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Influence of hook type and live bait on the hooking performance of inline spinners in the context of catch-and-release brook trout *Salvelinus fontinalis* fishing in lakes

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ABSTRACT

The objective of catch-and-release angling is for the fish to survive with minimal fitness consequences. However, fish survival can be compromised by a number of factors, especially anatomical hooking location. To evaluate whether hook type or bait influence hooking outcomes, we tested different combinations of hook (treble or single siwash hooks) and bait (hook tipped with worm or no worm) while angling for brook trout (*Salvelinus fontinalis*) with inline spinner-style fishing lures. The study was conducted at spring water temperatures (~20 °C) in small lakes stocked with trout in southwestern Quebec, Canada. Incidences of hooking in the interior of the mouth (i.e. internal hooking) were uncommon (19%), did not differ significantly between hook types or bait treatments, and occurred independently of fish size. Reflex impairments after hook removal were not related to hook or bait treatment. Short-term mortality was quantified with 24 h holding in net pens and was determined to be infrequent for all treatment groups (treble/worm: 6%; treble/no worm: 5%; single/worm: 2%; single/no worm: 0%). Although no fish were hooked in the gills, esophagus, stomach, odds of mortality increased by 14.21 when fish were hooked internally, which is consistent with the position that hook placement is an important predictor of the fate of fish released by anglers. However, our finding that neither hook nor bait type significantly increased the odds of internal hooking, bleeding, reflex impairment, or mortality in this study suggests that restrictions imposed on the use of baited lures or certain hook types attached to lures when fishing may have little influence on short-term catch-and-release mortality of brook trout at these temperatures.

1. Introduction

Recreational angling is popular throughout the world (Arlinghaus et al., 2015) with many anglers practicing catch-and-release (C&R) voluntarily or to comply with fishing regulations (Cooke and Cowx, 2004). However, the fate of released fish is often unknown, making it unclear if releasing fish is an effective management or conservation strategy (Cooke and Schramm, 2007). By quantifying C&R mortality as well as potential sublethal consequences (e.g., injury, stress, reflex impairment), it is possible to determine the sustainability of angling practices and refine them such that mortality and fitness impairment among released fish is suitably low (Arlinghaus et al., 2007; Cooke et al., 2013a).

Angling gear, fishing or handling techniques (i.e., active or passive angling, handling time, internal hook removal), and environmental conditions (i.e., capture depth, water temperatures) are all important factors that can contribute to mortality in C&R fisheries (Arlinghaus et al., 2007; Bartholomew and Bohnsack, 2005; Cooke and Suski, 2005). The proximate factor most linked to fish mortality is hooking in critical anatomical locations, including the gill arches, eyes, esophagus, and highly vascularized regions of the mouth interior (Bartholomew and Bohnsack, 2005; Fobert et al., 2009; Muoneke and Childress, 1994; Nuhfer and Alexander, 1992; Pauley and Thomas, 1993; Schisler and Bergersen, 1996). Although

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hooking in critical locations may not cause immediate mortality, it can exacerbate the physiological stress response and/or hinder recovery resulting from angling and handling stresses. The physiological stress response to angling is a significant consideration in C&R (Cooke et al., 2013b; Wedemeyer and Wydoski, 2008), the effects of which can be approximated by conducting reflex impairment tests that provide an index of fish vitality. Reflex impairment tests such as reflex action mortality predictors (RAMP) can be calibrated for individual species to predict survival from fisheries encounters (Davis and Ottmar, 2006; Raby et al., 2012). Understanding how gear types influence hooking location and resulting impairments in fishes can contribute to informed guidelines for regulations imposed on recreational fisheries (Arlinghaus et al., 2007).

Recreational anglers target salmonid fishes across the world. Given the economic value of salmonids and their variable conservation status, there has been extensive research on the effects of C&R, particularly for freshwater trout in lotic environments (e.g. Nuhfer and Alexander, 1993; Pauley and Thomas, 1993; Schill, 1996; Schisler and Bergersen, 1996). However, trout also inhabit lakes, which have unique hydrographic conditions that can affect fish ecophysiology, behaviour, feeding, and by extension recreational fishing (Higham et al., In Press). Brook trout (*Salvelinus fontinalis*) inhabit lakes and ponds throughout Eastern North America and have been introduced around the world (MacCrimmon and Campbell, 1969). Despite their distribution and abundance having drastically declined due to habitat loss, atmospheric changes, and overexploitation, brook trout remain a recreationally important species exposed to a relatively high degree of C&R (Detar et al., 2014; Hudy et al., 2008). Knowing the extent to which C&R results in mortality of fish is important for population modeling and thereby for fisheries management (Risley and Zydlewski, 2010); however, Hühn and Arlinghaus (2011) suggested that gear-specific research is lacking for this species. To examine the extent to which actively fished inline spinner-type lures (a common lure style for catching trout) contribute to short-term injury, impairment, and mortality of brook trout in such C&R settings, we fished for brook trout with spinners fitted with either treble or single hooks that were either baited or unbaited. Treble hooks are larger and presumably cannot be ingested as deeply as single hooks, but have more points of contact with the fish than single hooks, potentially increasing the likelihood of injury. Therefore, we predicted that fish captured by single hooks would have more instances of internal hooking than treble hooks but less instances of bleeding. Given that other C&R studies generally show that natural bait is ingested more deeply than artificial lures (e.g., Arlinghaus et al., 2008), we expected that trout captured by unbaited hooks would exhibit less internal hooking and bleeding. Finally, we expected reflex impairment and mortality to increase with injury and that treble hooks and baited hooks would result in more frequent reflex impairment and mortality relative to other treatments.

2. Methods

2.1. Study site

Angling was conducted at the Kenauk Nature Reserve near Montebello, Quebec, Canada in Lakes Jackson, L'Orignal, Collins, and de la Montagne (approximate coordinates: 45.7°N, 74.9°W). All lakes were stocked with brook trout from fish hatcheries near Mont-Tremblant, Quebec. Brook trout were angled from rowboats across the entire lake. Data collection took place on eight different days in June 2015 at surface water temperatures of 20.0 ± 1.5 °C (mean ± SD, range = 17.8–23.0 °C).

2.2. Equipment

Two hook types were fished with and without bait to test the influence of gear on hooking location. Hooks were either a treble or a single siwash-style hook on an inline spinner lure. All hooks were barbed, which reflected the common practice of recreational anglers in the region. For the baited treatments, hooks were bare or baited with ~2 cm of live earthworm. Medium-light action spinning rods were fished with 2.7 kg break strength monofilament fishing line. All anglers used either size 2 Blue Fox Vibrax (Rapala VMC Corporation, Helsinki, Finland), size 3 Panther Martin (Harrison-Hoge Industries Inc., Port Jefferson, New York, USA), or Mepps (Sheldons', Inc., Antigo, Wisconsin, USA) spinner lures in a variety of colours with no additional weight. The lures were of similar dimensions and of the same hook size (i.e., size 6 for treble and Siwash hooks).

2.3. Angling procedures

To capture brook trout, anglers either trolled the lures behind slowly moving rowboats or actively casted. Actual speed of movement of the lures through the water was similar between both fishing techniques. When a fish struck the lure, anglers set the hook using a sweeping lateral movement of the rod. Trout were landed in a knotless mesh net and transferred to a cooler filled with water to minimize air exposure (<10 s). We recorded fight time (s), total length (mm) and hooking location during transfer to the cooler. Anglers removed hooks with haemostats or pliers. Hook wounds were inspected and any bleeding was noted. After hook removal, RAMP was assessed (Davis and Ottmar 2006; Raby et al., 2012). The components of the RAMP test that were used were tail grab, body flex, and orientation (i.e. righting reflex), because these are often the best indicators of fish vitality in C&R scenarios (Brownscombe et al., 2013; Lennox et al., 2015a). The trout were then tagged with individually numbered plastic t-bar anchor tags and transferred into 0.9 × 0.9 × 0.9 m floating net pens that held up to 15 fish or 1.2 × 1.2 × 1.2 m net pens that held up to 30 fish (maximum fish density of 1 fish per 0.06 m^3) for 24 h to observe short-term mortality (hereafter referred to as mortality). Fish from both treatments were mixed in the net pens. After 24 h, tags were removed from surviving fish before they were released back into the lake.

2.4. Analyses

Analyses were conducted using R (R Core Team, 2014) statistical software. Multiple logistic regression was used to analyze the effects of hook type, bait, fish length and fight duration on the occurrence of internal hooking, bleeding and mortality as well as the degree of reflex impairment. Although fight duration can increase with body size, we found that fight duration and fish length were not collinear (R^2 = 0.07), therefore both variables were included in the analysis of bleeding, reflex impairment and mortality.

Hooking location data from 44 trout were missing because the hook was shaken out by the fish upon capture, therefore these individuals were excluded from statistical analyses. Hooking locations were categorized as either internal (tongue, eye, nare, gullet, inner roof of mouth, and gills) or superficial (upper, lower, and side of jaw). Hooking in the jaw is generally held to be non-invasive, easy to remove, and an area of limited vascularization compared to the internal buccal cavity where highly vascular muscle and tissue as well as organs can be pierced by hooks, prolonging unhooking time and increasing tissue damage and injury. Given small sample sizes of fish with multiple impaired reflexes, reflex impairment scores were divided into groups of fish that were unimpaired (RAMP = 0) and impaired (RAMP = 1–3) upon capture. Finally, hooking mortality estimates were generated for all brook trout captured. Fourteen trout disappeared from the net pens overnight; they may have escaped volitionally or been removed by predators/scavengers. Therefore, they were excluded from mortality calculations. Wilson confidence intervals are presented for mortality estimates and were calculated in the R (R Core Team, 2014) package binom (Dorai-Raj, 2014). Interaction terms were considered but dropped from models when not significant. We interpreted the fixed effects at $\alpha = 0.05$ and assessed variable influence using odds ratios (Platt, 1997).

3. Results

Among 228 brook trout captured, 184 (320 ± 42 mm; range: 255–432 mm) had sufficient data to be incorporated in the analysis of hook location. Thirty-five (19%) of these fish were internally hooked (63% tongue, 23% roof of the mouth, 8% eye or face, 6% nare) on various gear combinations. Notably, none of the brook trout were hooked in the gills or esophagus. Neither the hook type fixed to the lure ($z = 0.92$, $p = 0.36$) nor bait ($z = -0.52$, $p = 0.60$) affected internal hooking (Table 1). Importantly, internal hooking was independent of fish length ($z = 1.10$, $p = 0.27$).

Forty-one brook trout (22% of 184) were bleeding from the hook wound upon landing. Fifty-eight percent of the brook trout that were bleeding were also internally hooked, and odds of bleeding increased by 8.18 when a fish was internally hooked ($z = 4.70$, $P < 0.01$). Odds of bleeding were not affected by the hook type fixed to the lure ($z = 1.32$, $p = 0.19$) or by the presence of a worm ($z = -0.82$, $p = 0.41$; Table 2).

Half of the brook trout (50%; 92 of 184) in this study had impaired reflex actions after angling. Many of the brook trout exhibited impaired body flex after angling (49%) whereas only 2% had impaired tail grab and 8% impaired orientation after angling. Fish that were bleeding had higher odds of reflex impairment ($z = -2.07$, $p = 0.04$; Table 3). Reflex impairment was not affected by the hook type fixed to the lure or whether bait was used (Table 3).

Irrespective of gear treatment, hooking mortality of brook trout was low. After 24 h holding, seven brook trout were determined to have died. After excluding 14 individuals with unknown fate the estimate of total short-term mortality was 3% (95% CI = 2–7%; Table 4). The lowest mortality was for trout captured by unbaited single hooks, at 0% (95% CI = 0–8%) and highest for trout captured by baited treble hooks 6% (95% CI = 2–13%; Table 5). In constructing the logistic regression model of mortality, we found that the model would not converge with both bleeding and hook location included, likely due to collinearity of the predictors given that 58% of internally hooked fish were bleeding compared to 16% of superficially hooked fish bleeding. Therefore, we proceeded only with hook location in the model. We found that mortality was significantly influenced by hook location, with internal hooking increasing the odds of mortality by 14.21 ($z = 2.92$, $p < 0.01$; Table 4). Fishing with lures fixed with treble hooks increased the odds of mortality by 8.48 relative to single hooks, but the difference was not significant ($z = 1.73$, $p = 0.08$).

4. Discussion

Characterizing injury and impairment of angled fish is important to fisheries management because it provides relevant information about the survival probability of individual fish that are released by anglers. This information can be extended to evaluate gear types for use in recreational fisheries in order to establish best practice guidelines for anglers participating in live release fishing either voluntarily or to comply with regulations. Contrary to our initial expectations, the odds of injury and impairment in brook trout were not influenced by the use of treble hooks or bait on lures. Moreover, mortality of fish was infrequent across all treatments, suggesting that gear selection had limited lethal consequences for lentic brook trout captured with inline spinner lures.

DuBois and Kuklinski (2004) studied riverine brook trout in Wisconsin and found that 29% were internally hooked using actively retrieved baited barbed (24% of 100) and barbless hooks (33% of 99). However, they classified only gullet, gill, and esophagus hooking as internal (DuBois and Kuklinski, 2004), whereas we also categorized tongue and roof of mouth hooking as internal hooking because these tend to be highly vascularized regions of the salmonid buccal cavity where hook penetration can cause substantial tissue damage and bleeding. Notably, very few brook trout in our study were hooked in the esophagus, gills, or gullet compared to a relatively high percentage of brook trout in DuBois and Kuklinski (2004); this is surprising given that both studies used size 6 hooks. However, we were fishing for slightly larger trout (255–432 mm compared to 103–304 mm in DuBois and Kuklinski, 2004). Generally, internal hooking should increase when the hook is small relative to the fish because it is easier to ingest (Alós et al., 2008). Scaling bait or lure sizes to suit target fish is important, yet studies have not randomized hook size to identify appropriate hook sizes for angling and therefore this and other studies use biased hook sizes for recreational angling that might preclude some explanatory power when addressing internal hooking. It is also worth noting that we excluded fish (N = 44) from the analysis for which the hooks dislodged before we were able to identify their exact location. There is a strong likelihood that those would have been in relatively shallow locations, which enabled the hook to fall out. As such, our conservative approach to classifying fish may have inflated our calculation of internal hooking frequency.

Bleeding is generally associated with internal hooking (Bendock and Alexandersdottir, 1993; Cooke et al., 2003; Nuhfer and Alexander, 1992; Pauley and Thomas 1993; Schisler and Bergersen 1996) and, as expected, increased significantly among internally hooked brook trout. Bleeding has elsewhere been associated with the use of barbed hooks (DuBois and Kuklinski, 2004), which have a tendency to exacerbate tissue damage upon removal (DuBois and Pleski, 2007). We opted to maintain the barbs on all lures in this study, but the frequency of bleeding would likely have been reduced had we de-barbed the hooks. Our results are also likely to differ on account of using lures rather than hooks alone as assessed by DuBois and Kuklinski (2004). Active retrieval of spinner lures probably reduced the probability of deep hooking overall because fish would have difficulty approaching and ingesting the moving lures with enough velocity to engulf it deep into the buccal cavity. This distinction between active and passive fishing has been demonstrated elsewhere (e.g. Lennox et al., 2015b), showing that active fishing decreases instances of deep hooking in recreational fisheries. We suggest that this may extend to different levels of active fishing, but this merits a more controlled experiment.

We had anticipated that fishing with bait would increase instances of internal hooking in trout (Arlinghaus et al., 2008). Baiting lures with worms or other scented organic materials should theoretically increase the attractiveness of the lures to fish and elicit more aggressive strikes. At greater distances, fish may detect potential foraging opportunities using olfaction but tend to rely more on visual information at close ranges (Aksnes and Giske, 1993) in combination with mechanical or somatosensory information (New et al., 2001). Bait-tipped hooks would therefore not necessarily alter the close-range feeding behaviours of fishes or influence hooking location or depth (Myers and Poarch, 2000), although in some species live-bait may influence hook depth (Hoxmeier and Wahl, 2009). Consequently, any difference between baited and unbaited hooks would likely have manifested in differences in CPUE by attracting more fish into the area where fishing was taking place, and not likely in hooking location. The flashy blades used on the spinner-type lures might have been more visually attractive to fish

Table 1
Results of multiple logistic regression models predicting internal hooking of brook trout. For continuous variables, odds ratios indicate the change in odds for a unit increase in the independent variable; for categorical variables, odds ratios indicate the change in odds of mortality when switching from the reference level.

Independent Variable	Reference Level	Coefficient ± S.E.	z-value	P Value	Odds Ratio
Intercept		−3.23 ± 1.64	−1.97	0.05	
Hook type	Treble hook	0.37 ± 0.41	0.92	0.36	1.45
Bait	Baited	−0.21 ± 0.39	−0.52	0.60	0.81
Length (mm)		0.01 ± 0.00	1.10	0.27	1.01

Table 2
Results of multiple logistic regression models predicting the bleeding of brook trout from the hook wound. For continuous variables, odds ratios indicate the change in odds for a unit increase in the independent variable; for categorical variables, odds ratios indicate the change in odds of mortality when switching from the reference level.

Independent Variable	Reference Level	Coefficient ± S.E.	z-value	P Value	Odds Ratio
Intercept		0.40 ± 1.66	0.24	0.81	
Hook type	Treble Hook	0.57 ± 0.43	1.32	0.18	1.78
Bait	Baited	−0.33 ± 0.40	−0.82	0.41	0.72
Length (mm)		−0.01 ± 0.01	−1.62	0.10	0.99
Hooking location	Internal	2.10 ± 0.45	4.70	<0.01	8.18
Fight duration (sec)		0.03 ± 0.02	1.10	0.27	1.03

Table 3
Results of multiple logistic regression models predicting the reflex impairment of brook trout. Reflex impairment was determined with reflex action mortality predictors (see Methods). For continuous variables, odds ratios indicate the change in odds for a unit increase in the independent variable; for categorical variables, odds ratios indicate the change in odds of mortality when switching from the reference level.

Independent Variable	Reference Level	Coefficient ± S.E.	z-value	P Value	Odds Ratio
Intercept		2.59 ± 1.35	1.92	0.05	
Hook type	Treble hook	0.46 ± 0.34	1.37	0.17	1.58
Worm	Baited	−0.33 ± 0.32	−1.04	0.30	0.72
Length (mm)		−0.01 ± 0.00	−1.78	0.07	0.99
Hooking location	Internal	0.38 ± 0.44	0.87	0.39	1.47
Fight duration (sec)		−0.01 ± 0.02	−0.30	0.76	0.99
Bleeding	Bleeding	−0.87 ± 0.42	−2.07	0.04	0.42

Table 4
Summary of angling gear treatment groups and the corresponding incidences of internal hooking, bleeding, impaired reflexes and mortality. For mortality, N is adjusted to 52, 63, 55, and 44, respectively, to exclude fish that disappeared overnight (see Methods).

Hook type	Bait	N	Mean Length (mm) ± S.D.	Deep hooking%	Bleeding%	Impaired reflexes%	Mortality%
Treble	Baited	53	315 ± 37	15.09	18.87	33.96	5.77
Treble	Unbaited	70	311 ± 44	17.14	21.43	30.00	4.76
Single	Baited	55	332 ± 45	14.55	14.55	54.55	1.82
Single	Unbaited	50	324 ± 37	14.00	16.00	46.00	0.00

Table 5
Output of multiple logistic regression models predicting the mortality of brook trout. For continuous variables, odds ratios indicate the change in odds for a unit increase in the independent variable; for categorical variables, odds ratios indicate the change in odds of mortality when switching from the reference level.

Independent Variable	Reference Level	Coefficient ± S.E.	Wald Statistic	z-value	Odds Ratio
Intercept		−4.19 ± 3.85	−1.09	0.28	
Hook type	Treble hook	2.14 ± 1.24	1.73	0.08	8.48
Bait	Baited	0.53 ± 0.87	0.61	0.54	1.70
Length (mm)		−0.01 ± 0.01	−0.51	0.61	0.99
Hooking location	Internal	2.65 ± 0.91	2.92	<0.01	14.21
Fight duration (sec)		0 ± 0.06	0.31	0.75	1.02
Reflex action	Unimpaired	−0.89 ± 0.89	−1.00	0.32	0.41

than the worms, resulting in no difference in hooking tendencies between baited and unbaited hooks. Further research using different retrieval speed and method would be useful to separate the effects of gear and retrieval on hooking tendencies.

The RAMP index is a simple and accessible measure of animal vitality that has been adopted as a test for predicting mortality of fish captured by recreational or commercial anglers that are destined for release (Davis and Ottmar, 2006; Raby et al., 2012). However, the RAMP index requires species-specific calibrations such that the various indicators can be applied reliably as mortality predictors. In this study, reflex impairment was not a strong predictor of brook trout mortality. Moreover, it was not significantly related to fight duration. Generally, the longer the fight duration the more energy is expended, which leads to muscular exhaustion and cognitive impairment that manifest in the reflex impairment (Kieffer, 2000; Milligan, 1996; Raby et al., 2012). In smaller-bodied gamefish, fight duration and intensity may not be important factors affecting fish physiological stress or reflex impairment due to short fight times (Brownscombe et al., 2014a,b). In this study, fight durations were brief (17 ± 9 s) and therefore not necessarily exhausting to the trout. Further, RAMP scores were low with trout generally only exhibiting body flex impairment. Although impairment of the body flex reflex is a relevant indicator of impairment that can be linked to angling-induced exhaustion, it often fails to serve as a reliable predictor of mortality in practice (Brownscombe et al., 2014a,b; Lennox et al., 2015a). Further assessment of brook trout could provide better species-specific predictive reflex actions beyond those that we used in this study.

Exercise is more strenuous for salmonids when water rises to supraphysiological temperatures. Activity becomes increasingly anaerobic (Wilkie et al., 1997), heart pumping increases and can become erratic (Anderson et al., 1998), and mortality generally increases (Cooke and Suski, 2005; McMichael and Kaya, 1991; Nuhfer and Alexander, 1992; Schisler and Bergersen, 1996). In spite of fishing in relatively high temperatures for brook trout (Nuhfer and Alexander, 1992), we observed low rates of mortality of brook trout in this study (3–9%). Moreover, mortality was independent of gear type, fight time, total length, and reflex impairment. This uniformly low mortality on different hook types is different from other studies, which found 2.4% mortality of brook trout caught on lures with a single hook and 8.3% mortality caught on the same lures with a treble hook (Nuhfer and Alexander, 1992). Low mortalities could result from the majority of internally hooked brook trout being hooked in the tongue and roof of the mouth rather than in vital organs, a finding possibly related to the size of hooks used relative to the size of fish captured. Although the tongue and roof of mouth are highly vascularised and therefore have the potential to bleed extensively, hooking the gills or esophagus can result in critical organ damage and increased likelihood of mortality. Incidence of bleeding from the hook wound also increased the odds of mortality with 86% of the known mortalities bleeding after hook removal. This agrees with Nuhfer and Alexander (1992), who calculated high mortality of brook trout bleeding from the throat or gill arches within 48 h of capture. Eliminating or reducing injury is therefore important for maintaining high survival of fish after C&R. Steps such as cutting the line can be taken in order to reduce tissue damage associated with removing internal hooks (Fobert et al., 2009; Schill 1996; Warner, 1979). However, studies assessing the benefits of cutting the line have predominantly been conducted using baited hooks rather than lures, which are generally much larger and more intrusive than hooks. Therefore, further research is necessary to identify whether cutting the line is a viable option for reducing bleeding and hooking injury of fish internally hooked with lures.

Our approach in this study was to evaluate short-term hooking mortality but we acknowledge the role of delayed mortality in recreational fisheries. Mortality is generally highest within 24 h but there can be significant delayed mortality days after release (Muoneke and Childress, 1994). Moreover, fish released by anglers can be depredated by aquatic or aerial predators when they are in a weakened state after angling (Raby et al., 2014). In this system, snapping turtle (*Chelydra serpentina*), otter (*Lontra canadensis*), osprey (*Pandion haliaetus*), and other fish predators could be agents of post-release predation. Indeed, we observed snapping turtle to be attracted to the net pens while fish were being held. We acknowledge that some mortality may not have been captured in our experiment. However, we were aware of this in the study design phase and intentionally limited our observations to 24 h mortality to reduce holding stress (Gutowsky et al., 2015; Wedemeyer and Wydoski, 2008), and because we believed that there would be diminishing returns with longer-term observation.

5. Conclusions

In keeping with other studies of salmonids, we found that internal hooking of brook trout led to higher incidences of bleeding which in turn increased the probability of mortality. However, neither fishing gear nor fish size influenced the occurrence of internal hooking, bleeding, reflex impairment, or mortality. Generally, there is limited evidence that treble hooks increase mortality of fish relative to single hooks when fitted to lures (Klein, 1965; Matlock et al., 1993; Schaefer, 1989; Schill, 1996; Warner, 1979); however, treble hooks can increase handling time and air exposure, both of which negatively affect fish survival. Irrespective of gear type used by anglers, there will be some level of mortality associated with C&R fishing, but our results suggest that short-term mortality rates can be low for brook trout in lentic systems. Risley and Zydlewski (2010) modeled C&R mortality of brook trout and suggested that small increases in mortality can have significant effects on brook trout populations, making restrictions that manage fishing mortality important for management. However, given our findings, fishing restrictions limiting anglers to lures with one hook type (either a spinner equipped with single or treble hook) and bait treatment would not likely reduce the amount of unintended fishing mortalities and as such potential benefits of these restrictions are not supported by our data (Matlock et al., 1993). Angler attitudes towards gear restrictions and regulations have varied over the years with much controversy over management regulations on hook types and bait treatments (Schill, 1996; Warner, 1979); however, our findings suggest that such restrictions may not always be necessary or beneficial to target species (Carline et al., 1991; Schill, 1996).

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