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ARTICLE

# A Comparison of Different Tournament Weigh-In Formats on the Short-Term Postrelease Behavior of Black Bass Assessed with Biologgers

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***Abstract***
**Black bass *Micropterus* spp. live-release tournaments are a popular activity in North America. Efforts continue to further increase survival and enhance welfare of fish released from competitive angling events. Recently, some tournaments have adopted a new weigh-in format in which black bass are weighed immediately (hanging from a scale in air) and released at the capture location. More conventional tournaments involve retaining black bass in a live well and delivering them to a central location to be weighed (wet or dry weigh-in). We used biologgers that measured swimming activity, depth selection, and water temperature selection to examine how different weigh-in formats alter postrelease behavior of Smallmouth Bass *M. dolomieu* and Largemouth Bass *M. salmoides*. All fish showed a significant decrease in swimming activity as time progressed during the 10-min monitoring period, regardless of the weigh-in format. Swimming activity remained elevated (i.e., hyperactivity) for a longer period of time for black bass that were retained in live wells compared to those that were subjected to the catch, weigh, and release weigh-in format and the control (fish that were caught and immediately released without air exposure). Swimming activity of black bass tended to decrease as they achieved greater depths with cooler water temperatures. For both species, the water temperature selected postrelease was influenced by the weigh-in format. Black bass that were dry weighed and wet weighed spent more time in warmer water temperatures than fish in the control group or fish that were caught, weighed, and released. This study suggests that to reduce behavioral alterations associated with wet or dry weigh-ins, tournament organizations need to carefully select the weigh-in location, allowing easy access to refuge (i.e., habitat complexity similar to that of the capture location) having the cooler water temperatures commonly associated with deeper water. These results also suggest that catch, weigh, and release formats could be beneficial for black bass during periods of the year with elevated water temperature.**

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Live-release competitive angling events that target black bass *Micropterus* spp. are popular in North America, with over 10,000 events held annually (Duttweiler 1985; Schramm et al. 1991b). Competitive angling events provide immense economic benefits for rural communities by supporting local tackle stores, restaurants, hotels, and rental accommodations (Schramm et al. 1991a). However, concerns have been raised about the impacts of live-release tournaments on the sustainability of black bass populations (Holbrook 1975; Barnhart 1989; Schramm and Gilliland 2015), with evidence for such impacts being equivocal (e.g., Driscoll et al. 2007; Hysmith et al. 2014; Sylvia et al. 2021). Interest remains in identifying strategies to further reduce mortality and improve the welfare of fish in black bass tournaments (Schramm and Gilliland 2015).

Given the popularity of competitive black bass angling events in recent decades, strong emphasis has been placed on catch-and-release (C&R) tournament formats in accordance with jurisdictional regulations, permitting and licensing, tournament organization rules, and the conservation ethic of anglers (Duttweiler 1985; Schramm et al. 1991b). However, not all fish survive these events; therefore, the risk of tournament-related mortality has been identified as a concern (Schramm et al. 1991a, 1991b; Wilde 1998). There is evidence that physiological disturbances, physical body damage, and mortality are associated with black bass tournaments and are more common for tournament-caught fish compared to fish in a typical C&R scenario due to the tournament fish being handled for a longer period of time while retained in live wells and displaced from their site of capture (Hayes et al. 1995). Tournament directors and organizations are constantly trying to improve tournament protocols with new weigh-in formats and procedures to maximize the welfare of fish and ultimately reduce the risk of mortality (e.g., Tufts and Morlock 2004; Schramm and Gilliland 2015).

The most common black bass tournament format allows anglers to fish for 6–8 h while they attempt to catch a limit of five fish (most common; either restricted to one or multiple black bass species) and with a minimum fish length set by the tournament directors (usually ranging from 310 to 381 mm). Strict penalties are in place for dead fish during these tournaments, creating a strong incentive for anglers to ensure that their fish are brought to the weigh-in station alive. Black bass are usually brought to one central location to be weighed by tournament officials, and the fish are either released at the weigh-in location or placed into a live-release boat for transport to and release at a different location. Two common weigh-in formats are used for this style of event: (1) a dry weigh-in format, in which fish are placed into a plastic container without any water to be weighed; and (2) a newer, water weigh-in format, during which the fish remain in water for the entire time that they are being weighed (Tufts and Morlock 2004). The weigh-in format for the event is usually determined by the hosting organization, but there are some instances in which a regulatory body (e.g., natural resource management agency) may have policies regarding the tournament weigh-in format. Many studies have explored the potential factors that cause physiological alterations and mortality in black bass prior to weigh-ins, such as water temperature of the water body (Schramm et al. 1987; Bennett et al. 1989); water conditions in the live well, including water temperature, ammonia, and dissolved oxygen levels (Plumb et al. 1988; Hartley and Moring 1993; Kwak and Henry 1995; Suski et al. 2006); injuries from hooking and physiological alterations related to fight duration (Pelzman 1978; Schramm et al. 1987; Gustaveson et al. 1991); duration of tournaments (Bennett et al. 1989); and fish size (Meals and Miranda 1994). Other studies have focused on the implications of poorly organized (or poorly executed) weigh-in procedures for the survival of black bass (Hartley and Moring 1995; Weathers and Newman 1997). Furthermore, rough water, which is usually a result of high winds, can prolong the duration of time spent by black bass in the live well and has an impact on the overall welfare of black bass prior to release (Kwak and Henry 1995; Brooke et al. 2020). Individual angler experience and knowledge related to the welfare of fish while being held in the live well can also have an influence on the survival of released black bass (Edwards et al. 2004).

In recent years, a new tournament format has been embraced by some tournament organizers. This new format prevents anglers from holding fish in their live wells and involves catching and immediately weighing and releasing the fish (reviewed by Cooke et al. 2020). During events with this format, when a black bass is caught, it is immediately weighed on a scale affixed to the jaw of the fish with a mechanical grip by a tournament official and then is released. The angler that has the largest accumulated weight (or length for some events), regardless of the total number of fish captured during the tournament hours, is the winner of the tournament. Currently, this tournament style and weigh-in format have been embraced mostly by large organizations associated with the professional circuits and less so by small club events (notwithstanding kayak-based tournaments, which have long used such an approach). Due to the need for a tournament official (scrutineer) in each competitor's boat, it is difficult for small tournament series, organizations, and clubs to recruit personnel to officiate all of the registered boats in the tournaments. Some smaller events (such as the aforementioned kayak competitions) tend to use photo or video documentation, emphasizing that there are ways to adopt this method even during smaller club tournaments in which it is impractical to use scrutineers. The catch, weigh, and release format reduces the possible risks of black bass mortality associated with poor live well conditions and/or poor weigh-in conditions and procedures (Cooke et al. 2020). Moreover, this tournament format considerably reduces the displacement of black bass (Wilde 2003). It is well known that black bass that are caught during an angling event experience physiological alteration while confined in a live well and during the subsequent weigh-in procedure (Cooke et al. 2002; Suski et al. 2003, 2004), which may also contribute to behavioral impairments after release.

Although the potential benefits of the catch, weigh, and release tournament format include eliminating the risk of stress during live well confinement, inevitable subsequent handling (e.g., during culling), and fish displacement, there has been no research that explicitly compares the effects of different tournament formats on fish welfare. Such differences could include effects on immediate short-term behavior and fine-scale movement of black bass after experiencing different live-release weigh-in formats. Previous research has revealed that stress indicators measured prior to and shortly after handling are correlated with the long-term fate and survival of fish (Beitinger 1990; Iwama et al. 1997; Huntingford et al. 2006; Davis 2010). Moreover, behavior is a highly relevant indicator of fish stress for individuals in the wild (Schreck et al. 1997). For example, Raby et al. (2012) showed that immediate behavior assessed using reflex impairments (higher reflex action mortality predictors) was strongly correlated with longer-term behavior and postrelease survival of fish.

Biologgers equipped with acceleration (see Halsey et al. 2009; Gleiss et al. 2011), temperature, and pressure (depth) sensors are growing in popularity, allowing scientists to focus on how different fish handling practices influence the short-term behavior of fish (Halsey et al. 2009; Gleiss et al. 2011; Brownscombe et al. 2013; Wright et al. 2014). Obtaining fine-scale swimming activity information from triaxial accelerometer biologgers makes this method an excellent tool to calculate overall dynamic body acceleration (ODBA), which is a useful proxy for understanding the locomotion and field metabolic rate of fish (Wilson et al. 2006; Gleiss et al. 2011; Brownscombe et al. 2018). Moreover, because fish are ectotherms, the thermal environment selected by fish after release can also indicate the welfare status and health condition of the fish. Similarly, because fish live in a three-dimensional world, depth selection is also a relevant indicator of fish welfare status and health condition.

The objective of this study was to understand whether and how different tournament weigh-in formats impact the short-term postrelease behavior (i.e., swimming activity, water temperature selection, and depth selection) of black bass. To do this, we captured Smallmouth Bass *Micropterus dolomieu* (SMB) and Largemouth Bass *M. salmoides* (LMB) by means of angling in a popular tournament lake in eastern Ontario. We attached biologgers to the fish to assess their short-term behavior in the wild after exposure to various simulated black bass tournament weigh-in formats. The three weigh-in formats consisted of (1) catch, weigh, and release; (2) retention in a live well, followed by a dry weigh-in; and (3) retention in a live well followed by a wet weigh-in. All three are typical weigh-in formats seen in competitive black bass tournaments. We also included a control treatment in which fish were angled and immediately released without an air exposure period. It is not possible to tag a fish without catching and handling it, but by landing the fish rapidly and eliminating air exposure, this treatment served as a relevant control. To our knowledge, this study is the first to compare the effects of different tournament weigh-in formats on the postrelease behavior of black bass. The findings arising from this study will inform tournament organizers and fisheries managers about practices that maximize the welfare of black bass in water bodies where competitive angling events are held.

## METHODS

*Fish capture and tag attachment.—* All LMB and SMB were captured between July 1 and August 17, 2020, from Big Rideau Lake (44°43.887'N, 76°13.975'W) in eastern Ontario. Both species were captured by means of active angling using artificial lures according to the target species and habitat. Artificial lures had single barbed hooks or multiple-treble barbed hooks that were used with conventional fishing rods and reels, ranging from medium-power to extra-heavy-power rods, paired with braided fishing line between 4.5 and 22.7 kg. Once landed, fish were brought into the boat by hand (i.e., no net was used) and the hook (s) were removed by hand or with the aid of homeostats. The air exposure period associated with hook removal was less than 10 s in all cases. Deeply hooked fish were omitted from the study. Once the hook(s) were removed, fish were placed in a trough with fresh lake water to be identified by species, were measured for TL (mm), and received an external anchor tag (related to another study). Each day, a focus was placed on capturing either LMB or SMB in order to keep the two species separated and avoid cross-species interactions.

Activity, depth, and temperature data were collected on an Axy-Depth data logger (TechnoSmArt, Guidonia Montecelio, Italy; $12 \times 31 \times 11$ mm; 7.5 g in air) that was epoxied to a small piece of 1-mm-thick acrylic plate and secured to the mid-section of the fish by using a Velcro strap. The biologger was placed on the ventral side of the fish between the two pelvic fins (Figure 1). All of the biologgers were attached in the same way, compressing the dorsal fins to ensure precision of the results across all fish

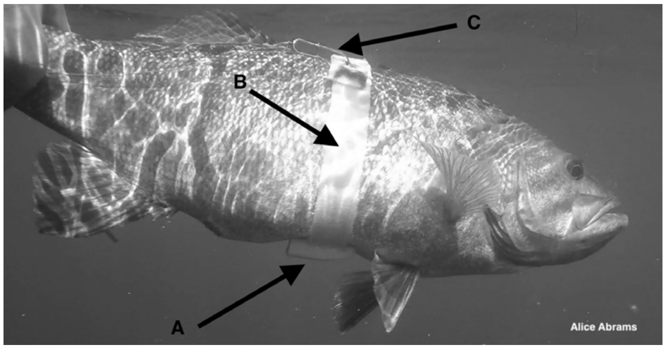


FIGURE 1. Smallmouth Bass with biologger (A) attached using a Velcro strap (B). Braided line was tied to a quick-release clip (C) fastened to the Velcro strap for retrieval of the biologger at the end of the 10-min monitoring period. Photo credit: Alice Abrams, Carleton University.

used in the study. During the process of biologger attachment, fish were always submerged in lake water while in the measuring trough. Biologgers were attached to the black bass before beginning the weigh-in process. Prior to release, a fast-attach clip with 13.6-kg braided fishing line was attached to the Velcro strap that was fastened to the fish. Black bass were then released for a 10-min postrelease monitoring period, with the bail of the reel open, allowing the fish to swim freely. Once the 10-min postrelease period was finished, the bail of the reel was closed and a firm tug was given on the braided fishing line, dislodging the Velcro strap and the biologger from the fish; the strap and biologger were then retrieved by reeling them back to the boat. The same approach was used to study the behavior of LMB that were captured and released during ice fishing (LaRochelle et al. 2021).

*Treatments.*— Treatments were conducted for LMB and SMB separately, and only fish with a minimum size of 300 mm TL were included. A maximum of five black bass of one species were captured and held together in the live well of a Ranger RT178C (95 L). The live well pump was always on, maintaining a constant flow of fresh, oxygenated water into the live well (3,028 L/h). Fish in the live well were identified by their external anchor tags, and the times of capture and release were recorded. Black bass placed in the live well were monitored for any symptoms related to barotrauma. When black bass were removed from the live well, they were placed in a trough where the biologger was attached (as described previously) and then were placed into a tournament weigh-in bag with 11.4 L of water for 1 min. Black bass were then removed individually and placed into a plastic basket without anything to prevent them from moving for 30 s and then released, simulating a dry weigh-in (dry treatment). Similarly, fish were removed from the live well, placed in the trough where the biologger was attached, and then placed into the tournament weigh-in bag for 1 min. Each fish was then removed and placed into a plastic basket, which was suspended into a larger bucket containing 33 L of water. The plastic basket, while suspended in the larger container, did not contain enough water for the fish to swim. Black bass were held in this basket for 30 s without any preventive measures to restrict movement (flopping) and then were released, typical of a wet weigh-in format (wet treatment). Black bass that were captured for the catch, weigh, and release weigh-in format or for the control were immediately placed into the water-filled trough once the hook was removed. Once in the trough, the biologger was attached to the fish. The black bass was then removed to be weighed using a plastic jaw lip grip (The Fish Grip; United Plastic Molders, Jackson, Mississippi) while being hung vertically for 15 s in air and then released (weigh–release treatment), or the fish was immediately released as the reference control treatment for each species (C&R treatment). For the purpose of this study, we considered the C&R treatment to be the closest approximation to "normal" behavior; therefore, we discuss changes in fish behavior in other treatments relative to this control.

*Data analysis.*— The acceleration ($g$) of LMB and SMB was measured across three axes ($A_x$ = surge, $A_y$ = sway, $A_z$ = heave; in respect to attachment orientation) with a sample rate of 25 Hz at an 8-bit resolution. The biologger model we used had a temperature resolution of ±0.1°C and a depth resolution of ±5 cm. Static acceleration (gravity) was removed from the dynamic acceleration (fish movement) by using a 2-s box smoother as described by Shepard et al. (2008) and Brownscombe et al. (2018). The ODBA was then obtained by summing the absolute dynamic acceleration from all three axes ($A_x$, $A_y$, and $A_z$; Wilson et al. 2006; Halsey et al. 2011), which served as a measure of postrelease swimming activity. All analyses were conducted in R version 3.6.2 via RStudio version 1.2.5033. Statistical models for SMB and LMB were analyzed separately following the recommendations of Garland and Adolph (1994). All models for both species were fitted using the *lmer* function from the lme4 package (Bates et al. 2015). In all models, minutes postrelease were treated as ordinal numbers, accounting for individual minute blocks from the 10-min postrelease monitoring period. For both species, the response variable ODBA was fitted with treatment, water temperature, minutes postrelease, time held in the live well, and the treatment × minutes postrelease interaction as the predictor variables. Analysis of variance with a threshold α value of 0.05 (95% confidence) was used to analyze *lmer* models to find the significant predictor variables. The significant predictor factors were then followed up with a Tukey post hoc test. To understand the temperature used by the fish during the postrelease period, a model with water temperature as the response variable was fitted with treatment, minutes postrelease, time held in the live well, and the treatment × minutes postrelease interaction as predictor variables. Finally, a model with ODBA as the response variable was fitted with the residuals of covarying variables (water temperature and water depth) as the predictor to understand the relationship between the position selected within the water column and the locomotory activity level of the black bass. All models included fish identity as a random effect variable to account for the repeated measures of individuals. The significant predictor variables were further analyzed using a post hoc test with the *glht* function from the multcomp package (Hothorn et al. 2008). All graphs were produced using ggplot2 (Wickham 2016) in RStudio. All values represent the mean ± SE. We present results separately for LMB and SMB without any formal statistical comparison given the inherent problems with doing two-species comparative studies (Garland and Adolph 1994), but we consider the species-specific trends in the Discussion.

## RESULTS

### Smallmouth Bass

In total, 62 SMB (380 ± 47 mm) were angled and subjected to one of the four treatments: C&R treatment ($n$ = 17; 377 ± 41 mm), weigh–release treatment ($n$ = 15; 393 ± 42 mm), dry treatment ($n$ = 15; 380 ± 56 mm), and wet treatment ($n$ = 15; 370 ± 47 mm). Fish were placed in the live well for a maximum of 510 min (146 ± 173 min) to simulate the typical duration that an SMB might spend in a live well during a tournament day. No SMB in this study showed symptoms or impairments related to barotrauma. There was no significant difference in length of SMB among the treatments ($F_{3,\ 58} = 0.731$, $P = 0.54$). The amount of time SMB spent in the live well did not influence the postrelease swimming activity (ODBA; $F_{1,\ 577} = 0.414$, $P > 0.05$). There was a significant positive relationship between water temperature and swimming activity during the postrelease period ($F_{1,\ 577} = 12.165$, $P < 0.001$). Across all weigh-in formats, swimming activity significantly decreased as time progressed during the postrelease period ($F_{9,\ 577} = 22.539$, $P < 0.001$). Swimming activity during the first minute postrelease was significantly greater than the activity in each subsequent minute (Figure 2). Additionally, swimming activity during the first minute postrelease differed significantly among weigh-in formats ($F_{3,\ 58} = 3.92$, $P = 0.013$). During the initial minute postrelease, swimming activity was significantly greater in SMB from the control treatment than in individuals that were subject to the wet treatment ($t_3 = -3.43$, $P = 0.006$). The total amount of time

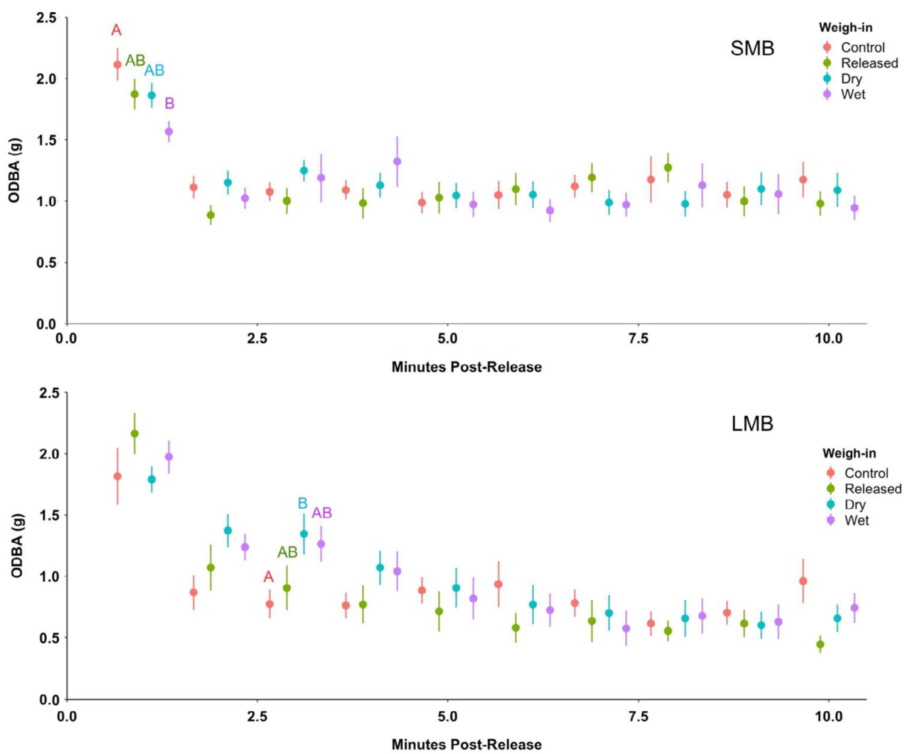


FIGURE 2. Mean overall dynamic body acceleration (ODBA) of Smallmouth Bass (SMB; $n = 62$; ODBA mean ± SE = 1.15 ± 0.03 g) and Largemouth Bass (LMB; $n = 56$; 0.93 ± 0.03 g) for each minute during the 10-min postrelease monitoring period. Weigh-in formats are differentiated by colors (Control = catch-and-release treatment; Released = catch, weigh, and release format; Dry = dry weigh-in format; Wet = wet weigh-in format), and the letters represent the dissimilarities among treatments.

spent in the live well did not significantly influence the postrelease water temperature selection by SMB ($F_{1,\ 578}$ = 0.417, $P > 0.05$). Water temperature selected by SMB during the postrelease period significantly differed based on the weigh-in format ($F_{3,\ 578} = 7.080$, $P < 0.001$; Figure 3). The SMB released from the control treatment selected cooler water temperatures than the SMB released after being subject to the wet treatment ($z_3 = 3.766$, $P < 0.001$). Water temperatures selected during the postrelease period were significantly cooler for SMB that were in the weigh–release treatment compared to SMB that were subject to the wet treatment ($z_3 = 3.974$, $P < 0.001$). Overall, the SMB from the weigh-in formats that released fish at the site of capture (control and weigh–release treatment) selected cooler water compared to fish that were placed in the live well (wet and dry treatments; Figure 3). There was also a significant negative relationship between minutes postrelease and water temperature ($F_{9,\ 578} = 12.015$, $P < 0.001$; Figure 3). Finally, there was a significant positive relationship between the swimming activity of SMB and the residuals from water depth and temperature, which covaried ($F_{1,\ 578} = 10.761$, $P < 0.001$). Swimming activity of SMB was higher in the warm, shallow water, and swimming activity decreased as the fish reached greater depths, which also tended to be cooler.

## Largemouth Bass

Overall, 56 LMB (mean TL ± SE = 382 ± 46 mm) were captured by means of recreational angling and were subjected to one of the four treatments: C&R treatment ($n$ = 15; 382 ± 53 mm), weigh–release treatment ($n$ = 13; 383 ± 50 mm), dry treatment ($n$ = 12; 380 ± 42 mm), and wet treatment ($n$ = 16; 385 ± 35 mm). All LMB were placed in the live well for a maximum of 510 min (151 ± 163 min) to simulate the typical duration that an LMB might spend in a live well during a tournament day. None of the LMB in this study showed symptoms or impairments related to barotrauma. There was no significant difference in length of LMB among the treatments ($F_{3,\ 52} = 0.735$, $P = 0.535$). Time spent in the live well did not significantly influence the postrelease swimming activity (ODBA) of LMB ($F_{1,\ 517}$ = 2.182, $P = 0.145$). The swimming activity of LMB significantly decreased as time progressed during the postrelease period ($F_{9,\ 517} = 38.909$, $P < 0.001$; Figure 2). The treatment × minutes postrelease interaction had a significant effect on swimming activity ($F_{27,\ 517} = 1.794$, $P = 0.009$). Only during the third minute postrelease did the swimming activity of LMB significantly differ among treatments. The LMB that were subject to the dry treatment had increased swimming activity compared to fish in the control treatment ($t_3$ = 2.661, $P = 0.048$). Swimming activity was significantly

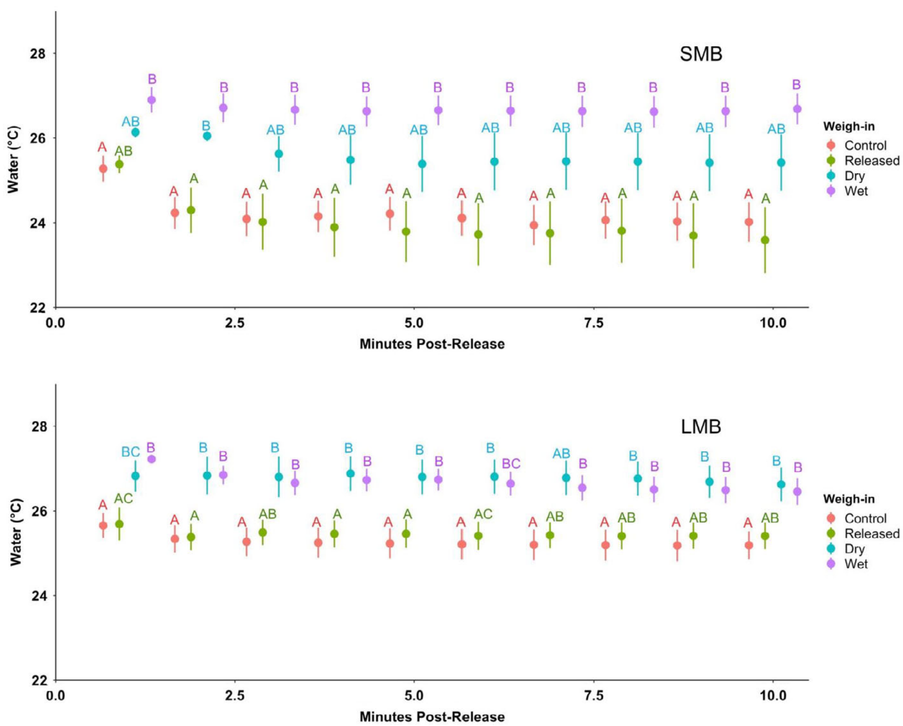


FIGURE 3. Mean water temperature selected by Smallmouth Bass (SMB; $n = 62$; mean ± SE = 25.09 ± 0.09°C) and Largemouth Bass (LMB; $n = 56$; 26.03 ± 0.06°C) at each minute during the 10-min postrelease monitoring period. Weigh-in formats are differentiated by colors (Control = catch-and-release treatment; Released = catch, weigh, and release format; Dry = dry weigh-in format; Wet = wet weigh-in format), and the letters represent the dissimilarities among treatments.

greater during the first minute postrelease compared to the following minutes across all weigh-in formats during the monitoring period. The duration of time spent in the live well did not influence water temperature selection by LMB ($F_{1,\ 590} = 2.086$, $P = 0.154$). The weigh-in format had a significant effect on the water temperature selected by LMB during the postrelease period ($F_{3,\ 518} = 8.252$, $P < 0.001$; Figure 3). There was no significant difference in selected water temperature between LMB in the control treatment and those in the weigh–release treatment ($z_3 = 0.392$, $P = 0.978$). There was also no significant difference in water temperature used upon release between LMB in the dry treatment and those in the wet treatment ($z_3 = -0.03$, $P = 1.000$). However, there was a significant difference in water temperature selected by LMB from the control treatment compared to the LMB from the dry ($z_3 = 4.169$, $P < 0.001$) and wet ($z_3 = 4.352$, $P < 0.001$) treatments. The LMB in the wet and dry treatments selected warmer water temperatures during the monitoring period compared to LMB in the control treatment. The LMB in the weigh–release treatment also selected significantly cooler water temperature during the postrelease period compared to fish that were subjected to the dry ($z_3 = 3.884$, $P < 0.001$) and wet ($z_3 = 4.049$, $P < 0.001$) treatments. Overall, the LMB from the weigh-in formats that released fish at the site of capture (control and weigh–release treatments) selected cooler water compared to the fish that were placed in the live well (wet and dry treatments; Figure 3). There was a significant negative relationship between the minutes postrelease and the water temperature selected by LMB during the monitoring period ($F_{9,\ 590} = 35.411$, $P < 0.001$). The treatment × minutes postrelease interaction indicated that LMB subjected to dry and wet treatments selected significantly warmer water temperatures compared to LMB that were subjected to the control and weigh–release treatments. Lastly, there was a significant positive relationship between the swimming activity of LMB and the residuals from water depth and temperature, which covaried ($F_{1,\ 578} = 10.613$, $P = 0.002$). Swimming activity of LMB was higher in the warm, shallow water, and swimming activity decreased as the fish reached greater depths, which also tended to be cooler.

## DISCUSSION

Regardless of black bass species, there is a degree of disorientation associated with being confined in a live well, displaced from the capture location, and then released in new habitat (Wilde 2003). The higher levels of swimming activity associated with the selection of shallow, warm water (Figure 3) suggested that live-well-confined, displaced black bass were engaging in a searching behavior when released, as the animals explored their new environment (Blake 1981; Richardson-Heft et al. 2000; Ridgway 2002). This searching behavior was demonstrated by both SMB and LMB during the first few minutes of the postrelease monitoring period, as the live-well-confined black bass that were displaced showed an increased level of swimming activity during those initial minutes relative to fish in the C&R (control) and weigh–release treatments (Figure 2).

During the period of live well confinement, black bass are presented with an opportunity to recover from the angling event, given that the live well conditions are adequate (e.g., dissolved oxygen, water temperature, and water chemistry; Suski et al. 2004). Depending on the time of year and the water body from which black bass are caught, the depth of capture may be a concern for adequate live well conditions to allow recovery from angling exhaustion. Live wells typically draw water for recirculation from surface water, which is often warmer and less oxygenated than the habitat of capture. Black bass that are caught at depth in cooler water may experience barotrauma, which can be exacerbated during the period of live well confinement (Elliott et al. 2021); in these situations, live wells may not provide an adequate recovery period. The black bass that were captured and placed in the live well during this study did not demonstrate symptoms of barotrauma (i.e., inflation of the air bladder, protruding stomach, and bulging eyes) while confined to the live well.

Habitat selection upon release could be a behavioral response intended to facilitate the recovery from exhaustive exercise as a result of the angling event and handling stress (Cooke et al. 2002, 2003; Suski et al. 2003, 2004). In our study, the SMB and LMB that were caught and immediately released (C&R treatment) or caught, immediately weighed, and then released (weigh–release treatment) were observed to select deeper water with cooler water temperatures. The physiological challenges created from exercise during an angling event (e.g., increased heart rate, as described by Cooke et al. 2003) create an oxygen debt, which may lead to selection of deeper and cooler water with a greater abundance of dissolved oxygen, thereby facilitating the recovery period. Tournaments with central weigh-ins present the additional physiological challenges of a handling period and/or air exposure for black bass (Cooke et al. 2002; Suski et al. 2003, 2004), which we simulated in this study. Furthermore, one of the most challenging aspects of C&R angling is the air exposure period (Cooke and Suski 2005; Cook et al. 2015), which may explain the slightly deeper and cooler water selected by fish that were released after a dry weigh-in compared to the wet weigh-in, during which the fish experienced little to no air exposure.

As previously mentioned, live wells may provide an opportunity for black bass to recover from the angling event if water conditions in the live well are adequate (Suski et al. 2004). However, fish are then introduced to bags for transfer, which may lead to rapid degradation of water quality and physiological alterations (Suski et al. 2004). Overall, the behavioral differences present in the water temperature selection may be attributed to the fact that recovery from angling exercise warrants the need for oxygen-rich, cooler water after release. This can also be said for black bass in which air exposure was induced by the dry weigh-in period compared to fish that remained in the water for the weigh-in, with little to no air exposure (Figure 3). Previous knowledge from a laboratory setting indicates that the locomotory activity of black bass is increased in warmer waters, while a reduction in swimming activity is often associated with cooler water temperatures (Hasler et al. 2009). Our study presents similar results relating swimming activity with water temperature and depth selection in wild populations of SMB and LMB. With the live well potentially being utilized for recovery from angling exhaustion (Suski et al. 2004) and given the current knowledge that swimming activity is increased in warm waters, black bass that were released after being confined in a live well and weighed may have been altering their behavior (relative to the control) to select warm, shallow waters. Selection of these shallow, warmer waters allows black bass to increase their swimming activity while they search and explore their new environment.

Overall, this study provides tournament organizers and fisheries managers with knowledge to make decisions about fish welfare. The SMB and LMB that were immediately weighed upon entering the boat and released at the location of capture showed minimal deviation in postrelease behavior (i.e., water temperature selection and swimming activity) relative to control fish that were caught and immediately released. Using this knowledge, tournament organizers will be able to better chose the appropriate tournament format for the time of year in which they intend to host the events. The weigh-in format in which black bass are caught, weighed, and immediately released would be beneficial for tournaments that occur during hot summer days when water temperature is high. In addition, black bass that are caught from depths are often subject to barotrauma, and placing them in the live well will often exacerbate the impacts associated with the change in pressure when fish are held at ambient atmospheric pressure (Elliott et al. 2021). Allowing the fish to immediately return to deeper and cooler water (Figure 3) can reduce the risks associated with placing black bass in the live well (Lee 1992). Furthermore, the dispersal behavior of black bass and the ability to return to their capture site vary by species when they are released at a central location where the weigh-in takes place (Wilde 2003; Siepker et al. 2007; Abrams et al. 2021).

Although this study had a limitation in only monitoring the behavior of black bass for a short period after release, previous knowledge provides a clear connection between deviation in the immediate postrelease behavior of fish and their long-term fate (Beitinger 1990; Brownscombe et al. 2013). This information should be considered by tournament organizers and regulators when determining the format of tournaments, while also placing critical consideration on establishing the central weigh-in/release location in an area that will facilitate the ability of the fish to seek refuge in their new environment with minimal swimming activity levels related to the selection of shallow, warm water after release (Figure 3). For situations in which black bass will be kept in live wells, tournament organizers should strive to practice weigh-in methods that promote keeping the fish in water at all times, thus reducing the air exposure period that is often associated with black bass tournaments. Reducing the amount of time for which tournament fish are removed from the water and placed on the scales or held in the air for pictures should be considered as the standard for weigh-in during tournaments. Although our data do not provide direct support for this recommendation, there is sufficient evidence to suggest that air exposure is one of the most challenging aspects of an angling event for fish, so minimizing air exposure during the weigh-in period could benefit black bass after release (Cooke and Suski 2005; Cook et al. 2015). We anticipate greater adoption of the catch, weigh, and release format for tournaments in the coming years (see Cooke et al. 2020), which will greatly reduce the risk of stress, behavioral alterations, and mortality associated with live well retention and weigh-in.

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