Post-tournament Largemouth Bass Mortality Associated with a Release Tube Compared to Other Release Methods

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Abstract: At Amistad Reservoir, Texas, the National Park Service (NPS) built a 46-m long release tube for convenient return of tournament-caught largemouth bass (*Micropterus salmoides*) to the reservoir following weigh-in. Several members of the public raised concerns to NPS that use of the tube might have been leading to increased tournament-associated mortality. We simulated two largemouth bass tournaments in August 2006 and March 2007 using volunteer anglers to compare six-day delayed mortality between fish returned to the reservoir via the tube and other methods. In summer, delayed mortality averaged 56% for boat-ramp hand-released fish, significantly lower than for fish released via the tube with chlorinated tap water running through it (89%). Initial mortality in the spring trial was 5%, significantly lower than in the summer trial (14%). In spring, delayed mortality was low across treatments (<12%), and did not differ significantly between treatments. We could not conclude that the release tube was primarily responsible for higher mortality, because chlorinated water used in conjunction with the release tube could have contributed to increased fish stress. The season in which a tournament is held seems to have more importance than use or non-use of the Amistad bass release tube in minimizing tournament-associated mortality. We recommend to the National Park Service that the use of the tube with chlorinated water be limited, especially in warm-weather months.

Key words: tournament, mortality, release tube, largemouth bass, Amistad

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Amistad Reservoir, Texas, has recently become one of the most popular largemouth bass (*Micropterus salmoides*) fisheries in the United States. Texas Parks and Wildlife Department (TPWD) creel surveys estimated largemouth bass fishing effort to be 199,087 h in spring 2007, and 266,419 h in 2003. In 2006, Entertainment Sports Programming Network (ESPN) labeled the reservoir as "the best largemouth bass lake in the country." Seven nationally-televised largemouth bass tournaments were held at the reservoir in 2007. Because much of the increase in angling effort has been attributable to bass tournaments and because tournament mortality can negatively impact largemouth bass fisheries (Allen et al. 2004), minimizing mortality of tournament-caught fish is of high priority to stakeholder groups.

To minimize tournament mortality, it is necessary to identify factors that contribute to mortality rate. Wilde (1998) found that water temperature is the most influential factor in determining post-tournament mortality rates. Fish handling during and after a tournament is also an important factor in determining post-tournament mortality rates (Kwak and Henry 1995). At Amistad Reservoir, controversy exists around the use of a release tube constructed by the National Park Service (NPS) for rapid and convenient return of tournament-caught bass to the reservoir following weigh-in. The fish release tube is located at a tournament weigh-in pavilion at Diablo East, the reservoir's most popular boat launching site, on the south shore 19.3 km from Del Rio, Texas. The tube is constructed of 20-cm diameter PVC pipe and is 46 m long, with an elevation drop of 9 m (average slope 11.5 degrees) from the inlet at the weigh-in pavilion to the outlet at the lake. Fish are oriented head-first when placed into the tube, and it takes between 10 and 15 seconds for fish to travel down the complete length of the tube. Water from a 7.6-cm diameter hose is pumped down the tube. Prior to March 2007, a potable (i.e. chlorinated) water supply was used as the water source, and the fish were sent down a 91-cm-long dry tube attached to the top of the main tube at a 45-degree angle; the fish were not in contact with water until they entered the main tube. As of March 2007, lake water is used in the tube during weigh-ins, and the top of the tube is modified to allow the fish to be placed more quickly in the water flowing down the tube.

Anglers and tournament directors were concerned that use of the release tube may contribute to greater delayed mortality because of additional trauma to the fish compared to other methods of returning fish to the reservoir. Our study objective was to compare six-day delayed mortality of tournament-caught largemouth bass returned

to Amistad Reservoir via the release tube to six-day delayed mortality of fish returned to the reservoir by other methods.

Methods

Lake Amistad is a 25,570-ha impoundment on the Rio Grande River in Val Verde County in south Texas. It was constructed in 1964 by the International Boundary Water Commission for irrigation and hydroelectric power generation for Mexico and the United States. The reservoir is characterized by steep bluffs, rocky substrate, clear water, and abundant aquatic vegetation (primarily *Hydrilla* sp.); it has a maximum depth of 66 m and experiences dramatic water level fluctuations. The NPS manages the cultural, biological, and recreational resources around the reservoir and controls access to the reservoir via nine boat launching sites.

We simulated two largemouth bass tournaments using volunteer anglers from TPWD and NPS to compare tournament-associated mortality between fish returned to the reservoir via the tube and other methods. The first simulated tournament was a two-day event and was held in August 2006 when surface water temperature was 26 C. The second tournament, a one-day event, was held in March 2007 when water temperature was 18 C. The tournaments were designed to simulate medium-sized (20–30 boats) bass club tournaments. Most anglers fished out of bass fishing-style boats with built-in aerated live wells. In the boats without built-in aerated live wells, anglers used ice chests with aerators. Anglers were encouraged to use a commercially available live well formula to decrease fish stress and were allowed to cull fish to increase their total stringer weight. Teams with single live wells were limited to 5 largemouth bass >35.5 cm and teams with double live wells were allowed 10 bass. Fishing began approximately 30 minutes before sunrise and ended between 7.5 and 8.5 h later.

For both trials, fish observed to be dead at the weigh-in were used in computing initial mortality (described below). Control fish collected with pulsed DC electrofishers were used in the same (5.5 x 5.5 m across x 10 m deep) holding pens with the treatment fish to account for holding pen-induced mortality. We also placed five control fish in each pen three days before the tournament, and checked for presence of these fish for the following three days by hauling the nets to the surface, to ensure that the pens did not allow fish to escape. We placed 10 largemouth bass >35.5 cm in each holding pen about 4 h after the day-1 weigh-in for the summer evaluation and about 16 h before the spring weigh-in. Electrofishing-induced mortality of control fish was assumed to be near zero (Bardygula-Nonn et al. 1995).

We checked the holding pens for dead fish each of six days following the mock tournaments. All fish found floating dead were removed, identified by fin clip and pen number, and measured for total length (TL). On day 6, all fish were removed from each pen, separated by treatment, and determined if live or dead. Initial, delayed (six days), and total mortality estimates were made according to Wilde et al. (2003), with total mortality inclusive of initial and delayed mortality. We used chi-square tests to compare delayed mortality rates between treatments, separately by trial. We also looked at the possible relationship between fish size and mortality rate by comparing mean TL of surviving fish to mean TL of dead fish after six days with a two-sample *t*-test ($P \leq 0.05$).

Summer 2006

For the summer evaluation, we compared delayed mortality of fish released via the tube with a chlorinated water supply (CTR) to delayed mortality of fish released by carrying to the boat ramp in lake-water-filled bags (BR1). Twenty-three teams participated on day one. Teams were randomly-assigned to one treatment or the other before the tournament. Fish were kept in boat live wells until arrival at the weigh-in pavilion, about 400 m from the launching ramp. Once at the weigh-in facility, anglers removed their fish from live wells and placed them in lake-water-filled bags to wait in line for weighing. After weighing, each team either released their fish down the tube into a 2- x 1- x 1-m holding net attached to the end of the tube in the water, or returned their fish to the boat ramp in water-filled bags where helpers were available to place fish into an identical holding net attached to a courtesy dock. When approximately 30 fish accumulated in the temporary holding nets, they were removed with dip nets and transported approximately 400 m in a boat-mounted aerated hauling tank to an adjacent cove where the three cylindrical holding pens were located. We used scissors to clip a designated fin on each fish for treatment discrimination and placed them randomly into one of the three holding pens. Eight fish were found to have over-inflated air bladders at weigh-in; to follow the common practice of tournament organizers, we used a large hypodermic needle to partially deflate the air bladders of these fish immediately prior to stocking them into the large holding pens.

All 34 fish that underwent the CTR treatment on day one of the summer trial were incorrectly marked; the fin clipped was the same for CTR fish and the first batch of control fish, making the groups indistinguishable. These fish were excluded from the study and subsequent analysis. We held another mock tournament on the following day to replace the CTR treatment fish; 13 of the 23 original teams fished again on day two. Procedures were followed as on day one, except all fish were release via the tube. The number of fish placed in each pen from each treatment ranged from 14 to 18.

Spring 2007

After the summer 2006 experiment was completed, we discovered that the tube's water supply was chlorinated. This led us to plan a follow-up study which would include the investigation of chlorine effects on the tube-released bass. Also, local community members had raised the idea of building an on-the-water weigh-in facility. In spring 2007 delayed mortality of tournament-caught fish was compared among four release methods: 1) tube release using chlorinated water treated with live well formula (described below; TCT), 2) tube release using lake water treated with the same formula (LTR), 3) carrying fish to the boat ramp in water-filled bags (BR2), and 4) on-the-water weigh-in (OWW). Thirty teams fished in the spring tournament, with each team randomly assigned to one of the four treatments.

Slightly different protocol was followed for the tube-released fish in the spring experiment to more closely simulate a real tournament—before we released fish down the tube, we held them in 640-L observation tanks for 2–10 min and then partially deflated the air bladders of fish that seemed over-inflated. Chlorinated water was used in the temporary holding tank and in the tube for the TCT treatment and lake water was used in the tank and tube for the LTR treatment. Because tournament organizers commonly use livewell formula in the temporary holding tanks, we added a popular, commercially available livewell formula (labeled to remove chlorine, calm fish, reduce weight loss, replace slime coat, and help heal hook wounds) at the manufacturer's recommended rate in temporary holding tanks for both tube treatments.

Chlorine concentration was measured three times in the potable water supply to get an average baseline concentration. To assess effectiveness of the livewell formula, chlorine in the temporary holding tank was measured three times following addition of the formula. Also, chlorine was measured in the lake water where the tube emptied into the reservoir.

For the OWW treatment at weigh-in time, anglers tied their boats to the courtesy dock at the launching ramp and, when prompted, carried their fish in water-filled bags to the scales on the dock for weighing. Following weighing, fish were fin-clipped and placed into a temporary holding net located in the lake adjacent to the dock. Fish were subsequently transported to the holding pens as described above. The number of fish placed in each pen for each release method treatment ranged from 10 to 12.

We conducted an additional experiment to evaluate external physical damage to fish caused by the release tube. Existing injuries of 10 largemouth bass > 35.5 cm collected by electrofishing were made readily observable using flourescein and ultra-violet light. Individual fish were dipped in a flourescein mixture for 10 min and placed under ultra-violet light, and then digitally photographed to document existing injuries. After fish were released down the tube, we re-evaluated external injuries on each fish. Post-tube treatment images were compared to pre-treatment images for each of the 10 fish to assess extent of external physical injury caused by use of the tube.

Results

Participants in the summer mock tournament brought 154 largemouth bass, ranging from 33.8 to 57.9 cm TL, to the weigh-in. Of those, 21 fish were determined to be dead at time of weigh-in, yielding an initial mortality rate of 14%. Delayed mortality averaged 56% for BR1 fish, which was significantly lower than for CTR fish (89%; $\chi^2 = 12.3$, $P < 0.001$; Table 1). After adjusting for holding pen-induced mortality and initial mortality, total mortality was estimated to be 32% for BR1 fish and 64% for CTR fish (Table 1).

The spring mock tournament yielded 139 bass ranging from 34.3 to 60.7 cm TL. Initial mortality in the spring trial was 5%, significantly lower than in the summer trial (14%, $\chi^2 = 6.25$, $P = 0.012$). Delayed mortality was low across treatments (Table 1), and did not differ significantly between treatments ($\chi^2 = 5.94$, $P = 0.114$). After adjusting for holding-pen-induced mortality (3%) and initial mortality, total mortality was estimated to be zero for BR2 fish, zero for TCT fish, 9% for LTR fish, and 2% for OWW fish (Table 1).

Total mortality was unrelated to fish size for the summer trial but was related to fish size for the spring trial. In summer, mean TL for surviving fish (41.91 cm, $n = 26$) and dead fish (41.89 cm, $n = 68$) was similar ($t = 0.32$, $P = 0.752$); in spring, mean TL was sig-

Table 1. Initial, delayed (six-day), and total mortality of largemouth bass caught in two mock tournaments (August 2006 and March 2007) and released by different methods at Amistad Reservoir, Texas. The BR1 and BR2 bass were returned to the reservoir via lake-water-filled weigh-in bags, CTR bass were returned via a 46-m long release tube using chlorinated water, TCT bass were returned via the release tube using chlorinated water treated with live well formula, LTR bass were returned via the release tube using lake water treated with livewell formula, and OWW bass were returned at an on-the-water-weigh-in station.

			Mortality rate (%)					
Trial	Treatment	*n*	Initial	Pen 1	Pen 2	Pen 3	Delayed[a]	Total[b]
Summer	BR1	54	14	63	50	56	56	32
	CTR	44	12	87	100	79	89	64
	Control	30	–	27	38	0	22	–
Spring	BR2	36	0	0	8	0	3	0
	TCT	31	6	0	0	0	0	0
	LTR	34	3	9	18	8.	12	9
	OWW	31	11	9	0	0	3	2
	Control	30	–	0	0	10	3	–

a. Average of all three holding pens

b. Includes initial (bass brought dead to weigh-in) and delayed mortality, adjusted for control bass (collected by electrofishing) mortality

nificantly greater for surviving fish (41.15 cm, $n = 126$) than dead fish (36.32 cm, $n = 6$), but sample size was very small.

The chlorine level in the potable water supply at the time of the study averaged 0.16 mg/L. Water contained in the temporary holding tank had an average chlorine level of 0.02 mg/L following treatment with livewell formula at the recommended rate. Immediately after the TCT treatment in the spring trial, chlorine level averaged 0.05 mg/L at the tube outlet in the reservoir.

Few external physical injuries were identified on fish as a result of being returned to the reservoir via the release tube. Comparison of the pre- and post-release photographic images of fish suggested only minor scraping on the head and eyes for 3 of 10 fish.

Discussion

In the summer trial, delayed mortality of tournament-caught largemouth bass was significantly greater for fish returned to the reservoir via the tube compared to fish manually returned to the reservoir in water-filled weigh-in bags. However, we could not conclude that the release tube was primarily responsible for higher mortality, because chlorinated water used in conjunction with the release tube could have contributed to increased fish stress. Any detectable amount of chlorine is undesirable for fish, with 0.003 mg/L considered to be the maximum tolerable limit for continuous exposure in aquaculture (USEPA 1973). Although chlorine exposure time was short (10–15 seconds) and only occurred when fish traveled down the tube, the chlorine level to which they were exposed was high (>0.1 mg/L, the potable water standard).

Delayed mortality is caused by the additive effects of a number of stressors, injuries, and disease (Pelletier et al. 2007); fish begin to die when a stress threshold level is reached. Multiple stressors existed in our experiments, including catch-associated factors (hooking, fish fatigue from playing, etc), high water temperature in summer, confinement in live wells, handling, confinement in weigh-in bags, chlorine exposure, and tube release. Because chlorine exposure was a confounding factor in our CTR treatment, we could not attribute increased delayed mortality to the release tube alone. Nevertheless, we found that use of the release tube in conjunction with chlorinated water during summer resulted in twice the delayed mortality compared to bass that were not exposed to the tube and chlorinated water.

In the spring trial, when water temperature was lower, delayed mortality was low and unrelated to release method. However, it is important to note that the addition of livewell formula into the temporary holding tank did not reduce the chlorine level below the maximum tolerable limit for fish. So, short-term exposure (<20 min) to this level of chlorine when water temperature is <18 C does not seem to increase delayed mortality.

Several factors such as tournament size (Schramm et al. 1985, 1987; Hartley and Mooring 1995), livewell conditions (Plumb et al. 1988, Kwak and Henry 1995, Gilliland 1997), and tournament procedures (Kwak and Henry 1995, Weathers and Newman 1997) have been shown to affect tournament-associated mortality of largemouth bass, but water temperature is likely the most influential factor (Wilde 1998). Our study results were consistent with Wilde's (1998) study which found low delayed mortality at cooler water temperatures. Also, summer total mortality level in our study (32%–64%) was similar to summer mortality reported previously by Wilde et al. (2002) for Amistad Reservoir before the release tube was constructed (47%–65%). The higher mortality rate of control fish in summer was also likely due to environmental stress compounded by higher water temperatures.

Tournament-associated mortality has the potential to negatively impact largemouth bass populations (Allen et al. 2004); however, seasonal differences in tournament activity should be considered when assessing population-level implications. At Amistad Reservoir, tournament activity is disproportional by season. In 2006, the number of fish weighed-in at tournaments in the summer months (June–September) represented 21% of the annual total number of weighed-in fish (unpublished tournament permit data, National Park Service). Potential impacts from tournament-associated mortality could be minimized by further encouraging organizations to schedule tournaments before June and after September when water temperatures are cooler and tournament-associated mortality is lower.

Tournament-associated mortality at Amistad Reservoir could be further minimized through improvements to the weigh-in facilities and educating anglers and tournament directors about fish care. The change from a chlorinated water supply to a lake water supply will eliminate the possibility of mortality due to chlorine exposure in temporary holding tanks or in the reservoir at the release tube outlet. We also encourage the NPS to discuss with tournament organizers the importance of expediting weigh-ins to minimize weigh-in lines and the duration that fish are confined in weigh-in bags. Tufts et al. (date unknown) estimated dissolved oxygen levels in weigh-in bags dropped to stressful levels in 4.5 min at 24 C when containing 7.7 kg of bass, and Schramm and Heidinger (1988) found dissolved oxygen levels in weigh-in bags dropped to stressful levels in 2 min at 30 C when the bags contained only 4.5 kg of bass. An on-the-water weigh-in, like the one in our spring trial, is one possibility to reduce or eliminate weigh-in lines.

The release tube alone did not appear to increase tournament-associated mortality. Very few injuries were visible on fish that we observed after tube release in our injury study, and total mortal-

ity was not higher for tube-released fish in the spring tournament. However, we did not measure non-visible stress indicators that might have been present, such as elevated plasma cortisol levels (Suski et al. 2003). Additionally, the method used for our injury study is experimental, and has not been proven effective for this type of study.

Season in which a tournament is held seems to have more importance than use or non-use of the Amistad bass release tube in minimizing tournament-associated mortality. If a tournament is held during relatively hot weather, taking extra care with the fish by avoiding exposure to potable water and returning the weighed fish to the lakeshore in bags, rather than using the release tube, will probably benefit the individual fish and potentially the bass population as a whole. Future research on tournament bass release methods should address these unanswered questions 1) does tube release increase mortality in summer if non-chlorinated water is used, and 2) would on-the-water weigh-in change mortality rates in summer?

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