Micro-fishing for Juvenile Bluegill: A catch-and-release study on an emerging form of recreational angling

In Prep For: North American Journal of Fisheries as a Management Brief

Declan Burton[1,*], Andy J. Danylchuk[2] and Steven J. Cooke[1]

[1]Fish Ecology and Conservation Physiology Laboratory, Department of Biology and Institute of Environmental and Interdisciplinary Science, Carleton University, Ottawa, ON, K1S 5B6, Canada

[2]Department of Environmental Conservation, University of Massachusetts Amherst, Amherst, MA, 01003-9485, USA

*Author for Correspondence: declanburton@cmail.carleton.ca

Abstract

Micro-fishing is an emerging form of predominantly catch-and-release recreational angling with the main target being diverse small-bodied non-game fish species and the early life stages of traditional game fish. While there has been an apparent increase in interest in micro-fishing, little is known about its impacts on fish and fisheries. Here we compared the effects of two hook sizes (i.e., a 22 sized hook [herein "small"] and a somewhat larger, yet still smaller than normal sized 12 hook [herein "large"]) on aspects of injury, handling, and mortality for juvenile Bluegill (*Lepomis macrochirus;* size range of 69 to 141 mm; n=54 for each hook size). Hook size was determined to have a significant influence upon injury and mortality. The smaller hooks resulted in longer handling time, more extensive tissue damage arising from challenges of hook removal, and higher levels of short-term mortality than the larger hooks. Additional research is needed to develop best practices for this emerging form of recreational angling on a wider range of species.

Key words: Angling, Micro-fishing, Catch-and-Release, Mortality

Introduction

Micro-fishing is a emerging form of recreational angling that uses specialized equipment that is much smaller than what is typically used with more conventional angling techniques (Cooke et al. 2020). Micro-fishing should not be confused with attempting to catch large fish on light gear/tactics (i.e., use of ultralight gear). Micro-fishing is described as targeting diverse smaller bodied non-game fish species and early life stages of more traditional target game-species in marine and freshwater habitats (Cooke et al. 2020). There has been an increasing interest in this method with one popular micro-fishing discussion forum seeing an almost 430% increase in membership from March 29, 2020 – March 18, 2021 (https://bit.ly/36PDC4o). Micro-fishing is thought to have emerged in Japan but is growing in popularity on a global basis. Not unlike bird watching, there is often a focus on creating a 'life list' encompassing the greatest diversity of fish that can be caught via micro-fishing (Martinez 2016).

Micro-fishing is presumed to be mainly a catch-and-release (C&R) fishery (Cooke et al. 2020), whether because of regulations or voluntary actions of the anglers (Arlinghaus et al. 2007). A tenet of C&R is that fish incur minimal injury and stress such that there is a high likelihood of post-release survival (Cooke and Schramm 2007). Observations from the aforementioned discussion forum on micro-fishing suggests that individual anglers have adopted specialized post-capture equipment for retaining fish (e.g., in water-filled plexiglass holding chambers) to enable observation/identification/admiration which aligns with science-based C&R best practices outlined by organisations such as Keep Fish Wet (https://bit.ly/3vM35YO). Best practices for C&R have been well studied in traditional recreational fisheries (reviewed in Brownscombe et al. 2017). However, fish captured and handled while micro-fishing have yet to be studied to the same extent, if at all. Even the most basic aspects of micro-fishing such as injury or mortality rate and how they vary with micro-fishing hooks is nonexistent (Cooke et al. 2020).

To that end, the purpose of this study was to assess the effects of micro-fishing on injury, handling time, reflex impairment, and short-term mortality of juvenile Bluegill (*Lepomis macrochirus*). Bluegill is a smaller bodied fish species that is a popular target for anglers (Reed and Parsons 1999; Edison et al. 2006; Naiman 2013). Bluegill are caught across a wide range of body sizes and developmental stages. Although not the typical target of micro-fishing Bluegill has been the focus of other C&R studies (Siewert and Cave 1990; Cooke et al. 2003; Hoxmeier and Wahl 2009; Lennox et al. 2015) and can be caught in large numbers, this species can serve as a model to further our understanding of issues that may be relevant to other species including rare or imperiled species targeted by micro-fishing. For the purpose of the study, we used barbed hooks and compared two hook sizes – a size 22 hook (which is extremely small) and the comparatively larger, size 12 hook which is still about half the size of traditional hooks used for Bluegill (e.g., size 6; see (Cooke et al. 2003, 2005)).

Methods

The study was conducted on Big Rideau Lake, Ontario, 44.7706° N, 76.2152°, W on July 3, 2020. The surface water was observed to be 24-26°C throughout the day that the fish were captured and held. All hooks were Mustad Dry Fly Hook, 94840, Standard, Forged, Down Eye – Bronze, barbed in size 22 (“small”) and size 12 (“large”) (figure 1). Hooks were baited with 1/3rd of a Berkley Power Maggot (Berkley Fishing, Spirit Lake, Iowa, USA) which was roughly 2mm in diameter and 3 mm long. All fishing was conducted by boat using ultralight fishing rods equipped with 2lb (0.9 kg) test monofilament fishing line. A single 0.4 gram split shot sinker was pinched onto the line to allow the bait to sink to depth. Baits were cast out and were rapidly attacked by the target species. Fight time was standardized to 5 seconds. Immediately after capture and while still on the line, the fish were placed in a 10l bucket filled with fresh ambient lake water. The same researcher conducted all fish handling to ensure consistency while a single, intermediate angler captured all the fish. The fish were removed from the bucket and the researcher assessed anatomical hooking location, which was classified as corner of mouth, lower jaw, upper jaw, roof of mouth, tongue, or body (foul hooked but near mouth). The relative hooking depth was calculated as the distance from the outermost edge of snout to the area of hook penetration; this process took ~ 5 seconds. The researcher then used their fingers to attempt hook removal at which point a timer was initiated. The fish were held by a wet hand and air exposed during this period. Small pliers were also available for the researcher to use if there were challenges with removing the hook by hand. If fish were deeply hooked (in the gullet) the line was cut as per Fobert et al. (2009). The unhooking time (s) was determined with a stopwatch and was the time from when the researcher first began to remove the hook until the moment the fish was removed from the hook (to the nearest second). After hook removal, individual Bluegill were observed for physical damage in the form of the presence of blood at the hooking location and tissue damage, both as binary "yes" or "no" observations. The fish were then placed into a water filled trough where total length (mm) was recorded. Fish were then observed for reflex impairment (Davis 2010). Specifically, fish were held upside down in the trough and given 3 seconds to right themselves along with response to tail pinching (i.e., did they burst or not). Failure to regain equilibrium or exhibit bursting constituted reflex impairment. Fish were then tagged with a small external anchor tag (FD-68B Fine Fabric, Floy

Manufacturing Inc) to enable the identification of individuals to be held for short-term mortality assessment. All fish were then held in a 55l boat livewell (operated on flow through) for up to 2 hr before transport (<10 min) to a holding facility located on the shore of the lake. Fish were carefully removed from the livewell with a dip net and transferred to a common holding tank. The holding tank was 85l with flow-through ambient lake water (at ~26°C). Fish were held for 24 hr. Fish that were dead (lack of ventilation) were classified as mortalities. Reflex impairment was assessed and fish for which both reflexes (as above) were absent were considered to be moribund and were euthanized. Fish that had intact reflexes were released alive.

To determine the datasets compliance with the assumptions of homogeneity and distribution of normality Kolmogrov-Smirnov and Shapiro-Wilk tests for normality along with Q-Q Plots were used. Mann-Whitney test was used to test if total length of the individuals caught was influenced by hook size. We used a Pearsons Chi-Squared contingency table analysis to establish if hook size influenced anatomical hooking location. We then tested for differences in length-corrected hooking depth between the two hook sizes using a Mann-Whitney test. Length-corrected hooking depth was calculated using the total length and hooking depth to size correct for hooking depth (Cooke et al. 2005). This was followed by further Pearsons Chi-Squared analysis to determine if use of pliers for hook removal varied by hook size. The influence of hook size on handling time was tested for via the use of a Mann-Whitney test. Pearson’s Chi-Squared tests were then used to explore hook size influence on mouth damage, presence of blood and mortality outcome. To establish if mortality outcome varied due to increasing handling time, we used a Kruskal-Wallis test. Because handling time and hook size had a significant influence on mortality, we used a binary logistic regression to establish an odds ratio in order to explore the degree of impact handling time and hook size had upon fish health outcomes. To do this, the mortality outcomes were changed to alive or dead at 24 hr with moribund at 24 hr being included in the dead category. We ran two separate logistic regressions for handling time and hook size in order to maintain a significant model. A general liner model (GLM) was created to establish if there was a combined interaction between hook size and handling time upon mortality outcome (dead or alive). Statistical significance was assessed at $\alpha = 0.05$. The majority of the statistical analysis was conducted using RStudio running R version 4.0.2, using the default packages. The binary logistic regression was conducted using IBM SPSS Statistics 27.

Results

We captured 108 Bluegill in one day (n=54 individuals per hook treatment). The total length of fish was similar between fish captured using both hook sizes (small, 94 ± 15 mm; large, 93 ± 16 mm; W = 1406, p = 0.752). Hook size had no influence on anatomical hooking location with almost all fish hooked in the upper jaw (X^2= 1.87, p = 0.866). There was also no difference in length-corrected hooking depth for fish caught on the two hook sizes (W= 1367, p = 0.958). When pliers were needed to remove hooks, they were used more for large size hooks (n=4) more than small size hooks (n=1), but there was no significant statistical difference between treatments (X^2 = 0.83, p = 0.360). No fish required the line to be cut because of a deep hooking location. Handling time varied by hook size, with it taking significantly longer to remove small hooks remove (8 ± 6 sec) when compared to the larger hooks (4 ± 3sec; W= 745.5, $p < 0.001$). During hook removal, smaller hooks were more likely to cause tissue tears in the jaw (small, n=6 damaged; large, n=0 damaged) (X^2 = 4.412, $p < 0.05$). There was no observed difference between hook size and the presence of blood (X^2 = 0, p = 1.00), with only one incident of blood being recorded for the small hook and none for the large hooks.

Out of 108 individuals, 13 (12.0%) were either dead (n=9) or moribund (n=4) after 24 h. All other individuals displayed positive reflex responses and were released alive. Hook size (X^2= 8.31, p < 0.02) had a significant influence on mortality outcomes with the smaller hooks resulting in a higher degree of mortality (n=8; 14.8%) and moribund status (n=3; 5.6%) when compared to the larger hook mortality (n=1; 1.9%) and moribund status (n=1; 1.9%) (figure 2). Handling time had a significant influence upon the mortality of individuals (H (19) = 38.08, p <0.01). The binary regression analysis suggested that for every 1 second increase in handling time, the predicted probability of mortality increased by 15% (B = 0.14, ExpB 1.15, p <0.01). The probability of mortality for fish captured on the small hooks was 88% higher than those hooked on the larger hooks (B= 2.00, ExpB 7.43, p<0.02). The GLM indicated that there was no significant interaction of both handling time and hook size upon mortality outcome (F (2,104) = 0.867, p >0.05).

Discussion

Given the growing interest in micro-fishing, it is prudent and timely to use science to guide the development of best practices. Using Bluegill as a model species, we found that hook size can have negative outcomes for post-release survival on fish within the first 24 hr. Specifically, we found that the smaller micro-hooks used here yielded more negative outcomes (i.e., 22.2% combined mortality and morbidity) than the larger hooks (i.e., 3.7% combined mortality and morbidity). While only 12.9% of fish died during this study, it is important to consider that micro-fishing is targeting species and life stages that were previously largely unimpacted by targeted angling. Indeed, that level of mortality could be deemed to be exceedingly high for some rare or threatened species (Coggins et al. 2007). Moreover, we only examined mortality within the first 24 hr after release during which the fish were held in an artificial environment. As such, our study did not account for long-term mortality, including the potential for post-release predation (Danylchuk et al. 2007).

A previous study exploring hooking mortality within Bluegill was conducted using different size 6 hook patterns (Cooke et al. 2003), which could be considered to many North American anglers as small. The results of that study found a mortality in Bluegill of 1.3% across all treatments and a wide range of temperatures, which is considerably less than the 12.9% mortality we observed in our study. Differences between mortality estimates are likely due to the substantially smaller hooks used in our study when compared to those used by Cooke et al. (2003). Our study found the smaller hooks took on average 72% longer to remove which is likely due to the increased challenge posed by manipulating the tiny size 22 hooks. This increased removal challenge of the small hooks resulted in a higher degree of post-release mortality relative to the larger size 12 hooks. Although angling experience could impact hook removal times and hooking damage, all fish in our study were handled by an experienced angler reducing the likelihood that this resulted in differences between treatments.

The impacts of C&R recreational angling have been evaluated across different angling methods, gear types, locations and species (Muoneke and Childress 1994; Bartholomew and Bohnsack 2005; Arlinghaus et al. 2007). This has helped establish science-based best practices that can be used to reduce fish mortality and sublethal effects (Brownscombe et al. 2017), and support recreational fisheries policy and management (Pinder et al. 2019). The results of our study suggest a key influence on the success of a C&R interaction is handling time with the longer handling interaction resulting in a higher likelihood of post-release mortality. Handling time is associated with air exposure which has been documented to be a significant influence on the post-release survival (Brownscombe et al. 2017). The ease of hook removal directly impacts handling time and with the small size of hook coupled with the small-bodied nature of micro-species, it is likely that specialized handling and removal tools/methods will need to be established to help mitigate this issue. While the size of these hooks appears relatively uncommon in popular North American angling practices, they are globally utilized in other C&R fisheries. For example, recreational fly anglers commonly use tiny hook sizes to imitate small food items to target a range of species and life history stages, thus a focus on small hook influences on hooking injury and handling time is warranted beyond just their use in micro-fishing.

Hooking depth, location, and subsequent removal, has also been previously observed to have a significant impact on the success of post-release survival in many fish species, so much so that best practices for deep hooked fish suggest that cutting the line can be the best option to maximize survival probability (Cooke and Danylchuk 2020). It was proposed that the smaller hooks were more likely to be taken deeper by larger fish posing a greater threat to the survival of these individuals. However, this study found that there was no significant difference between the two scaled down hook sizes and relative hooking depth. It is important to consider that using a small size of hook will enable smaller individuals to be targeted but does not prevent larger individuals from also being captured. This is clear with hook size displaying no influence on the size of individual captured. However, further research is needed to establish if larger individuals, either target or bycatch, could be more at risk from micro-fishing hook types due to deeper hooking and the established relationship between hooking depth/removal time and post-release mortality (Cooke and Danylchuk 2020). Typically, if the hooking location is not the heart or gills the occurrence of bleeding is low (Cooke et al. 2001). While there was only one incident of bleeding in the study, cutting the line on deep hooked fish may be prudent to convey to anglers, however research is needed to determine the hook retention and shedding ability for species targeted when micro-fishing (Fobert et al. 2009; Litt et al. 2020).

This study found that mortality varied with hook size for juvenile Bluegill with the smallest hook having mortality and morbidity levels of ~20% which is a level of mortality deemed by Muoneke and Childress (1994) as “high”. Given that we used a model species rather than those typically targeted by anglers when micro-fishing, there is still much to be examined about how different elements of the capture, handling, and release of fish caught via micro-fishing impact fish welfare, and how the outcome of such science can form the basis of best practices to inform conservation and management.

Acknowledgements

We are grateful to the Ontario Ministry of Natural Resources and Forestry for providing a scientific collection permit to enable this research. Andrew Mallon served as the angler for this study.

References

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

Arlinghaus, R., T. Klefoth, S. J. Cooke, A. Gingerich, and C. Suski. 2009. Physiological and behavioural consequences of catch-and-release angling on northern pike (Esox lucius L.). Fisheries Research 97(3):223–233.

Bower, S., A. J. Danylchuk, J. W. Brownscombe, J. D. Thiem, and S. J. Cooke. 2016. Evaluating effects of catch-and-release angling on peacock bass (Cichla ocellaris) in a Puerto Rican reservoir: a rapid assessment approach. Fisheries Research 175:95–102.

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

Coggins, L. G., M. J. Catalano, M. S. Allen, W. E. Pine, and C. J. Walters. 2007. Effects of cryptic mortality and the hidden costs of using length limits in fishery management. Fish and Fisheries 8(3):196–210.

Cooke, S. J., B. L. Barthel, C. D. Suski, M. J. Siepker, and D. P. Philipp. 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 American Journal of Fisheries Management 25(1):211–219.

Cooke, S. J., and A. J. Danylchuk. 2020. Hook disgorgers remove deep hooks but kill fish: a plea for cutting the line. Fisheries Management and Ecology 27(6):622–627.

Cooke, S. J., R. J. Lennox, B. Cantrell, and A. J. Danylchuk. 2020. Micro-fishing as an emerging form of recreational angling: research gaps and policy considerations. Fisheries 45(10):517–521.

Cooke, S. J., D. P. Philipp, K. M. Dunmall, and J. F. Schreer. 2001. The influence of terminal tackle on injury, handling time, and cardiac disturbance of rock bass. North American Journal of Fisheries Management 21(2):333–342.

Cooke, S. J., and H. L. Schramm. 2007. Catch-and-release science and its application to conservation and management of recreational fisheries. Fisheries Management and Ecology 14(2):73–79.

Cooke, S. J., C. D. Suski, B. L. Barthel, K. G. Ostrand, B. L. Tufts, and D. P. Philipp. 2003. Injury and mortality induced by four hook types on bluegill and pumpkinseed. North American Journal of Fisheries Management 23(3):883–893.

Danylchuk, S. E., A. J. Danylchuk, S. J. Cooke, T. L. Goldberg, J. Koppelman, and D. P. Philipp. 2007. Effects of recreational angling on the post-release behavior and predation of bonefish (Albula vulpes): the role of equilibrium status at the time of release. Journal of Experimental Marine Biology and Ecology 346(1–2):127–133.

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

Edison, T. W., D. H. Wahl, M. J. Diana, D. P. Philipp, and D. J. Austen. 2006. Angler opinion of potential bluegill regulations on Illinois lakes: effects of angler demographics and bluegill population size structure. North American Journal of Fisheries Management 26(4):800–811.

Fobert, E., P. Meining, A. Colotelo, C. O’Connor, and S. J. Cooke. 2009. Cut the line or remove the hook? An evaluation of sublethal and lethal endpoints for deeply hooked bluegill. Fisheries Research 99(1):38–46.

Hoxmeier, R. J. H., and D. H. Wahl. 2009. Factors influencing short-term hooking mortality of bluegills and the implications for restrictive harvest regulations. North American Journal of Fisheries Management 29(5):1372–1378.

Lennox, R., K. Whoriskey, G. T. Crossin, and S. J. Cooke. 2015. Influence of angler hook-set behaviour relative to hook type on capture success and incidences of deep hooking and injury in a teleost fish. Fisheries Research 164:201–205.

Litt, M., B. Etherington, L. Gutowsky, N. Lapointe, and S. Cooke. 2020. Does catch-and-release angling pose a threat to American eel? A hooking mortality experiment. Endangered Species Research 41:1–6.

Martinez, S. 2016. Little fish tales: micro fishers focus on the species, not size. NPR: National Public Radio. (https://perma.cc/WL7A-YTFA)

Muoneke, M. I., and W. M. Childress. 1994. Hooking mortality: A review for recreational fisheries. Reviews in Fisheries Science 2(2):123–156.

Naiman, R. 2013. Socio-ecological complexity and the restoration of river ecosystems. Inland Waters 3(4):391–410.

Pinder, A. C., J. R. Britton, A. J. Harrison, P. Nautiyal, S. D. Bower, S. J. Cooke, S. Lockett, M. Everard, U. Katwate, K. Ranjeet, S. Walton, A. J. Danylchuk, N. Dahanukar, and R. Raghavan. 2019. Mahseer (Tor spp.) fishes of the world: status, challenges and opportunities for conservation. Reviews in Fish Biology and Fisheries 29(2):417–452.

Reed, J. R., and B. G. Parsons. 1999. Angler opinions of bluegill management and related hypothetical effects on bluegill fisheries in four Minnesota lakes. North American Journal of Fisheries Management 19(2):515–519.

Siewert, H. F., and J. B. Cave. 1990. Survival of released bluegill, Lepomis macrochirus, caught on artificial flies, worms, and spinner lures. Journal of Freshwater Ecology 5(4):407–411.

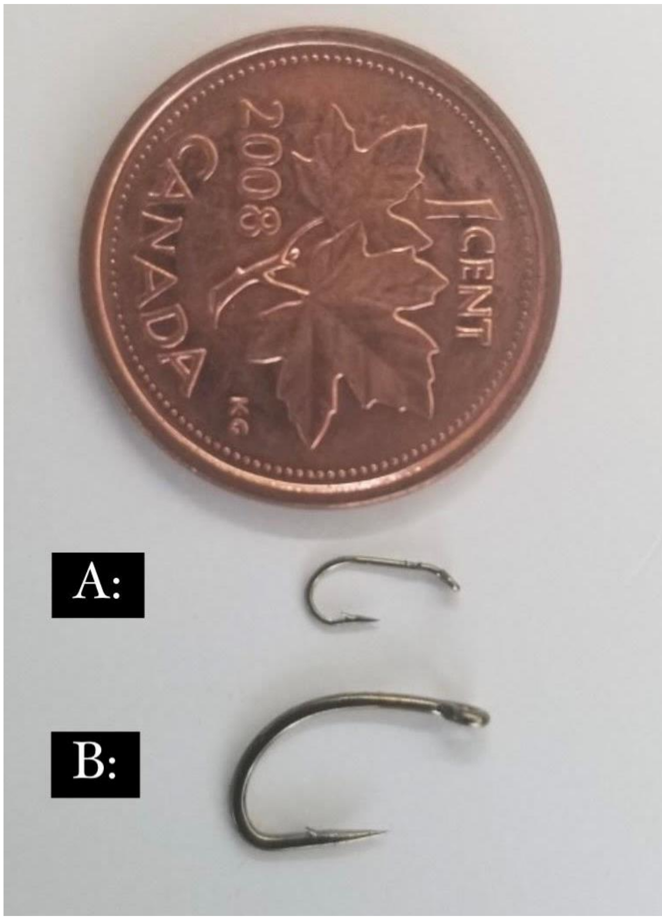

Figure 1: Hook size comparison against a Canadian 1 cent coin. Hook type = Mustad Dry Fly Hook, 94840, Standard, Forged, Down Eye – Bronze, barbed. Hook A: Size 22, Hook B: Size 12

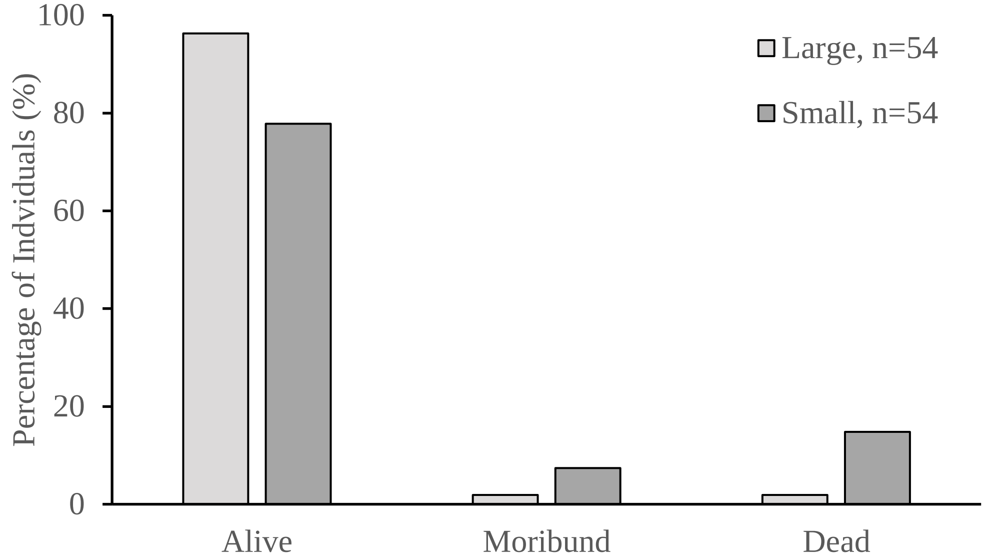

Figure 2: Influence of hook size on percentage of individual Bluegill Alive, Moribund and Dead, after 24hr captured on both hook sizes “Large” size 12 and “Small” size 22.