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Efficacy of dehooking tools for the removal of hooks from the jaw region of angled fish

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ABSTRACT

There are a variety of tools that have been developed to aid in hook removal of angled fish that are intended for release. The premise of these tools is that they enable rapid hook removal while causing negligible injury to fish. Here we scientifically assessed the efficacy of dehooking tools for the removal of single barbed J-hooks from the jaw region (i.e., shallowly hooked) of smallmouth bass (*Micropterus dolomieu*). Specifically, we compared dehooking time and physical injuries caused by using bare hands, hemostats, pliers, a push-pull device, and a mechanical dehooking device. Bare hands yielded the most rapid dehooking time and the least injury. Dehooking times were the longest for push-pull and mechanical dehooking tools. Moreover, those two purpose-built tools caused the most injury, including tissue tears and bleeding. Dehooking times were intermediate for hemostats and pliers, and they yielded injury similar to use of bare hands. Overall, there was no evidence of conservation benefit arising from use of dehooking tools with smallmouth bass caught on single barbed J-hooks. However, there are other contexts where they may be use useful, such as dehooking sharp-toothed fishes, and if fish are hooked in areas other than the jaw. This research suggests that dehooking tools are not universally useful to achieve optimal catch-and-release outcomes and their utility likely depends on context. Given the wide diversity of fish caught by recreational anglers, as well as the diversity and sizes of hooks, more research on hook removal tools is needed.

1. Introduction

Recreational fishing is popular around the globe with variable proportions of captured fish released (i.e., catch-and-release, C&R) to comply with regulations or because of angler conservation ethic (Arlinghaus et al., 2007). The premise of C&R is that the majority of fish survive and do so with minimal injury or sublethal impairments in physiology or behaviour (Cooke and Schramm, 2007). Great effort has been devoted to understanding the factors that influence mortality or sublethal injuries or impairments (reviewed in Bartholomew and Bohnsack, 2005). Such information is useful for fisheries management planning (Wydoski, 1977) but also reveals opportunities to refine C&R practices to benefit fish and fisheries (Cooke and Suski, 2005). Indeed, many different tools and tactics have been developed to reduce mortality, injury and stress (reviewed in Brownscombe et al., 2017), yet the efficacy of many remain untested using a systematic scientific approach. For example, in the last decade or so there has been interest in developing tools that enable the rapid dehooking of fish in an effort to reduce handling and air exposure. Although many such tools (often called dehooking tools) now exist, there is little research evaluating the extent to which they benefit fish.

Dehooking tools have recently been studied in an attempt to understand if they are able to safely remove hooks that are deeply set, such as in the gullet (Cooke and Danylchuk, 2020). Although the study by Cooke and Danylchuk (2020) was terminated prematurely due to high levels of mortality for all gear types, it did highlight the importance of cutting the line for hooks that are in deep locations. The authors concluded that although dehooking tools should not be used for deeply hooked fish, they may still have value for shallowly hooked fish (e.g., in the jaw or other regions of the mouth). Indeed, nearly all guidelines

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produced by government agencies in North America emphasize the importance of minimizing handling time and air exposure, and encourage anglers to have pliers or other dehooking tools at the ready (Pelletier et al., 2007). Moreover, such dehooking tools are discussed in angler forums and media (e.g., http://www.floridasportsman.com/2013/08/21/the-art-and-science-of-dehooking-2/; https://coastalanglermag.com/dehooking-device-fishing/) and are even a requirement to have in ones possession when fishing for certain species in some jurisdictions (e.g., in Federal and State marine waters of Florida when targeting reef fish; https://myfwc.com/fishing/saltwater/recreational/gear-rules/). Despite the general sentiment that dehooking tools are useful for expediting hook removal to the benefit of the fish, there is little (we were not able to find any, even for instances where such gears are regulated) research to evaluate this notion. To that end, the objective of this study was to evaluate the efficacy of various dehooking devices (including hemostats, pliers, a push-pull device, and a mechanical dehooker) and bare hands for the removal of hooks from the jaw region of a teleost fish. Endpoints examined included dehooking time, tissue damage, and bleeding. We used smallmouth bass (*Micropterus dolomieu*) captured on barbed jigs as a model for this study given their popularity as a gamefish (Quinn and Paukert, 2009).

2. Methods

All research was conducted under the auspices of a Scientific Collection Permit from the Ontario Ministry of Natural Resources and Forestry and an Animal Care Certificate from Carleton University (2020-Cooke-CRU). This study was conducted between 26 July and 23 August of 2020 on Big Rideau Lake, Ontario, Canada. Because research was conducted during the COVID-19 pandemic, we operated under the Cooke Lab Research Resumption Plan approved by Carleton University with all field work conducted by the Cooke family household bubble (see https://www.cbc.ca/radio/quirks/sep-12-summer-science-special-fishing-with-the-boys-covid-garbage-and-more-1.5720234/a-fisheries-biologist-copes-with-the-shutdown-by-drafting-his-kids-as-research-assistants-1.5720237). Surface water temperature during the study was stable at ~26 °C.

Angling was conducted from a shallow-water fishing boat and smallmouth bass were captured on medium action spinning rods and reels with 3.6 kg (8 lb) line. All fish were captured using 1.77 g (1/16 oz) barbed jig heads rigged with 6.4 cm (2.5 inch) soft plastic grubs. Fight times were standardized between 20–30 s. Fish were landed using a rubber net and immediately transferred to a 20 L cooler filled with ambient lake water. Fish were processed immediately upon capture by a single researcher (SJC). Fish were removed from the cooler and held vertically by the lip at which point it was verified that the fish was hooked in a shallow location (i.e., not in the gullet or gills, or externally foul hooked). Any fish that were deeply hooked had the line cut and were released. Similarly, any fish that fell off prior to handling were excluded from the study.

For shallow hooked fish, five treatments were alternated randomly to remove the hook while the fish was out of the water (a common practice used by bass anglers). For all but the push-pull treatment, the fish was held with one hand, while the other hand was used to apply the hook removal treatment. The "hand" treatment involved using only the thumb and fingers to remove the hook. The plier (Fig. 1A; Berkley Aluminum, 17.8 cm) and hemostat (Fig. 1B; Dr. Slick Stainless Steel, 14.0 cm) treatments involved gripping the shank of the hook and used wrist movement and leverage to apply force until the hook was extracted from the jaw. Following manufacturer guidelines, the push-pull (Fig. 1C; Anglers Choice TBL-095, 24.1 cm) treatment involved holding the fish above the cooler by the line and jerking rapidly on the device repeatedly until the hook was removed. We acknowledge that push-pull devices take time to learn how to use effectively but the researcher using the device has removed over 200 fish with the device, thus could be considered to be experienced. The last treatment involved using a

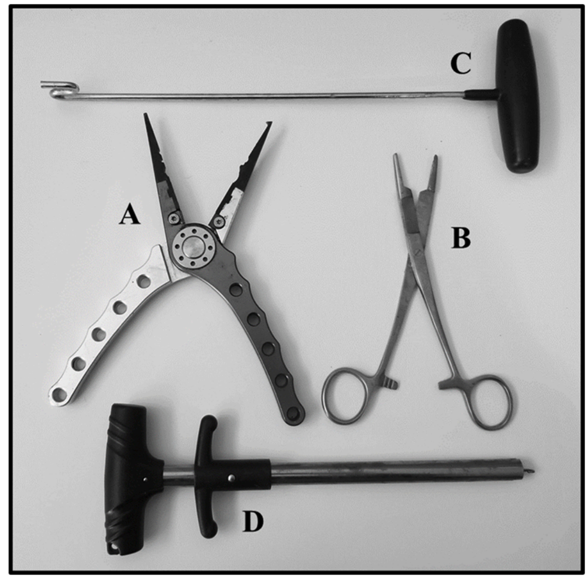

Fig. 1. Hook removal devices used in this study: A) Berkley Aluminum pliers, B) Dr. Slick Stainless Steel hemostat, C) Anglers Choice push-pull device, and D) Easy Reach mechanical fish hook remover.

mechanical dehooking device (Fig. 1D; Easy Reach Fish Hook Remover Squeeze-Out Fish Hook Separator, 21.0 cm). We followed the manufacturer instructions and gripped the hook at the bend of the shank, depressed the plunger and used wrist movements to apply force to remove the hook. For all treatments, the time to remove the hook was recorded (to the nearest s). The timer began when the dehooking gear (or fingers for the hand treatment) moved to within 1 cm of the hook and was stopped when the hook was removed. The researcher then recorded the depth of hook penetration (measured from the tip of the snout to the nearest mm; as per Cooke et al., 2001), measured the length of tissue tear (as per DuBois and Dubielzig, 2004; e.g., tearing of the buccal membrane), and noted any evidence of bleeding. Fish were then transferred to a water filled trough to where they were measured (total length) to the nearest mm. All fish were then tagged with a T-bar anchor tag (Floy Manufacturing) to ensure that they were not reused in the study.

While fish were being released they were assessed for reflex impairment while being held in water alongside the boat (Davis, 2010). Fish were held upside down to determine if they could right themselves within 3 s. Next, the tail of the fish was grabbed to determine if they responded by bursting away. These two reflexes, when absent, have previously been documented as being indicative of post release mortality (Raby et al., 2012).

2.1. Statistical analysis

Fish sizes (mm) and length-corrected hooking depths (i.e., hooking depth/total length; as per Cooke et al., 2001) were compared amongst treatments, each with a one-way analysis of variance (ANOVA). To explore whether there were significant differences between unhooking treatments in fish health outcomes, unhooking time (seconds), tissue tear length (mm), and occurrence of bleeding (binomial yes/no) were compared. Unhooking time and tissue tear length were each compared amongst treatments with a one-way ANOVA. These responses were log transformed prior to analysis to reduce heterogeneity of variance amongst treatments. For the occurrence of bleeding response one treatment group had zero variance and hence a generalized linear model could not be used. It was therefore analyzed with a Bayesian generalized linear model with uninformative priors and treatment as the predictor. All analysis was conducted in R (R Core Team, 2019) via RStudio

(RStudio Team, 2016), with ANOVAs fit with the stats package (R Core Team, 2019) and the Bayesian GLM was fit with the arm package (Gelman and Su, 2020).

3. Results

There was no significant difference in the total length of smallmouth bass among treatments (one-way ANOVA; $F_{4,163} = 1.2$, $p = 0.33$). However, there was a significant difference in body size corrected hooking depth (one-way ANOVA; $F_{4,163} = 4.7$, $p = 0.001$), with hooking depths in the hand treatment being significantly less than the haemostat, pliers, and mechanical treatments (Tukey's HSD; $p < 0.05$). No significant differences were noted amongst the other treatments.

Dehooking times, tissue tear lengths, and occurrence of bleeding from the hook wound were variable among treatments, but were generally higher when dehooking devices were used and lowest when only a hand was used (Fig. 2). There was a significant difference in dehooking time among treatments (one-way ANOVA; $F_{4,163} = 43.5$, $p < 0.001$), with all treatments significantly different from each other (Tukey's HSD; $p < 0.05$) except for between pliers and haemostat ($p = 0.70$) (Fig. 2A). There was also a significant difference amongst treatments in tissue tear length (one-way ANOVA; $F_{4,163} = 25.7$, $p < 0.001$), and all treatments were significantly different from each other (Tukey's HSD; $p < 0.05$) except for between pliers and haemostat ($p = 0.83$), and push pull and mechanical ($p = 0.58$) (Fig. 2B). There was a significantly higher occurrence of bleeding in the mechanical device treatment than all other treatments (Bayesian GLM; $z<2.3$, $p < 0.05$), except for when the push pull device was used ($z=-1.7$, $p = 0.10$) (Fig. 2C). There was also a marginally significantly higher occurrence of bleeding in the push pull device than by hand ($z=-2.0$, $p = 0.049$). Reflex indicators were almost entirely intact and no fish died during handling or immediately following release.

4. Discussion

Since C&R angling became popular in the 1970s (Arlinghaus et al., 2007), much effort has been devoted to creating strategies and tools intended to benefit fish and fisheries. Dehooking devices have long been assumed as something that is good for fish because they enable rapid dehooking while minimizing injury and stress (reviewed in Brownscombe et al., 2017). This study represented one of the first such tests of this supposition. Surprisingly, the use of bare hands yielded more rapid dehooking times than all tools. Hemostats and pliers were intermediate in terms of dehooking times while the two purpose-built tools (the push-pull device and mechanical dehooker) took the longest.

Longer hook removal times are associated with more handling and air exposure which can collectively lead to greater levels of physiological disturbance (Cooke et al., 2001; Cook et al., 2015). The mean dehooking time was less than 10 s for all treatments which is the generalized threshold identified by Cook et al. (2015) as being a target for maximum air exposure durations for fish. However, approximately 20 % of observations for the mechanical dehooker exceeded 15 s of handling with values as high as 33 s. The only other treatment that had observations that exceeded 15 s was the push-pull dehooker. Given that the researcher doing the dehooking is experienced (as both an angler and fisheries researcher) it is conceivable that the time to remove hooks would be higher in less experienced individuals. As such, although the differences observed here are relatively small (on the order of a few seconds among most treatments), in real angling scenarios these differences could be magnified.

We observed clear differences in injury and bleeding among the treatments. Injuries as judged by tearing were greatest in the push-pull and mechanical dehooker, and nearly twice the size (i.e., ~4 mm) of the tears arising from use of bare hands, hemostats and pliers (i.e., ~2 mm). The mechanical dehooker often slipped off and sometimes required some level of twisting to remove the hook. The push-pull device led to tearing as the fish was hung and often took several "shakes" before the fish dropped off. Use of fingers, hemostats or pliers provided more control to the individual removing the hook and provided an opportunity to look closely at the hooking site while the hook was being removed. This ability to both see the hook site and adjust hook removal behaviour in real time (which was not possible with the push-pull or mechanical dehooker) seemed to yield less injury. Reduced tearing was also coincident with less bleeding. Although none of the bleeding observed in our study would be considered severe, blood loss is clearly a useful indicator of welfare status (Johansen et al., 2006).

An important consideration here is that all fish were initially landed and placed in a cooler before hook removal was attempted. Moreover, smallmouth bass have fine, almost granular teeth and hence are easy to handle and can be gripped by the lower jaw to render the fish largely immobile. All hook removal for this study occurred in air. Additional research is needed where hook removal gear is used either in the water or over the water (e.g., over side of a boat, standing on the shoreline, or when wading) and where the fish itself is not touched by the angler. If a fish is to be released and there is no need to remove it from the water, then being able to release the fish without handling it at all, including no

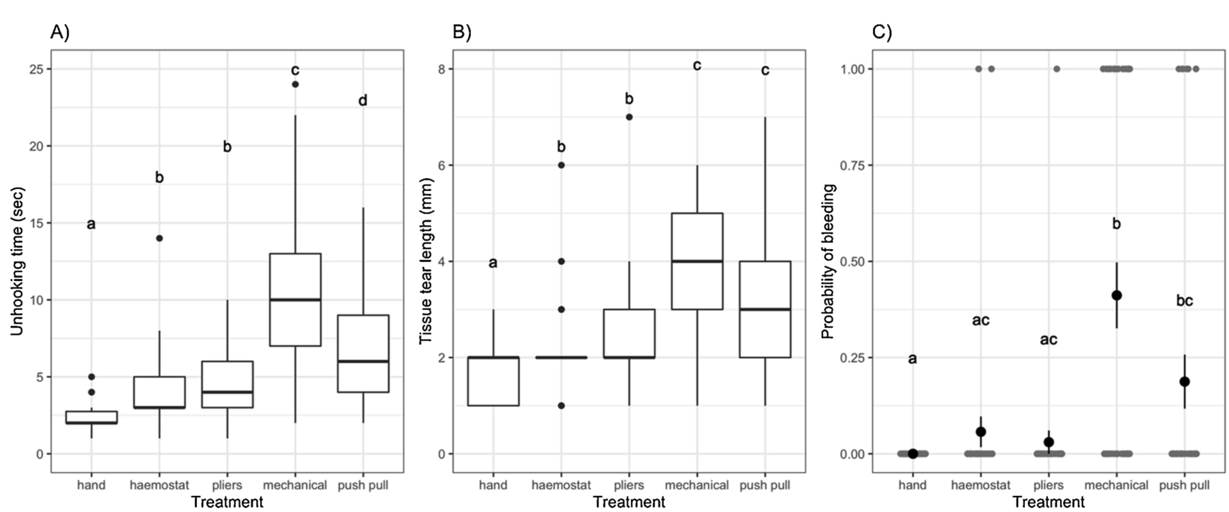

Fig. 2. A) unhooking time, B) tissue tear length, and C) occurrence of bleeding in fish exposed to unhooking treatments including by hand, using haemostats, pliers, a mechanical unhooking tool, or a push pull unhooking tool. Boxplots indicate the median (thick line), the 25 % and 75 % quartiles (boxes), 1.5 times hinge of the inter quartile range (lines), and outliers (points). The 95 % confidence intervals in C) represent standard error.

air exposure, would be of great benefit to the fish.

This study was approached from the perspective that some fish are landed and exposed to air with the time of air exposure directly linked to the ease of hook removal. As such, our findings are important but more work is needed as different hook removal gears may perform differently in other contexts. It is also worth noting that we used small single barbed hooks. Other hook styles (e.g., treble hooks, barbless hooks) may influence the performance of different dehooking devices. Moreover, although it was not possible to quantify other potential welfare impacts (e.g., psychological impacts; Chandroo et al., 2004), the prolonged time for removal with the push-pull method may have had additional consequences.

In the context studied here, we found that when fish were removed from the water to remove the jig hooks, bare hands were the fastest and yielded the least injury. However, it is important to note that the fish in the bare hands treatment were on average hooked in more shallow locations so caution needs to be used in interpreting that finding. Notwithstanding that confounding factor, we observed significant variation in the performance of the different dehooking tools. Simple hemostats or pliers were faster at removing hooks than purpose-built dehooking devices of two styles. Moreover, hemostats and pliers led to less tearing and bleeding relative to the commercial dehooking devices. These findings emphasize the benefit that can be derived from using simple and inexpensive hemostats and pliers where needed, however bare wet hands may be equally or even more effective for removing shallow hooked single barbed J-hooks.

Given the diversity of fish species captured and hook types and configurations used, there is need for additional research on this topic such as for fish with sharp dentition where use of dehooking devices is needed for angler safety (e.g., Dubois et al., 1994; O'Toole et al., 2010) and for more sensitive fish species for which any level of handling can be detrimental (e.g., Schill, 1996). Our findings also emphasize the importance of testing the claims of different products that are marketed as being beneficial for fish but may in fact do more harm than good. As is the case with most C&R guidance, context matters (Cooke and Suski, 2005).

Author contributions

All authors were involved with conceptualizing the study; C.J.A.C., J. T.H.C., B.W.C.C. and S.J.C. collected the data; J.W.B analyzed the data; S.J.C. wrote the draft manuscript and all authors provided input (of varying forms) on the final draft; B.W.C.C. fell overboard once during the study.

CRediT authorship contribution statement

Steven J. Cooke: Conceptualization, Methodology, Investigation, Data curation, Writing - original draft. **Cameron J.A. Cooke:** Methodology, Investigation. **Joshua T.H. Cooke:** Methodology, Investigation. **Benjamin W.C. Cooke:** Methodology, Investigation. **Andy J. Danylchuk:** Conceptualization, Writing - review & editing. **Jacob W. Brownscombe:** Formal analysis, Writing - review & editing.

Declaration of Competing Interest

The authors report no declarations of interest.

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References

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, 75–167.

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 (1-2), 129–154.

Brownscombe, J.W., Danylchuk, A.J., Chapman, J.M., Gutowsky, L.F., Cooke, S.J., 2017. Best practices for catch-and-release recreational fisheries–angling tools and tactics. Fish. Res. 186, 693–705.

Chandroo, K.P., Duncan, I.J., Moccia, R.D., 2004. Can fish suffer?: perspectives on sentience, pain, fear and stress. Appl. Anim. Behav. Sci. 86 (3-4), 225–250.

Cook, K.V., Lennox, R.J., Hinch, S.G., Cooke, S.J., 2015. Fish out of water: how much air is too much? Fisheries 40 (9), 452–461.

Cooke, S.J., Danylchuk, A.J., 2020. Hook disgorgers remove deep hooks but kill fish – a plea for cutting the line. Fish. Manage. Ecol. 27, 622–627.

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

Cooke, S.J., Dunmall, K., Schreer, J.F., Philipp, D.P., 2001. The influence of terminal tackle on physical injury, handling time and cardiac disturbance of rock bass. N. Am. J. Fish. Manage. 21, 333–342.

Davis, M.W., 2010. Fish stress and mortality can be predicted using reflex impairment. Fish. Fish. 11 (1), 1–11.

DuBois, R.B., Dubielzig, R.R., 2004. Effect of hook type on mortality, trauma, and capture efficiency of wild stream trout caught by angling with spinners. N. Am. J. Fish. Manage. 24 (2), 609–616.

DuBois, R.B., Margenau, T.L., Stewart, R.S., Cunningham, P.K., Rasmussen, R.W., 1994. Hooking mortality of northern pike angled through ice. N. Am. J. Fish. Manage. 14, 769–775.

Gelman, A., Su, Y.-S., 2020. Arm: Data Analysis Using Regression and Multilevel/Hierarchical Models. R Package Version 1.11-2. https://CRAN.R-project.org/package=arm.

Johansen, R., Needham, J.R., Colquhoun, D.J., Poppe, T.T., Smith, A.J., 2006. Guidelines for health and welfare monitoring of fish used in research. Lab. Anim. 40 (4), 323–340.

O'Toole, A.C., Danylchuk, A.J., Suski, C.D., Cooke, S.J., 2010. Consequences of catch-and-release angling on the physiological status, injury, and immediate mortality of great barracuda (Sphyraena barracuda) in The Bahamas. ICES J. Mar. Sci. 67 (8), 1667–1675.

Pelletier, C., Hanson, K.C., Cooke, S.J., 2007. Do catch-and-release guidelines from state and provincial fisheries angencies in North America conform to scientifically-based best practices? Environ. Manage. 39, 760–773.

Quinn, S., Paukert, C., 2009. Centrarchid fisheries. In: Cooke, S.J., Philipp, D.P. (Eds.), Centrarchid Fishes – Diversity, Biology, and Conservation. John Wiley & Sons, West Sussex, UK, pp. 312–339.

R Core Team, 2019. R: A Language and Environment for Statistical Computing. Available from. R Foundation for Statistical Computing, Vienna, Austria. https://www.r-project.org/.

R Studio Team, 2016. RStudio: Integrated Development for R. Available from. RStudio, Inc., Boston, MA. http://www.rstudio.com/.

Raby, G.D., Donaldson, M.R., Hinch, S.G., Patterson, D.A., Lotto, A.G., Robichaud, D., English, K.K., Willmore, W.G., Farrell, A.P., Davis, M.W., Cooke, S.J., 2012. Validation of reflex indicators for measuring vitality and predicting the delayed mortality of wild coho salmon bycatch released from fishing gears. J. Appl. Ecol. 49, 90–98.

Schill, D.J., 1996. Hooking mortality of bait-caught rainbow trout in an Idaho trout stream and a hatchery: implications for special-regulation management. N. Am. J. Fish. Manage. 16 (2), 348–356.

Wydoski, R.S., 1977. Relation of hooking mortality and sublethal hooking stress to quality fishery management. In: Barnhart, R.A., Roelofs, T.D. (Eds.), Catch-and-Release Fishing as a Management Tool. Humbolt State University, Arcata, California, pp. 43–87.