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MANAGEMENT BRIEF

Do Live-Well Temperatures Differ from Ambient Water During Black Bass Tournaments?

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Abstract
Elevated water temperature has been shown to influence mortality during fishing tournaments. However, data on water conditions in live wells are lacking, and the benefits of managing live-well temperature are equivocal. The objective of the current study was to define water temperature in a live well during live-release black bass *Micropterus* spp. angling tournaments, and to compare live-well temperatures with ambient temperatures in the surrounding lake. For this, thermal loggers were added to live wells during three different tournaments (17 live wells across three tournaments), and anglers fished in the tournament using automatic live-well recirculating pumps (recirculation and aeration occurs and freshwater is pumped in). Live wells were found to be significantly cooler (~1°C) than the epilimnion for two of the three tournaments examined, and 1°C warmer than the epilimnion in the other tournament examined. Based on these findings, fish held in live wells during black bass tournaments do not appear to be experiencing significant thermal differentials relative to ambient water in the lake from which they were caught during live-well confinement. Rather than targeting live wells to mitigate thermal stressors, tournament anglers and organizers should consider other measures to reduce thermal stressors for fish.

Live-release angling tournaments are a significant use of inland fisheries resources (Arlinghaus et al. 2007). Every year there are thousands of fishing tournaments that catch tens of thousands of fish (Schramm and Hunt 2007). A goal of many tournaments is to release fish alive so they can reproduce and be caught again. While mortality rates at tournaments are typically low (e.g., 1.0–3.2% for small club tournaments [Edwards et al. 2004]), when both the size of the tournament industry and the number of fish that are caught annually are considered, even low levels of mortality have the potential to translate into a large impact on fish populations (Johnston et al. 2015). Adequate fish care and handling techniques during tournaments are therefore critical to minimize the potential impacts to individuals and populations.

Many studies have identified water temperature as a key factor driving fish mortality during angling tournaments, with thermal stress from higher water temperatures being identified as a contributor to mortality (Schramm et al. 1987; Plumb et al. 1988; Wilde 1998; Loomis et al. 2013). While the ultimate source of thermal stressors for tournament-caught fish has not been defined, the holding of fish during a live well has the potential to thermally impact fish. For example, due to high air temperatures and exposure to sunlight, live-well water may warm relative to ambient water during an angling day and thereby act as a source of thermal stress for fish, suggesting a need for thermal control. Consequently, anglers may add ice to live wells in an attempt to maintain water temperature at thermal targets (Kwak and Henry 1995; Gilliland 2002; Ostrand et al. 2011; B.A.S.S. 2014). The cooling of live wells may also reduce the activity and metabolic rate of fish, and raise dissolved oxygen concentration in the live well, providing a number of potential mechanisms to offset negative thermal challenges for fish and optimizing holding conditions. Indeed, studies have demonstrated that cooling of live-well water can reduce the initial mortality of fish (Gilliland 2002; Schramm et al. 2006). In contrast, live wells that regularly intake surface water and recirculate it may maintain water temperatures similar to that of the surrounding water body. In this case, the need for thermal control may be minimized due to a lack of thermal differences for fish, and, more importantly, excessive cooling may result in negative consequences for fish

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(Suski et al. 2006; VanLandeghem et al. 2010). In addition, studies have demonstrated no improvement in survival when anglers cool their live well (Ostrand et al. 2011).

At present, little information exists on water quality parameters in a live well during an actual angling tournament. Several studies have simulated angling tournaments in an effort to generate these data (e.g., field simulation: Plumb et al. 1988, Ostrand et al. 2011; laboratory simulation: Loomis et al. 2013), and work has been done to collect data from live wells at the end of a tournament day (Kwak and Henry 1995). However, few studies have compared water conditions of live wells with that of the surrounding water body to define temperature differences (if any) that fish are experiencing during live-well holding. Without data on water temperature in live wells during an angling tournament, specifically live-well water temperature relative to the temperature of the surrounding water body, it is difficult to make confident and informed management recommendations related to prophylactic treatments to use in live wells to minimize tournament stressors for fish. Improper recommendations may cause anglers to utilize suboptimal fish handling techniques that can cause unnecessary stress for fish, potentially leading to increased sublethal stressors, mortality, or both.

Based on this background, the objective of the current study was to define the water temperature in live wells during actual live-release black bass *Micropterus* spp. angling tournaments and to compare live-well water temperatures with ambient temperatures in the water body. This information will help define the potential for thermal stress to which tournament-caught bass may be exposed, and it can provide information to anglers, organizers, and managers on the best practices to use during tournaments to minimize impacts on fish and to maximize survival.

METHODS

*Study sites.—*Water temperature sampling was conducted at three separate competitive angling tournaments, held as part of the Midwest Collegiate Fishing Series, on Clinton Lake (latitude–longitude of lake center: 40.156365, −88.82163; date of tournament: October 29, 2012), Lake Shelbyville (39.477865, −88.710566; September 23, 2012), and Mill Creek (39.430784, −87.805009; June 10, 2012) in Illinois. All three lakes are dimictic. Clinton Lake is 1,983 ha in total area and has an average depth of approximately 7.5 m (maximum depth is approximately 14.5 m). On the day of the tournament, the high air temperature was 10.0°C. The wind was from the southeast at 6.0 km/h. Lake Shelbyville is 4,452 ha in total area and has an average depth of 5.0 m, and with the exception of a 20-m-deep area near a dam, most of the other deeper parts of the lake are approximately 7.5 m. On the day of the tournament, the high air temperature was 18.9°C. The wind was from the northwest at 3.2 km/h. Mill Creek is a shallow lake with a total area of 328 ha. The high air temperature for the day of the tournament was 30.1°C. The wind speed was 20.9 km/h from the north. The lake has an average depth of 6.7 m. All depths were determined using a sonar depth finder (HDS 7; Lowrance, Tulsa, Oklahoma), and weather data were obtained from Weather Underground (hourly means based on weather data recorded at nearby airports, personal weather stations, and National Oceanic and Atmospheric Administration-managed weather stations) for the day of each tournament (www.wunderground.com/), and are provided as a coarse overview of weather conditions during each tournament. Fish were captured at shallow locations during the day of the tournament (tournament anglers, personal communications). All three tournaments targeted black bass, primarily Largemouth Bass *M. salmoides*.

*Temperature sampling.—*Water temperatures were recorded using thermal loggers (iButton DS1921Z; factory-stated resolution, ±0.1°C; accuracy, ±1.0°C; Maxim Integrated Productions, Sunnyvale, California) dipped in Plasti Dip (Performix Brand, Blaine, Minnesota). Loggers were programmed to sample every minute. Similar plasticized loggers were tested by Donaldson et al. (2009) in a laboratory setting and found to have a mean (±SD) accuracy of 0.4 ± 0.3°C and a mean precision of 0.2 ± 0.3°C. One logger was placed in the live well of each participating tournament angler before the start of each tournament. Anglers ($n = 6$, Clinton Lake; $n = 6$, Lake Shelbyville; $n = 5$, Mill Creek) were given instructions to fill their live wells with water once the tournament started and use the "auto" setting on the recirculating pump in their live well. When the live well is set to auto, freshwater is automatically pumped into the live well from the surface of the lake for a few minutes every few minutes (note: the actual duration varies between boat makes and models, and it depends on whether the boat is on or off plane). Temperature loggers were not affixed to the wall of the live well and were allowed to move freely within the live well. No ice was used in the study. A second set of thermal loggers acted as reference loggers to quantify temperatures within the lake. These loggers were placed on a 15-m rope equipped with a weight and buoy, and one logger was placed <0.7 m below surface (i.e., within the epilimnion), with a second logger secured near the bottom of the lake; these loggers were programmed to record water temperatures at settings identical to that of the loggers in live wells. One reference string of loggers was used in each lake and was placed near the lake center near the mouth of a cove. Temperature sampling occurred from the start to the end of each tournament: between 0800 and 1600 hours at Clinton Lake, between 0800 and 1300 hours at Lake Shelbyville, and between 0600 and 1500 hours at Mill Creek Lake. On average, 341 ± 110 temperature records were measured per live well at Clinton Lake, and 273 and 544 temperature records were measured per live well at Lake Shelbyville and Mill Creek Lake, respectively.

*Statistical analysis.—*Temperature data collected at each lake were binned by hour, and two-way repeated-measures ANOVA tests (RMANOVA) were used to compare water temperature between locations (Sokal and Rohlf 1995; Zar 1999). The main effects in the model were logger location (live well, shallow reference site, or deep reference site), time (h), and a location × time interaction (Sokal and Rohlf 1995; Zar 1999). Nonsignificant interaction effects were removed from the model, and models were subsequently rerun (Engqvist 2005). Logger identification number was also entered into the model as a random effect (nested within time) because multiple data points were collected from each logger during a tournament, meaning that each measurement was not independent and potentially correlated within a logger (Laird and Ware 1982; Lindstrom and Bates 1990). Data were ranked transformed to meet assumptions of normality and homogeneity of variances (Sokal and Rohlf 1995; Zar 1999). Normality was verified through visual inspection of fitted residuals using a normality probability plot (Conover and Iman 1981; Iman et al. 1984; Potvin and Roff 1993), while homogeneity of variances was confirmed using a Hartley's F_{max} test (Anscombe and Tukey 1963), coupled with visual analysis of fitted residuals using a residual by predicted plot. A Tukey–Kramer honest significant difference post hoc test was used to separate means if at least one main effect in the model was significant or if the interaction was significant (Hartley 1950). Statistical analyses were conducted using JMP Pro 11.1.1 (SAS Institute, Cary, North Carolina), means are reported as ±SD to highlight data dispersions (Barde and Barde 2012), and significance was set at $\alpha = 0.05$.

RESULTS

During the competitive angling tournaments examined, live-well water temperatures ranged from a minimum of 12.5°C to a maximum of 16.5°C in Clinton Lake, 24.0°C to 28.0°C in Mill Creek Lake, and 18°C to 21.5°C in Lake Shelbyville. During tournaments at Mill Creek Lake and Lake Shelbyville, live-well temperatures were significantly cooler (event differences of ~0.4°C and ~1.0°C, respectively; Table 1; Figure 1A, B) than at the shallow reference site in the lake across all time periods examined (Figure 1A, B). At Clinton Lake, live-well temperature was significantly warmer

TABLE 1. Results of statistical tests for two-way RMANOVA, comparing water temperature across times in anglers' live wells relative to ambient. Nonsignificant interaction effects were removed prior to running the final model; significant differences ($\alpha = 0.05$) are in bold italics.

Tournament location	Parameter	*F*-ratio	df	*P*-value
Mill Creek Lake	Logger location	62.21	2, 52	<***0.0001***
	Time	9.99	8, 52	<***0.0001***
Lake Shelbyville	Logger location	12.07	2, 33	***0.0002***
	Time	0.93	4, 33	***0.0034***
Clinton Lake	Logger location	8.33	2, 43	***0.0035***
	Time	0.52	7, 43	0.7826

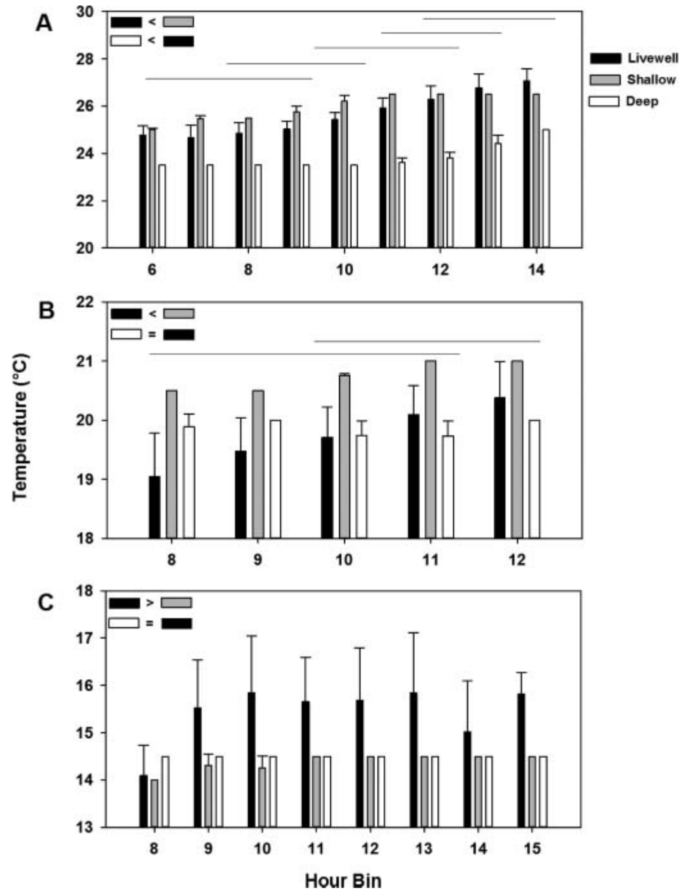

FIGURE 1. Hourly mean and SD (whiskers) of recorded water temperature from live wells (black; $n = 6$, Clinton Lake; $n = 6$, Lake Shelbyville; $n = 5$, Mill Creek), shallow reference sites (light gray), and deep reference sites (white) at **(A)** Mill Creek Lake, **(B)** Lake Shelbyville, and **(C)** Clinton Lake. Bars connected with straight lines indicate similarity with respect to the time factor, and statistical similarity between temperature collection sites determined by a Tukey post hoc analysis are indicated with an equal sign and statistical differences with a less than sign or greater than sign. Times shown represent the hourly periods for which the tournaments occurred.

(event difference of ~1°C) than at the shallow reference site but not statistically different than at the deep reference site (Table 1; Figure 1C). In addition to the differences found between deployment locations at Mill Creek Lake and Lake Shelbyville, overall water temperature across locations increased throughout the day, with temperatures rising from an average of 24.9°C in the morning (0600 hours) to 25.7°C in the afternoon (1400 hours) for Mill Creek Lake, and 19.3°C in the morning (0800 hours) to 20.4°C at noon (1200 hours) for Lake Shelbyville (Table 1; Figure 1A, B).

DISCUSSION

Results from the current study show a strong similarity between the temperature of live wells and the temperature of the epilimnion of tournament lakes. More specifically, though all three lakes examined showed statistically significant differences between live wells and surface water, temperature differences between the live well and water body were approximately 1°C or less across the tournament day, indicating considerable agreement between live-well water temperature and data from stationary loggers in the lake. There are two reasons for the close association between live-well temperatures and the epilimnia of lakes. First, the epilimnia of lakes are well mixed due to wind action, waves, and differences in density of water; thus, the epilimnion of a lake is typically homogeneous for characteristics such as water temperature and dissolved oxygen (Schertzer et al. 1987; Wetzel 2001). Second, live wells are filled with surface water. As such, during a fishing tournament, black bass caught and held in live wells experience water temperatures similar to that of the ambient surroundings and to that which fish are likely acclimated based on movement behaviors (Demers et al. 1996; Suski and Ridgway 2009), with little evidence to suggest that live-well temperatures differ greatly from that of the surrounding lake.

Water temperature has been shown to be a key driver of mortality at fishing tournaments, and elevated surface temperatures correlates with higher mortality rates for a range of locations, systems, and periods in the year (Wilde 1998). There are a number of reasons this relationship between high temperatures and high mortality rates exists for fish caught and handled during angling tournaments, including elevated metabolic rates and other physiological disturbances (Cooke et al. 2002; Suski et al. 2003), increased activity rates (Suski et al. 2005), and reduced live-well oxygen concentrations (Hartley and Moring 1995; Cooke et al. 2002). Despite evidence to the contrary (Gilliland 2002), results from the current study indicate that it may not be necessary to manage live wells to reduce water temperatures because live-well temperatures did not vary by more than 1°C from ambient lake temperatures, and, in the case of two of the three lakes, live-well temperatures were cooler. Therefore, prophylactic treatments to reduce live-well water temperature likely would do little to reduce the potential for thermal stress caused by elevated live-well temperature. Live wells have the potential to subject fish to stressors other than temperature, such as crowding (Cooke et al. 2002), wave action (Suski et al. 2005), and low oxygen (Hartley and Moring 1995), all of which can contribute to mortality, sublethal physiological disturbances, or both, and influence mortality (either directly or indirectly). In fact, research has shown that the period of live-well holding has the potential to both allow fish to recover from angling-induced stressors (Suski et al. 2004) and to not impose additional stressors on fish, provided that water quality parameters remain optimal (Suski et al. 2006). Work has also shown that variations in water quality parameters away from the "ideal" can impart additional physiological disturbances on fish and impede the recovery from fish held in "ideal" conditions. For example, both hypoxia and hyperoxia (i.e., over-oxygenation) of water will impair recovery from angling disturbances (Suski et al. 2006) and may cause mortality at low dissolved oxygen levels (Loomis et al. 2013). Similarly, transferring fish from warm water (i.e., epilimnion) into a coldwater environment (i.e., ice combined with the water in the live well) can result in cold shock, which can have physiological, behavioral, and fitness consequences for fish (Donaldson et al. 2008). For example, for Largemouth Bass, an acute 12°C cold shock resulted in a number of physiological disturbances indicative of stress, and even a 5°C cold shock caused physiological disturbances to occur (VanLandeghem et al. 2010). Furthermore, water 5°C below ambient will impede recovery from angling disturbances for Largemouth Bass relative to fish recovered at ambient temperatures (Suski et al. 2006). Therefore, caution needs to be used when adding Largemouth Bass to cold water. More importantly, work by Ostrand et al. (2011) found the addition of ice to live wells containing tournament-captured Largemouth Bass did not significantly reduce delayed mortality, despite surface temperatures ranging from 25.1°C to 34.5°C. Overall, results from the current study show that live-well temperatures do not deviate substantially from ambient water temperatures, providing little evidence for the occurrence of thermal challenges resulting from live-well confinement.

Results from the current study suggest that, if anglers, organizers, or managers have concerns related to the impacts of elevated water temperatures on the health, condition, or survival of fishes caught in angling tournaments, the greatest benefits would likely occur from actions taken at a tournament-wide level as opposed to targeting the period of live-well confinement. Actions such as refraining from angling in the warmest part of the day, running "honor system"-type tournaments where fish are measured and released immediately, or scheduling tournaments in cooler periods of the year may be more beneficial than promoting the use of prophylactic treatments to cool live wells that do not appear necessary based on the results of this study. Assuming that anglers run live wells on automatic continuously as they did in the current study, live-well temperatures should not increase relative to the littoral areas of a lake, and black bass likely should not experience temperatures that are warmer than what they would have encountered if they were not caught. In addition, continuous live-well running should work to maintain dissolved oxygen levels at appropriate levels, and nitrogenous wastes likely do not accumulate to problematic levels in angling tournaments (Plumb et al. 1988; Gustaveson et al. 1991; Suski et al. 2007; Loomis et al. 2013). Future work should investigate the potential for differences in water temperatures across the components of an angling tournament (i.e., weigh-in, transport bags, release boats, etc.) and also how differences in live-well water temperature may be related to angler behavior (i.e., boat location), live-well size and operations, and other times of the year, as these variables were not considered in this study. Thermal optima for fish will also vary by species, so species-specific considerations to thermal recommendations should also be considered (Cooke and Suski 2005). With proper attention to fish care and handling, anglers and tournament organizers can work to reduce stressors for tournament-caught fish to ensure minimal disturbance and maximum survival.

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REFERENCES

Anscombe, F. J., and J. W. Tukey. 1963. The examination and analysis of residuals. Technometrics 5:141–160.

Arlinghaus, R., S. J. Cooke, J. Lyman, D. Policansky, A. Schwab, C. Suski, S. G. Sutton, and E. B. Thorstad. 2007. Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. Reviews in Fisheries Science 15:75–167.

Barde, M. P., and P. J. Barde. 2012. What to use to express the variability of data: standard deviation or standard error of mean? Perspectives in Clinical Research 3:113–116.

B.A.S.S. (Bass Anglers Sportsman Society). 2014. Keeping bass alive - livewell management. Available: http://www.bassmaster.com/. (September 2015).

Conover, W. J., and R. L. Iman. 1981. Rank transformations as a bridge between parametric and nonparametric statistics. American Statistician 35:124–129.

Cooke, S. J., J. F. Schreer, D. H. Wahl, and D. P. Philipp. 2002. Physiological impacts of catch-and-release angling practices on Largemouth Bass and Smallmouth Bass. Pages 121–134 *in* D. P. Philipp and M. S. Ridgway, editors. Black bass: ecology conservation and management. American Fisheries Society, Symposium 31, Bethesda, Maryland.

Cooke, S. J., and C. D. Suski. 2005. Do we need species-specific guidelines for catch-and-release recreational angling to effectively conserve diverse fishery resources? Biodiversity and Conservation 14:1195–1209.

Demers, E., R. S. McKinley, A. H. Weatherley, and D. I. McQueen. 1996. Activity patterns of Largemouth and Smallmouth bass determined with electromyogram biotelemetry. Transactions of the American Fisheries Society 125:434–439.

Donaldson, M. R., S. J. Cooke, D. A. Patterson, S. G. Hinch, D. Robichaud, K. C. Hanson, I. Olsson, G. T. Crossin, K. K. English, and A. P. Farrell. 2009. Limited behavioural thermalregulation by adult upriver-migrating Sockeye Salmon (*Oncorhynchus nerka*) in the lower Fraser River, British Columbia. Canadian Journal of Zoology 87:480–490.

Donaldson, M. R., S. J. Cooke, D. A. Patterson, and J. S. Macdonald. 2008. Cold shock and fish. Journal of Fish Biology 73:1491–1530.

Edwards, G. P., R. M. Neumann, R. P. Jacobs, and E. B. O'Donnell. 2004. Impacts of small club tournaments on black bass populations in Connecticut and the effects of regulation exemptions. North American Journal of Fisheries Management 24:811–821.

Engqvist, L. 2005. The mistreatment of covariate interaction terms in linear model analyses of behavioural and evolutionary ecology studies. Animal Behaviour 70:967–971.

Gilliland, E. R. 2002. Livewell operating procedures to reduce mortality of black bass during summer tournaments. Pages 477–487 *in* D. P. Philipp and M. S. Ridgway, editors. Black bass: ecology conservation and management. American Fisheries Society, Symposium 31, Bethesda, Maryland.

Gustaveson, A. W., R. S. Wydoski, and G. A. Wedemeyer. 1991. Physiological response of Largemouth Bass to angling stress. Transactions of the American Fisheries Society 120:629–636.

Hartley, H. O. 1950. The maximum *F*-ratio as a short-cut test for heterogeneity of variance. Biometrika 37:308–312.

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

Iman, R. L., S. C. Hora, and W. J. Conover. 1984. Comparison of asymptotically distribution-free procedures for the analysis of complete blocks. Journal of the American Statistics Association 79:674–685.

Johnston, F. D., B. Beardmore, R. Arlinghaus, and V. Trenkel. 2015. Optimal management of recreational fisheries in the presence of hooking mortality and noncompliance—predictions from a bioeconomic model incorporating a mechanistic model of angler behavior. Canadian Journal of Fisheries and Aquatic Sciences 72:37–53.

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

Laird, N. M., and J. H. Ware. 1982. Random-effects models for longitudinal data. Biometrics 38:963–974.

Lindstrom, M. J., and D. M. Bates. 1990. Nonlinear mixed effects models for repeated measures data. Biometrics 46:673–687.

Loomis, J. H., H. L. Schramm, B. Vondracek, P. D. Gerard, and C. J. Chizinski. 2013. Effects of simulated angler capture and live-release tournaments on Walleye survival. Transactions of the American Fisheries Society 142:868–875.

Ostrand, K. G., M. J. Siepker, and D. H. Wahl. 2011. Effectiveness of livewell additives on Largemouth Bass survival. Journal of Fish and Wildlife Management 2:22–28.

Plumb, J. A., J. M. Grizzle, and W. A. Rogers. 1988. Survival of caught and released Largemouth Bass after containment in live wells. North American Journal of Fisheries Management 8:325–328.

Potvin, C., and D. A. Roff. 1993. Distribution-free and robust statistical methods: viable alternatives to parametric statistics. Ecology 74:1617–1628.

Schertzer, W. M., J. H. Saylor, F. M. Boyce, D. G. Robertson, and F. Rosa. 1987. Seasonal thermal cycle of Lake Erie. Journal of Great Lakes Research 13:468–486.

Schramm, H. L., P. J. Haydt, and K. M. Portier. 1987. Evaluation of prerelease, postrelease, and total mortality, of Largemouth Bass caught during tournaments, in two Florida lakes. North American Journal of Fisheries Management 7:394–402.

Schramm, H. L., and K. M. Hunt. 2007. Issues, benefits, and problems associated with fishing tournaments in inland waters of the United States: a survey of fishery agency administrators. Fisheries 32:234–243.

Schramm, H. L., A. R. Walters, J. M. Grizzle, B. H. Beck, L. A. Hanson, and S. B. Rees. 2006. Effects of live-well conditions on mortality and Largemouth Bass virus prevalence in Largemouth Bass caught during summer tournaments. North American Journal of Fisheries Management 26: 812–825.

Sokal, R. R., and F. J. Rohlf. 1995. Biometry: the principles and practice of statistics in biological research, 3rd edition. Freeman, New York.

Suski, C. D., S. J. Cooke, S. S. Killen, D. H. Wahl, and D. P. Philipp. 2005. Behaviour of Walleye, *Sander vitreus*, and Largemouth Bass, *Micropterus salmoides*, exposed to different wave intensities and boat operating conditions during livewell confinement. Fisheries Management and Ecology 12:19–26.

Suski, C. D., J. D. Kieffer, S. S. Killen, and B. L. Tufts. 2007. Sublethal ammonia toxicity in Largemouth Bass. Comparative Biochemistry and Physiology Part A Molecular and Integrative Physiology 146:381–389.

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

Suski, C. D., S. S. Killen, J. D. Kieffer, and B. L. Tufts. 2006. The influence of environment temperature and oxygen concentration on the recovery of Largemouth Bass from exercise: implications for live-release angling tournaments. Journal of Fish Biology 68:120–136.

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

Suski, C. D., and M. S. Ridgway. 2009. Seasonal pattern of depth selection in Smallmouth Bass. Journal of Zoology 279:119–128.

VanLandeghem, M. M., D. H. Wahl, and C. D. Suski. 2010. Physiological responses of Largemouth Bass to acute temperature and oxygen stressors. Fisheries Management and Ecology 17:414–425.

Wetzel, R. G. 2001. Limnology: lake and river ecosystems, 3rd edition. Academic Press, San Diego, California.

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

Zar, J. H. 1999. Biostatistical analysis. Prentice Hall, Upper Saddle River, New Jersey.