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MANAGEMENT BRIEF

Mortality of Palmetto Bass Following Catch-and-Release Angling

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Abstract
Palmetto bass (Striped Bass *Morone saxatilis* × White Bass *M. chrysops*) have been stocked into reservoirs in the southeastern USA since the late 1960s and have gained widespread acceptance as a sport fish. These fisheries are growing in popularity and catch-and-release (CR) fishing is commonplace; however, there is a dearth of information on CR mortality of palmetto bass. We experimentally angled palmetto bass ($n = 56$; >373-mm TL) in a Tennessee reservoir using traditional angling gear in water temperatures ranging from 13°C to 32°C. Ultrasonic transmitters equipped with floats were externally attached to fish, which were released immediately and tracked multiple times within 10 d of release. Mortality was negligible (3.6%) in fall and spring at cool water temperatures but was high (39.3%) in summer when water temperatures exceeded 26°C. The best logistic regression model based on Akaike's information criterion for small sample sizes scores relied on water temperature alone to predict CR mortality of palmetto bass; there was little support for other models that included all possible combinations of the six other predictor variables we tested. Palmetto bass in our study experienced lower CR mortality than Striped Bass in other systems, but CR mortality rates for palmetto bass that approach or exceed 40% during summer are still problematic if the goal is to maintain fishing quality.

Palmetto bass (Striped Bass *Morone saxatilis* × White Bass *M. chrysops*) have been stocked into reservoirs in the southeastern USA since 1966 and have gained widespread acceptance as a sport fish. Bishop (1968) reported that palmetto bass grew faster, survived better, and were easier to catch than Striped Bass. Until recently, Striped Bass were the predominant moronid species stocked into Tennessee reservoirs; however, poor water quality (warm water temperatures and low dissolved oxygen during summer months) in some reservoirs has prompted the Tennessee Wildlife Resources Agency (TWRA) to reduce Striped Bass stockings. Palmetto bass, more tolerant of poor water quality, now dominate the moronid fishery in reservoirs such as Cherokee Lake, a tributary reservoir that experiences Striped Bass die-offs due to a pronounced temperature and dissolved oxygen "squeeze" during stratification (Coutant 1985). It has long been recognized that palmetto bass can be stocked in a variety of systems unsuitable for Striped Bass (e.g., Axon and Whitehurst 1985), and that trend is continuing in Tennessee and elsewhere (Bettoli 2013).

As palmetto bass fisheries expand and become more popular, the frequency of catch-and-release (CR) fishing is likely to increase. In the four most popular palmetto bass fisheries in Tennessee, release rates ranged from 28% to 93% (P. Black, Tennessee Wildlife Resources Agency, unpublished data). In order for minimum length regulations or the voluntary efforts of anglers to succeed in maintaining quality fisheries, most released fish need to survive. The literature is replete with studies of CR mortality of many species, including Striped Bass; however, little information exists on CR mortality of palmetto bass despite their growing popularity. Childress (1989) angled Striped Bass and palmetto bass, placed them in live wells for up to 1 h, and then transferred them to net-pens where they were held for 72 h. Striped Bass in that study experienced higher CR mortality in winter and summer (11% and 69%, respectively) than palmetto bass (1% and 29%, respectively). Although those fish experienced the same stressors a fish would experience when hooked

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and landed by a recreational angler, holding fish in live wells and pens could increase stress and bias estimates of CR mortality (Carmichael et al. 1984; Donaldson et al. 2008). Confining fish in pens is especially problematic when dealing with pelagic fishes such as Striped Bass and palmetto bass (Skomal 2007).

Biotelemetry is becoming increasingly popular as a means to estimate CR mortality. In a review of published literature up through August 2005, Arlinghaus et al. (2007) found 242 CR mortality studies dating back to 1957, of which 23% ($n = 55$) used biotelemetry. In our study, we estimate for the first time the CR mortality rates of free-ranging palmetto bass caught using natural baits and artificial lures.

STUDY SITE

J. Percy Priest Lake (hereafter, JPPL) is located on the Stones River, a tributary of the Cumberland River in middle Tennessee. Constructed in 1969, this 7,630-ha eutrophic reservoir is managed for recreation, flood control, and hydroelectric power by the U.S. Army Corps of Engineers. At full pool, the reservoir has an average depth of 9 m and an average hydraulic retention time of 139 d. When the reservoir is thermally stratified between late spring and late fall, a pronounced temperature and dissolved oxygen squeeze exists (Coutant 1985). In a typical summer, the hypolimnion below 6 m is anoxic (USACE 2007).

METHODS

Fish collection and tag implantation.—Angling was conducted over a wide range of water temperatures (13–32°C) in 2011 and 2012. In order to mimic typical palmetto bass fishing techniques, professional fishing guides or members of a local palmetto bass club accompanied us on all sampling trips. Artificial baits (umbrella rigs with one to five hooks) were trolled at speeds ranging from 4.0 to 6.4 km/h using downriggers. Natural baits (Gizzard Shad *Dorosoma cepedianum*, Threadfin Shad *D. petenense,* and Bluegill *Lepomis macrochirus*) were fished on the bottom, midwater while drifting, or pulled with planer boards. Fight time, net time, and handling time were recorded for each fish caught, as well as surface water temperature, bleeding status (0 = none; 1 = slight; 2 = blood flowing freely), and fishing method (artificial or natural baits). After a fish was reeled in (hook up to landing = fight time), the fish was netted and the hook was removed (landing to hook removal = net time). If fish were deeply hooked, the line was cut and the hook was left in place. After the hook was removed or the line was cut, the fish was placed in a 95-L cooler filled with untreated lake water where it was measured for TL and the tag was attached (amount of time in cooler = handling time). Only palmetto bass longer than 293-mm TL (~325 g) were tagged to satisfy the "2% rule" (Winter 1983).

Sonotronics IBT-96-2-E ultrasonic tags (33 × 9 mm, 4.8 g, battery life of 3 months) were externally attached to angled fish. A float-and-tag system similar to what Osborne and Bettoli (1995) used to tag Striped Bass was used in this study. Each tag was attached to an 80-mm-long piece of Last-A-Foam using monofilament. Last-A-Foam is rigid polyether polyurethane foam with fine closed-cell structure that resists compression when submerged. Chromic gut suture (#3), which was used to attach a barrel swivel to the tag-and-float assembly, decomposed in 7–25 d (depending on water temperature) and allowed the tag to float to the surface where it could be retrieved and reused. The total assembly weighed 6.5 g in air. Using a 3/8 triangular circle needle (size 6), Vicryl suture material was passed through the dorsal musculature anterior to the dorsal fin and a small loop was tied using a surgeon's knot; the barrel swivel was then attached to that loop. Following tag attachment, each fish was released and a GPS waypoint was taken.

A Sonotronics directional hydrophone (DH-4) and Sonotronics receivers (USR-5W and USR-96) were used to locate telemetered fish and detached tags. Fish were tracked multiple times during the first 10 d following release. Tracking events occurred 2 out of the first 3 d postrelease to assess short-term mortality and at least two additional days from 4 to 10 d postrelease to assess delayed mortality. When tagged fish were located we recorded tag number and time, and a waypoint was taken. All waypoint locations were imported as shapefiles in ArcMap 10.0 using DNR Garmin 5.4.1 (MNDNR 2008). A fish had to be located at least two times before a fate was assigned. A fish was considered dead if it did not move more than 100 m from its previous location or was discovered floating on the surface.

Data analysis.—Logistic regression was used to model the effects of TL, fight time, net time, handling time, surface water temperature, bleeding status, and fishing method on palmetto bass CR mortality. We used Akaike's information criterion for small sample sizes (AIC_c) to assess the relative support for logistic regression models containing all possible combinations of the seven predictor variables. All analyses were performed using Statistical Analysis System version 9.1 (SAS Institute 2009).

Tagging effects experiment.—To test for possible tagging effects, palmetto bass were collected using boat-mounted DC electrofishing gear (Smith-Root Type VI-A electrofisher) in April and May 2012 in the Holston River in east Tennessee. Twenty-nine palmetto bass were captured and transported to Eagle Bend State Fish Hatchery in Clinton, Tennessee, and placed in a 0.04-ha hatchery pond. Fish were allowed 3–15 d to acclimate to the pond's water temperature before initiating the experiment. The pond was drained on 30 April 2012, and 14 palmetto bass were randomly selected for tagging using dummy transmitters after first recording their TL. The dummy transmitters weighed 6.5 g, and the attachment method was identical to that used on angled fish. Fifteen fish that served as controls were measured for TL but were not tagged. The 29 fish (tagged and control) were then placed into an adjacent hatchery pond. The average water temperature in the hatchery pond over the 7-d holding period was 25.1°C, and dissolved oxygen concentrations measured once every other day averaged 8.4 mg/L. The mean lengths of the 14 tagged fish (501-mm TL; SE = 30.4) and 15 control fish (505-mm TL; SE = 35.8) were similar ($t = 0.08$, df = 26, $P = 0.9380$). When the hatchery pond was drained after 7 d, all fish (tagged and control) were alive; thus, we concluded that our tagging procedure did not confound our estimate of CR mortality of palmetto bass in JPPL.

RESULTS

We caught, tagged, and released 64 palmetto bass in JPPL. Eight of the tagged fish were never located following release and were discarded from further analysis. The remaining 56 fish were tracked for at least 4 d to determine their fate. They ranged in TL from 379 to 682 mm (mean = 581; SE = 8.9). Fight time ranged from 40 to 228 s (mean = 104; SE = 6.1); net time ranged from 0 to 147 s (mean 39; SE = 4.1), and handling time ranged from 65 to 285 s (mean 118; SE = 5.6).

Only one palmetto bass died immediately upon release. Nine of the remaining 55 palmetto bass died within 48 h of release (i.e., short-term mortality = 16.4%), and two others died after 72 h (delayed mortality = 3.6%). During the summer months when water temperatures exceeded 26°C, pooled CR mortality was 39.3% (i.e., 11 of 28 fish died). During fall and spring (March, April, May, and October) at cooler temperatures ($\leq$25°C), CR mortality was only 3.6% (i.e., 1 of 28 fish died).

Of the 56 palmetto bass whose fate was known, 24 were caught with artificial lures. Twenty-three of the 24 fish caught on artificial lures were hooked in the mouth and one fish was hooked in the gills; that fish subsequently died. Pooled mortality for palmetto bass caught on artificial lures over all seasons was 21%. Pooled mortality was 22% for the 32 fish caught on natural baits. Fifty-three percent of the fish caught on natural baits were hooked in the mouth or jaw, and 47% were hooked in the esophagus or swallowed the hook. The line was cut on 10 of the 32 fish caught on natural bait, and three of those fish subsequently died.

The top five models according to AIC_c scores all included water temperature as a predictor variable (Table 1), and the best model contained only the water temperature variable. There was little support for the four next-best models that included fight time, bleeding status, method, and net time as predictor variables. Water temperature was the only significant predictor ($\chi^2 = 7.7$, df = 1, $P = 0.0055$, SE = 0.0964) of hooking mortality in palmetto bass. The probability of mortality as a function of water temperature was expressed as

$$P_{\text{mortality}} = e^{-8.3325+0.2675\cdot\text{temperature}}/(1 + e^{-8.3325+0.2675\cdot\text{temperature}}).$$

The 90% profile likelihood confidence interval for the water temperature parameter was 0.1276–0.4497. The Hosmer–Lemeshow goodness-of-fit test indicated that the model provided a good fit to the data ($\chi^2 = 3.2$, df = 6, $P = 0.7827$). The probability of CR mortality at water temperatures of 10, 20, and 30°C was 0.3, 4.8, and 42.4%, respectively.

TABLE 1. Rankings based on an information theoretic approach of the top five logistic regression models predicting CR mortality of palmetto bass. See text for description of fight time, net time; method refers to natural or artificial baits. Delta AIC_c represents the change in AIC between a given model and the top model (i.e., the one with the lowest AIC score); Akaike weight represents the relative likelihood of each model.

Model	AIC_c	Delta AIC_c	Akaike weight
Water temperature	52.2	0	0.148
Water temperature, fight time	53.6	1.4	0.072
Water temperature, bleeding	53.7	1.5	0.071
Water temperature, method	54.1	1.9	0.058
Water temperature, net time	54.2	2.0	0.054

DISCUSSION

This study provides the first estimate of CR mortality of free-ranging palmetto bass, and water temperature was the most important factor influencing mortality. Likewise, CR mortality of Striped Bass varies directly with water temperature (e.g., Harrell 1988; Hysmith et al. 1994). Hooking mortality increases with water temperature in most other species as well, including Walleye *Sander vitreus* (Reeves and Bruesewitz 2007), Largemouth Bass *Micropterus salmoides* (Gustaveson et al. 1991; Meals and Miranda 1994), and Smallmouth Bass *M. dolomieu* (Cooke and Hogle 2000).

Wilde et al. (2000) compiled results from seven Striped Bass hooking mortality studies in a meta-analysis and used logistic regression to model the effects of bait type and water temperature on mortality of 1,275 experimentally angled Striped Bass. The predicted CR mortality of palmetto bass in JPPL was below the predicted mortality of Striped Bass caught on either artificial baits or natural baits, especially at water temperatures between 15°C and 30°C (Figure 1). The higher mortality associated

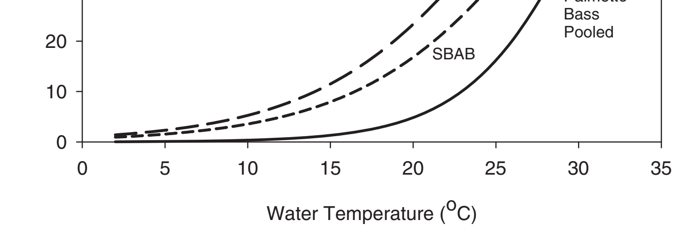

FIGURE 1. Catch-and-release mortality as a function of water temperature for Striped Bass caught using artificial baits (SBAB) and natural baits (SBNB), and palmetto bass angled in JPPL using both natural and artificial baits. The two Striped Bass models are from a meta-analysis reported by Wilde et al. (2000).

with natural baits that Wilde et al. (2000) detected for Striped Bass is also observed for other species (e.g., Walleye [Payer et al. 1989]; Smallmouth Bass [Weidlein 1987; Clapp and Clark 1989]; Bluegill [Siewert and Cave 1990]). In the present study, however, there was little support for a bait effect on CR mortality of palmetto bass, despite the fact that palmetto bass caught on natural baits were more likely to have been hooked in locations other than the jaw or buccal cavity. We cut the line on 10 palmetto bass that swallowed natural baits and seven survived. Cutting the line on deeply hooked fish is known to increase survival rates for other species such as Bluegill (Fobert et al. 2009), Rainbow Trout *Oncorhynchus mykiss* (Mason and Hunt 1967; Schill 1996; Schisler and Bergersen 1996), and White Seabass *Atractoscion nobilis* (Aalber et al. 2004).

Although palmetto bass in JPPL experienced lower hooking mortality than Striped Bass in other systems, losing ~40% of palmetto bass angled and released during summer months represents cryptic exploitation and reduces the number of fish available for anglers to catch. Several approaches are available to reduce cryptic exploitation during the summer months. Bettoli and Osborne (1998) suggested implementing a no-cull regulation for Striped Bass or closing the fishery during summer months. A no-cull regulation prohibits anglers from catch-and-release fishing; all fish that are caught must be harvested until the creel limit (2 fish/d) is reached. Alternatively, Striped Bass in some Tennessee reservoirs are managed with a small size limit in the summer months (when most released fish are expected to succumb to CR mortality) and a high size limit in winter when most released fish will survive. Some fishing clubs choose to avoid fishing for palmetto bass on JPPL in summer because of perceived high CR mortality. Their voluntary efforts to conserve the palmetto bass fishery suggest that other palmetto bass anglers may be receptive to the idea of enacting regulations to reduce cryptic exploitation.

All palmetto bass angled with artificial baits in our study were caught on trolled umbrella rigs. Although no statistical difference in survival was observed between artificial and natural baits, and handling times were similar between the two types of baits, additional research is needed to estimate hooking mortality when other types of artificial baits are used (e.g., plugs, spoons). Umbrella rigs are heavy and are trolled at faster speeds than single plugs or spoons and shoreline anglers cast and retrieve their lures. It is unknown whether palmetto bass caught from shore or caught while trolling more "traditional" lures would experience the same hooking mortality rates we observed. It is also unknown whether our estimates of CR morality are conservative given that our anglers were experienced palmetto bass anglers and, presumably, better at handling palmetto bass than generalist anglers. If more estimates of CR mortality for palmetto bass become available, a meta-analysis similar to that of Wilde et al. (2000) can be performed and the more difficult, but important, task of addressing the population level impacts of CR mortality on palmetto bass fisheries can be undertaken (Kerns et al. 2012).

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