Population-level Impacts of Largemouth Bass Mortality Associated with Tournaments in a Texas Reservoir

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Abstract: Previous studies of tournament-related impacts on black bass (*Micropterus* spp.) have concluded that live-release tournaments have minor effects on fisheries. Prompted by a decline in numbers of largemouth bass (*M. salmoides*) ≥458 mm total length (TL) and a high ratio of tournament weighed-in fish to harvested fish by non-tournament anglers, we assessed the impacts of tournament angling at Amon G. Carter Reservoir, Texas (623 ha). In 2007, we tagged 786 largemouth bass and estimated fishing mortality separately for tournament and non-tournament anglers. Instantaneous total fishing mortality was estimated to be 0.14, with tournament mortality responsible for 65% of all angling-caused fish deaths. Our simulation model predicted abundance of largemouth bass ≥356 mm and ≥457 mm would increase by 6% and 9%, respectively, under a 50% reduction in tournament catch and by 13% and 20%, respectively, if there was no retention of tournament fish. Tournament angling impact on total fishing mortality and largemouth bass population abundance was greater at Amon G. Carter Reservoir than at previously investigated reservoirs.

Key Words: tagging study, exploitation, catch and release mortality, angling

Journal of the Southeastern Association of Fish and Wildlife Agencies 1:98–102

Numbers of competitive black bass (*Micropterus* spp.) angling events in the United States continue to rise (Kerr and Kamke 2003), and tournament angling can be an important component of many fisheries (Edwards et al. 2004, Dennis et al.2006, Driscoll et al. 2007). However, tournaments could potentially impact black bass populations (Hayes et al. 1995). Tournament-retained fish often experience greater mortality (0–98%; Wilde 1998, Neal and Lopez-Clayton 2001) than fish immediately released after capture (<15%; Pelzman 1978, Hayes et al. 1995). Despite widespread distribution of and interest in black bass tournament angling there have been a few studies evaluating population-level effects of tournament-associated mortality. These studies have shown negligible impacts (Kwak and Henry 1995, Neal and Lopez-Clayton 2001, Allen et al. 2004, Edwards et al. 2004, Driscoll et al. 2007), but none of them quantified what the population response would have been with lower tournament mortality.

Changing angling behavior has resulted in tournament mortality becoming a more important component of total fishing mortality. Allen et al. (2008a) estimated that largemouth bass (*Micropterus salmoides*) fishing mortality declined from 0.35 over 1976–1989 to 0.18 over 1990–2003, and catch-and-release angling was implicated as the cause (Myers et al. 2008). The magnitude that tournament mortality affects total fishing mortality is a function of tournament mortality rate which is largely influenced by water temperature (Wilde 1998), proportion of total catch subjected to tournament weigh-in processes, and catch release mortality (Allen et al. 2004).

Allen et al. (2004) determined the ratio of tournament weighed-in fish to harvested fish by non-tournament anglers was useful in judging the potential impact of tournaments and suggested that ratios exceeding 3.0 warranted more detailed study. Ratios for most Texas reservoirs have generally been below 3.0 (unpublished data, Texas Parks and Wildlife Department, TPWD). However, ratios varied from 19.0 in 2003 to 4.6 in 2006 at Amon G. Carter Reservoir, a 623-ha popular tournament fishery located near Dallas-Fort Worth, Texas (unpublished data, TPWD). Routine population surveys at the reservoir indicated a decrease of largemouth bass ≥458 mm total length (TL) since 1995. Objectives of this study were to quantify the current impacts of tournament mortality on the largemouth bass population in Amon G. Carter Reservoir and model population responses to lower tournament mortality.

Methods

From October 2007 to November 2007, a total of 786 largemouth bass was collected throughout Amon G. Carter Reservoir, Texas, using a boat-mounted electrofishing unit. All fish were double-tagged with sequentially-numbered T-Bar tags following the methods of Guy et al. (1996). Following the methods of Driscoll et al. (2007), a portion (47%) of the tagged fish were less than minimum length limit (≥356 mm TL) to account for sub-legal length fish recruiting to legal-harvestable size during the study period. Tagged fish minimum length (305 mm TL) was determined as the length recruiting to legal-harvestable size at the study mid-point (six months) from a von Bertalanffy growth curve fitted to mean length-at-age data. The proportion of sub-legal fish to tag was set to approximate total annual mortality (0.53) estimated from catch-curve analysis.

To estimate the number of tagged fish captured by all anglers, a stratified random roving creel survey (Malvestuto 1996) was conducted a total of 72 days (40 weekend and 32 week days) from 1 December 2007 to 30 November 2008. Sample days and start times were selected randomly within day type strata using equal probabilities. The entire reservoir was surveyed each sample day. Sampling duration varied seasonally (5 h in winter and fall and 6 h in spring and summer) so that sampling occurred during approximately half of the available daylight. All anglers encountered were interviewed to determine directed angling effort, tournament or non-tournament angler, and number of fish possessed and released. Tournament anglers were additionally asked if released fish were legal-size or not. All largemouth bass found in possession of interviewed anglers were visually inspected by the creel clerk for presence or absence of tags and measured for TL (25.4-mm group).

Because tag retention has been shown to vary greatly (4%–78%, Wilbur and Duchrow 1972; Ager 1978; Tranquilli and Childers 1982; Keefer and Wilson 1993), tag loss was estimated using the logistic model by Miranda et al. (2002). Anglers voluntarily reporting catches of tagged fish were queried for tag numbers and date of catch and number of tags present. Similarly, creel clerks recorded the actual number of tags observed per retained fish along with date of catch.

Prior to estimating total number of tagged fish caught during the study period, the number of tagged fish observed during creel interviews was adjusted for tag loss as described by Miranda et al. (2002). Standard creel analysis procedures as described by Malvestuto (1996) were used in conjunction with the adjusted tagged fish observation data to estimate total number of tagged fish harvested by non-tournament anglers, total number of fish retained by tournament anglers, total number of legal-length fish released immediately after capture, and angling effort.

All symbols used in this manuscript are defined in Table 1, and methods similar to those of Allen et al. (2004) and Driscoll et al. (2007) were used to determine relative contributions of angler harvest, tournament mortality, and catch and release mortality to total fishing mortality. We used instantaneous mortality rate estimates instead of empirical rate estimates to facilitate use of the age-structure model described below. Simulation combinations were conducted using the instantaneous fishing mortality rate (F_h) estimated from this study, and also F_h+1 SE to account for variability associated to our estimate of F_h similar to Driscoll et al. (2007) to represent worst-case harvest mortality. Tournament mortality rates for black bass vary widely due to water temperature (Wilde 1998), thus simulations were conducted across a range of tournament mortality rates (0.0–0.5). Simulations were conducted at two levels (0.05 and 0.10) of catch and release mortality (CR) reported for largemouth bass by Muoneke and Childress (1994). We assumed that all sources of fishing mortality (harvest, tournament, and catch and release) were additive, but that some fish caught by each mortality source would not be available for another source (Kokoska and Nevison 1989). Total lengths of largemouth bass tagged, tournament-retained, and harvested were compared using Kolmogorov-Smirnov (KS) two-sample tests. Comparisons were made to determine if anglers selected for different size fish than the tagged fish sample and if size differences existed between tournament-retained fish and fish harvested by non-tournament anglers.

We used a modified version of an age-structured model formulated by Allen et al. (2008b) to predict changes in largemouth bass population size structure and abundance given hypothetical 25%, 50%, 75%, and 100% reductions in the number of fish retained by tournament anglers. Maximum theoretical length and growth coefficient obtained from the von Bertalanffy model (526 mm and 0.306, respectively) were used in the model, and we assumed an instantaneous natural mortality rate of 0.4 as per Allen et al. (2008a). We modeled the current regulation of a 356-mm minimum length

Table 1. Equations used to determine the total instantaneous fishing mortality rate at Amon G. Carter Reservoir, Texas, from 1 December 2007 to 30 November 2008.

Equations	Variable descriptions
$F_h = -\log_e(1 - TFC/TF)$	Fh = instantaneous fishing mortality due to harvest TFC = estimated number of tagged fish harvested by non-tournament anglers TF = total number of tagged fish
$N = H/F_h$	N = largemouth bass population size of legal length before harvest H = total number of fish harvested by non-tournament anglers
$F_{to} = -\log_e(1 - TDEATHS/N)$	F_{to} = instantaneous fishing mortality due to tournament mortality
$TDEATHS = TCR * TM$	TDEATHS = estimated number of tournament-retained fish that died as a result of tournament mortality TCR = number of tournament-retained fish weighed-in TM = tournament mortality rate (0.0 to 0.5, by 0.1 intervals)
$F_{to} = -\log_e(1 - TDEATHS/N)$	F_{to} = instantaneous fishing mortality due to tournament mortality
$F_{cr} = -\log_e(1 - RDEATHS/N)$	F_{cr} = instantaneous fishing mortality due to catch-and-release
$F = F_h + F_{to} + F_{cr}$	F = the total instantaneous fishing mortality rate

limit, and used the fishing mortality estimates obtained from this study in the model. We used the model to simulate how much the adult population abundance would change if tournament catch was reduced by each hypothetical value. Thus, the model was used to predict the effects of lower tournament catches, via a regulation, on the total F and fish abundance.

Results

A total of 43 tagged fish were found in possession of anglers during creel interviews. Anglers reported catching an additional 129 tagged fish. Of these 172 total fish for which tag loss information was obtained, 77 contained only one tag. The logistic model revealed a significant relationship between days-at-large and single tag loss (Wald $X^2 = 6.36$, $P = 0.012$, c = 0.611). At 183 days following completion of tagging (mid-point of the study), the predicted probability of losing one tag and both tags was 0.433 and 0.189, respectively.

After adjusting for tag loss, the number of tagged fish observed during creel interviews retained by tournament and non-tournament anglers is detailed in Table 2. Of the 786 tagged fish, 43% were retained by tournament anglers; in comparison, only 4% were harvested by non-tournament anglers. Annual angling effort directed specifically for largemouth bass was estimated to be 12,504 h (SE = 2269) for tournament anglers and 9007 h (SE = 1333) for non-tournament anglers.

Tournament mortality (F_{to}) was responsible for the majority of largemouth bass F and exceeded the contributions of F_h and F_{cr} for all simulation combinations except when TM was <20% (Figure 1). At F_h of 0.038, CR of 0.05, and TM rates ranging from 0.10 to 0.5, F_{to} comprised 40% to 78% of F. F_h was computed to be 0.294 when one SE (171) was added to the non-tournament angler fish harvest estimate (TFC), At this much higher F_h, F_{to} similarly accounted for a majority of F (42%–93%). The higher CR mortality rate of 0.1 also had minimal effect at both F_h estimates on the relative importance of F_{to}, with F_{to} accounting for 36%–92% of F. At the average reported TM of 0.283 (range = 0.00 to 0.52; Wilde 1998), CR = 0.05, and our estimate of F_h (0.038), F was estimated at 0.140, with F_{to} responsible for 65% of all angling-related fish deaths. At this same TM and CR scenario, catch–and-release angling ($F_{cr} = 0.011$) and harvest by non-tournament anglers ($F_h = 0.038$) accounted for 8% and 27% of all angling-related fish deaths, respectively. Thus, our results showed that tournament mortality was the primary source of fishing mortality in this system, followed by harvest, then catch and release angling.

Tournament anglers did not select for larger largemouth bass relative to the tagged fish population sample. The lengths of tournament retained fish ≥356 mm ($n = 230$ $x = 377$ mm TL) were similar to the lengths of tagged fish ≥356 mm ($n = 417$ $x = 382$ mm TL; asymptotic KS statistic = 0.567, $P = 0.904$). Size structure comparisons involving fish harvested by non-tournament anglers were not conducted because of insufficient sample size ($n = 18$ fish).

The age-structured model predicted that largemouth bass F would decrease and abundance of fish ≥356 mm and ≥457 mm would increase if tournament catch were reduced. The magnitude of changes in F and fish abundance increased with tournament catch reduction, but also was disproportionate because other

Table 2. The number of tagged largemouth bass observed retained by tournament anglers and non-tournament anglers during creel interviews and the number of observed tagged fish corrected for tag loss at Amon G. Carter Reservoir, Texas, from 1 December 2007 to 30 November 2008. Also derived from creel surveys and shown by angler type is the estimated total number of tagged fish retained, total number of fish retained, and total number of legal-length fish (≥356 mm total length) caught and immediately released. Standard errors are in parenthesis.

Parameter	Tournament	Non-tournament
Number of tagged fish observed	39	4
Corrected number of tagged fish observed	49	5
Estimated number of tagged fish retained	340 (273)	29 (171)
Estimated total number of fish retained	2590 (927)	312 (412)
Estimated number of legal-length fish caught and released	446 (192)	1434 (491)

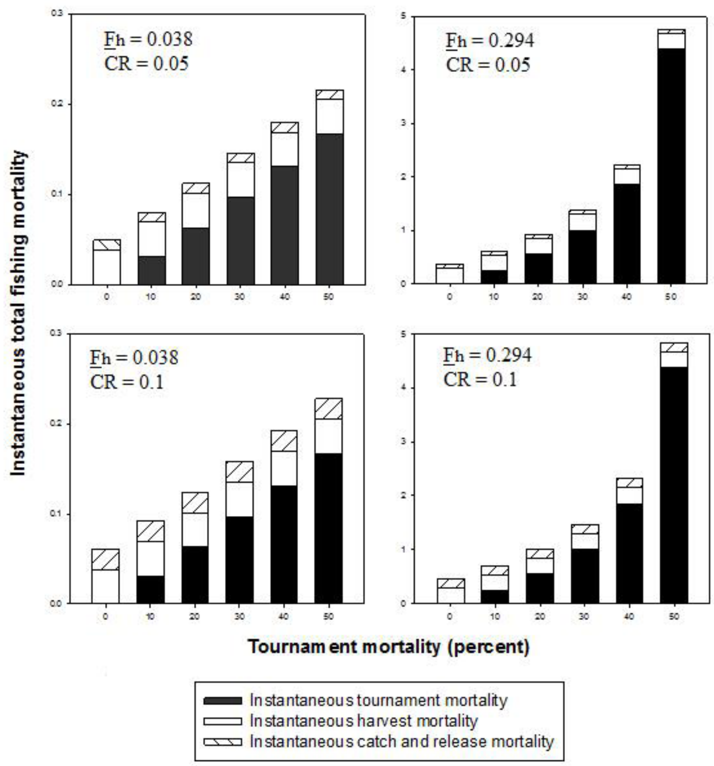

Figure 1. Contribution of instantaneous tournament mortality, harvest mortality, and catch and release mortality to total instantaneous fishing mortality for largemouth bass at Amon G. Carter Reservoir, Texas. Simulations were conducted using tournament mortality rates ranging from 0 to 50%, two levels of catch and release mortality (CR), and two levels of instantaneous harvest mortality (F_h).

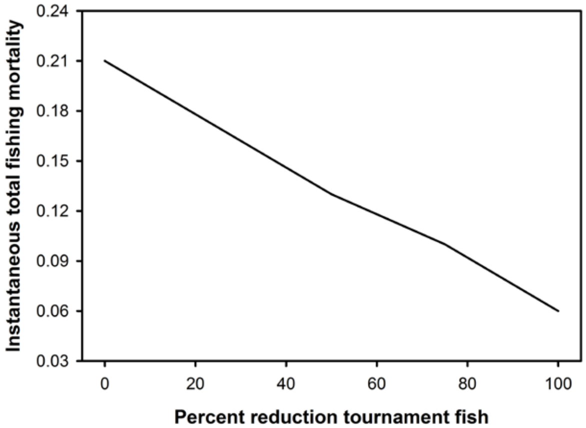

Figure 2. Predicted effect of reduction in tournament-retained largemouth bass on total instantaneous fishing mortality at Amon G. Carter Reservoir, Texas.

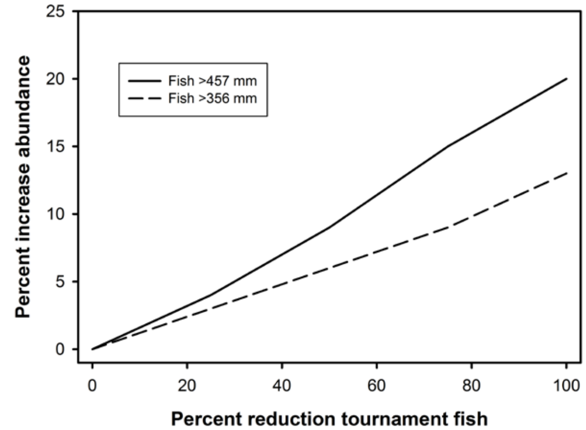

Figure 3. Predicted effect of reduction in tournament-retained largemouth bass on population abundance at Amon G. Carter Reservoir, Texas.

sources of fishing mortality (harvest and catch and release) would be unaffected by reductions in tournament angler catch. Given average TM (0.283) and CR of 0.05, a tournament catch reduction of 50% would lower F by 34% from 0.140 to 0.091 (Figure 2). Under the scenario of zero tournament catch (100% reduction), F was predicted to decrease by 66% to 0.047. With tournament catch reductions of 25% and 75%, F was predicted to be 0.106 and 0.067, respectively, with a decrease of 24% and 52%, respectively. Abundance of fish ≥356 mm and ≥457 mm would increase by 6% and 9%, respectively, under a 50% reduction in tournament catch (Figure 3).

Discussion

Based on population modeling, retention of high numbers of fish by tournament anglers impacted abundance of largemouth bass in Amon G. Carter Reservoir. Abundance of fish ≥356 mm and ≥457 mm were predicted to increase by 6% and 9%, respectively, under a 50% reduction in tournament catch and by 13% and 20%, respectively, if there was no retention of tournament fish. Although F_{to} represented the majority of F, F was relatively low and similar to average F reported by Allen et al. (2008a). Population implications would have been greater at Amon G. Carter Reservoir had F been higher. Nevertheless, tournament angling impacted population abundance.

Reservoir size and the amount of tournament pressure likely influences the effects of tournament mortality. Tournament mortality has little effect on the largemouth bass population in Sam Rayburn Reservoir, Texas (43,356 ha), where annual tournament angling effort was only 3.2 h ha^{-1}, compared to 17.1 h ha^{-1} at the much smaller Amon G. Carter Reservoir (623 ha). Therefore, tournament angling pressure was five times greater on the smaller largemouth bass population at Amon G. Carter Reservoir. Based on our findings, there is a greater chance of tournament effects when tournament angling pressure is high.

Tournament angling has been shown to disproportionately affect large fish abundance (Meals and Miranda 1994, Weathers and Newman 1997). However, the size-distribution of largemouth bass caught by tournament anglers was similar to that of the tagged fish population at Amon G. Carter Reservoir. Reductions in tournament catch were predicted to provide a proportionally greater increase in abundance of largemouth bass >457 mm than fish >356 mm. In previous studies tournament mortality accounted for a smaller fraction of total angling mortality and had minimal or no detectable impact to largemouth bass populations (Kwak and Henry 1995, Neal and Lopez-Clayton 2001, Edwards et al. 2004, Driscoll et al. 2007). Tournament mortality was a greater proportion of total largemouth bass fishing mortality at Amon G. Carter Reservoir than at previously studied systems.

Potential strategies to increase abundance of largemouth bass and reduce tournament impacts could include the prohibition of largemouth bass tournaments, restriction of the number of tournaments, seasonal prohibition of tournaments, implementation of more restrictive size limits, reduction of the daily bag limit, and improved weigh-in protocols to increase survival. Benefits of more restrictive regulations would include a reduction in F and an increase in the abundance of legal-sized largemouth bass. Managers may opt to institute no minimum length limit with a five fish daily bag where only two fish <457 mm TL may be harvested or consider a 356 to 457-mm slot limit with a five fish daily bag limit. Either regulation would serve to protect largemouth bass by reducing F, resulting in an increase in the abundance of fish >356 mm (Figure 3, Beard et al. 2003). Alternatively, tournament-impacted largemouth bass populations may improve under existing harvest regulations if some tournament anglers occasionally changed their venue to other waters, thereby reducing tournament angling pressure (Parkinson et al. 2004).

Understanding angler attitudes and opinions regarding potential management actions has become an increasingly important component of fisheries management (Parkinson et al. 2004, Allen et al. 2013, Van Poorten et al. 2013). Generally anglers expect more and bigger fish in trade for more restrictive regulations. In this study we identified the magnitude of increase in population abundance in response to a decreased tournament catch. This measurable information would be beneficial to both managers and anglers in considering strategies that could improve largemouth bass fisheries.

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