Hooking Mortality of Striped Bass in Lake Texoma, Texas–Oklahoma

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Abstract: We investigated mortality of striped bass (*Morone saxatilis*) within a length range of 229–762 mm total length (TL), caught with artificial lures with a single hook, artificial lures with treble hook(s), and live bait with a single hook. Striped bass (N = 307) were caught during a 2-year period in Lake Texoma starting June 1989 and concluding June 1991. Captured fish were measured, fin-punched for identification, and transported to a net pen in the lake and held 72 hours. Overall, hooking mortality was 38%. Hooking mortality was significantly ($P < 0.05$) related to length, season, and bait type. There was a direct relationship between fish length and hooking mortality, and a predictive model for hooking mortality was developed. Hooking mortality was higher in spring (69%) and summer (47%) than in fall (8%) and winter (13%). Hooking mortality (58%) was significantly higher when live bait was used.

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Striped bass were stocked into Lake Texoma by the Oklahoma Department of Wildlife Conservation (ODWC) from 1965 to 1974 (Harper and Namminga 1986). Natural reproduction, first confirmed in 1973, has occurred annually (Mauck 1991). From 1987 through 1990 an estimated 371,000 to 648,000 anglers visited the reservoir annually, during which time the annual harvest of striped bass ranged from 630,000 to 970,000 fish. Striped bass is the most popular sport fish in Lake Texoma, accounting for 61% to 72% of the angling pressure (Mauck 1991).

Striped bass regulations in Lake Texoma have changed in response to changes in the size and structure of the striped bass population. Beginning 1 September 1967, there was a 1-fish/day bag limit. On 1 September 1977, the regulation changed to 3 fish/day, followed by a change to 5 fish/day on 1 January 1980, and increased again on 1 September 1982 to 15 fish/day, only 5 of which could be ≥508 mm total length

(TL). The current harvest regulation was implemented 1 September 1989 and allows 15 fish/day, only 1 of which can be ≥508 mm. The current regulation was implemented to provide protection for large fish, while encouraging exploitation of abundant small fish.

While the special regulation on Lake Texoma requires the release of fish ≥508 mm, the Texas statewide striped bass harvest regulation (minimum 457 mm TL and 5 fish/day) requires release of all fish <457 mm. A major concern with restrictive harvest regulations is the fate of the released fish. Hooking mortality studies on freshwater fishes have primarily dealt with salmonids (Horak and Klein 1967, Wydoski et al. 1976, Hulbert and Engstrom-Heg 1980, Dotson 1982), centrarchids (Moody 1974, Seidensticker 1974, Rutledge and Pritchard 1977, Pelzman 1978, Green et al. 1987, Lee 1987, Childress 1989*a,* Hubbard and Miranda 1989), and walleye *Stizostedion vitreum* (Fletcher 1987, Parks and Kraai 1991). Childress (1989*b*) studied hooking mortality of striped bass caught during February and June regardless of bait used. Harrell (1987) also researched striped bass hooking mortality, but he limited the study to fish <508 mm. The objective of this study was to determine total and seasonal hooking mortality of striped bass released after being caught with single-hook artificial lures, treble-hook artificial lures, and single hook baited with live fish. Differences in hooking mortality of striped bass ≥508 mm TL versus those <508 mm and those ≥457 mm versus <457 mm were also determined.

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Methods

The study was conducted at Lake Texoma, a 36,018-ha impoundment of the Red River on the Texas–Oklahoma border. The reservoir was constructed by the U.S. Army Corps of Engineers in 1944 and is located 120 km north of the Dallas–Fort Worth metroplex. Striped bass were collected by angling from 21 June 1989 through 20 June 1991. Quarters consisted of summer (21 Jun–22 Sep), fall (23 Sep–21 Dec), winter (22 Dec–19 Mar), and spring (20 Mar–20 Jun). Terminal tackle included single-hook lures, treble-hook lures, and single hook baited with live fish. Each bait type was used at least once each season.

Angling was conducted during daylight hours in areas of the reservoir holding concentrations of fish. These areas were determined ahead of time from marina and tackle store operators, fishing guides, and our experience. Each fish was caught, dip-netted into the boat, and the hook was carefully removed. If the hook was ingested or deeply imbedded in the buccal cavity, the leader was cut to leave the hook embedded as suggested by Hulbert and Engstrom-Heg (1980). Each fish was measured to the nearest 25.4-mm TL length-group (229-mm = 229–253 mm, 254-mm = 254–279 mm, etc.), fin punched for later identification, and released immediately either into a short-term (<6 hours) holding tank mounted on a deck boat or into a short-term holding pen secured alongside the boat. The holding tank was a 1.3-m diameter circular galvanized metal tank, equipped with a flow-through pipe, and a recirculating water pump and spray bar. The holding pen, 1.2 m wide x 1.8 m long x 1.2 m deep, was constructed of 13-mm bar mesh nylon netting. At the end of each fishing day or when 10 fish were caught, the deck boat proceeded to a protected site, where 2 circular net pens were moored for long-term holding. The pens, with a diameter of 5.5 m and a depth of 10 m, were constructed of 13-mm bar mesh nylon netting. Captured fish that survived short-term holding were transferred from short-term to long-term holding facilities with a dip net. A minimum of 1 fish and a maximum of 17 fish per long-term net pen were used for an experiment. All fish in the long-term holding pens were held 72 hours. Each pen was inventoried for dead and live fish at the end of each long-term holding period. Mortality was expressed as total mortality, the sum of short- and long-term mortalities.

The GLIM statistical package (Numerical Algorithms Group 1986) was used to fit a generalized linear model (McCullagh and Nelder 1989, Agresti 1990) in which mortality was modeled as a function of fish length, season, and bait type. Mortality was modeled as a binomial variate (dead, live) with a logit transformation. We first fit a saturated model (main effects and all interactions), and then re-fit the model by sequentially deleting individual terms. Only those terms which explained a significant ($P < 0.05$) portion of the variance in mortality were retained.

Results and Discussion

Although 14% of captured striped bass died within 6 hours (short-term holding) of capture, overall striped bass hooking mortality was 38%. However, mortality varied with fish length, season, and bait type (Table 1). In combination, these factors and their 2-way interactions explained 34% of the total variation in hooking mortality (Table 2). The large residual variation (66%) in hooking mortality is primarily a result of the binomial nature of mortality: individual fish either survived or died. However, other factors not included in our study design, such as playing time (Wydoski et al. 1976) and handling (Dotson 1982), might also explain significant portions of the residual variation in mortality. Possible effects of depth of capture (Hubbard and Miranda 1989) and water temperature (Wydoski 1977, Lee 1987) on hooking mortality, although not explicitly included in our analyses, are incorporated by our seasonal factor.

There was a direct relationship between length (mm) and hooking mortality:

$$\text{Mortality rate} = \frac{e^{-2.642 + (0.0049 \times \text{length})}}{1 + e^{-2.642 + (0.0049 \times \text{length})}}.$$

Although length alone accounted for only 4% of the variation in hooking mortality, this relationship can be used to estimate mortality for various length

Table 1. Mortality of striped bass 72 hours post-capture by angling, Lake Texoma, Texas–Oklahoma, June 1989 through June 1991. Sample sizes in parentheses.

Bait/ Fish length	% Mortality				
	Spring	Summer	Fall	Winter	Overall
Bait					
Artificial					
Treble hook	76.2	31.9	5.6	0.0	32.3
	(21)	(47)	(18)	(13)	(99)
Artificial					
Single hook	50.0	33.3	0.0	0.0	15.7
	(2)	(36)	(35)	(10)	(83)
Live bait					
Single hook	66.7	66.1	23.8	44.4	57.6
	(36)	(59)	(21)	(9)	(125)
Fish length					
≥508 mm	94.1	60.0	16.7	0.0	56.4
	(17)	(45)	(6)	(10)	(78)
<508 mm	59.5	40.2	7.4	18.2	33.3
	(42)	(97)	(68)	(22)	(229)
≥457 mm	86.1	56.3	12.5	6.3	53.0
	(36)	(64)	(16)	(16)	(132)
<457 mm	43.5	38.5	6.9	18.8	28.5
	(23)	(78)	(58)	(16)	(175)
Seasonal overall	69.5	46.5	8.1	12.5	38.1
	(59)	(142)	(74)	(32)	(307)

Table 2. Factors explaining a significant portion ($P < 0.05$) of the variation in striped bass hooking mortality; chi-square (X^2), degrees of freedom (df), and level of significance are presented for each factor.

Parameter	X^2	df	P	Variance explained (%)[a]
Fish length	15.02	1	<0.0001	3.68
Season	63.68	3	<0.0001	15.61
Bait type	19.33	2	<0.0001	4.74
Fish length and season	18.19	3	<0.0001	4.46
Fish length and bait	9.66	2	<0.01	2.37
Season and bait	13.66	6	<0.05	3.35
Total model[b]	139.54	17		34.20
Error	268.53	289		

[a]Percentage of the variation in hooking mortality explained by each factor.
[b]Includes all terms and their 2-way interactions.

classes of striped bass (Fig. 1). The greatest discrepancies between predicted and observed mortality occurred for length classes with small sample sizes; in particular, the 229-mm and 254-mm length classes had sample sizes of 4 and 3, respectively, and sample sizes for the 660-mm and 737-mm length classes were 3 and 1, respectively. Predicted mortality was ≤20% in the 229-mm and 254-mm length classes and increased to 74% for the 737-mm length class; this represents a 350% increase in hooking mortality over this range in length. This relationship also suggests striped bass <457 mm, the current statewide minimum length, would, on average, incur no greater than 37% hooking mortality. Striped bass ≥508 mm, for which there is a 1-fish daily bag limit on Lake Texoma, would be expected to experience at least 47% hooking mortality.

Hooking mortality for all length classes of striped bass was greater in spring (69%) and summer (47%) than in fall (8%) and winter (13%) (Table 1). Harrell (1987) and Childress (1989*b*) reported similar seasonal trends. We found seasonal differences to be significantly related to length (significant length-season interaction term in Table 2) for 2 reasons. First, during spring through fall, mortality was greater in larger than in smaller striped bass (Table 1); however, this pattern was reversed during winter. Childress (1989*b*) also reported significantly higher hooking mortality in smaller (<457 mm) striped bass during the winter; however, he found no significant difference in hooking mortality of small (<457 mm) versus large (≥457 mm) striped bass during the summer. Second, our results indicated seasonal differences in mortality were greater in larger than in smaller striped bass (Table 1).

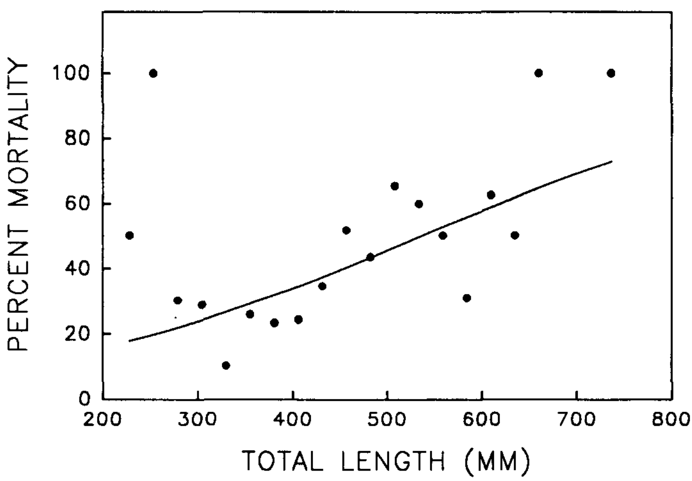

Figure 1. Relationship (predictive model) between hooking mortality and total length in striped bass, Lake Texoma, Texas–Oklahoma, 1989–1991. Solid circles summarize observations for a given length class (229-mm = 229–253 mm, 254-mm = 254–279mm, etc.); sample sizes for individual length classes ranged from 1 to 37.

Results for the <457 and <508 mm length classes were generally similar, except during spring, when striped bass <457 mm experienced 43% mortality, and striped bass <508 mm experienced 59% mortality. Harrell (1987) reported only 19% hooking mortality among striped bass <508 mm caught during the spring.

Striped bass hooking mortality varied significantly among bait types (Table 2); overall mortality was greatest for striped bass captured with live bait on a single hook (58%), followed by artificial lures with treble hook(s) (32%) and artificial lures with a single hook (16%) (Table 1). Higher hooking mortality for many species is associated with live or natural baits versus artificial baits (Wydoski 1977, Payer et al. 1987, Weidlein 1987, Clapp and Clark 1989); however, Harrell (1987) failed to find such differences with striped bass. Our results show the effects of bait type varied with striped bass length (significant length-bait interaction term, Table 2). There was a non-significant, positive relationship between length and hooking mortality for striped bass captured with artificial lures (with single or treble hooks); however, there was no apparent relationship between length and hooking mortality for striped bass captured with live baits. Bait effects were not consistent in magnitude across seasons (significant interaction term, Table 2). In spring, the greatest mortality was associated with treble hooks (76%) and live baits (67%). Greatest hooking mortality in summer was associated with live baits (66%), followed by artificial lures with single (33%) and treble hooks (32%). In fall and winter, hooking mortality was greatest for fish captured with live baits (24% and 44%, respectively), whereas mortality for striped bass captured on artificial lures was low (0% to 6%), regardless of hook type.

We believe the high mortality rate of striped bass caught on live bait during spring and summer requires greater management consideration. Striped bass of any length captured with live baits during spring and summer are twice as likely to die as to survive; only 29% of striped bass ≥508 mm survive capture and release under these conditions. A management option would be to prohibit the use of live (or natural) bait during the spring and summer as a method of taking striped bass. Although such an option is potentially contentious among anglers, in a statewide survey of Texas freshwater anglers Wilde and Ditton (1991) found 62% of striped bass anglers were neutral or did not oppose bait prohibitions. An alternative management option would be to reduce the creel limit during spring and summer and allow anglers to retain all striped bass, regardless of length, until the bag limit is reached. This option would probably meet little opposition, but could result in over-exploitation of large striped bass in Lake Texoma.

In summary, hooking mortality rates of striped bass in this study suggest catch-and-release fishing associated with restrictive harvest limits for striped bass is a feasible management strategy for Lake Texoma. Overall survival of fish in this study was 62%. Striped bass of any size caught by any method during the spring have the lowest survival (31%). Regardless of size or season, survival of striped bass caught by live bait was 42%, while survival of striped bass caught on artificial lures (treble and single hook) was 75%. Of primary importance on Lake Texoma is the fate of released striped bass ≥508 mm. Average survival for these fish was 53%; however, as noted above, mortality was exceptionally high in spring and summer, perhaps requiring a seasonal change in management strategy. Applied to statewide striped bass fisheries, results of this study suggest the average survival of released fish <457 mm is 63%. The acceptability of these survival rates depends on local factors such as striped bass population dynamics, whether the fishery is maintained by stocking or natural reproduction, and angler exploitation rates.

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