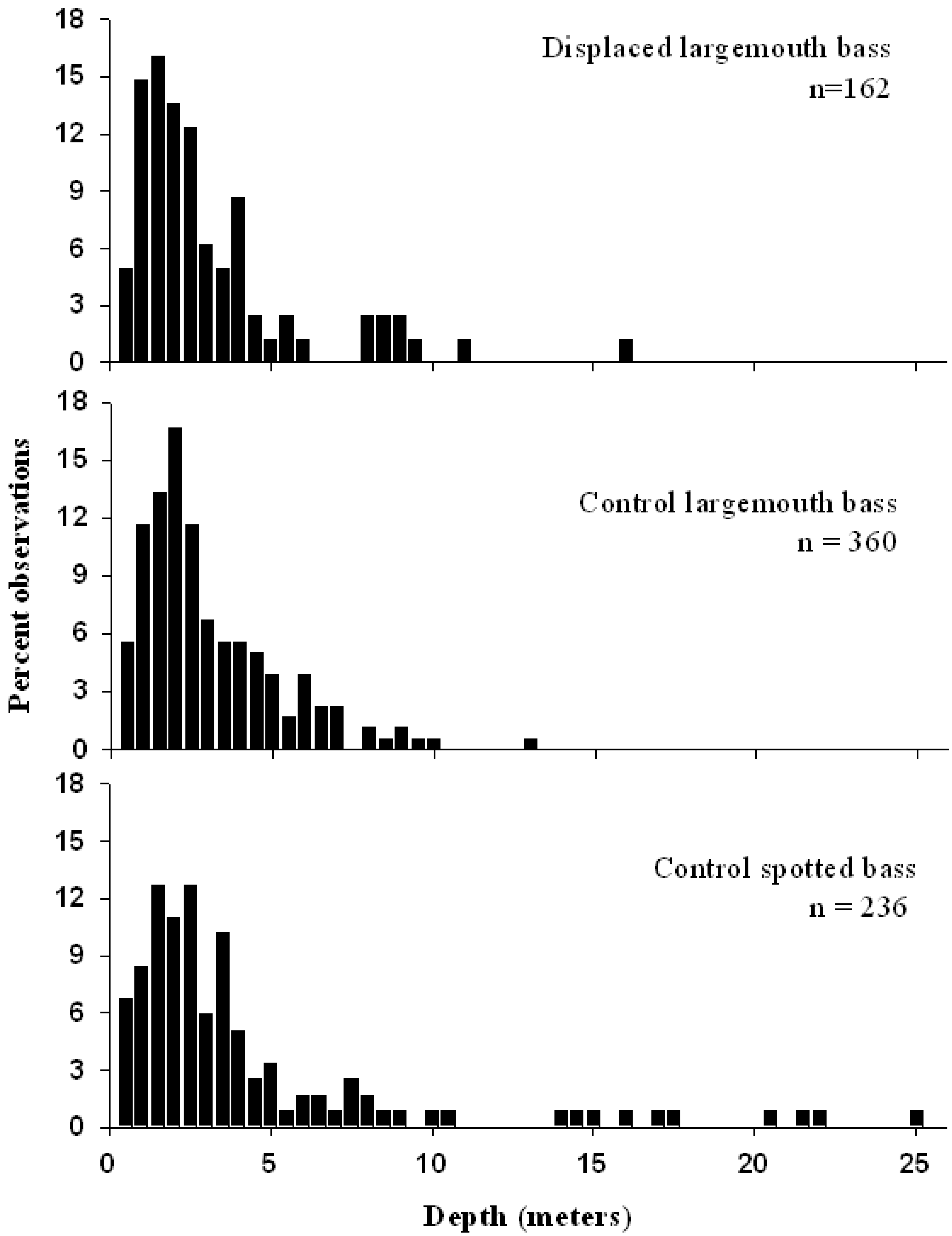

Figure 13. Depth frequency distributions for displaced and control largemouth bass and control spotted bass over a one-year period.

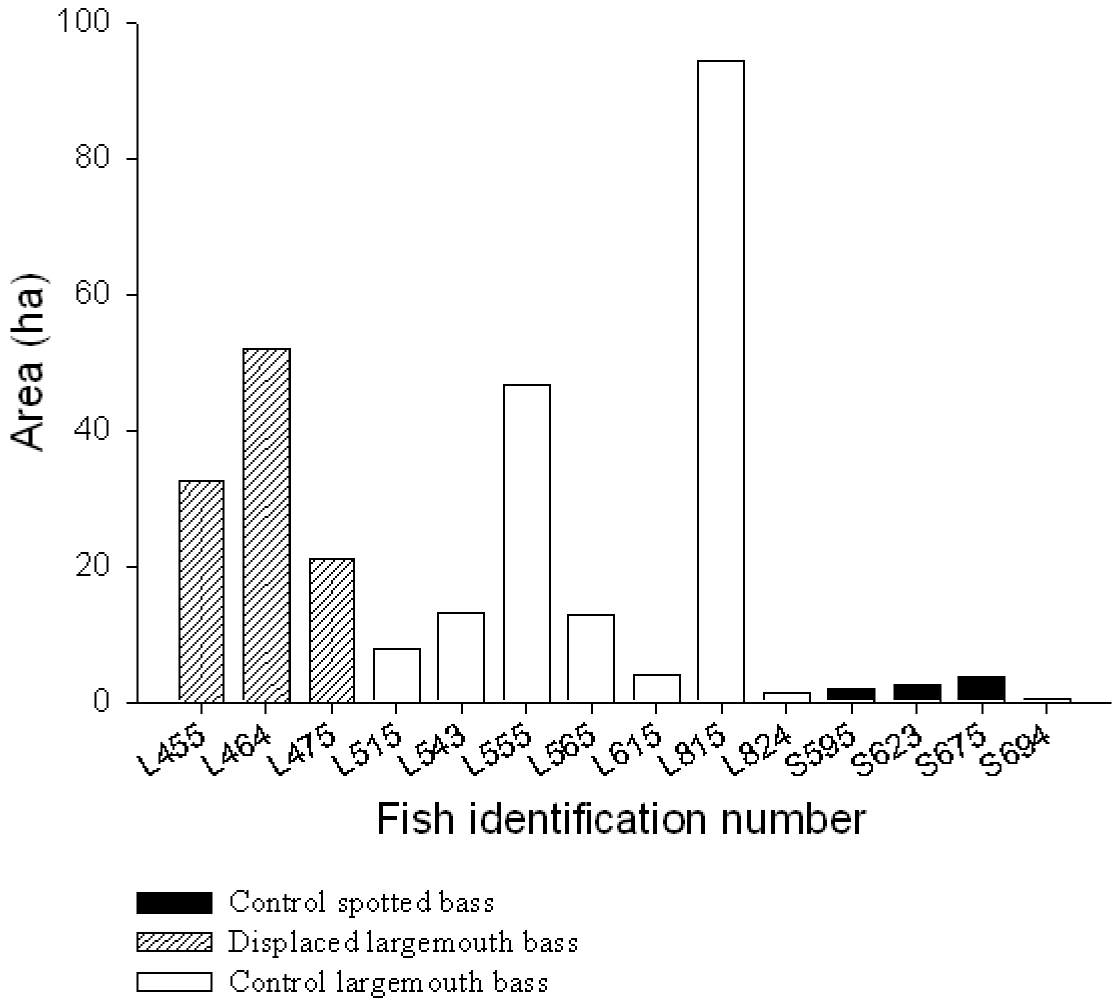

Figure 14. Fifty percent kernel home range areas for displaced and control largemouth bass and control spotted bass.

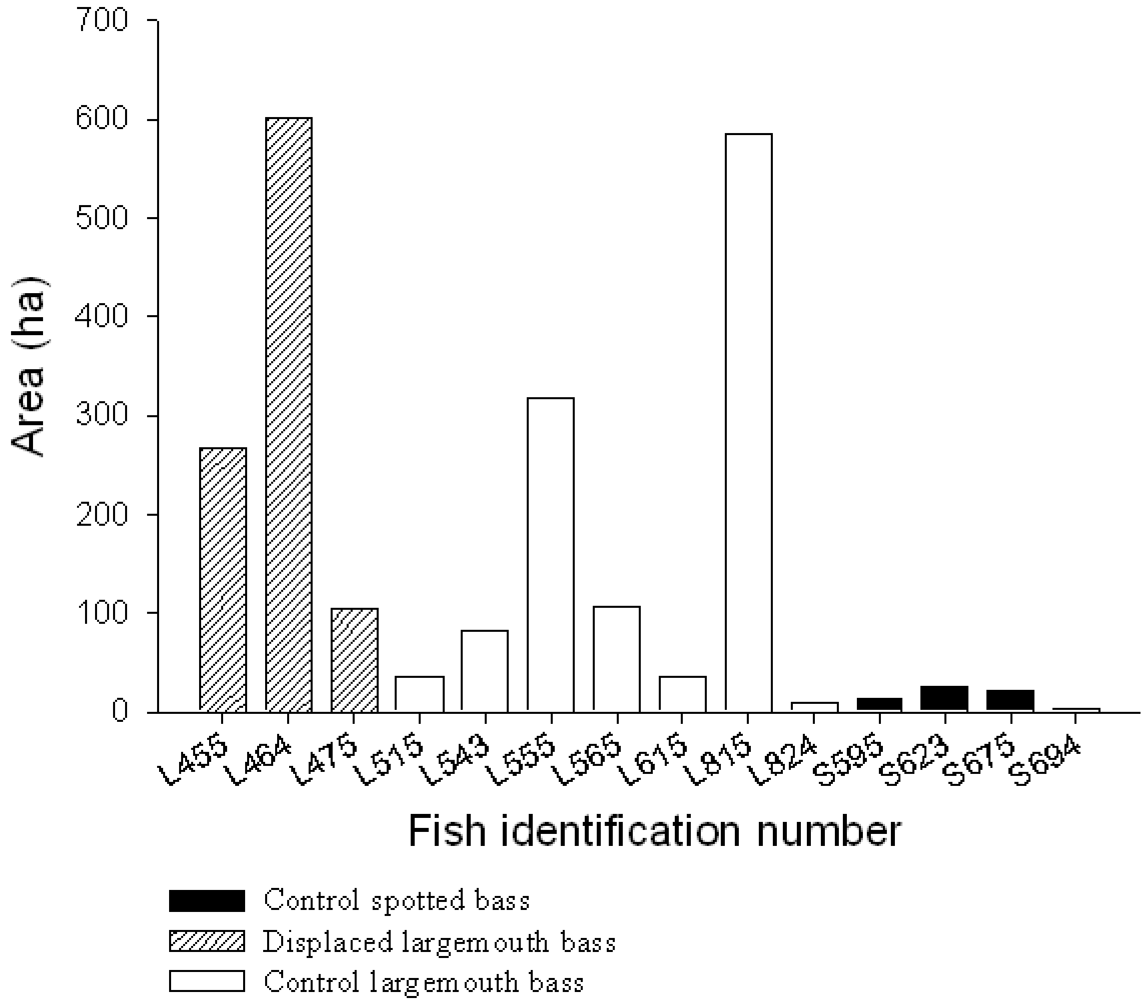

Figure 15. Ninety five percent kernel home range areas for control and displaced largemouth bass and control spotted bass.

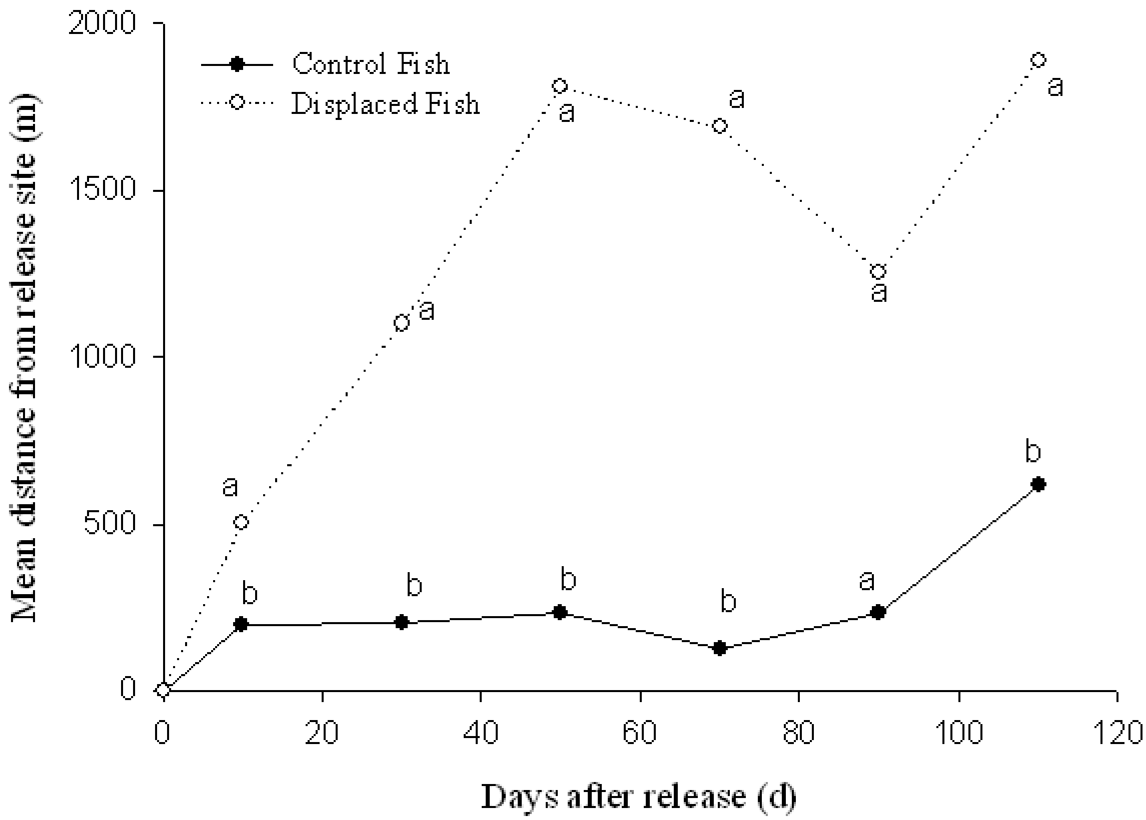

Figure 16. Mean distance dispersed from WCSP for tournament displaced and control fish (species pooled) tagged and released on 13 November 2005. Mean values labeled with the same letter were not significantly ($P > 0.05$) different for each time period comparison.

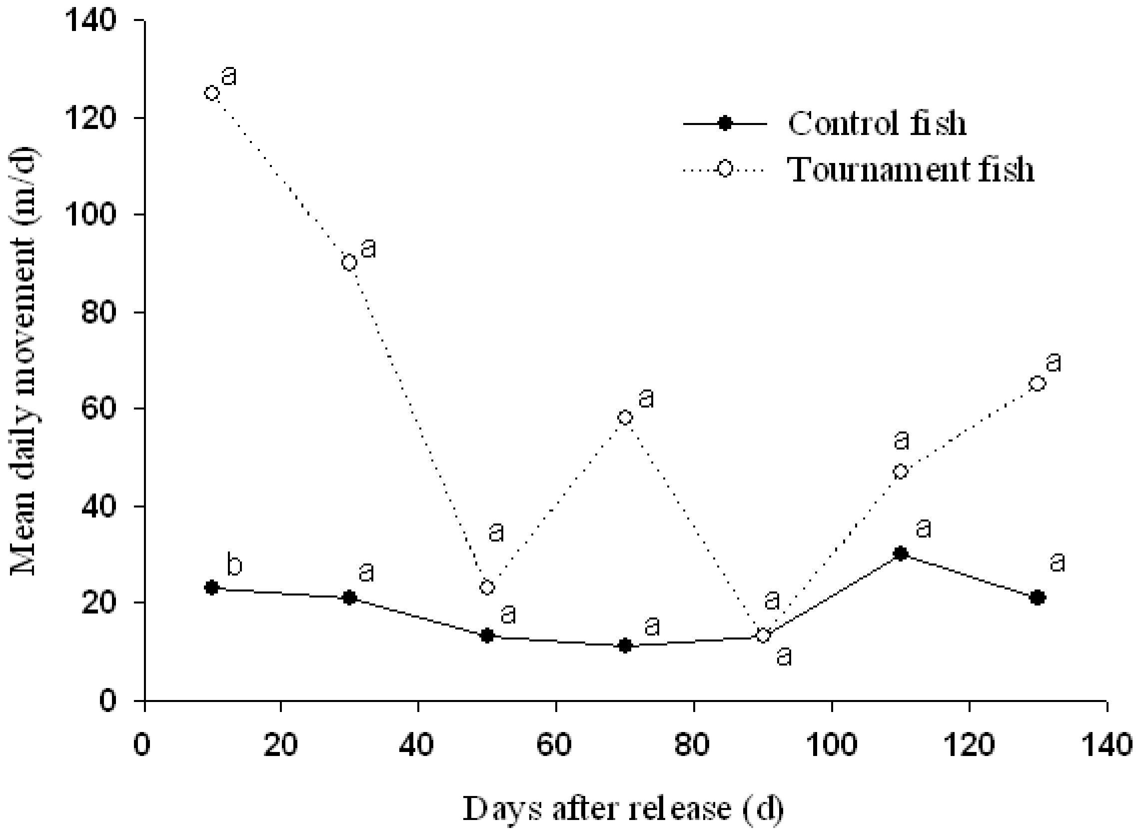

Figure 17. Mean movement (m/d) of control and displaced largemouth and spotted bass (species pooled) over the 138 d at large. Mean values labeled with the same letters were not significantly ($P > 0.05$) different for each time period comparison.

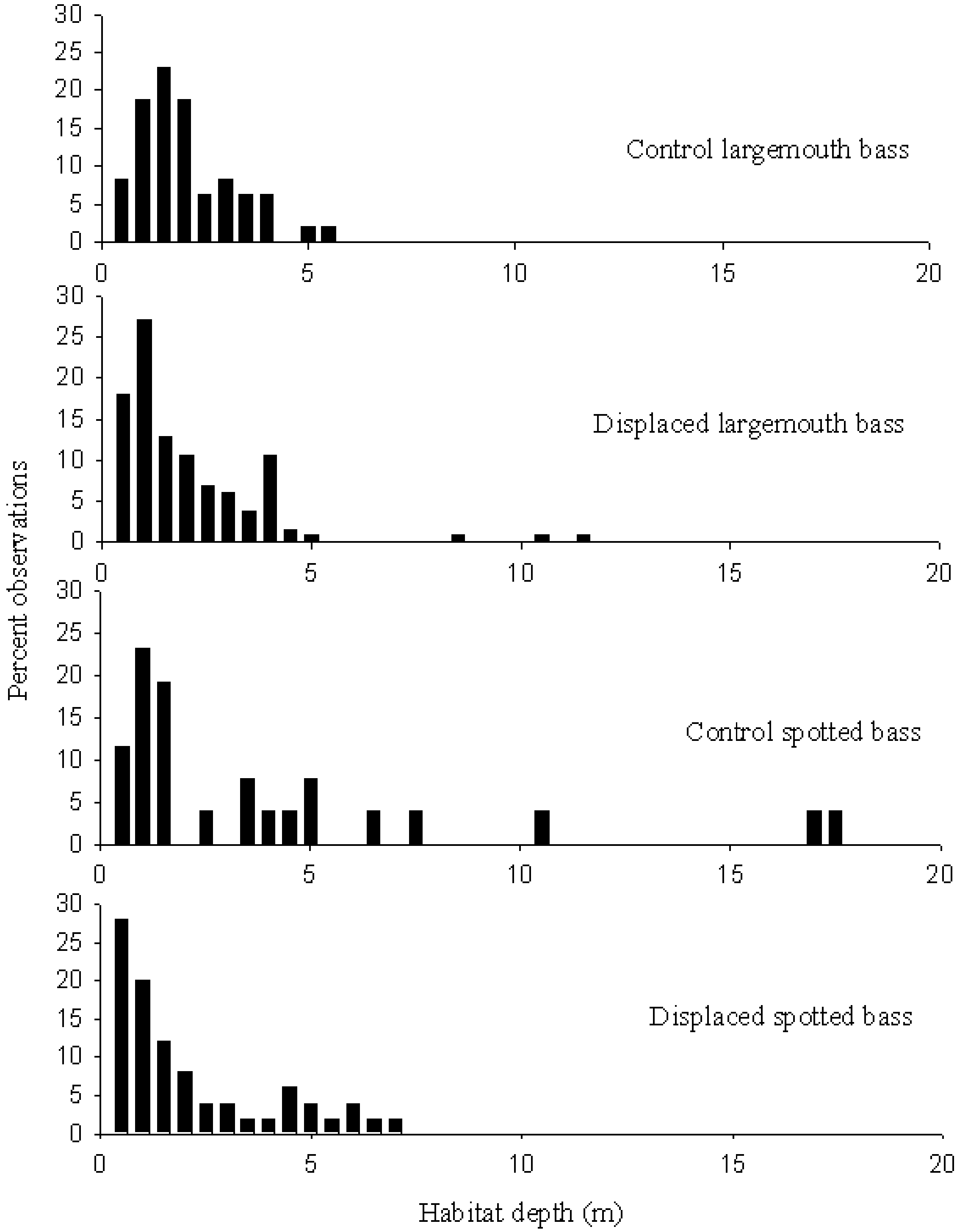

Figure 18. Depth frequency distributions of tournament displaced and control largemouth and spotted bass from 13 November 2005 to 27 March 2006.

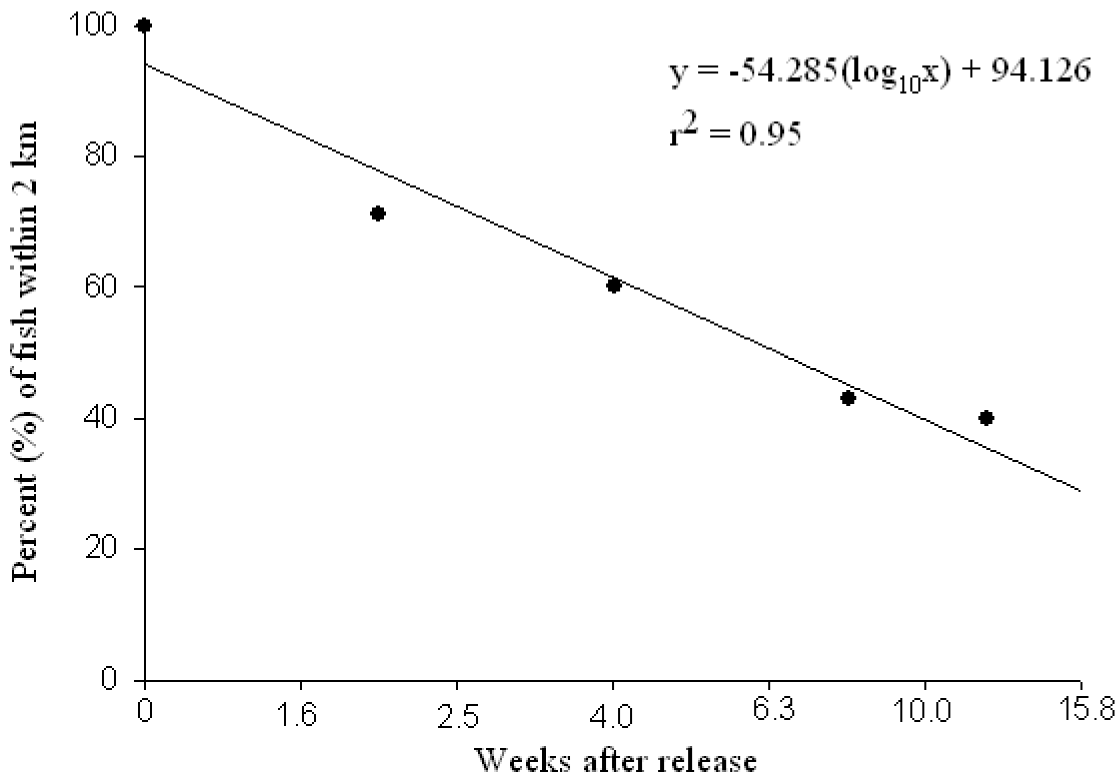

Figure 19. Regression predicting the percentage of black bass remaining within 2 km of the WCSP release site over time.

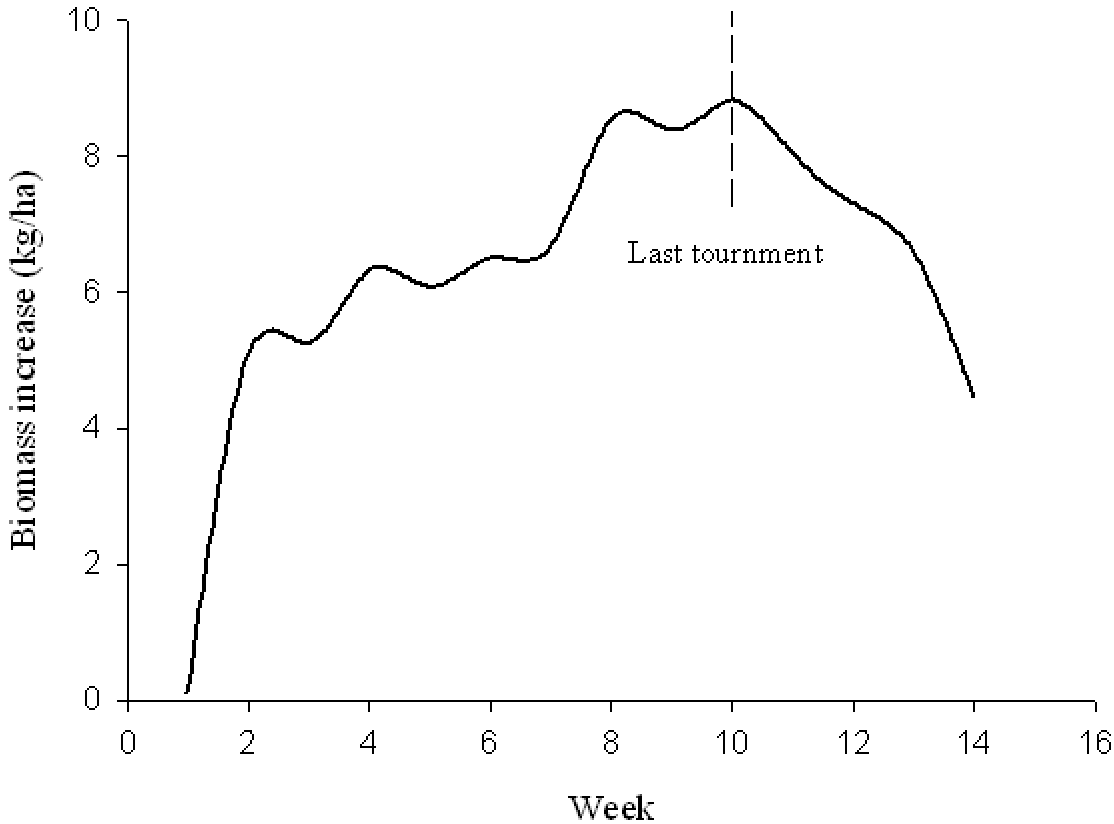

Figure 20. Estimated increase in black bass biomass within 2 km of WCSP, during spring 2005.

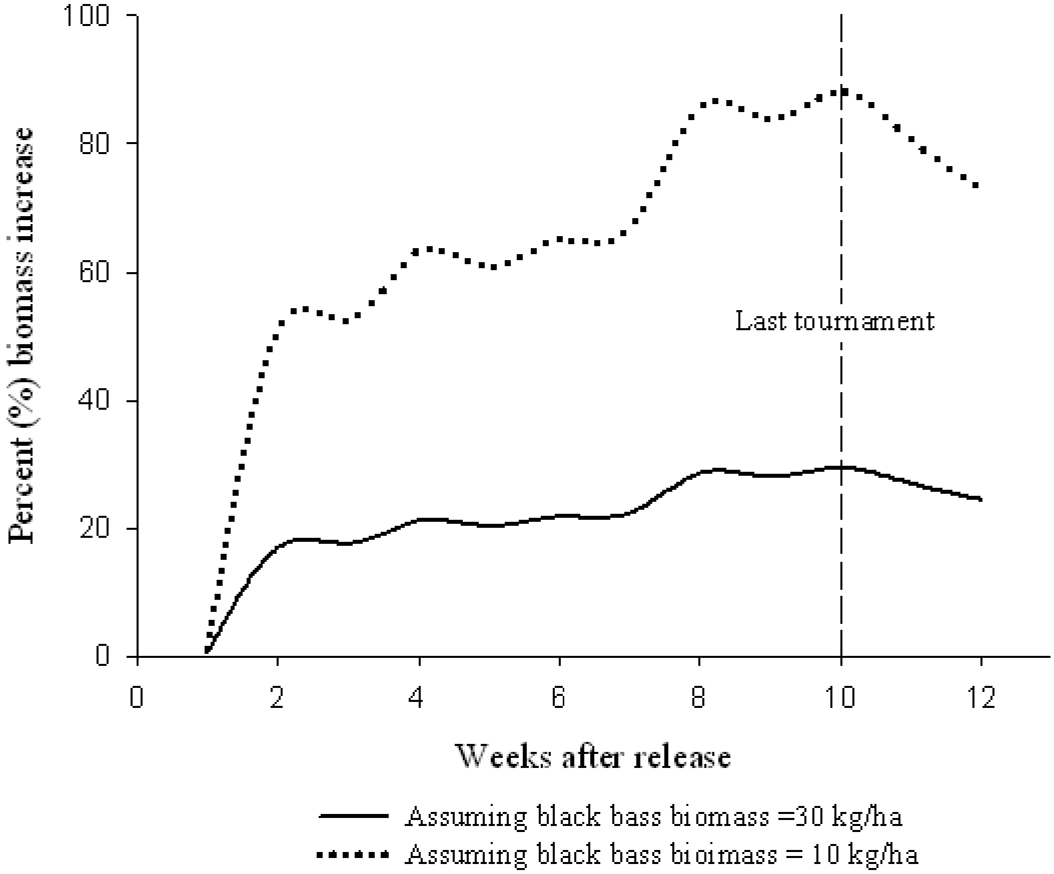

Figure 21. Estimated percent biomass increase within 2 km of WCSP during spring 2005 fishing tournament season in Lake Martin. The dotted line represents the estimated percent increase in biomass of black bass if the natural standing stock biomass was 10 kg/ha and the solid line represents the estimated percent increase if the natural stock biomass was 30 kg/ha.

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