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Short communication

Largemouth bass catch rates and injury associated with non-offset and offset circle hook configurations

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Abstract

Although circle hooks are being viewed as a means to reduce injury and mortality of recreationally caught-and-released fish, subtle differences in hook configuration (such as the degree that the hook point is offset from the shank) could affect performance. We compared hooking and landing efficiency, anatomical hooking depth and location, ease of hook removal, and amount of bleeding between largemouth bass angled on either non-offset (0°) or slightly offset (2°) circle hooks. Non-offset circle hooks were more efficient at hooking and landing largemouth bass than the offset design. Fish were hooked more deeply with non-offset hooks; non-offset hooks penetrated the corner of the mouth whereas the offset hooks penetrated the terminal upper and lower lip. Overall, there were no differences in the frequency that fish were hooked in potentially lethal locations (e.g. gullet, eye). The design and hooking location of non-offset hooks led to greater difficulty in hook removal and slightly higher rates of bleeding. Offset circle hooks have been identified as more injurious in previous studies but we found little difference in injury that may lead to serious infection or mortality between hook types. Given that non-offset circle hooks have a higher capture efficiency for largemouth bass, anglers will likely adopt their use.

Keywords: Circle hooks; Largemouth bass; Angling injury

1. Introduction

Largemouth bass *Micropterus salmoides* are one of the most commonly sought after freshwater species in North America and are frequently subject to the practice of catch-and-release angling (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2002). Although fish are released for many reasons (e.g. harvest regulations, live release competitive angling events,

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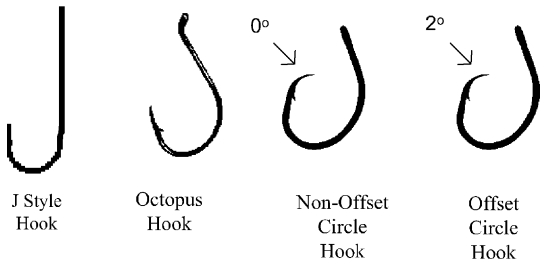

Fig. 1. Representation of non-offset J-style and octopus hook designs and two circle hook configurations. Off-set circle hook configurations refer to the deviation (in degrees, 2°) in the plane of hook point relative to that of the shank; whereas, non-offset circle hooks do not deviate from the plane of the shank.

conservation ethic, etc., Schramm et al., 1991; Wilde, 1998), there is a common interest in ensuring that fish which are released survive and have negligible sublethal stress (Cooke et al., 2002). For this reason, many studies have examined largemouth bass hooking mortality, focusing on gear related factors, such as type of bait, hook size, hook design, and environmental/biological factors, such as fish size and water temperature (e.g. Rutledge and Pritchard, 1977; Pelzman, 1978). Tackle manufacturers have responded to the interest in catch-and-release angling and the demand for a decrease in hooking injury and mortality by developing and promoting novel gear types. One of the most recent and promising developments in gear technology has been the circle hook. Circle hooks differ from conventional hooks in that the point is aligned perpendicular to the shank of the hook rather than parallel to the shank as with conventional hook types (Cooke and Suski, 2004; Fig. 1). Due to the design, circle hooks should minimize deep hooking in potentially lethal regions and instead, hook fish in the upper jaw (Montrey, 1999). Indeed, existing empirical research suggests that although circle hook performance varies widely, there are some clear conservation benefits associated with their use (Cooke and Suski, 2004).

As with all hook types, there are differences in circle hook design and configuration among different models and manufacturers such as whether the hook point is offset. Offset hooks refer to the amount of deviation (in degrees) in the plane of hook point relative to that of the shank (see Cooke and Suski, 2004). The degree to which the point is offset relative to the shank of the hook may have implications for hooking efficiency and result in differing injury and mortality rates. Anecdotal evidence suggests the smaller the degree of offset the more likely the hook will be set shallow in the corner of the jaw (see Cooke and Suski, 2004). Hand (2001) compared offset and non-offset circle hooks on striped bass *Morone saxatilis* and determined that offset hooks were more damaging than non-offset hooks. Similarly Prince et al. (2002) found that for billfish offset hooks removed most benefit associated with using circle hooks over conventional J-style hooks.

Lower catch rates have been reported for circle hooks in comparison with other hook types. Cooke et al. (2003c) found reduced hooking efficiency in largemouth bass on offset circle hooks when compared to octopus hooks (i.e. variation on J-style hook; Fig. 1). The question remains whether non-offset circle hooks have different hooking efficiencies than offset circle hooks and could therefore increase hooking efficiency while continuing to provide conservation benefits. Catch rates of striped bass in Chesapeake Bay indicted anglers landed more fish per strike when using non-offset circle hooks than with offset circle hooks (Lukacovic, 2001). However, it has not been determined what effect degree of offset would have on a freshwater species, such as largemouth bass.

Based upon the need for additional data regarding the effectiveness and performance of offset and non-offset circle hooks for largemouth bass, we conducted a study to examine the catch rates and injury of these two hook configurations and sought to gain a better understanding of the conservation benefits and hooking performance offered by each. Our objective was to provide management agencies and anglers with data to make educated decisions when determining which hook type to choose that will result in the least injury while concurrently maintaining acceptable hooking rates, thus potentially enhancing the sustainability of catch-and-release fisheries.

2. Methods and materials

The experiment was conducted in 0.04 ha clay-lined experimental ponds at the Sam Parr Biological Station, Kinmundy, IL, USA. The ponds supported sparse aquatic vegetation and had populations of largemouth bass, small (≤120 mm TL) bluegill *Lepomis macrochirus*, and naturally colonized invertebrates. Angling was conducted from the shore during April

29–June 10, 2003, when surface water temperatures ranged from 21 to 23 °C. We used commercially available offset (2° offset) circle hooks (Mustad Ultrapoint Demon Circle; size 4; model 39952BL). We also modified these hooks to produce non-offset circle hooks (0° offset). All anglers fished with standard bass angling gear typified by medium action rods equipped with 10 lb test line. Anglers used spring floats (3/8 in. (10 mm) Pencil, 6 in. (152 mm) stem) placed about 0.25 m above one of the two hook configurations that were baited with a live fathead minnow *Pimephales promelas*. Anglers rotated rods at 1 h intervals to ensure that all anglers used different hook types.

Anglers were instructed to cast the bait and let the float set upright. The anglers were then told to wait for the float to go under before collecting the slack line and gently pulling up on the rod and beginning to reel. Unlike conventional hooks, circle hooks perform optimally when gentle pressure is applied rather than a strong quick hook set. If upon responding to a bite a fish was hooked, the angler reeled in the fish and recorded hook configuration, presence or absence of bleeding, and anatomical location of the hook (upper jaw, lower jaw, side jaw, roof, eye, or gullet). The anatomical location of hook penetration (i.e. hooking penetration) was measured from the anterior aspect of the lower lip to the most posterior point of hook penetration (Dunmall et al., 2001; Cooke et al., 2003a). We used the depth of hook penetration divided by the total length of the fish to permit comparison of hook penetration among fish of different sizes (Dunmall et al., 2001). Ease of hook removal was categorized as: (1) easy, hook could be removed by hand without the use of hemostats, (2) hard, hook removal required hemostats but did not cause substantial injury, and (3) impossible, hook was not possible to remove without causing substantial injury (Cooke et al., 2001). If hook removal was categorized as impossible the line was cut. Injury was determined to be severe if fish exhibited bleeding and/or were hooked in the roof, eye or gullet that resulted in "impossible" hook removal. Anglers also recorded the number of hooked largemouth bass and whether the fish was either landed or not. Higher relative landing values indicate that a particular hook is performing better. Upon landing, fish were weighed (g) and measured for total length (mm) before being released. Patchiness of fish or angler ability was not considered to be important because fish were sufficiently abundant and because all anglers had intermediate levels of fishing experience.

Analysis of variance (ANOVA) was used to test for differences between the hook penetration, total length, and weight of fish angled with non-offset and offset circle hooks (SAS Institute Inc., 1999). We used χ^2-tests for goodness of fit to compare categorical variables (i.e. hooked, landed, location, ease of removal, presence of bleeding) between offset and non-offset circle hooks (Sokal and Rohlf, 1981).

3. Results

We angled 126 largemouth bass on offset hooks and 121 on non-offset hooks that ranged in size from 208 to 342 mm. The total length and mass of the fish captured did not vary with hook configuration (Table 1). Non-offset hooks were more efficient at hooking ($\chi^2 = 3.85$, d.f. = 1, $P = 0.04$) and landing ($\chi^2 = 7.52$, d.f. = 1, $P < 0.01$) largemouth bass than offset circle hooks. Sixty percent of the fish that struck at non-offset gear were hooked compared to only 37% for offset hooks. Largemouth bass were landed more frequently when hooked on non-offset (46%) gear compared to offset hooks (29%). The hooking penetration was marginally greater for non-offset than offset configurations (Table 1).

Table 1
Average total length, weight, and hook penetration (±1 S.E.) for adult largemouth bass angled on either non-offset or offset circle hooks

Variable	Non-offset (mean ±S.E.)	Offset (mean ±S.E.)	Contrasts	
			F-value (d.f.)	*P*-value
Length (mm)	281 ± 03	278 ± 04	0.50 (1, 90)	0.48
Weight (g)	242 ± 07	235 ± 11	0.31 (1, 90)	0.58
Hook penetration	0.11 ± 0.006	0.09 ± 0.008	3.40 (1, 90)	0.06

Comparisons for all response variables between treatments were analyzed with analysis of variance.

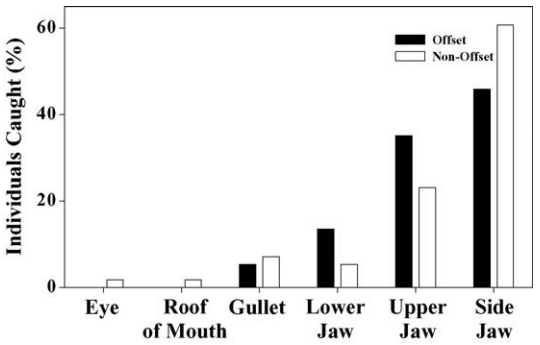

Fig. 2. Percent of individual largemouth bass hooked in different anatomical locations by non-offset or offset circle hooks.

Anatomical hooking location did not differ significantly ($\chi^2 = 5.16$, d.f. = 5, $P = 0.39$) by hook configuration. Overall, largemouth bass were hooked most frequently in the side of the jaw (55%) followed by the upper jaw (28%), and lower jaw (9%; Fig. 2). Very few fish were seriously injured by being hooked in the gullet (6%), roof of the mouth (1%) or eye (1%). Difficulty of hook removal varied significantly ($\chi^2 = 6.40$, d.f. = 2, $P = 0.04$) with hook configuration (Fig. 3a). Hooks of both types were generally easy to remove (offset, 89%; non-offset, 67%); however, non-offset circle hooks were categorized as "difficult" to remove about five times more often than offset circle hooks. Similarly, non-offset hooks were not possible to remove without causing serious injury more often than offset circle hooks. As a result, incidences of bleeding were marginally greater ($\chi^2 = 3.49$, d.f. = 1, $P = 0.06$) for non-offset than offset circle hook configurations (Fig. 3b).

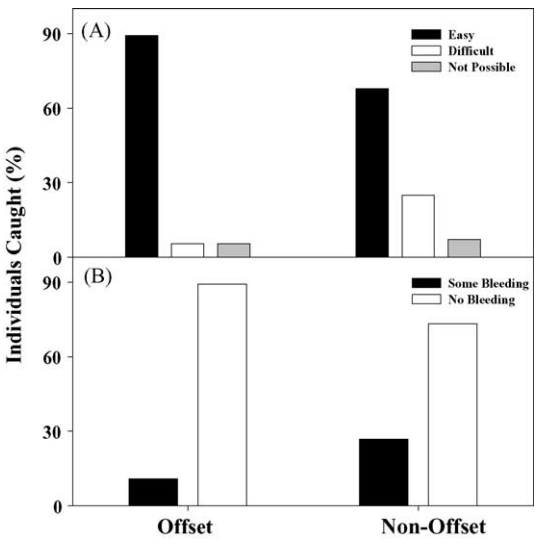

Fig. 3. Comparison of ease of hook removal (A) and bleeding levels (B) of largemouth bass captured on either non-offset or offset circle hooks.

4. Discussion

Hooks having subtle differences in configuration, specifically the degree to which the point is offset from the shank, varied in their ability to successfully hook and land largemouth bass. In our study, approximately 1.5 times as many fish were hooked and landed with non-offset circle hooks compared to offset circle hooks. Similarly Lukacovic (2001) showed that anglers landed more striped bass per strike when using non-offset circle hooks than offset hooks. Collectively, these results suggest a reduction in capture efficiency when using offset circle hooks. The differences we observed in capture efficiencies will likely be influenced by the degree of deviation in the plane of the hook point relative to the shank, sizes of hooks, and size and species of fish angled.

Capture efficiencies may also be affected by anatomical location of hooking between non-offset and offset circle hooks. Although not statistically different, fewer largemouth bass were hooked in the corner of the mouth with the offset configuration. When performing optimally, circle hooks are intended to capture most fish in the corner of the mouth (Cooke and Suski, 2004), hence maximizing capture rates and potentially minimizing injury. We observed that less than 9% of the fish captured on either hook configuration penetrated in areas that were considered to be potentially lethal (i.e. the gullet, roof of the mouth, eye, or gill arches). More often, individuals were captured in the corner of the mouth, upper jaw, or lower jaw. In addition to hooking location, the disparity in hooking penetration and capture efficiency that we observed for largemouth bass caught on non-offset or offset circle hooks may be associated with the ability of the hook to penetrate the tissue and the fish's ability to expel the hook. Few fish caught on offset circle hooks were hooked in the corner of the mouth compared to non-offset hooks. As a result, non-offset circle hooks conform more closely to

the original intent of the circle hook design (Cooke and Suski, 2004). Since the point of the offset circle hook is more exposed, it has a greater probability of penetrating at initial contact whereas the non-offset hook rotates and slides toward the side corner of the mouth and then penetrates the jaw (Cooke and Suski, 2004).

In our study, non-offset circle hooks caused more injury than offset hooks; however, we used hooks that were only slightly offset (2°). The major differences in injury that we noted compared to other studies of offset hooks (e.g. Prince et al., 2002) seems to be related to the amount of deviation in the plane of the hook point relative to that of the shank (Prince et al., 2002; Cooke and Suski, 2004). Severe ($\geq$4°) offset circle hooks may tend to cause more injury than non-offset circle hooks (Hand, 2001) or slightly offset hooks ($\leq$2°). Although we did observe some increased bleeding in largemouth bass captured on non-offset hooks relative to offset circle hooks the deep-hooking and bleeding that we observed for both types of circle hooks was quite low compared to largemouth bass caught on J-hooks (Cooke et al., 2003b,c). Slight degrees of offset ($\leq$2°) may offer some benefits by further reducing injury and possibly mortality in angled largemouth.

The potential decreases in deep hooking and related injury in bass caught on slightly offset circle hooks may be an important management consideration given the continued popularity of angling for this species, including the common practices of catch and release (Quinn, 1996) and competitive angling events (Schramm et al., 1991; Wilde, 1998). Even though the differences in injury for different circle hook configurations were minimal differences in circle hook performance could become more important if anglers use hooks with more severe offsets as has been observed for other species. Because capture and landing rates were significantly lower for offset configurations, it is likely that anglers will choose non-offset designs. Our study emphasizes that circle hook performance is species-specific and that developing generalized guidelines for circle hook configurations may be challenging.

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