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Influence of angler hook-set behaviour relative to hook type on capture success and incidences of deep hooking and injury in a teleost fish

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ABSTRACT

One of the primary factors associated with mortality in catch-and-release recreational fisheries is depth of hook position relative to the snout, with deeper hooking locations (i.e., gullet) increasing risk of injury to vital tissues. As a result, there have been attempts to develop angling methods and gear that are less likely to result in deep hooking. Circle hooks represent an alternative to conventional "J" style hooks (J-hooks), and in general circle hooks have been shown to reduce the tendency for deep hooking in a variety of species, which can significantly improve post-release survival. Relative to fishing with J-hooks, circle hook manufacturers typically recommend that anglers use a rod movement (i.e., hook-set) of reduced intensity and force (i.e., a light hook-set), thereby maximizing the benefit of circle hooks by reducing the tendency for deep hooking and injury. To evaluate whether hook-set technique can affect hooking and injury in fish, we tested different combinations of hooks (circle hooks and J-hooks) and hook-set techniques (e.g., light, moderate, or heavy force, or with a bobber) in an angling study for bluegill (*Lepomis macrochirus*) in Lake Opinicon, Ontario, Canada. Binary responses of capture success and deep hooking were analysed with logistic regression. There was no significant interaction between hook type and hook-set, but overall, J-hooks increased the odds of successfully capturing a bluegill and also the odds of deep hooking a bluegill relative to circle hooks. The bobber hook-set technique increased the odds of deep hooking a bluegill relative to the active hook-setting techniques. This study suggests both deep hooking and capture of bluegill are significantly affected by both hook types and hook-set techniques.

1. Introduction

Catch-and-release angling has been promoted within recreational fisheries as a strategy for reducing the harvest-related mortality of fish populations (Arlinghaus et al., 2007; Cooke and Schramm, 2007). Research has identified a variety of biological (e.g., fish size, species), environmental (e.g., water temperature), gear-related (e.g., hook type, bait type), and angler-related (e.g., level of experience) factors that can contribute to incidental mortality in catch-and-release fisheries (reviewed in Arlinghaus et al., 2007; Bartholomew and Bohnsack, 2005; Cooke and Suski, 2005). A consistent finding among catch-and-release studies is that deep hooking (i.e., in the gullet) increases the likelihood of internal organ trauma at capture, which can then lead to delayed mortality upon release (Arlinghaus et al., 2007; Bartholomew and Bohnsack, 2005; Cooke et al., 2012; Muoneke and Childress, 1994; Schaefer, 1989). This effect is exacerbated by increases in handling time and air exposure, because deeply lodged hooks typically take longer to remove (Aalbers et al., 2004; Pauley and Thomas, 1993). To some extent, anglers can reduce the likelihood of deep hooking by choosing suitable baits (Noble and Jones, 1999) and tackle (Bartholomew and Bohnsack, 2005; Muoneke and Childress, 1994). One promising method for reducing deep hooking is via the use of circle hooks as an alternative fishing tackle to conventional J-hooks (Cooke and Suski, 2004; Cooke et al., 2012).

Circle hooks are distinguished from J-hooks (e.g., octopus hooks, Aberdeen hooks, bait holder hooks) by a hook-point that angles

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at least 90-degrees towards the hook shank (Serafy et al., 2012). This configuration allows the hook to be ingested by the fish without penetrating the oesophagus, gullet, gills, or other deep tissue, lodging instead in the mouth or jaw. However, simply exchanging J-hooks for circle hooks will not necessarily reduce incidences of deep hooking, because the effectiveness of circle hooks depends on interspecific variation in feeding style, dentition, and anatomy of the target fish species (Cooke et al., 2003), as well as on hook size (Cooke et al., 2005; Robert et al., 2012) and angler experience (Dunmall et al., 2001; Meka, 2004). Additionally, the hook-set technique that an angler uses when capturing a fish can affect the performance of circle hooks (Cooke and Suski, 2004; Cooke et al., 2012; Sullivan et al., 2012). To maximize performance of circle hooks, manufacturers therefore recommend that anglers avoid a hook-set of heavy force when the fish strikes (Cooke and Suski, 2004; Johannes, 1981; Montrey, 1999). So important is the role of angler hook-setting technique on circle hook performance that it was identified as a research priority by the Atlantic States Marine Fisheries Commission (2003), in a review of circle hooks by Cooke and Suski (2004), and at the First International Symposium on Circle Hooks in Research, Management, and Conservation (Cooke et al., 2012; Serafy et al., 2012). At present, there has been only one systematic study that has tested the efficacy of circle hooks in reducing deep hooking when used with different hook-setting intensities (Sullivan et al., 2012). However, understanding how circle hooks perform with other fisheries and how they can be used more broadly as a conservation tool in recreational fisheries requires further research.

In this study, our objective is to address the knowledge gap that exists between circle hook performance and angler hook-setting techniques. Using a controlled angling study design, we quantified both the capture efficiency and propensity of injury to bluegill sunfish (*Lepomis macrochirus*), using both circle hooks and J-hooks with various hook-setting techniques. Research efforts focused on bluegill given that they are a popular recreational fisheries species, and because they have been previously used as a model for catch-and-release studies with circle hooks (Cooke et al., 2003).

2. Methods

Data were collected at Lake Opinicon, a shallow mesotrophic lake in Eastern Ontario, Canada. Angling was conducted from July 17 to July 26, 2012, from floating docks at the Queens University Biological Station and from a boat. Fishing from a drifting boat can confound hook-setting angle and velocity (Zimmerman and Bochenek, 2002), so when fishing from the boat it was anchored to prevent trolling. Anglers fished with identical 6′ medium action Rapala fishing kits with monofilament line and drag settings on the reel maximized so that it did not influence the hook-set. Two individuals participated in the angling, one of whom captured the majority of fish. Generic, commercially available size 12 circle hooks were used and matched with a J-hook of similar length (No. 8 Eagle Claw L181G-8 Lazer Sharp) because there is lack of an industry-wide sizing standard between circle hooks and J-hooks (Serafy et al., 2012). Both hooks were offset (i.e., point shank and main shank are not parallel) by the manufacturer, but the offset was corrected prior to angling because offset hooks are considered more injurious to fish (Bartholomew and Bohnsack, 2005; Cooke and Suski, 2004; Sullivan et al., 2012). A single split shot weight was attached to the line approximately 30 cm above the hook for all treatments, which helped to lower the bait into the water column to the depth frequented by fish. Hooks were baited with small pieces of live earthworms, which are commonly used as bait by novice and experienced bluegill anglers (Cooke et al., 2003). For the passive treatment with a bobber, a pencil bobber was used to suspend the bait motionless in the water column (Table 1 summarizes treatments). Whereas all other treatments were used with an active retrieve of the bait, the bobber was a completely passive treatment in which there was no movement of the bait or tension of the line when the fish ingested the hook.

Anglers rotated among four hook-setting treatments with either a circle hook or a J-hook. Hook-set techniques were considered either passive as in the bobber treatment (i.e., with the hook left motionless in the water column; see Table 1) or active (i.e., while reeling in the hook), as in the light, moderate, and heavy hook-set treatments (terminology based on relative force applied during the hook-set). For the passive treatment, the bobber was attached approximately 60 centimetres above the bait and the bait was cast and left motionless under the bobber until its movement made a strike detectable. Treatments without a bobber required the angler to slowly reel the line in, often while raising and lowering the rod tip slowly to keep line tension, allowing the bait to suspend in the middle of the water column where fish would be able to see it. If a strike was detected by feel or by sight, anglers were instructed to engage the assigned hook-setting forcefulness (for active treatments) or simply begin attempting to retrieve the fish by steadily reeling in the line (for the passive treatment). Because angling was conducted primarily by one angler, the hook-setting techniques could easily be stereotyped.

If an angler was unsuccessful in capturing the fish that struck the bait, the angling event was classified as a failure in order to calculate and compare the capture success of all hook types and hook-set techniques. Before removing hooks from landed fish, anatomical hooking location was recorded as esophagus, gullet, gills, jaw, eye, as in Cooke et al. (2003, 2005), but were reduced to a binary, deep (e.g., gills, gullet, esophagus) and shallow (e.g., jaw, mouth, external), variable as in DuBois and Kuklinski (2004) to increase the sample size. Eye-hooking was grouped as a shallow hooking location because of its position relative to the jaw, although eye-hooking is considered to be problematic when fishing with circle hooks by Skomal et al. (2002) and specifically for bluegill in Cooke et al. (2003). After hook removal, individuals were measured (total length [mm]) and it was noted whether there was bleeding. Because the likelihood of mortality of bluegill has been closely correlated with deep hooking and bleeding (Cooke et al., 2003), fish were promptly released after processing and not held for further evaluation (as in Cooke et al., 2005).

All statistical analyses were conducted in R (R Core Team, 2014). We used logistic regressions with a logit link to relate binary response data (either capture success or deep hooking) to both categorical (hook type, hook set) and continuous (mean-centered fish length) predictor variables. With all models, we first tested for interaction; however, no interaction terms were significant, therefore we re-fit the models without these terms. To investigate the relationships between categorical levels, we computed pairwise odds ratios and used Wald tests to check for significance. A Bonferroni correction to the P-value was used when such multiple comparisons within a single categorical variable were needed. We also used this procedure when testing for interaction. To assess model fit, we used a Hosmer–Lemeshow test. We examined the relationship between bleeding (presence or absence of blood) and hooking location (deep or shallow hooking location) with Fisher's exact test.

3. Results

For this study, 618 bluegill with an average total length of 151 ± 29 mm were captured. Odds of capturing a bluegill were influenced by hook type ($P < 0.05$; Fig. 1). Odds of capturing a bluegill increased when a J-hook was used relative to a circle hook

Table 1
Characteristics of different hook-setting techniques used in this study. All hook-setting techniques were used in association with either a J-hook or a circle hook. The bobber technique is considered to be a passive treatment because it did not involve reeling in the line, whereas the light, moderate, and heavy hook-sets are considered active hook-set techniques because they require active retrieval of line along with a rod movement of varying forcefulness.

Hook-set techniques	Description of angler hook-setting intensities
"Bobber"	Angler cast the bait and allowed it to rest motionless with a relatively slack line under the bobber until a strike was perceived, at which moment the angler began to steadily retrieve without a hook-set.
Light hook-set	Angler cast the baited hook and began to slowly retrieve, maintaining the hook in the middle of the water column. If a strike was perceived, the angler continued to reel in slowly, unabated with no movements of the rod or increase in reeling cadence.
Moderate hook-set	Angler cast the baited hook and began to slowly retrieve, maintaining the hook in the middle of the water column. If a strike was perceived, the angler pulled the rod and the line with a moderate, sweeping hook-setting action, drawing the rod tip steadily backward to pull on the line in an attempt to secure the hook. Thereafter the angler proceeded to retrieve.
Heavy hook-set	Angler cast the baited hook and began to slowly retrieve, maintaining the hook in the middle of the water column. If a strike was perceived, the angler made an abrupt, intense, backwards motion with the rod tip to forcefully secure the hook with significant force. After making the hook-set movement the angler proceeded to retrieve.

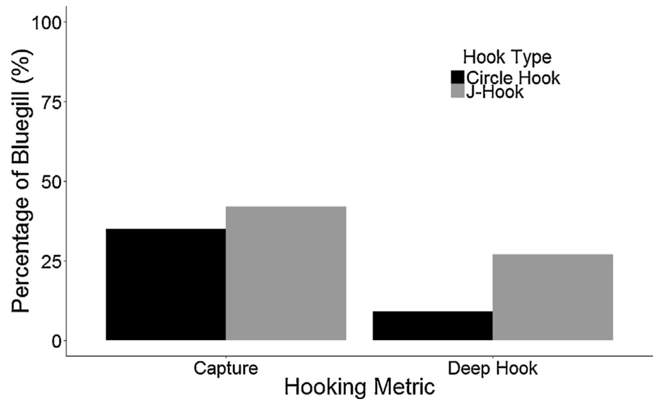

Fig. 1. Effect of hook type on capture success and observations of deep hooking in bluegill. Bluegill were angled using two hook types and instances of capture and deep hooking were recorded. Angling with J-hooks (grey) resulted in higher rates of capture but also higher rates of deep hooking (i.e., in the esophagus or gullet) relative to circle hooks (black).

(odds ratio = 1.27). Likewise, the odds of capture were affected by hook set used, decreasing for heavy hook sets relative to bobbers (odds ratio = 0.70) and increasing when using light (odds ratio = 1.12) or moderate (odds ratio = 1.20) hook sets relative to bobbers (Fig. 2); however, the only significant difference was between heavy hook sets and bobbers ($P < 0.0083$). Odds of capture increased when using a light or moderate hook-set over a heavy hook-set (odds ratios = 1.58 and 1.70, respectively; both significant at $P < 0.0083$), and increased when using a moderate over a light hook-set (odds ratio = 1.07; not significant).

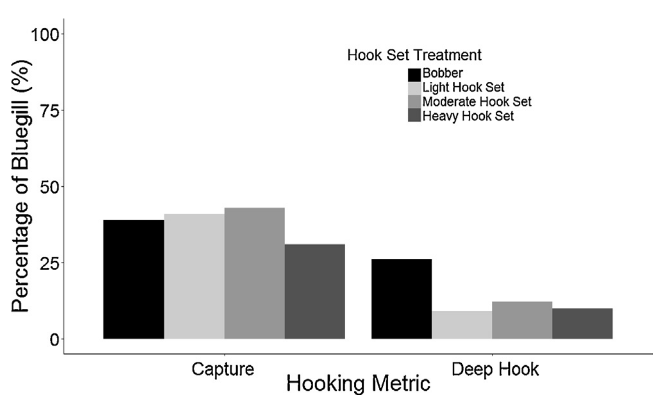

Fig. 2. Effect of angler hook-set technique on capture success and observations of deep hooking in bluegill. Bluegill were angled using four different hook setting techniques and the instances of capture and deep hooking were recorded. Bluegill were captured most frequently while using moderately forceful hook sets and were most frequently deeply hooked (i.e., in the esophagus or gullet) when fishing with bobbers.

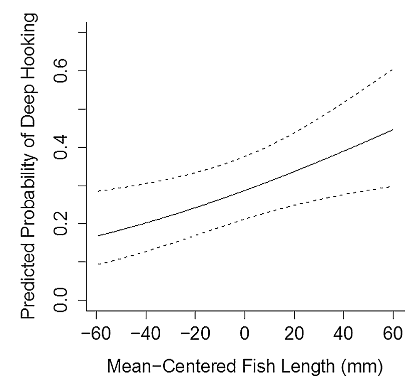

Fig. 3. Model predicted probability of deep hooking given increasing mean-centered fish length. Dashed lines bound the 95% confidence interval of the model predicted probability. Increasing fish length corresponded to increasing probability of deep hooking irrespective of hook type or hook set based on the results of logistic regression.

In the analysis of deep hooking, hook type and fish length coefficients were statistically significant ($P < 0.05$). Odds of deep hooking increased when a J-hook was used as opposed to a circle hook (odds ratio = 2.36; Fig. 1). However, odds of deep hooking also decreased when a heavy, light, or moderate hook-set was used instead of a bobber (odds ratios = 0.35, 0.27, and 0.33, respectively); decreased when a light or moderate hook-set was used instead of a heavy hook-set (odds ratios = 0.76 and 0.94, respectively), and increased when a moderate hook-set was used instead of a light hook-set (odds ratio = 1.25). The odds of deep hooking using heavy, light, and moderate hook-set techniques were significantly different ($P < 0.0083$) from odds of deep hooking with a bobber, but all other pairwise comparisons were not (Fig. 2). For each increase in millimetre total length, odds of being deeply hooked increased by 1.01 (Fig. 3).

Eighty bluegill (13%) were deeply hooked in the study, 30% of which were also bleeding ($N = 24$). Although we could not generate an appropriate model that predicted bleeding in bluegill, we found that there was a significantly higher percentage of bleeding bluegill ($N = 29$) when deeply hooked (83%) than when shallowly hooked (17%; Fisher's exact test, $P < 0.01$).

4. Discussion

Historically, anglers tend to think about hooks as a tool for capturing fish and less about their effects on fish after release (Jordan, 1999). However, the introduction of circle hooks is altering perceptions such that fish welfare is emerging as a consideration when purchasing fishing gear for recreational catch-and-release fisheries. As we have shown here, and which has been shown previously, circle hooks can effectively reduce deep hooking in different species, which is the most consistently identified correlate of post-release angling mortality (Arlinghaus et al., 2007; Cooke and Suski, 2004). Our results show that relative to conventional J-hooks, circle hooks reduce the odds of deep hooking in angled bluegill. However, circle hooks also lower the odds of successfully capturing a bluegill. Collectively, this study provides useful information that fisheries managers can share with the public to help promote circle hooks as an effective conservation tool in recreational catch-and-release fisheries. This is also the first study to show that bobbers, which are used extensively by recreational anglers but whose impacts have never been assessed in catch-and-release fisheries, significantly increase the frequency of deep hooking irrespective of hook type.

As suggested by circle hook manufacturers, circle hooks are best used with a light hook-set to prevent fish injury. This suggests an interaction between hook type and hook-setting technique when quantifying deep hooking. However, our results did not reveal this interaction, which contrasts with Sullivan et al. (2012) who found that combinations of hook type and hook-set individually influenced deep hooking in salmonids (see below). Our results suggest that in bluegill, only the main effects of hook type and hook set significantly predict deep hooking, with circle hooks reducing its incidence relative to J-hooks. However, the mitigating effects of circle hooks on deep hooking come with a cost in terms of capture success, given the observation that circle hooks were less effective at successfully landing a bluegill relative to J-hooks (Fig. 1). This could pose a dilemma to anglers wanting to adopt fish welfare best practices but not wishing to reduce their odds of catching fish.

Despite the benefits of circle hooks in terms of reducing the incidence of deep hooking, these benefits may be attenuated when used in combination with bobbers, which are a very widely used gear accessory. Bobbers lead to high frequencies of deep-hooking with both circle hooks and J-hooks in this study, likely because fish have an easier time fully ingesting the stationary hook before a strike is ever detected by the angler when there is less tension on the line. To our knowledge, no existing studies have considered the effects of bobbers on angling success and hooking dynamics. In a study of rainbow trout, Schisler and Bergersen (1996) found that fish were susceptible to deep hooking when bait (in this case artificial trout eggs) was passively set on a slack line. The result was that angled trout entirely ingested the slack baited hooks and became deeply hooked. Although that study demonstrated high rates of deep hooking with slack lines rather than with bobbers, both angling methods provide fish the opportunity to become hooked in the absence of a hook-set (i.e., via ingestion of the hook), and therefore corroborate the negative impacts of bobbers that we observed in bluegill. One way to potentially mitigate this is by increasing the weight attached to a bobbered leader, which can make strikes more immediately detectable (Beckwith and Rand, 2005).

As noted above, we did not identify a significant interaction between hook-set and hook type, as previously identified in salmonids by Sullivan et al. (2012), but we also remind the reader that only 12.9% (80) of our study fish were deeply hooked. It is not surprising that our conclusion in bluegill differs, because different species typically have different buccal anatomy and feeding kinetics (e.g., Cooke et al., 2003), and thus varying susceptibility to deep hooking. In addition, fishing in a lentic environment such as Lake Opinicon may change the action of the hook in the water column relative to the lotic environment where Sullivan et al. (2012) collected data. For instance, Beckwith and Rand (2005) found deep hooking of red drum (*Sciaenops ocellatus*) decreased when fishing in areas with water currents or in tidal inlets relative to calmer waters; they pointed out that it is relatively unclear how intertial forces affect deep hooking and that environmental influences may be important variables meriting further evaluation. Taken together, the results of this study and Sullivan et al. (2012) indicate that generalizations across species and environments may be inappropriate, but demonstrate that the effects of angler hook-set technique should be considered when evaluating injury and capture success of fish with different hook types.

Interestingly, odds of deep hooking increased with bluegill total length (Fig. 3). The significant effects of total length on deep hooking may have been related to the hook size used. Robert et al. (2012) found that larger hooks (size 8 relative to size 12) may cause more hooking damage to bluegill likely because the longer hook point has greater penetration potential. Alternatively, smaller hooks may be more likely to become deeply hooked due to the relative ease with which they can be ingested (Alós et al., 2008; Beckwith and Rand, 2005). Similar to Sullivan et al. (2012), it is expected that the constant hook sized used in this study would hook large fish differently than small fish, potentially explaining the observed effects of total length. Using gear of appropriate size is an important component of responsible angling, because both hooks that are too large or too small for the targeted species can increase the likelihood of damage to fish.

Recreational anglers tend to believe that circle hooks are an appropriate tool for reducing instances of deeply hooked fish (Cooke et al., 2012). However, recommendations that circle hooks be used differently from J-hooks can confuse anglers, which may contributed to the slow acceptance of circle hooks by some anglers (Cooke et al., 2012). Adoption of circle hooks will mostly be voluntary among conservation-minded anglers (Cooke et al., 2012; Sullivan et al., 2012), although some fisheries management agencies have incorporated circle hooks into policy (see Serafy et al., 2012). Even though we did not identify an interaction between hook type and hook-set, managers and researchers evaluating the effectiveness of circle hooks should be mindful that simply substituting circle hooks for J-hooks may not achieve the desired results (Sullivan et al., 2012). Because species-specific guidelines are essential for proper fisheries management (Cooke and Suski, 2005), further consideration and evaluation of angler hook-set technique is recommended in studies considering the fish welfare effects of circle hooks.

5. Conclusion

Promoting circle hooks in recreational fisheries requires appropriate understanding of the variables affecting their performance compared to standard methods. However, many investigations of circle hooks that have indicated their utility for catch-and-release fisheries have failed to characterize the effects of angler hook-setting techniques on hooking variables. Given the results of this study, managers considering circle hooks as a conservation tool in catch-and-release fisheries should be aware that simply exchanging J-hooks for circle hooks may not automatically reduce the frequency of deep hooking some fish species, and that hook-set technique is a factor to be considered. Notably for managers interested in promoting the conservation benefits of catch-and-release angling with circle hooks, further research may indicate that new and novice anglers may be good targets for circle hook promotion. For example, Jones (2005) predicted passive hook-sets to be easier for novice anglers to learn than the active, rapid hook-sets that are characteristic of J-hooks and require fast reaction times. Moreover, 53% of respondents in Cooke et al. (2012) either agreed or strongly agreed that circle hooks are useful for novice anglers. Although species-specific studies are essential to generate appropriate management strategies (Cooke and Suski, 2005), our finding that both hook types and hook-setting techniques can independently affect fish hooking is relevant to fisheries management and future fisheries research.

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References

Aalbers, S.A., Stutzer, G.M., Drawbridge, M.A., 2004. The effects of catch-and-release angling on the growth and survival of juvenile white seabass captured on offset circle and J-type hooks. North Am. J. Fish. Manage. 24 (3), 793–800.

Alós, J., Palmer, M., Grau, A.M., Deudero, S., 2008. Effects of hook size and barbless hooks on hooking injury, catch per unit effort, and fish size in a mixed-species recreational fishery in the western Mediterranean Sea. ICES J. Mar. Sci.: J. Cons. 65 (6), 899–905.

Arlinghaus, R., Cooke, S.J., Lyman, J., Policansky, D., Schwab, A., Suski, C.D., Sutton, S.G., Thorstad, E.B., 2007. Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. Rev. Fish. Sci. 15 (1–2), 75–167.

Atlantic States Marine Fisheries Commission, 2003. Circle hook definition and research issues. In: ASFMC, Special Report 77. ASFMC, Arlington, Virginia.

Bartholomew, A., Bohnsack, J.A., 2005. A review of catch-and-release angling mortality with implications for no-take reserves. Rev. Fish Biol. Fish. 15, 129–154.

Beckwith, G.H., Rand, P.S., 2005. Large circle hooks and short leaders with fixed weights reduce incidence of deep hooking in angled adult red drum. Fish. Res. 71 (1), 115–120.

Cooke, S.J., Schramm, H.L., 2007. Catch-and-release science and its application to conservation and management of recreational fisheries. Fish Manage. Ecol. 14, 73–79.

Cooke, S.J., Barthel, B.L., Suski, C.D., Siepker, M.J., Philipp, D.P., 2005. Influence of circle hook size on hooking efficiency, injury, and size selectivity of bluegill with comments on circle hook conservation benefits in recreational fisheries. North Am. J. Fish. Manage. 25 (1), 211–219.

Cooke, S.J., Nguyen, V.M., Murchie, K.J., Danylchuk, A.J., Suski, C.D., 2012. Scientific and stakeholder perspectives on the use of circle hooks in recreational fisheries. Bull. Mar. Sci. 88 (3), 395–410.

Cooke, S.J., Suski, C.D., 2004. Are circle hooks an effective tool for conserving marine and freshwater recreational catch-and-release fisheries? Aquat. Conserv.: Mar. Freshwater Ecosyst. 14, 299–326.

Cooke, S.J., Suski, C.D., 2005. Do we need species-specific guidelines for catch-and-release recreational angling to effectively conserve diverse fishery resources? Biodivers. Conserv. 14, 1195–1209.

Cooke, S.J., Suski, C.D., Barthel, B.L., Ostrand, K.G., Tufts, B.L., Philipp, D.P., 2003. Injury and mortality induced by four hook types on bluegill and pumpkinseed. North Am. J. Fish. Manage. 23, 883–893.

DuBois, R.B., Kuklinski, K.E., 2004. Effect of hook type on mortality, trauma, and capture efficiency of wild, stream-resident trout caught by active baitfishing. North Am. J. Fish. Manage. 24 (2), 617–623.

Dunmall, K.M., Cooke, S.J., Schreer, J.F., Mckinley, R.S., 2001. The effect of scented lures on the hooking injury and mortality of smallmouth bass caught by novice and experience anglers. North Am. J. Fish. Manage. 21, 242–248.

Johannes, R.E., 1981. Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia. University of California Press, Los Angeles, CA.

Jones, T.S., 2005. The influence of circle hooks on the capture efficiency and injury rate of walleyes. North Am. J. Fish. Manage. 25 (2), 725–731.

Jordan, J., 1999. Going full circle. Big Game Fish. J. 12 (3), 52–62.

Meka, J.M., 2004. The influence of hook type, angler experience, and fish size on injury rates and the duration of capture in an Alaskan catch-and-release rainbow trout fishery. North Am. J. Fish. Manage. 24, 1309–1321.

Montrey, N., 1999. Circle hooks ready to boom: design pierces fish through jaw, promotes conservation. Am. Sportfish. 2 (January 1999), 6–7.

Muoneke, M.I., Childress, W.M., 1994. Hooking mortality: a review for recreational fisheries. Rev. Fish. Sci. 2, 123–156.

Noble, R.L., Jones, T.W., 1999. Managing fisheries with regulations. In: Kohler, C.C., Hubert, W.A. (Eds.), Inland fisheries Management in North America. , second ed. American Fisheries Society, Bethesda, MD (Pages 455–477).

Pauley, G.B., Thomas, G.L., 1993. Mortality of anadromous coastal cutthroat trout caught with artificial lures and natural bait. North Am. J. Fish. Manage. 13 (2), 337–345.

R Core Team, 2014. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, ISBN 3-900051-07-0, ⟨http://www.R-project.org⟩.

Robert, J.J., Larocque, S.M., Cooke, S.J., 2012. Influence of hook size and style on short-term survival of deeply hooked bluegill. North Am. J. Fish. Manage. 32, 869–874.

Schaefer, W.F., 1989. Hooking mortality of walleyes in a northwestern Ontario Lake. North Am. J. Fish. Manage. 9, 193–194.

Schisler, G.J., Bergersen, E.P., 1996. Postrelease hooking mortality of rainbow trout caught on scented artificial baits. North Am. J. Fish. Manage. 16 (3), 570–578.

Serafy, J.E., Cooke, S.J., Diaz, G.A., Graves, J., Hall, J., Shivji, M., Swimmer, Y., 2012. Evaluating circle hooks in commercial, recreational and artisanal fisheries: research status and needs for improved conservation and management. Bull. Mar. Sci. 88, 371–391.

Skomal, G.B., Chase, B.C., Prince, E.D., 2002. A comparison of circle hook and straight hook performance in recreational fisheries for juvenile Atlantic bluefin tuna. Am. Fish. Soc. Symp. 30, 57–65.

Sullivan, C.L., Meyer, K.A., Schill, D.J., 2012. Deep hooking and angling success when passively and actively fishing for stream-dwelling trout with baited J and circle hooks. North Am. J. Fish. Manage. 33 (1), 1–6.

Zimmerman, S.R., Bochenek, E.A., 2002. Evaluation of the effectiveness of circle hooks in New Jersey's recreational summer flounder fishery. In: Lucy, J.A., Studholme, A.L. (Eds.), Catch and Release in Marine Recreational Fisheries. American Fisheries Society, Bethesda, MD (Symposium 30, Pages 106–109).