Observations of Mudpuppy (*Necturus maculosus*) bycatch in a recreational ice fishery in northern Ontario

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Abstract

Bycatch in fisheries is a well-explored topic, although less so in recreational fisheries. We encountered frequent bycatch of Mudpuppy (*Necturus maculosus*), a neotenic aquatic salamander that is active in winter, in passively baited ice-fishing gear targetting teleost fishes. We noted hook location in Mudpuppies captured by two hook types: J-hooks and circle hooks. Our prediction was that circle hooks would reduce the frequency of deep hooking of Mudpuppies, which is often cited as an important predictor of post-release mortality in fishes. We found no difference in the frequency of deep hooking of Mudpuppies captured by circle or J-hooks, although, in a subset of Mudpuppies (n = 13) held for 24 h after capture, one death occurred (8%). Further research may be necessary to determine whether deeply hooked Mudpuppies can pass or shed hooks and survive beyond the 24-h period we monitored. However, our findings suggest that anglers and managers should consider refinements to handling practices for Mudpuppies captured as bycatch, because they are likely to survive if handled cautiously. These results, which are among the first describing non-fish bycatch in recreational fisheries, call for managers and anglers who encounter Mudpuppies during recreational fishing to seek more information and educational opportunities to improve the fate of this important component of temperate freshwater ecosystems and ecological indicator species that is incidentally captured by ice fishing.

Key words: Mudpuppy; *Necturus maculosus*; fisheries management; winter biology; circle hook

Introduction

In many nations, recreational fisheries are more economically valuable than the commercial sector, with billions of fish captured annually by recreational angling (Cooke and Cowx 2004; Tufts *et al.* 2015). The methods used to target fish in recreational fisheries tend to be more limited than in commercial fisheries, as fishing is predominantly conducted by hook and line with various lures, flies, or baits used to attract fish to hooks. Although the gear selected by anglers is often chosen to suit a specific target species or group of species (Pope *et al.* 2016), the incidental bycatch of non-target fishes can be considerable, as is the potential for capture of non-target taxa. Freshwater bycatch is an emerging conservation challenge (Raby *et al.* 2011; Stoot *et al.* 2013), although the literature has been focussed predominantly on commercial fishing (e.g., Silva and Best 1996; Bell and Lyle 2016).

Little research has been carried out on ice fishing, a type of recreational fishery popular at higher latitudes (Deroba *et al.* 2007; Twardek *et al.* 2018). Ice fishing involves drilling or cutting through ice to gain access to winter-active fish. Typically, a hook is baited with live or cut bait and set using rod or passive lines at an appropriate depth for the targetted game fish. Most jurisdictions allow for more than one line per angler at any one time and this, combined with water conditions and hole size, make observation difficult, hindering angler-mediated selectivity.

Understanding the impact of fishing practices on captured species is necessary to achieve sustainable fisheries. Best practices in recreational fisheries can be implemented to minimize impacts on captured animals (Brownscombe *et al.* 2017). This includes appropriate selection of terminal tackle (i.e., hooks), which is often regulated by management authorities (Schill and Scarpella 1997; Cerdà *et al.* 2010). Circle hooks have been marketed as an effective tool for reducing mortality of captured fish by minimizing deep-hooking (Serafy *et al.* 2012). The circle hook is designed with the point oriented 90° to the shank so that it rotates when ingested by an animal and lodges more frequently in the lips rather than the gullet. Circle hooks are used in both commercial and recreational fisheries to minimize bycatch of non-target fish as well as other taxa such as marine turtles (Cooke and Suski 2004; Sales *et al.* 2010).

Mudpuppy (*Necturus maculosus*) is a species of neotenic freshwater salamander native to North American

lakes and rivers. Mudpuppy activity is highest in cold temperatures, and they feed on many of the same prey items as game fish (Shoop and Gunning 1967; Beattie *et al.* 2017). Although not listed as at risk in most jurisdictions, including Canada (SARA Registry 2018), declines in population levels have been reported (Mifsud 2014; Harding and Mifsud 2017), and several United States agencies have granted them various conservation statuses (Matson 2005). Mudpuppies are long-lived (Bonin *et al.* 1995) and late to mature (Bishop 1943), likely making them sensitive to adult mortality (Congdon *et al.* 1994). Siltation and chemical pollutants (Bonin *et al.* 1995; Matson 1998, 2005) are likely chronic threats to local populations, and bycatch in recreational ice fisheries is a recognized but poorly quantified risk.

Capture of Mudpuppies by ice fishing is incidental in the winter, when Walleye (*Sander vitreus*) and other teleosts are targetted with baited hooks, often on passively set lines near the substrate where Mudpuppies are most active (Craig *et al.* 2015). Mudpuppies may ingest hooks on set lines, resulting in deep-hooking, a topic that has been extensively explored for teleost species and consistently demonstrated to be one of the most important predictors of post-release mortality in recreational catch-and-release fisheries (Muoneke and Childress 1994). Although Mudpuppies may be captured by recreational anglers, their presence in lakes may not be well known among anglers, and some anglers may cull them out of spite or misunderstanding of their ecological role (Craig *et al.* 2015). Retrieval, handling, unhooking, and release of Mudpuppies may be inconsistent among anglers with a poor understanding of the species biology, particularly without guidelines regarding best practices. Moreover, it is uncertain whether Mudpuppies captured and released through ice holes are likely to survive or if the retrieval, exposure to air and cold, handling, or hooking damage will lead to mortality.

In this study, we compare the hooking of Mudpuppies captured on two terminal hooking gears, circle hooks and J-hooks, and quantify the short-term survival of Mudpuppies released following recreational angling.

Methods

Mudpuppies were captured as bycatch (Figure 1) between 2100 and 0700 while fishing for Walleye on South Bay, Lake Nipissing, Ontario, Canada (46.2730°N, 79.8022°W). Between 10 January and 3 February 2017, we set passive lines using tip-ups, which have a spring-loaded mechanism for signalling the hooking of a fish that has struck a baited hook passively suspended beneath the ice. The sensitivity of these devices is set to detect the presence of larger teleost fishes that pull on the spool with more force than Mudpuppies; thus, the reliability of the flag signal to detect Mudpuppies was poor. Tip-ups were set 15–30 cm off bottom (depth ~7–8 m) with both circle and J-style hooks (Octopus 4 and Octopus circle 4; Gamakatsu, Tacoma, Washington, USA) baited with live shiners (e.g., *Notropis* spp.) and weighted with a 7-g lead sinker. Water temperature remained at 4°C in the hypolimnion layer where Mudpuppies were captured, while ambient air temperature varied from −19.4°C to 3.3°C during the study period.

Mudpuppies were landed by angling in approximately 20 s, with little variation among individuals. For each Mudpuppy that was captured, we estimated the length (to the nearest centimetre) and characterized the anatomical hooking location. Following practices of local anglers who captured Mudpuppies, we removed the hooks from individuals hooked in the lip and cut the lines on all deeply hooked Mudpuppies. The observation period resulted in about 45 s of air exposure. A subset of 13 Mudpuppies was transferred into conical holding pens (volume = 0.5 m^3) suspended beneath the ice at the depth at which the Mudpuppies were captured (~7–8 m). Nets were emptied after 24 h to determine Mudpuppy survival. No net held more than three Mudpuppies during an overnight holding period.

Because of this small sample size, statistical analysis was not feasible to determine drivers of mortality; thus, we simply provide accounts of the mortality. A χ^2 test was used to evaluate potential differences in hooking locations of Mudpuppies caught by circle and J-style hooks using the chisq.test function in R (R Core Team 2017).

Results

During an estimated 3655 rod-h on Lake Nipissing using both passive and active lines, we captured 80 Mudpuppies, ~0.02/rod-h. Although not quantified, most Mudpuppies were captured at night and on passive baited lines. For our study, we captured 48 Mudpuppies on passively set ice fishing lines. One of these was captured by a dead-stick (i.e., ice fishing rod passively suspending a baited lure) with a treble hook and was excluded from further description because of low sample size with this gear; however, this individual was hooked in the outer lip and survived. We were unable to measure most Mudpuppies because they responded to capture and handling by curling into a small ball. However, we estimate that most were ~18–22 cm long. At these sizes, they are not likely to be fully mature (McDaniel *et al.* 2009).

Only four of the 47 Mudpuppies (9%) were shallow hooked in the lips; the remainder had ingested the baited hook, which we assumed was lodged inside the stomach (Figure 2). There was no difference in the incidence of deep hooking with circle hooks compared with J-hooks ($\chi^2_1 < 0.01$, $P = 1.00$). Despite the high frequency of deep hooking, only one of 13 Mudpuppies died (8%) during the 24-h holding. This individual was captured using a circle hook and ingested the hook. All other Mudpuppies were released back into the water.

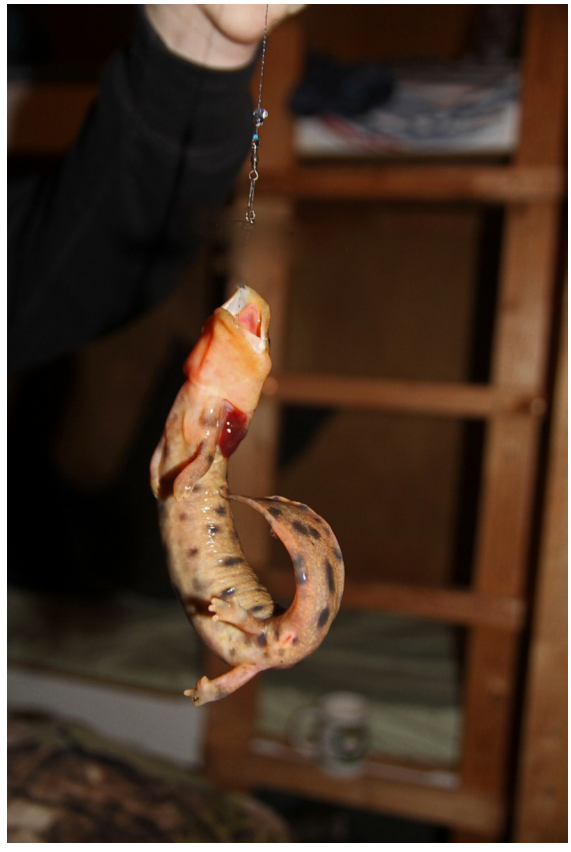

Figure 1. Mudpuppy (*Necturus maculosus*) captured by ice fishing in Lake Nipissing, Ontario, Canada. This individual was not included in the study, but is representative of the type of capture event investigated. Photo: W.M. Twardek.

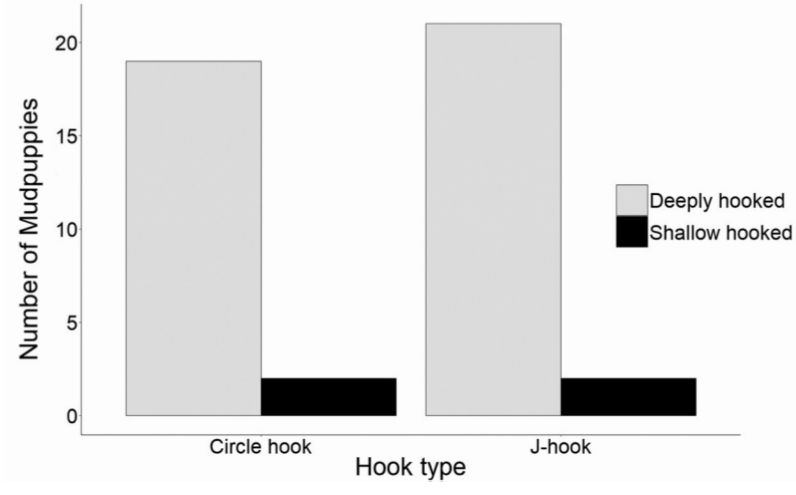

Figure 2. Hooking locations, characterized visually, and hook types observed to capture Mudpuppies (*Necturus maculosus*) while ice fishing in Lake Nipissing, Ontario, Canada.

Discussion

This was an opportunistic study of Mudpuppies conducted during an ice fishing project targetting Walleye, and sample sizes were small. However, it is clear that a large number of Mudpuppies may be captured and released by recreational anglers in winter ice fisheries. Our findings present the first evidence that Mudpuppies survive encounters with recreational anglers even when deeply hooked and call for additional research on the extent and impact of recreational bycatch of Mudpuppies.

Encounters with anglers in the fishery suggested that they were unfamiliar with Mudpuppies and unaware of their presence in Lake Nipissing, which is a prominent ice fishing destination. We observed some anglers capturing Mudpuppies and jettisoning them onto the ice to inspect them before we suggested that they cut the line and release them down the hole. We did not study the effect of prolonged exposure to sub-zero air temperatures, but given that Mudpuppies respire by lungs, gills, and through the epithelium, these external organs (gills and skin) may be sensitive to freezing temperatures and the formation of ice crystals on these structures could cause permanent damage. Additional research is necessary to determine the effect of cold air exposure, but presumably the most risk-averse and recommended behaviour would be for anglers to rapidly unhook (or cut) Mudpuppies from the line and release them back into the water with limited air exposure. This is consistent with guidelines for fish captured either incidentally or intentionally that are destined to be released (Cook *et al.* 2015), but could be more urgent at lower temperatures.

Relative to most fish captured by hook and line, the observed rates of deep hooking in Mudpuppies were high (Hühn and Arlinghaus 2011). This is likely related to the feeding ecology of Mudpuppies that use interlocked lips to suction-feed on prey (Gans and Nussbaum 1992). Some anglers targetting Walleye or other teleosts may insist on removing hooks from deeply hooked Mudpuppies; however, evidence from teleosts consistently suggests that hook removal from deeply hooked animals results in organ injury and bleeding, whereas cutting the line may allow the animal to pass or shed the hook (e.g., Weltersbach *et al.* 2016). Although we did not experiment with different hook removal techniques, our results suggest that cutting the line and releasing deeply hooked Mudpuppies results in infrequent short-term mortality. Further research may investigate whether survival is significantly different for hook removal compared with cutting the line. However, removing the hook from a deeply hooked Mudpuppy would most likely be fatal; thus, we only ever cut the line. Whether Mudpuppies can successfully expel a hook could be further studied using longer-term observations of survival or radiography (see Weltersbach *et al.* 2016).

In this study, we found that circle hooks did not reduce the frequency of deep-hooking Mudpuppies and, therefore, are not necessarily an effective means of improving the fate of Mudpuppies captured by anglers. However, larger sized hooks may preclude swallowing by Mudpuppies and their potential could be further investigated alongside a Walleye fishery to compare catch rates of Walleye and critical hooking rates of Mudpuppy. Observed high rates of deep-hooking are likely similar to those naturally occurring in the fishery but may be because of low sensitivity of the tip-ups, which were calibrated for detecting bites from Walleye.

Mudpuppies are an important component of freshwater ecosystems and are long-lived and late maturing, life history traits that make them vulnerable to overexploitation as bycatch in recreational fisheries (Matson 2005; Craig *et al.* 2015). Their presence in freshwater systems is a good indicator of ecosystem health (Craig *et al.* 2015), and their conservation should be a priority for those who work for natural resource management agencies, including fisheries managers, to ensure that they are covered in fishing regulations. Given that we frequently captured Mudpuppies while fishing for Walleye, a better understanding of the responses of Mudpuppies to angling may be necessary to provide recommendations to anglers who capture them, dispel myths about their negative interactions with gamefishes, and promote best handling practices so that Mudpuppies can be released from ice fisheries alive (Craig *et al.* 2015).

Author Contributions

Writing – Original Draft: R.J.L, W.M.T.; Writing – Review & Editing: R.J.L., W.M.T., S.J.C.; Conceptualization: R.J.L., W.M.T., S.J.C.; Investigation: R.J.L., W.M.T.; Methodology: R.J.L., W.M.T.; Formal Analysis: R.J.L.; Funding Acquisition: S.J.C.

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