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Management Brief

Evaluating hook removal techniques on jaw-hooked Smallmouth Bass captured with soft plastic jigs

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ABSTRACT

Objective: Products that are intended to facilitate the release of angled fish continue to be developed by the fishing industry without systematic and objective evaluation to test their effectiveness for releasing fish without causing undue harm. Here, we evaluated the efficacy of dehooking methods (i.e., removing the hook with bare hands, pliers, or a mechanical dehooking device) while either holding the fish in air by the lower mandible or without touching the fish.

Methods: We captured 131 Smallmouth Bass *Micropterus dolomieu* by using barbed Ned rigs (single-hook, soft plastic jig-style lures) and assessed the duration of time needed to remove the hook, the extent of physical injury caused by the hook removal method, and the extent of reflex impairment of the fish.

Results: Unhooking time was influenced by hook removal method and fish length. Physical injury was also influenced by the unhooking method; the use of pliers while holding the fish by the lower mandible resulted in no observed injuries compared to all other dehooking methods, which resulted in some proportion of fish being injured. Longer unhooking time increased reflex impairment. The traditional method of holding the lower mandible of black bass yielded faster dehooking times and fewer injuries irrespective of hook removal method, but the use of hands proved to be the fastest method.

Conclusions: Our research suggested that an alternative method of touchless dehooking and the use of a mechanical dehooking tool were not effective when releasing shallow-hooked Smallmouth Bass. Our findings also suggested that gripping the fish by the lower mandible and using hands constituted the most effective hook removal approach for Smallmouth Bass in the context studied here.

KEYWORDS: catch and release, dehooking, injury, *Micropterus dolomieu*, recreational angling

LAY SUMMARY

Gripping Smallmouth Bass while removing hooks after angling is an effective strategy, enabling rapid dehooking and minimizing injury to the fish.

INTRODUCTION

Recreational fishing is a popular leisure, sporting, and subsistence activity that is enjoyed by many people around the globe (Arlinghaus et al., 2021; Embke et al., 2022). Each year, it is estimated that tens of billions of fish are caught across the world by anglers, with over 60% of them released (Cooke & Cowx, 2004). Fish may be released to comply with regulations (i.e., season closures, slot lengths, and possession limits), if they are a nondesired fish species, or voluntarily to satisfy a personal conservation ethic (Arlinghaus et al., 2007; Cooke et al., 2021; Sass & Shaw, 2020). Catch-and-release (C&R) fishing is seen by many as a strategy to conserve fisheries and to promote sustainability of aquatic resources (Arlinghaus et al., 2007; Cooke & Schramm, 2007). This technique assumes that fish are released back into the water in which they were captured and that they survive with minimal sublethal impairments (Arlinghaus et al., 2007). To effectively manage C&R fisheries, it is important to identify and understand factors during angling interactions that contribute to sublethal impairment (i.e., reduced ability to feed or reproduce) or, in severe cases, mortality (Cooke & Schramm, 2007). Single stressors or the combination of many stressors, such as angler behavior (i.e., gear choice and

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air exposure period), environmental factors (i.e., water temperature and chemistry), ecological conditions (i.e., predator burden and disease), and species characteristics (i.e., depth of capture), can influence the rate of injury, sublethal impairment, and mortality (Brownscombe et al., 2017).

Hooking injury is the leading cause of angling-related mortality in C&R (Bartholomew & Bohnsack, 2005; Cooke & Suski, 2005; Muoneke & Childress, 1994). Anglers routinely aim to hook the fish in the mouth or jaw (mainly comprised of skin, cartilage, or muscle), leaving a small puncture wound that does not impair the fish. At times, fish can be unintentionally hooked in more sensitive areas (e.g., the gills, body, eyes, or esophagus), thus causing physical damage, including tearing and bleeding (Brownscombe et al., 2017; Muoneke & Childress, 1994). The anatomical location and size of the hook wound can influence mortality, which tends to occur within minutes to hours after the hooking injury was sustained (Muoneke & Childress, 1994). It is almost always futile to remove the hook if deeply embedded in the gullet, as this will result in a lethal injury (e.g., Butcher et al., 2007; Cooke & Danylchuk, 2020; Cooke, LaRochelle et al., 2022; Mason & Hunt, 1967; Roberts et al., 2011; Schisler & Bergersen, 1996); however, it is generally advisable to remove hooks from the mouth or jaw.

Beyond hooking injury, the length of time that is needed to remove hooks from fish increases the air exposure and handling period (Cooke & Suski, 2005). Both have been found to impair reflexes in fish, which can lead to negative lethal and sublethal effects (reviewed by Bartholomew & Bohnsack, 2005). Handling can cause dermal injuries, including mucus and scale loss, leaving fish vulnerable to disease and fungal growth (Colotelo & Cooke, 2011). Prolonged air exposure can result in adhesion of gill filaments, thus reducing the ability to uptake oxygen and resulting in blood acidosis in severe cases (Ferguson & Tufts, 1992; reviewed by Cook et al., 2015). Therefore, it is important that anglers remove hooks from fish in the fastest manner possible to avoid the cascading effects that prolonged air exposure and handling have on fish.

Hook removal devices have been increasing in popularity and availability (Cooke & Danylchuk, 2020). Traditional devices, such as pliers and hemostats, are easy to acquire and commonly used by anglers. However, there is a growing number of dehooking tools that are specifically marketed for reducing handling and air exposure during the hook removal process. It is recognized that the efficacy of these devices requires further testing and research (Cooke & Danylchuk, 2020). A recent study by Cooke, Cooke et al. (2022) tested five hook removal devices compared with bare hands for Bluegill *Lepomis macrochirus*. That study found that simple devices such as pliers were more effective and resulted in less tearing and bleeding, whereas none of the purpose-built dehooking tools performed well (Cooke, Cooke et al., 2022). Hussey et al. (2023) found that some hook removal devices could reduce unhooking difficulty and assist anglers in the timely release of captured Bluegill. Other studies have suggested that dehooking tools are not universally beneficial for all applications but may be useful in some contexts (reviewed by Brownscombe et al., 2017; Cooke et al., 2021).

The objective of our study was to evaluate the effectiveness of dehooking tools used by anglers targeting Smallmouth Bass *Micropterus dolomieu* (SMB) to test whether tools and related techniques enabled the rapid release of fish with minimal reflex impairment and physical injury. We selected the SMB as a study species because it is a relatively abundant sport fish in North America and is commonly targeted by anglers, making the SMB an excellent model species for this study (Quinn & Paukert, 2009). Using immediate reflex impairment levels and injury, we tested three hook removal methods while holding SMB by the lower mandible (in air) and tested the same three methods without holding the fish (rapid release technique) while it was in a water-filled live well. Our results will contribute to improving handling practices in the C&R fishing of SMB and will contribute more broadly to defining best handling practices.

Figure 1. Hook removal devices used in this study: T-shaped mechanical dehooker (bottom) and needle-nose pliers (top), with a dime (Canadian 10-cent coin) for scale.

METHODS

Dehooking

Our study was conducted during August 15–September 26, 2023, on Big Rideau Lake (44.750°N, −76.233°W), with surface temperatures ranging from 18°C to 24°C. Three anglers captured SMB by using 213-cm, medium-action rods lined with 4.5-kg-test braid. All fish were caught using size-1 barbed jig heads fitted with an artificial, soft plastic jig (i.e., Ned rig) with a length of 70 mm. The Ned rig is a common type of finesse lure that is often used by SMB anglers.

Fight times were kept to less than 20 s. Once landed, fish were randomly assigned to one of six treatments. Methods used to remove hooks during our study were needle-nose pliers; a plunger-actuated, T-shaped mechanical dehooking tool (hereafter, termed "dehooking tool" or "dehooker"; Figure 1); and hook removal by hand (hook removed by the index finger and thumb). The six dehooking treatments included hook removal by hand while holding the fish (Holding & Hand), hook removal with pliers while holding the fish (Holding & Pliers), hook removal with the dehooking tool while holding the fish (Holding & Dehooker), dehooking by hand without holding the fish (Hand), dehooking with pliers without holding the fish (Pliers), and hook removal with the dehooking tool without holding the fish (Dehooker). Dehooking without holding the fish was done to simulate a rapid release, which is performed directly after capture, likely boatside. In practice, this would likely occur with the angler leaning over the side of the boat, dock, or shoreline. Once the hook was gripped by the removal device, the device was either rotated (in the case of pliers or hand) or plunged (in the case of the dehooking tool) to remove the fish. During this time, neither the body nor the jaw of the fish was held, with the only contact being on the hook itself. Air exposure occurred during hook removal to obtain leverage (i.e., utilize the body weight of the fish to remove the hook). Hook removal while holding the fish involved gripping the fish by hand in the mandible (lower jaw) and removing the hook using one of the three methods. Such restraint works well for SMB given that they have small, sandpaper-like teeth, and this technique is widely used by bass anglers of all abilities. Fish that were deeply hooked or foul-hooked (i.e., hooked past the jaw or elsewhere on the body) were excluded from our study. If a fish was hooked outside of the mouth (i.e., in the operculum or the side of the body), the hook was removed and the fish was immediately released. If the fish was deeply hooked in the mouth or in a vital location (i.e., gills or esophagus), the line was cut and the fish was released to maximize the survival success of the fish (Cooke & Danylchuk, 2020).

Dehooking time (to the nearest second) was recorded with stopwatches and began upon first contact of the dehooking device with the Ned rig hook and ended once the hook was removed. Anatomical hooking location (upper or lower jaw) was then recorded. If the hook was not successfully removed after 30 s of effort, the removal of the hook was prioritized (as per our animal care protocol), often consisting of stripping the plastic from the hook to get a better hold of the hook.

Condition assessment

Once unhooked, the reflex impairment of the fish was evaluated in a 30-L live well after hook removal. Five reflexes that are commonly used in C&R studies (Lennox et al., 2024) were tested immediately after hook removal; these included tail grab (to test bursting response), body flex (attempts to escape when held around the body), equilibrium (righting ability), head complex (maintenance of regular opercular beats), and bite (mouth clamping). Reflex impairment was tested, scored in binary (with 0 indicating no impairment or 1 indicating impairment), and combined for a total proportional score between 0 and 1. These reflexes were used because they have been documented to be predictors of postrelease mortality (Davis, 2010). Injury and evidence of bleeding (presence or absence) were noted, with injury being considered as any tear greater than the puncture wound from the hook. The fish was then placed into a water-filled measuring trough, and its total length was recorded (to the nearest millimeter). Just prior to release, each fish was tagged with an anchor tag (Floy Manufacturing) to ensure that the individual would not be reused in our study.

Data analysis

A one-way ANOVA was used to test whether there was a difference in SMB total length across the different treatments. Hook removal time was assessed using a multiple regression linear model, with unhooking time (s) used as the response variable. The predictor variables included the hook removal method (treatment), hook location (upper or lower jaw), angler, and fish total length (mm). A backwards stepwise regression was used to determine the model of best fit, whereby models within a Δ of 2 would be considered. If the multiple regression linear model had a significant categorical predictor variable, a Tukey post hoc test was performed using the glht function in the multcomp package (Horthorn et al., 2008), which allowed us to further explore the nuances in unhooking time across the different significant predictor variables.

Using the AICcmodavg package (Mazerolle, 2023), we conducted model selection based on Akaike's information criterion corrected for small sample size (AIC_c) to test which variables affected reflex impairment. We constructed 12 generalized ordinal models with reflex score as the response variable, and the predictor variables included treatment, angler, unhooking time, hooking location, fish total length, injury score (binomial yes/no), and bleeding (binomial yes/no). Each model selection included one null model for comparison, and only models within 2 AIC_c units of the highest ranking model were considered.

To test which variables affected injury occurrence, a generalized linear model with a binomial distribution was created. The model contained injury (binomial) as the response variable, with treatment, angler, unhooking time, hooking location, and fish total length as predictor variables. Backwards stepwise regression was conducted to determine the model of best fit ($\Delta = 2$). A chi-square post hoc test was used to further explore the differences in injury across the significant predictor variables in the model. The threshold for significance (α) was 0.05 for all tests. Analysis and figure creation were conducted in RStudio via R (Posit Team, 2024; R Core Team, 2023).

Table 1. Summary of Smallmouth Bass sample size and length data (mm total length) for all hook removal treatments (see *Methods* for a description of each).

Treatment	*N*	Mean total length ± SE	Length range
Holding & Hand	22	243 ± 13	172–422
Holding & Pliers	22	251 ± 12	170–404
Holding & Dehooker	20	246 ± 10	150–307
Hand	23	257 ± 13	156–364
Pliers	22	258 ± 10	162–404
Dehooker	22	252 ± 11	194–430
All	131	251 ± 5	150–430

RESULTS

We captured 131 SMB for this study; the mean length ± SE of the SMB was 251 ± 5 mm ($N = 131$; range = 150–450 mm) and did not differ across the six unhooking treatments ($F_{125,5} = 0.244$, $P = 0.942$). Sample sizes and fish lengths for each of the treatments are summarized in Table 1. The selected multiple regression linear model had unhooking method and fish total length as the predictor variables. All other models had Δ values greater than 2. There was a significant positive relationship between SMB total length and the time it took to remove the hook ($F_{124,1} = 5.60$, $P = 0.019$). Time to remove the hook was also significantly influenced by the hook removal method ($F_{124,5} = 9.71$, $P < 0.001$; Figure 2). The post hoc results indicated that

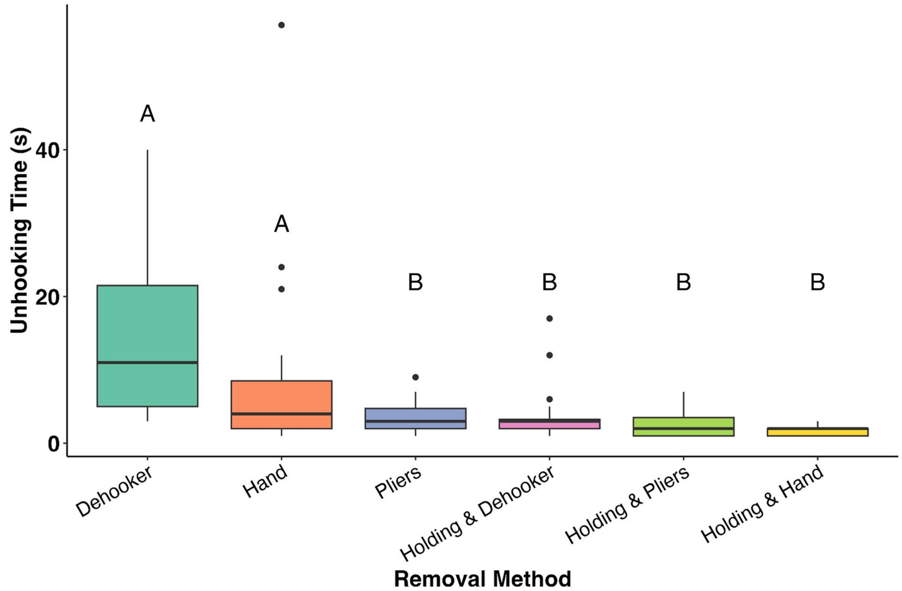

Figure 2. Smallmouth Bass unhooking time by hook removal method (see *Methods* for a description of each). The line within each box indicates the median, the ends of the box represent the first and third quartiles, and ends of whiskers show the minimum and maximum values. Outliers are represented by black dots. Dissimilar letters represent significant differences in hook removal time between methods.

Table 2. Tukey post hoc results of unhooking times for Smallmouth Bass across hook removal treatments (see *Methods* for a description of each) compared to each other. The *P*-values for significant comparisons are shown in bold.

Comparison	Estimate	SE	*t*-value	*P*-value
Holding & Hand vs. Hand	−6.2279	2.131	−2.923	**0.0464**
Holding & Dehooker vs. Hand	−3.9444	2.1819	−1.808	0.4645
Holding & Pliers vs. Hand	−5.6663	2.1259	−2.665	0.0897
Dehooker vs. Hand	5.9779	2.1254	2.813	0.0622
Pliers vs. Hand	−4.7575	2.1245	−2.239	0.2274
Holding & Dehooker vs. Holding & Hand	2.2835	2.2014	1.037	0.9044
Holding & Pliers vs. Holding & Hand	0.5617	2.1499	0.261	0.9998
Dehooker vs. Holding & Hand	12.2058	2.1506	5.676	**<0.001**
Pliers vs. Holding & Hand	1.4704	2.1544	0.683	0.9836
Holding & Pliers vs. Holding & Dehooker	−1.7219	2.2017	−0.782	0.9701
Dehooker vs. Holding & Dehooker	9.9223	2.2021	4.506	**<0.001**
Pliers vs. Holding & Dehooker	−0.8131	2.2048	−0.369	0.9991
Dehooker vs. Holding & Pliers	11.6441	2.1481	5.421	**<0.001**
Pliers vs. Holding & Pliers	0.9087	2.1494	0.423	0.9982
Pliers vs. Dehooker	−10.7354	2.1489	−4.996	**<0.001**

hook removal took significantly longer when the fish were not held and the dehooking tool was used (Dehooker treatment) when compared to all treatments other than when the hook was removed by hand without holding the fish (Hand treatment; Table 2; Figure 2).

The highest ranking model based on the AIC_c model selection determined the variables that influenced the reflex impairment score. The best model contained only unhooking time as the response variable ($AIC_c = 3.00$; Akaike weight = 0.76). There was a significant positive relationship between unhooking time and the reflex impairment level of SMB ($z = -3.22$, $P = 0.001$; Figure 3). No other models were within a ΔAIC_c of 2.

The best model that explained the injury score only included treatment as a predictor. The post hoc tests indicated that holding the fish and removing the hook with pliers (Holding & Pliers treatment) resulted in a significantly lower incidence of injury than all other treatments except Holding & Dehooker (Dehooker: $\chi^2 = 5.64$, $P = 0.018$; Pliers: $\chi^2 = 9.78$, $P = 0.002$; Hand: $\chi^2 = 9.31$, $P = 0.002$; Holding & Hand: $\chi^2 = 4.40$, $P = 0.036$). The Holding & Dehooker treatment was nonsignificant (Figure 4).

DISCUSSION

The popularity of recreational C&R fishing has led to the development of several hook removal methods and specific dehooking tools that are marketed as easy to use for the rapid release of fish. Our study found that not holding SMB during the hook removal process resulted in longer hook removal time,

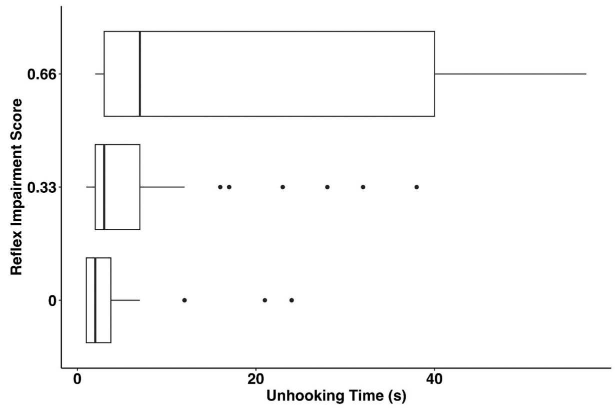

Figure 3. Number of reflex impairments (gill, tail grab, head complex, equilibrium, and bite) in Smallmouth Bass compared to unhooking time. The line within each box indicates the median, the ends of the box represent the first and third quartiles, and the ends of whiskers show the minimum and maximum values. Outliers are represented by black dots.

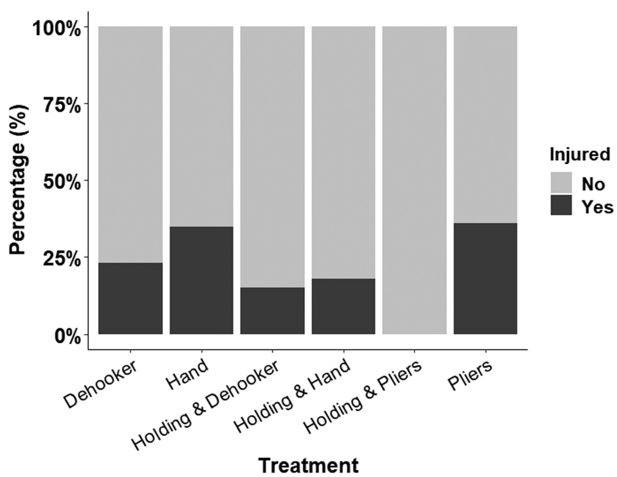

Figure 4. Presence of injury (tearing; %) in Smallmouth Bass by hook removal method (see *Methods* for a description of each).

prolonged air exposure, and greater levels of reflex impairment and injury. Specifically, the dehooking tool took longer to remove hooks when not holding the SMB during hook removal compared to the other unhooking treatments. The only other treatments with significant differences included the use of Holding & Hand having faster unhooking times when compared with hands alone (Hand treatment). The touchless hook removal method had tension from the body weight of the fish on the hook when it was being removed, resulting in increased difficulty when attempting to retrieve the hook from the original puncture area.

Gripping SMB by the lower mandible during hook removal immobilized the fish, allowing for greater precision while attempting to secure the hook and remove it from the fish with bare hands, pliers, or the dehooking tool. The different tool types were roughly comparable in dehooking time while holding the fish during hook removal. However, the fastest process of dehooking was with bare hands (hook removed by the index finger and thumb), followed closely by using pliers, and both while holding the fish. We found that prolonged unhooking times (>10 s) resulted in an increased number of reflex impairments, likely because of the increased air exposure and handling (Figure 3). This result was similarly found in previous dehooking studies (Cooke, Cooke et al., 2022). Reflex impairment is regarded as a useful indicator of fish vitality and is even correlated with survival (Davis, 2010; Lennox et al., 2024). Given that reflex impairment was correlated with unhooking time in this study, our results suggest that reducing the dehooking time has a large influence on the postcapture recovery of the fish (Figure 3).

Although holding fish and unhooking with bare hands constituted the fastest technique in our study, there were also observed differences between unhooking tools when the fish were not held. We reasoned that unhooking times were the fastest for hooks removed by hand while holding the fish (Holding & Hand treatment) due to the shallow hooking locations (i.e., not deeply hooked) and the size of the hooks. The hooks on the Ned rigs were large enough to be grasped quickly and securely with bare hands, thereby allowing for the fast removal of the hooks. It is important to note that removing hooks by hand is context dependent (hook size, hooking location, and species) and is not always the most effective and best for the fish. The ability of pliers to firmly grip the hook mid-shank and maneuver freely within the mouth resulted in significantly faster unhooking times with fewer injuries than the dehooking tool (Figure 4). This is likely because the pliers allowed for greater control and easy rotation of the hook out of the penetration site. The dehooker and the pliers allowed for good visibility of the hook within the mouth of the SMB, but it was more difficult to grip the hook with the dehooking tool. Often, the Ned rig prevented the dehooker from firmly gripping the shank of the hook due to the small opening of the device (Figure 1). The increased precision required to remove the lure without having to strip the plastic made it difficult to remove the hooks. The dehooker also had poor tactile feedback to the user, making it more difficult to maneuver the hook during removal.

In the context of our study, we found that the timely removal of the Ned rig jig in shallow-hooked SMB was most effective when holding the fish by the lower jaw and removing the hook by hand. All treatments that involved holding the fish resulted in fewer injuries than treatments in which fish were not held during the hook removal process (Figure 4). Although pliers and the dehooker were not considerably slower at hook removal, more time would be needed to access the hook removal devices once a fish was landed. This retrieval period could prolong the air exposure, implying that anglers should remove the hooks with their bare hands while holding the fish. Other lure and hook types remain to be tested to determine the effectiveness of dehooking tools across different species. We also recognize that not all fish can be safely restrained by the lower mandible due to dentition or morphology. Although holding black bass vertically by the lower mandible can potentially harm large black bass (i.e., trophy fish; Skaggs et al., 2017), it was not a concern for our study. We suggest that anglers grip the lower mandible while unhooking black bass and avoid vertically holding larger fish if possible. Further, some fish (e.g., Northern Pike *Esox lucius*) may need to be held by the body, which may lead to slime removal or other dermal disturbance that could yield latent fungal infections.

Hook removal is an important and potentially injurious step of the C&R process and is rightly the subject of a rapidly expanding area of literature on best practices and species-specific reactions. While unhooking is always a similar process, different hook size needs and mouth morphologies of species mean that ideal hook removal tool choices differ by species. Our results were generally in agreement with past studies on SMB, with Cooke et al. (2021) finding that bare hands (while holding the fish) were the fastest at hook removal from SMB, whereas purpose-built tools like the dehooker took the longest. However, for Bluegill that were similarly assessed, the dehooker was proven to be among the easiest and fastest techniques, although the most injurious (Cooke, Cooke et al., 2022; Hussey et al., 2023). Our findings showing the speed of holding fish during dehooking do have a downside: While dehooking and air exposure are minimized, handling time increases. Extra handling is particularly needed when barbed hooks are used, as they require more leverage to remove (Cooke, Cooke et al., 2022). A recent study on cyprinid dehooking found that hook removal was most efficient for barbless hooks and least efficient for circle hooks; circle hooks required a tool for dehooking 10 times more frequently (Kapusta & Czarkowski, 2022). Our study focused on barbed hooks, which are a popular choice among SMB anglers, but some research has been done to investigate an alternative hook type that can both reliably land fish and allow for a boatside self-release. Bite-shortened hooks, for example, have been found to be an efficient choice to both land Spotted Seatrout *Cynoscion nebulosus* reliably and release them without any handling (Harris et al., 2021).

Our study demonstrated the importance of testing products produced by the fishing industry since they may not function as advertised and could do more harm than good to the fish. Our recommendation for SMB anglers is to hold the lower jaw of the fish with one hand and unhook the fish with the other hand. We suggest that if anglers opt to use pliers as a hook removal tool, they should hold the fish by the lower jaw when attempting to remove the hook. Having pliers readily available while angling may also be beneficial in case of slightly deeper hooked fish (i.e., not in the gills or esophagus), foul-hooked fish, or the capture of nontarget species that have sharp dentition (Cooke et al., 2021; Cooke, Cooke et al., 2022). The touchless release method should not be used for SMB, although it may be more effective with other hook/lure configurations or with barbless hooks. Although it is desirable to minimize air exposure and lengthy handling, tissue damage from the hook removal method must also be considered when examining hook removal methods.

DATA AVAILABILITY

Data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

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).

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CONFLICTS OF INTEREST

None declared.

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