Effects of Bait Type and Hooking Location on Post-release Mortality of Largemouth Bass

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Abstract: We compared post-release mortality of largemouth bass *(Micropterus salmoides)* caught with treble hook lures, soft plastic worms, and live common carp *(Cyprinus carpio)*. Also, we evaluated relations between mortality, bait type, anatomical hooking location, bleeding occurrence, and fish total length (TL). Thirty fish were caught with each bait type during each of 2 angling events conducted at Lake Umphrey, Texas, during August 1995, tagged and held for 72 hours in a cage located in the lake. Mortality ranged from 13% to 33% across bait types and angling events and was not related to bait type for fish caught during either angling event. However, hooking location was related to mortality and bait type. Throat-hooked fish experienced greater mortality (48%) than fish hooked in the gill (17%) and mouth (20%). Fish caught with plastic worms were more likely to be hooked in the throat than fish caught with the other bait types. Bleeding occurrence was related to mortality and hooking location, but not bait type. Fifty percent of bleeding fish died, whereas 20% of fish not bleeding died. Bleeding was more frequent for fish hooked in the throat (48%) and gill (50%) than for fish hooked in the mouth (1%). Probability of mortality of fish caught with treble hook lures decreased as fish TL (mm) increased. For fish caught with the other bait types, a relationship between fish TL and mortality was not detected. Results of our study suggest that a bait type restriction probably would not result in an overall decrease in largemouth bass post-release mortality because differences in mortality were not significant across bait types.

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Low mortality of released fish is fundamental to the success of catch and release angling (Muoneke and Childress 1994). In a review of studies concerning tournament-associated mortality of largemouth bass, Wilde (1998) reported that delayed mortality ranged from 0% to 52% during the 1990s. High post-release mortality may limit the effectiveness of largemouth bass harvest restrictions (Muoneke and Childress 1994) and could potentially effect population size when coinciding with high angler catch rate.

Studies have been conducted to evaluate the effect of gear and bait type on post-release mortality of black basses *(Micropterus spp.)*. Pelzman (1978) reported that juvenile largemouth bass hooked in the esophageal area experienced higher post-release mortality (56%) than fish hooked in other locations (2–4%) and noted that the majority of deep-hooked fish were caught with small natural baits (worms and salmon eggs). Likewise for smallmouth bass *(M. dolomieui)*, the use of live bait has been associated with higher post-release mortality (Clapp and Clark 1989). In contrast, Rutledge and Pritchard (1977) reported that largemouth bass caught with artificial and natural baits (types not specified) experienced similar mortality.

The use of live bait for largemouth bass angling has been controversial at some waters, especially those where highly restrictive harvest regulations and quality fisheries exist. Some Lake Fork Reservoir, Texas, anglers contend that the use of live baits such as waterdogs *(Ambystoma tiginum)*, shad *(Dorosoma spp.)*, and golden shiners *(Notemigonus crysoleucas)* results in deeper hooking than artificial baits, thus greater post-release mortality (K. Pratas, Texas Parks and Wildl. Dep., pers. commun.).

Additional information concerning the relations between largemouth bass post-release mortality, bait type, and anatomical hooking location may better enable managers to address angler concerns about the use of live bait and predict the likelihood of success of bait and gear type restrictions for reducing largemouth bass post-release mortality. Our primary study objective was to compare post-release mortality of largemouth bass caught with treble hook lures, plastic worms, and live common carp. Also, we explored relations between mortality, bait type, anatomical hooking location, occurrence of bleeding, and fish TL.

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Methods

Largemouth bass angling was conducted on 1 and 28 August 1995 at Lake Umphrey (18 ha), a private East Texas reservoir. Each day, 4 teams of 2 anglers initiated angling at daylight. For each angling event, each team of anglers was randomly assigned (by drawing) a bait type to use. Bait types were: 1) similar size treble hook lures (7 g Rebel Pop-R, 7 g Rat-L-Trap, and 14 g Bomber 7A), 2) plastic worms (178 mm) fished "Carolina rigged" with a single 3/0 hook, 3) live common carp (51–127 mm TL) hooked in the mouth with a 3/0 single hook fished under a float, and 4) similar size common carp hooked in the mouth fished on a weighted line without a float. Live common carp fished with and without a float were treated as separate bait types. During each angling event, 30 largemouth bass ≥356 mm TL were caught with each bait type. Surface water temperature was recorded at the conclusion of each angling event.

For each captured fish, anglers recorded bait type used, TL (mm), hooking location, occurrence of bleeding, and if the hook was left embedded in the fish. Captured fish were tagged with individually numbered, size 3 Monel tags (Natl. Band and Tag Company, Newport, Ky.) clamped to the opercle. Fish hooked in the lip, tongue, roof of mouth, and jaw areas were designated as hooked in the gill. Fish hooked in the area behind the tongue or in the esophagus were designated as hooked in the throat. Fish hooked in multiple hooking locations were classified as hooked in the presumably most severe hook location (e.g., fish hooked in both the mouth and gill were designated as hooked in the gill). Fish were inspected prior to removal of hook(s) for occurrence of bleeding. Hooks were removed from fish caught with treble hook lures, whereas hook removal was optional for deeply hooked fish (in the esophagus and throat region) caught using baits with a single hook. Because cutting the line and leaving the hook embedded in throat-hooked fish is a common practice, anglers in our study were given this option if they presumed hook extraction would affect survival by causing additional tissue damage. Fish were retained in a boat-mounted water-filled aerated live wells (15 minutes maximum) until transfer to a 4.5-m diameter by 6.1-m deep floating cage constructed of 19-mm mesh nylon net material anchored in the lake. Fish observed to be dead at the time of transfer from angler's boats to the holding cage were not placed in the cage. All fish placed in the cage were removed 72 hours after the conclusion of each angling event with tag numbers recorded for dead individuals.

For combinations of the variables (e.g., post-release mortality by bait type, bait type by hooking location, etc.), contingency tables were tabulated to obtain the frequencies of occurrence in the various categories of one variable associated with the frequencies of occurrence in the various categories of a second variable. We used chi-square (χ^2) goodness of fit tests (Sall et al. 1996, Zar 1999) to determine if the frequencies of occurrence in the various categories of one variable were independent of the frequencies of occurrence in the second variable. The relationship between post-release mortality and bait type was evaluated for each angling event separately, whereas the data from both angling events were pooled to evaluate the other relationships. Logistic regression (Sall et al. 1996) was used to evaluate the relation between TL and post-release mortality for fish caught on each bait type. Statistical significance was declared at $P \leq 0.05$.

Results

Largemouth bass angling occurred for 4.6 hours during the first angling event and 5.4 hours during the second event. Surface water temperature at Lake Umphrey was 31.1 and 32.8 C at the conclusion of the first and second angling events, respectively. Three fish caught during each angling event were dead at the time of transfer from angler's boats to the holding cage. In all, 22 of 120 fish (18%) captured during the first angling event and 31 of 120 (26%) captured during the second angling event were dead at 72 hours after the conclusion of the angling. Total post-release mortality was 22%.

Across all bait types, post-release mortality of largemouth bass caught during the first and second angling event ranged from 10% to 33% and from 23% to 33%, respectively (Table 1). Mortality was not significantly related to bait type for fish

Table 1. Summary of largemouth bass post-release mortality for fish caught with 4 bait types during 2 angling events at Lake Umphrey, Texas, in August 1995. After capture, fish were held for 72 hours in a cage anchored in the lake to estimate mortality.

Parameter	Treble hook lures	Plastic worms	Common carp with float	Common carp without float
First angling event				
Total fish caught	30	30	30	30
N fish dead	4	10	5	3
Mortality (%)	13	33	17	10
Second angling event				
Total fish caught	30	30	30	30
N fish dead	7	7	10	7
Mortality (%)	23	23	33	23

caught during the first angling event (χ^2=6.24; df=3; P=0.10) or the second (χ^2 =1.11; df=3; P=0.77). Also, mortality was not significantly related to bait type category (live or artificial) for fish caught during the first angling event (χ^2=2.00; df =1; P=0.157) and the second (χ^2=0.39; df=1; P=0.532). Mortality of fish caught with live baits (common carp with or without a float) and artificial baits (plastic worms and treble hook lures) during the first angling event was 13% and 23% respectively. Mortality of fish caught during the second angling event with live baits and artificial baits was 28% and 23%, respectively.

With the data pooled, 192, 12, and 21 largemouth bass were hooked in the mouth, gill, and throat, respectively (Table 2). One fish caught with a treble hook lure was hooked in the belly, and hooking location was not recorded for 14 fish caught with live common carp fished with a float. Only data for fish hooked in the mouth, gill, or throat were used for assessments of relationships involving hooking location. Hooking location was significantly related to post-release mortality (χ^2=8.31; df =2; P=0.016) and bait type (χ^2=22.77; df=6; P=0.001). Mortality of fish hooked in the throat (48%) was greater than mortality of fish hooked in the gill (17%) and mouth (20%). Although the majority of fish caught on each bait type were hooked in the mouth (>80%), the percentage of fish hooked in the gill and throat varied across

Table 2. Number of largemouth bass caught for each hooking location for fish caught with various bait types from Lake Umphrey, Texas, in August 1995. Number of fish that were found dead after being held in a cage for approximately 72 hours after capture is shown in parentheses.

Bait type	*N* total fish	*N* fish mouth-hooked	*N* fish gill-hooked	*N* fish throat-hooked
Treble hook lures	59	49 (9)	8 (1)	2 (1)
Plastic worms	60	49 (12)	0 (0)	11 (5)
Common carp with float	46	44 (11)	0 (0)	2 (2)
Common carp without float	60	50 (7)	4 (1)	6 (2)
All bait types	225	192 (39)	12 (2)	21 (10)

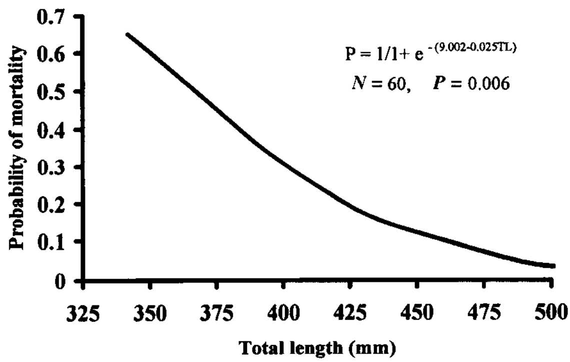

Figure 1. Logistic regression curve describing the relationship between fish total length and probability of post-release mortality of largemouth bass caught with treble hook lures from Lake Umphrey, Texas, during August 1995. Fish were held for approximately 72 hours after capture in a cage located in the lake to estimate mortality.

bait types. The percentage of throat-hooked fish was greatest (18%) for individuals caught with a plastic worm and the percentage of gill-hooked fish was greatest (14%) for individuals caught with treble hook lures.

Bleeding occurrence was significantly related to largemouth bass post-release mortality (χ^2=7.67; df=1; P=0.006) and hooking location (χ^2=86.61; df=2; P =0.001), but not bait type (χ^2=3.37; df=3; P=0.338). of the 240 fish captured, 19 individuals were observed bleeding. Nine of the 19 bleeding fish (47%) died, whereas 44 of the 221 individuals (20%) not bleeding died. Bleeding was more frequently observed for fish hooked in the throat (48%) and gill (50%) than for fish hooked in the mouth (1%). The percentage of fish bleeding ranged from 3% to 13% across bait types.

Anglers left embedded hooks in 16 of 21 throat-hooked largemouth bass. Eight (50%) of these fish and 2 of the 5 (40%) throat-hooked fish from which the hook had been removed were dead after 72 hours. Insufficient sample size precluded a statistical assessment of the relationship between mortality and hook removal.

Post-release mortality of largemouth bass was significantly related to fish TL for individuals caught with treble hook lures (logistic regression; P=0.006). Probability of mortality decreased as fish TL increased (Fig. 1). Fish TL of individuals caught with plastic worms, common carp with a float, and common carp without a float was not significantly related to post-release mortality (logistic regression; P=0.78, 0.71, and 0.19, respectively). Low sample size precluded an assessment of the relationship between fish TL and hooking location for fish caught with each bait type.

Discussion

Results of our study indicated that largemouth bass post-release mortality was independent of bait type. Fish caught with treble hook lures, plastic worms, common carp with a float, and common carp without a float experienced similar mortality. However, our findings suggest that bait type may be indirectly related to mortality via an interaction with hooking location. We detected a significant relationship between mortality and hooking location and between hooking location and bait type. Thus, on a large scale or with an increased sample size, a significant direct relationship between mortality and bait type may exist. Nevertheless, our findings indicated that potential differences in post-release mortality across bait types were not considerable. Further, we found no conclusive evidence to suggest that fish caught with live bait experienced higher post-release mortality than fish caught with artificial baits. Although common carp are not extensively used for largemouth bass angling, they have a similar body shape to the popularly used golden shiners and probably are representative of other fish species used as live bait for largemouth bass angling.

Factors such as bait shape and size, hook type and size, position of hook point, and angling style are variable across bait types, can be variable within bait types, and may effect hooking location, and in turn, post-release mortality of largemouth bass. We found that fish caught with plastic worms were more likely to be hooked in the throat than fish caught with the other bait types and that throat-hooked fish experienced greater mortality relative to fish hooked in the mouth and gill. Because of their slim shape and unexposed hook point, plastic worms may be inhaled deeper than a treble hook lure. The high number of exposed points and less streamlined shape of treble hook lures may result in hooking nearer the mouth opening. The amount of time anglers allow for between strike detection and hook-set is generally greater for live bait and plastic worms than treble hook lures. Thus, the greater the hesitation before hook-set, presumably the deeper a bait could be engulfed. Pelzman (1978) noted from autopsies of throat-hooked largemouth bass that when the hook was ventrally embedded it cut through the esophagus rupturing the heart. Although the practice of cutting the line and leaving the hook embedded in a fish's throat is common, its use may not result in increased survival of released fish, especially when the hook point has penetrated the ventral surface of the esophagus and vital organs are damaged. Because of hook differences (size, shape, and number of points), depth of penetration and probability of organ damage is likely greater for bait types having a single hook (plastic worms and live bait) than treble hook lures. Although throat hooking did result in greater mortality in our study, mortality also did occur for fish hooked in the mouth, presumably, the least severe hooking location. Thus, fish hooking, playing, landing, and hook removal contribute substantially to post-release mortality (Wilde 1998).

We found that probability of mortality decreased as fish TL increased for fish caught with treble hook lures, but not for fish caught with the other 3 bait types. Similarly, Wilde (1998) reported that delayed mortality of largemouth bass caught during tournaments on presumably various artificial bait types was negatively correlated with fish TL. Additional studies are needed to gain an increased understanding of the relations between bait type, fish TL, and post-release mortality.

Results of our study indicated that largemouth bass caught with treble-hook lures, plastic worms, and live common carp did not experience considerably different rates of post-release mortality. Therefore, prohibiting the use of any of these bait types probably would not result in a decrease in overall post-release mortality dramatic enough to have an impact on population size.

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