Barotrauma related mortality of Florida-strain largemouth bass from winter tournaments in Diamond Valley Lake, California

Quinn Granfors*

California Department of Fish and Wildlife, 33752 Newport Rd., Winchester, CA 92596, USA

Correspondent: Quinn.Granfors@wildlife.ca.gov

Fish captured and retained during fishing tournaments can experience initial or delayed mortality from barotrauma caused by the rapid elimination of hydrostatic pressure that occurs when a fish is brought from depth to the surface. Florida-strain largemouth bass (FLMB), (*Micropterus salmoides floridanus)* in Diamond Valley Lake, California are vulnerable to barotrauma-related stress when caught, due to their consistent habitation in depths that result in barotrauma (9 to 27 meters; personal observations). Bass tournaments are held on Diamond Valley Lake (DVL) up to 85% of all weekends annually. The small size of the reservoir, large number of tournaments and the vulnerability of FLMB to barotrauma-related stress can potentially affect the fishery. Eight bass tournaments were sampled for the incidence of barotrauma-related symptoms and 36-hour delayed mortality rates of bass with and without physical signs of barotrauma, caught as part of catch-and-release fishing tournaments during winter. The 36-hour delayed mortality rates of manually deflated FLMB with barotrauma were determined to be significantly lower than those that were not deflated following capture in winter tournaments. Florida-strain bass caught in tournaments with physical symptoms of barotrauma were also more likely to die than those asymptomatic. Bass tournament organizations that manually deflate barotrauma afflicted FLMB by knowledgeable and qualified staff would reduce 36-hour mortalities.

Key words: barotrauma mortality, Diamond Valley Lake, California, largemouth bass tournaments, *Micropterus salmoides floridanus*

Largemouth bass angling in freshwater is a popular recreational and competitive activity that is growing in popularity, with many thousands of tournaments held in North American inland waters annually that target black bass, including Florida-strain largemouth bass (FLMB; *Micropterus salmoides floridanus*) (Schramm et al. 1991, Kerr and Kamke 2003). Of the 1.35 million freshwater anglers in California, 33% spent 6.69 million days pursuing black bass (U.S Fish and Wildlife Service 2013). Additionally, California Department of Fish and Wildlife (CDFW) issued 835 black bass tournament permit applications statewide in 1991, and that number increased to 1,989 in 2012 (Krogman 2013). Tournament angling is an important part of fishing activities (Schramm et al. 1991) and is most often associated with catch-and-release fishing. However, compared with non-competitive catch and release fishing, fish caught by tournament anglers may suffer higher mortality due to stressors applied during a tournament. These stressors include relocation, air exposure, extensive handling (Hartley and Moring 1995, Killen et al. 2003, Edwards et al. 2004), prolonged retention time (Neal and Lopez-Clayton 2001, Graeb et al. 2005), livewell anoxia or hypoxia (Carmichael et al. 1984, Furimsky et al. 2003), livewell crowding, weigh-in procedures (Suski et al. 2004), and barotrauma (Siepker et al. 2007).

Barotrauma can affect any fish brought out of deeper water to the surface (Wilde 2009), although physoclistous fish, including largemouth bass, are most often visibly affected due to the expansion of their gas bladder (Shasteen and Sheehan 1997, Gravel and Cooke 2008) and a consequential increase in partial pressure of dissolved gases that can form bubbles (i.e., emboli) within the fish's organs and fluids. Resulting emboli can form in the eyes, brain, heart, arteries, gills, spleen, fins, musculature, and skin beneath the scales (Feathers and Knable 1983, Parrish and Moffit 1993, Kerr 2001, Brown et al. 2007, Wilde 2009).

Physical signs resulting from barotrauma include a distended or ruptured gas bladder, abnormal swimming behavior, protruding eyes, protrusion of internal organs through the mouth, internal and external hemorrhaging, cloacal protrusions, and death (Feathers and Knable 1983, Kerr 2001, Gravel and Cooke 2008). The extent and severity of the physiological and physical symptoms of barotrauma increase with increased depth of capture (Feathers and Knable 1983, Gitschlag and Renaud 1994) beyond the minimum of 3.5 meters (Shasteen and Sheehan 1997).

Recognition of barotrauma as an important physiological consequence of catch-and-release bass tournaments is increasing. Bass caught and released during tournaments held on reservoirs where a majority of the bass population resides in deeper water are particularly vulnerable to barotrauma (Morrissey et al. 2005). Per the California Code of Regulations (Lee 1992a), bass tournaments in California must require that "all fish shall be returned to the water alive and in good condition." This requirement is successful only if released bass survive. Therefore, artificial deflation (deflation) of an overinflated gas bladder or deep water release (crating) is required by CDFW during tournaments as part of the conditions of a permit, and generally is promoted throughout California inland waters (Lee 1992b).

Crating is the lowering of barotrauma afflicted bass to be released with a weighted basket or clip attached to the fish to a depth (generally 30 feet or more) of re-acclimatization to regain neutral buoyancy. Deflation of an expanded gas bladder is accomplished by inserting a hypodermic needle into the gas bladder to release the excess pressure. Although the release of excess gas from an over-inflated gas bladder cannot rectify all decompression trauma, it can allow bass that are positively buoyant and suffering from barotrauma-associated stress the opportunity to swim to a depth of neutral buoyancy, and potentially increase survival (Lee 1992a, Keniry et al. 1996). Only nine U.S. states, and no Canadian

provinces, advocate deflation (Kerr 2001, Myers 2012). Further, deflation of bass caught in tournaments is likely discouraged in many states because insertion of a needle to relieve pressure can potentially miss the intended target and puncture other vital organs or vascular tissue. The ability of personnel applying technique is highly variable and, in some instances may actually increase mortality if not properly carried out. For these reasons, Wilde (2009) suggested that management agencies discourage or prohibit deflation techniques on fish exhibiting evidence of barotrauma. It is important to recognize that there may be substantial variation in response to angling induced stressors like barotrauma among various black bass species (Siepker et al. 2007) or, in this case, sub-species. Therefore, my objective was to determine barotrauma incidence of FLMB during winter tournaments (December–February) and if deflation by entities conducting tournaments is a meaningful requirement. Further, I describe the results of an assessment of barotrauma-related tournament mortality of FLMB from Diamond Valley Lake (DVL), a 1,983 ha reservoir in Riverside County, California.

METHODS

Study area.—Diamond Valley Lake is an off-stream storage reservoir built by Metropolitan Water District of Southern California, and is located 6.4 kilometers (km) southwest of Hemet in western Riverside County, California. The mean depth at full pool (elevation 535 m) is 61 m, 49 m at the East Dam, and 79 m at the West Dam. The lake has approximately 40 km of shoreline including the three dams. DVL is subjected to annual water level fluctuations of approximately 10 m, with the maximum drawdown to the emergency supply level at 27 m below full pool.

Diamond Valley Lake was selected due to the large number of tournaments and the number of FLMB caught from depths that result in symptoms of barotrauma. Tournaments are held on up to 85% of all weekends annually, with 63 contests held on DVL in 2011 and 52 contests held in 2012 (Krogman 2013). A large quantity of the bass caught, retained and brought in to be weighed at this reservoir are caught from depths from 9 to 18 m, as determined from interviews with participating anglers and from personal observations.

Methods.—Bass were collected at DVL during eight bass tournaments from December 2012 through February 2013, when bass within the reservoir are typically captured from the greatest depths and the risks of barotrauma and mortality are greatest. All tournaments during this period were subjected to a 3-fish bag limit per boat to reduce potential non-barotrauma-related stressors associated with tournaments, and to minimize mortality from untreated barotrauma. Bass were collected after the weigh-in process at a release-boat, where the bass were segregated by CDFW staff into (1) individuals showing external physical signs of barotrauma; (2) those not showing external physical signs of barotrauma; or (3) initial mortalities. Bass were held in an aerated, 500-l holding-tank filled with ambient lake water adjacent to the release boat. External physical signs of barotrauma were classified as (1) positive buoyancy or abnormal swimming; (2) external hemorrhaging; (3) bulging eyes; or (4) gas-bladder distention.

Dead or moribund bass brought to the release boat were evaluated for physical signs of barotrauma, recorded and set aside as initial mortalities. Moribund bass are those that underwent the weigh-in process and were deemed "alive" by tournament staff, which were beyond resuscitation. Half of the bass not exhibiting physical signs of barotrauma were measured, tallied, tagged with a blue Floy© anchor-tag below the second dorsal fin, recorded, and placed into a 1,000-l release tank equipped with 5,500 l/hr water inflow system

on the release boat. The other half not exhibiting external physical signs of barotrauma were measured, tallied, not tagged, recorded, and placed in the same release tank. Bass exhibiting external evidence of barotrauma were alternately segregated into two study groups (treatment [yellow anchor-tag] and control [red anchor-tag]), and marked accordingly. Fish in each of these groups were then measured, tallied, recorded, and placed into the same release tank after tagging. Tournament personnel treated bass with obvious signs of barotrauma by deflation (treatment group); no fish in the control group were treated. Surface water temperature was recorded the day of each tournament using a digital thermometer.

All live bass collected from each tournament were transferred to a mesh-covered floating net-pen (1.2-m x 1.2-m x 3.0-m deep, with 10 mm nylon mesh) for approximately 36 hours to assess delayed mortality. A 36-hr holding period was selected due to logistical constraints, and previous investigators (Schramm et al. 1987) reported that highest incidence of mortality was most likely to occur within 24 hours. The net-pen was tied to the lee side of a floating wave attenuator approximately 300 m from the boat-launching facility. Bass in the net-pen were checked for mortalities the following morning, and again 24 hrs. later. Dead bass were checked for the presence or absence of an anchor-tag. A dead bass without an anchor-tag was assumed to have died from a stressor independent of the application of the anchor tag or tournament handling. Mortality of bass marked with a blue anchor tag was assumed to be the result of a stressor independent of barotrauma, but possibly related to tagging or handling. Mortality of bass in the control group (red anchor-tag) was assumed to be the result of stressors associated with untreated barotrauma or untreatable barotrauma afflictions. Mortality of bass in the treatment group (yellow anchor-tag) was assumed to be the result of untreatable barotrauma afflictions or improper gas bladder deflation. All bass still alive and suitable for release following the second morning mortality check were released.

Statistical analysis.—I used Cochran-Mantel-Haenszel chi-squared tests for *k* strata, wherein each tournament represented a different stratum, and set α = 0.05. Similar to a general chi-squared test, this test detects differences between groups using 2x2 contingency tables (Hollander and Wolfe 1999). Differences in mortality were tested between (1) FLMB with and without physical signs of barotrauma; (2) artificially deflated-barotrauma and non-barotrauma FLMB; and (3) deflated and non-deflated barotrauma FLMB.

RESULTS

Reservoir surface water temperatures ranged from 14° to 17° C during tournament sampling. Bass (*n* = 655) were collected and examined for physical signs of barotrauma following eight bass tournaments held between December 2012 and February 2013. Of the total, 214 bass (33%) exhibited physical signs of barotrauma, 413 (63%) exhibited no apparent signs of barotrauma, and 28 (4%) were moribund. All moribund FLMB had severe symptoms of barotrauma, including bulging eyes or gas bladder distention. Tournament workers present at all eight tournaments deflated 107 (50%) of the 214 bass that exhibited signs of barotrauma. The other 107 FLMB exhibiting external signs of barotrauma received no treatment.

Thirty-four (34) of the 107 FLMB (32%) that were not deflated died, while 15 of the 107 FLMB (14%) that were deflated were mortalities. The mortality rates for the eight tournaments ranged from 25 to 56% for un-deflated fish and from 0 to 29% for those that were deflated (Figure 1). Mortality rates of FLMB without signs of barotrauma ranged from 0 to 14% ($\bar{x}$ = 2%, *s* = 3.88). Regardless if deflation treatment occurred, the mortality rate

of FLMB exhibiting symptoms of barotrauma, was significantly greater than that of FLMB exhibiting no signs of barotrauma ($P < 0.001$, 1 *df*, *MH* = -8.68). Furthermore, the mortality rate of deflated FLMB with barotrauma was still significantly greater than the mortality rate of FLMB without barotrauma ($P < 0.001$, 1 *df*, *MH* = -5.43). However, deflated FLMB with barotrauma displayed significantly lower mortality than un-deflated FLMB with barotrauma ($P = 0.001$, 1 *df*, *MH* = 3.06). Tagging did not have a significant effect on 36-hour mortality during this study ($P = 0.5$, 1 *df*, *MH* = 0.013).
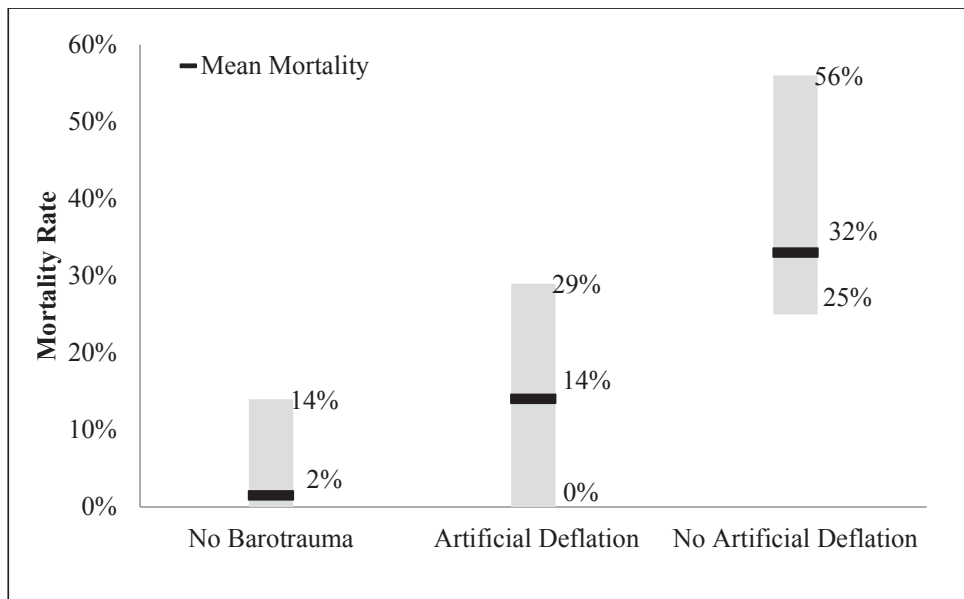

FIGURE 1.—Thirty-six hour delayed mortality rates of Florida-strain largemouth bass (*Micropterus salmoides floridanus*) caught during winter tournaments at Diamond Valley Lake, Riverside County, California, 2012–2013

DISCUSSION

This study evaluated winter (December – February) tournament mortality rate over 36 hours, comparing FLMB with physical signs of barotrauma and those without, and of bass exhibiting symptoms of barotrauma that undeerwent air bladder deflation and those that were not deflated. Other studies evaluating barotrauma on freshwater species have focused on yellow perch, (*Perca flavescens)* (Keniry et al. 1996), smallmouth bass, (*Micropterus dolomieu)* (Morrissey et al. 2005, Gravel and Cooke 2008), black crappie, (*Pomoxis nigromaculatus)* (Childress 1987), walleye, (*Sander vitreus)* (RL&L 1995, Talmage and Staples 2011), or largemouth bass, (*Micropterus salmoides)* (Feathers and Knable 1983, Lee 1992a, Shasteen and Sheehan 1997). The effects of barotrauma and deflation, specifically on FLMB in California reservoirs have not been evaluated. This study was conceived as a retult of the increased recognition of barotrauma as a significant issue affecting the survival of tournament caught fish and a lack of information on the incidence of barotrauma and associated mortality rates of FLMB occurring in DVL. These data are necessary to

recommend prudent and effective management measures to reduce the potential adverse impacts resulting from fish captured at barotrauma-inducing depths during tournaments.

Barotrauma is a factor affecting the condition and survival of black bass captured at depth and subsequently released, particularly during live-release angling tournaments (Morrissey et al. 2005, Siepker et al. 2007, Gravel and Cooke 2008). The FLMB population in DVL is particularly vulnerable to barotrauma-related tournament mortality due to the small size of the reservoir, large number of tournaments held annually, and the tendency of the FLMB to be captured from 9 to 27 m during winter. Tournaments occur at DVL on up to 85% of the weekends annually, and resulted in 3,836 FLMB reported caught in 2012. A FLMB population estimate conducted at DVL during 2012 ranged from ~5,971-8,199 ($\bar{x}$ =6,910, α=0.05; Schnabel estimate) tournament legal FLMB greater than 380 mm in length (California Department of Fish and Wildlife, unpublished data). The number reported caught represents a large portion of the available population (47–64%) within the lake. The number reported caught does not include fish caught and released during competitions prior to weigh-in (culling), fish captured by tournament anglers on non-tournament days (pre-fishing) or fish caught and released by non-tournament anglers.

External symptoms of barotrauma were evident in 27– 40% ($\bar{x}$ =34%) of all of the FLMB caught during this study. DVL water levels were high and relatively stable with abundant inundated woody habitat in the littoral zone during the study period. This could have kept more fish shallower than in prior years with lower water levels when shallow woody habitat was not as prevalent. Barwick (2004) reported higher bass abundance in littoral areas with coarse woody debris than other habitats. Abundant woody habitat in the littoral zone during this study could have resulted in barotrauma incidence at the low end of the range witnessed in other studies with smallmouth bass (29–66%; Morrissey et al. 2005), (32–76%; Gravel and Cooke 2008), and largemouth bass (34–68%; Myers 2012).

FLMB with barotrauma had a significantly higher mortality rate than those without barotrauma, regardless of deflation. However, deflation significantly reduced mortalities from >30% to ~15%. Consistent with other studies (Feathers and Knable 1983, Lee 1992a, Keniry et al. 1996, Shasteen and Sheehan 1997), my results demonstrated that deflating FLMB exhibiting signs of barotrauma can improve survival rate. Deflation of FLMB can significantly reduce mortality, but deflation cannot rectify the physiological effects other than an overinflated gas bladder. Morrissey et al. (2005) reported that deflation may provide some benefits to decompressed fish by allowing them to return to depth, but it would probably have little impact on any tissue damage that already had occurred. Virtually every organ in the body of a fish is affected by barotrauma and up to 70 different types of injuries have been documented (Feathers and Knable 1983, Rummer and Bennett 2005, Wilde 2009). Gas emboli, protruding eyes, protrusion of internal organs through the mouth, cloacal protrusions, and internal or external hemorrhaging cannot be addressed after the fact. Although the potential long-term survival of FLMB caught may have been reduced due to internal and physiological damage, the effects of which were not assessed in this study, and potentially explained why deflated bass still suffered higher mortality than non-barotrauma FLMB despite treatment.

This study evaluated only the 36-hour mortality rate, and it is possible that a percentage of bass that survived to be released did not survive. Mortality observed in this study was likely the result of relatively acute injuries resulting from barotrauma, severe tournament-related stress, errors in deflation technique, or all of the above. Mortality from severe injury or acute stressors should result in rapid death, whereas cumulative effects of

sub-lethal stressors are more likely to result in delayed mortality (Kwak and Henry 1995). Less acute barotrauma-induced mortality would likely occur beyond the 36-hour retention time of this study. The cumulative and interactive effects of sub-lethal stressors can eventually lead to death, even if the individual factor alone does not exceed physiological tolerances (Carmichael et al. 1984, Wedemeyer et al. 1990). Other investigators (Morrissey et al. 1995, Gravel and Cooke 2008) reported stress indicators (i.e. blood glucose and lactate levels) in post-mortem bass with barotrauma were significantly higher than fish with negligible barotrauma, and bass that survived with severe barotrauma had intermediate glucose or lactate levels. Coupling the potentially acute physiological effects of barotrauma with the stressors associated with tournaments, it becomes paramount that participants and organizers of tournaments are aware of the signs and conditions likely to cause, severe barotrauma, the increased risk of mortality, and institute proper care and handling to maximize the survival of fish collected and retained (Shasteen and Sheehan 1997).

Organizations conducting tournaments at DVL are required to have staff proficient in artificial deflation on hand at the release location as a condition of the requisite permit, although the level of expertise likely varies. Mortality rates of deflated FLMB ranged from 0 to 29% during the study period, and variability in proficiency likely contributed to the variation in mortality rate because success of deflation depends on the training and experience of the individual performing the procedure (Kerr 2001). Education and training directed at tournament organizations and participants concerning techniques to properly alleviate an over-inflated gas bladder also are needed. During this study, the most common potential error committed by tournament staff was the release of most — or all — of the air from the gas bladder, such that the fish became negatively buoyant. Another common potential error posing a risk to fish health and survival is the inability to consistently hit the gas bladder, thereby requiring repeated punctures resulting in possible damage to other vital organs. The method of depressurization could also affect the success of deflation. Some chose to go through the side of the fish, which allows a greater margin of error to find the gas bladder to release air. Texas Parks and Wildlife recommends anglers attempt deflation through the side within the first hour of capture (TPW Magazine 2011) to minimize potential error in missing the gas bladder. Though the side method may be preferred, the fish is typically kept out of the water, and often times flops itself onto the ground, further contributing to handling stress. A second technique is to puncture the air bladder through the mouth, a method that decreases the margin for error. Greater precision is required, but the fish can be restrained and held in the water, which can minimize additional handling stress. The bass can also be held vertically, thereby allowing air to escape when the fish is submerged after the bladder has been punctured. However, Myers (2012) reported that deflation through the mouth led to 14% lower survival than side-deflation.

My objective was to determine the incidence of barotrauma occurring during winter tournaments and if tournament staff were increasing survival at tournaments by deflating bass, per the conditions of their permit. It was not an objective to assign a deflation method to tournament staff fulfilling their permit requirement or evaluate between the different methods available to address barotrauma following weigh-in. Cumulatively, using either method showed improved survival of bass. Crating fish to a desired depth with barotrauma is an alternative to alleviate barotrauma and is not invasive; however, it was not utilized or evaluated in this study. Crating appears more logistically practical while anglers are on the water when individual fish need assistance to depths of re-acclimatization, rather than at the end of a tournament when numerous fish with barotrauma need to be addressed following weigh-in.

Water temperature taken the day of each tournament (14 – 17°C) did not affect mortality based on studies that reported consistently low mortality at temperatures ≤20°C (Bennett et al. 1989, Schramm et al. 1987). Further, Hartley and Moring (1995) reported no correlation between the numbers of fishes held in live cages and delayed mortality. Tranquilli and Childers (1982) reported minimal effect on mortality rates from tagging with Floy© anchor-tags, which was confirmed in this study. Therefore, confinement likely had no effect and tagging had no effect during this study. It is not known if any FLMB were treated for barotrauma by the competitors during the tournaments at DVL prior to weigh-in. Myers (2012) reported only 6–24% of participants treated their catch for barotrauma prior to weigh-in. In this study, the number of fish treated prior to weigh-in is likely comparable, as the primary objective of tournament anglers is to catch the biggest limit of bass possible in the limited amount of time allotted to do so. Time taken to address barotrauma-afflicted bass already captured and retained detracts from the tournament angler's primary objective of catching fish. However, it is also unknown if fish immediately treated for barotrauma following capture have lower mortality than fish that have barotrauma treatment addressed after weigh-in, and is an issue requiring further study.

Deflation of FLMB is most prudent on smaller waters with bass populations that experience large amounts of tournament fishing pressure such as DVL, which had ~47–64% of the estimated legal FLMB population (CDFW, unpublished data) reported caught during tournaments in 2012. Artificial deflation of barotraumatized FLMB can significantly reduce mortality rates of bass captured at depth from DVL, contributing support of CDFW's requirements for deflation of bass following a tournament. In addition to deflation, managing the number of tournaments could also be useful on waters with vulnerable FLMB populations by managing the opportunity for mortalities to occur on high-use, high-barotrauma incidence waters. Since mortalities associated with barotrauma are probably greatest during fishing tournaments in which fish are retained by anglers for some period of time, a shortened tournament duration (6 h; Lee 1992a) conducted when FLMB are in deeper water may reduce mortality. Also, because stress is cumulative in fish (Gravel and Cooke 2008), a reduced bag limit could minimize stress on all fish in the livewell resulting from confinement (Kwak and Henry 1995) and reduce stress associated with handling during weigh-in by shortening bagging time. Further study is needed to evaluate how immediate or delayed deflation, the two artificial deflation methods, shortened tournament duration, or a reduced bag limit affect FLMB barotrauma mortality to provide sound scientific recommendations to fisheries managers.

LITERATURE CITED

BARWICK, D. H. 2004. Species richness and centrarchid abundance in littoral habitats of three southern U.S. reservoirs. North American Journal of Fisheries Management. 25:76-81.

BENNETT, D. H., L. K. DUNSMOOR, R. L. ROHRER, AND B. E. RIEMAN. 1989. Mortality of tournament-caught largemouth and smallmouth in Idaho lakes and reservoirs. California Fish and Game. 75:20-26.

BROWN, R. S., T. J. CARLSON, A. E. WELCH, J. R. STEPHENSON, C. S. ABERNETHY, C. A. MCKINSTRY, AND M. H. THERIAULT. 2007. Assessment of barotrauma resulting from rapid decompression of depth-acclimated juvenile Chinook salmon bearing radio telemetry transmitters. Report PNNL-16790. Pacific Northwest National Laboratory, Richland, Washington, USA.

CARMICHAEL, G. J., J. R. TOMASSO, B. A. SIMCO, AND K. B. DAVIS. 1984. Confinement and water quality-induced stress in largemouth bass. Transactions of the American Fisheries Society 113:767-777.

CHILDRESS, W. M. 1987. Catch-and-release mortality of white and black crappie. Pages 175-198 in R. A. Barnhart and T. D. Roelofs, editors. Catch-and-release fishing: a decade of experience. Humboldt State University, Arcata, California, USA.

EDWARDS, G. P., R. M. NEUMANN, R. P. JACOBS, AND E. B. O'DONNELL. 2004. Factors related to mortality of black bass caught during small club tournaments in Connecticut. North American Journal of Fisheries Management 24:801-810.

FEATHERS, M. G., AND A. E. KNABLE. 1983. Effects of depressurization upon largemouth bass. North American Journal of Fisheries Management 3:86-90.

FURMINSKY, M. S., S. J. COOKE, C. D. SUSKI, Y. WANT, AND B. L. TUFTS. 2003. Respiratory and circulatory responses to hypoxia in largemouth bass and smallmouth bass: implications for "live-release" angling tournaments. Transactions of the American Fisheries Society 132:1065-1075.

GITCHSLAG, G. R., AND M. L. RENAUD. 1994. Field experiments on survival rates of caged and released red snapper. North American Journal of Fisheries Management 14:131-136.

GRAEB, B. D., J. L. SHEPARD, D. W. WILLIS, AND J. S. SORENSEN. 2005. Delayed mortality of tournament caught walleyes. North American Journal of Fisheries Management 25:251-255.

GRAVEL, M., AND S. J. COOKE. 2008. Severity of barotrauma influences the physiological status, post release behavior, and fate of tournament-caught smallmouth bass. North American Journal of Fisheries Management 28:607-617.

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

HOLLANDER, M., AND D. A. WOLFE. 1999. Nonparametric statistical methods. Second edition. Wiley and Sons, New York, USA.

KENIRY, M. J., W. A. BROFKA, W. H. HORNS, AND J. E. MARSDEN. 1996. Effects of decompression and puncturing the gas bladder on survival of tagged yellow perch. North American Journal of Fisheries Management 16:201-206.

KERR, S. J. 2001. A review of "fizzing" — a technique for swim bladder deflation. Ontario Ministry of Natural Resources, Fish and Wildlife Section, Peterborough, Ontario, Canada.

KERR, S. J., AND K. K. KAMKE. 2003. Competitive fishing in freshwaters of North America: a survey of Canadian and U.S. jurisdictions. Fisheries 28(3):26-31.

KILLEN, S. S., C. D. SUSKI, M. B. MORRISEY, P. DYMENT, M. FURMINSKY, AND B. L. TUFTS. 2003. Physiological responses of walleyes to live release angling tournaments. North American Journal of Fisheries Management 23:1238-1246.

KROGMAN, R. 2013. Summary report of black bass fishing contests held in California during 2012. Fisheries Branch, California Department of Fish and Wildlife, Sacramento, USA.

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

LEE, D. P. 1992a. Gas bladder deflation of depressurized largemouth bass. North American Journal of Fisheries Management 12:662-664.

LEE, D. P. 1992b. Releasing black bass caught from deep water. Inland Fisheries Informational Leaflet 14. California Department of Fish and Game, Sacramento, USA.

MORRISSEY, M. B., C. D. SUSKI, K. R. ESSELTINE, AND B. L. TUFTS. 2005. Incidence and physiological consequences of decompression in smallmouth bass after live-release angling tournaments. Transactions of the American Fisheries Society 134:1038-1047.

MYERS, R. 2012. Barotrauma in tournament largemouth bass and comparison of treatment methods at Amistad Reservoir, Texas. AFS 142nd Annual Meeting. American Fisheries Society, Bethesda, Maryland, USA.

NEAL, J. W., AND D. LOPEZ-CLAYTON. 2001. Mortality of largemouth bass during catch and release tournaments in a Puerto Rico reservoir. North American Journal of Fisheries Management. 21:834-842.

PARRISH, F. A., AND R. M. MOFFITT. 1993. Subsurface fish handling to limit decompression effects on deep-water species. Marine Fisheries Review 43:29-32.

RL&L ENVIRONMENTAL SERVIES LTD. 1995. Effects of swim bladder deflation ("fizzing") and depth of capture on walleye survival. Prepared for Alberta Fish and Wildlife Services. RL&L Report 408F, Edmonton, Alberta, Canada.

RUMMER, J. L., AND W. A. BENNETT. 2005. Physiological effects of swim bladder overexpansion and catastrophic decompression on red snapper. Transactions of the American Fisheries Society 134:1457-1470.

SCHRAMM, H. L. JR., P. J. HAYDT, AND K. M. PORTIER. 1987. Evaluation of prerelease, post release, and total mortality of largemouth bass caught during tournaments in two Florida lakes. North American Journal of Fisheries Management 7:394-402.

SCHRAMM, H. L. JR., M. L. ARMSTRONG, N. A. FUNICELLI, D. M. GREEN, D. P. LEE, R. E. MANNS JR., B. D. TAUBERT, AND S. J. WATERS. 1991. The status of competitive sport fishing in North America. Fisheries 16(3):4-12.

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

SIEPKER, M. J., K. G. OSTRAND, S. J. COOKE, D. P. PHILIPP, AND D. H. WAHL. 2007. A review of the effects of catch and release angling on black bass, *Micropterus* spp.: implications for conservation and management of populations. Fisheries Management and Ecology 14:91-101.

Suski, C. D., S. S. Killon, S. J. Cooke, J. D. Kiefer, 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.

Talmage, P. J., and D. S. Staples. 2011. Mortality of walleyes angled from deep waters of Rainy Lake, Minnesota. North American Journal of Fisheries Management 31:826-831.

TPW Magazine. Scientists test cures for overinflated bass [cited 2013 Nov 1]. Available from: http://www.tpwmagazine.com/archive/2011/aug/scout1_bassfizzing/

Tranquilli, J. A., and W. F. Childers. 1982. Growth and survival of largemouth bass tagged with Floy anchor tags. North American Journal of Fisheries Management 2:184-187.

U.S. Fish and Wildlife Service. 2013. 2011 national survey of fishing, hunting, and wildlife-associated recreation. US Department of the Interior and US Department of Commerce, Washington, D.C., USA.

Wedemeyer, G. A., B. A. Barton, and D. J. McLeay. 1990. Stress and acclimation. Pages 451-489 in C. B. Schreck and P. B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland, USA.

Wilde, G. R. 2009. Does venting promote survival of released fish? Fisheries 34 (1):20-28.