BULLETIN OF MARINE SCIENCE. 88(3):395–410. 2012
http://dx.doi.org/10.5343/bms.2011.1056

SCIENTIFIC AND STAKEHOLDER PERSPECTIVES ON THE USE OF CIRCLE HOOKS IN RECREATIONAL FISHERIES

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ABSTRACT

Catch-and-release science has revealed that one of the strongest correlates of mortality for fishes is deep hooking in areas such as the esophagus, gills, or stomach, which is largely influenced by gear choice and angler behavior. Circle hooks represent a gear type that has been shown to reduce incidences of deep hooking, but not for all species or fishing methods. The apparent condition-dependent success as well as wide range of circle hook configurations causes confusion for the angling community and challenges for fisheries managers. An online snowball-style survey (n = 1354 completed) targeting North American anglers that have used circle hooks was implemented to examine stakeholder perspectives, an approach that has the potential to reveal issues and opportunities with respect to circle hook use and implementation as a management tool. Our survey identified that respondent perspectives tended to be consistent with scientific literature. Most respondents reported that circle hooks are useful (in terms of enabling capture and shallow hooking) for certain species and types of fisheries/methods, but of little use for others (i.e., low hookup rates). However, a number of respondents identified the need for additional education, particularly related to hook sets. Most respondents were apprehensive about broad-scale regulations requiring circle hooks, but felt that such regulations could be used in specific instances. Identifying the factors that influence when circle hooks are effective and the barriers to angler adoption of circle hooks in instances where they are deemed effective represent key research needs. Regional or fishery-specific social science surveys based on random sampling are needed to further advance understanding of circle hooks and ultimately lead to a reduction in deep hooking and fish mortality.

Since its inception in the 1970s, catch-and-release science has focused on identifying the consequences of catch-and-release angling on fish (e.g., injury levels, stress, mortality), identifying factors that contribute to undesirable outcomes (e.g., environmental conditions, gear type), and defining strategies for improving outcomes for released fish (Cooke and Schramm 2007). To date, several hundred scientific papers have been published on the biological aspects of catch-and-release for a wide range of marine and freshwater fishes (reviewed in Arlinghaus et al. 2007).

There have been a number of attempts to synthesize this work to identify common themes, particularly with respect to identifying factors that lead to mortality. From these syntheses, multiple factors have been identified as being important in improving outcomes of catch-and-release events, leading to general guidelines applicable to all fisheries. Developed by Cooke and Suski (2005), these catch-and-release guidelines encourage anglers to: (1) minimize angling duration, (2) minimize air exposure, (3) avoid angling during extremes in water temperature, (4) use barbless hooks and artificial lures/flies, and (5) refrain from angling fish during reproductive periods. Nevertheless, the factor most consistently identified as being associated with

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mortality in catch-and-release events is the extent to which fish are deeply hooked (reviewed in Muoneke and Childress 1994, Bartholomew and Bohnsack 2005, Cooke and Suski 2005, Arlinghaus et al. 2007).

Deep hooking, characterized by the hook penetrating the esophagus, gills, or other sensitive tissue(s) beyond the mouth cavity (e.g., pericardial cavity, stomach, liver), can inflict more substantial physical injury than shallow hooking (Bartholomew and Bohnsack 2005). Often, deep hooking is associated with extensive bleeding, sometimes to the point of exsanguination (Arlinghaus et al. 2007). When a fish is deeply hooked, an angler can either cut the line and release the fish with the hook embedded in the tissue, or the angler can attempt to remove the hook. There is a growing body of evidence demonstrating that leaving a deep hook in place results in less mortality than when deep hooks are removed (reviewed in Bartholomew and Bohnsack 2005). However, when hooks are left in place, there still can be problems with blocking the alimentary canal (Schisler and Bergersen 1996), reductions in growth (Aalbers et al. 2004), pathological consequences (Borucinska et al. 2001, 2002), and physiological disturbances (Fobert et al. 2009), even though some hooks are shed in due course. Clearly, the best strategy to minimize negative outcomes for released fish is to identify means of reducing deep hooking in the first place.

There are a number of factors that influence the occurrence of deep hooking for catch-and-release angling events. For example, studies have revealed that live or natural bait results in a significantly higher incidence of deep hooking than flies or artificial lures (Taylor and White 1992). Moreover, smaller lures or baits are more likely to be deeply ingested than larger baits (Arlinghaus et al. 2008). Angler experience also has the potential to influence deep hooking rates as novice anglers may be less able to detect strikes resulting in increased likelihood of deep hooking due to fish swallowing lures (Dunmall et al. 2001). Given that the hook(s) serve as the point of contact between the angler and the fish, there has also been substantial effort devoted to exploring hook designs that would minimize deep hooking. Of particular promise is the circle hook, given that it has the potential to be used in combination with live or organic baits or lure types, and minimize the occurrence of deep hooking.

Circle hooks have a long history of use (reviewed in Cooke and Suski 2004), but most notably were used for passive long-line commercial fisheries in the last century. In the mid-1990s, hook manufacturers began to test and market them for recreational fisheries. Circle hooks are designed such that the point of the hook is perpendicular to the shank rather than parallel to the shank, as it is with more conventional hook designs. A review of circle hooks by Cooke and Suski (2004) revealed that circle hooks can be highly effective at minimizing negative outcomes for a number of marine and freshwater recreational fisheries relative to conventional J-style hooks. In this context, the word "effective" refers to both the ability of the hook to land fish, as well as the ability of the hook to contact fish in an anatomical location that is relatively benign (i.e., shallow). Circle hooks tend to hook fish in the corner of the jaw, although exceptions to this trend exist (Cooke and Suski 2004). Subtle differences in the size of the hook can also influence the ability of the hook to hook fish in the jaw, and can lead to eye injuries (Cooke et al. 2003a). In addition, circle hook configuration (i.e., inline vs offline; Prince et al. 2002) can dramatically alter conservation benefits with severely offset hooks tending to result in injuries and hooking locations similar to J-style hooks (Cooke and Suski 2004). There are certain gears (e.g., some lures), species (i.e., certain anatomy, dentition, and feeding behavior), and

fishing methods (e.g., trolling) where circle hooks fail to minimize injury. More recently, however, circle hooks have been regarded by the management community as a conservation tool, and there are now several examples of where circle hook use is mandatory for certain fisheries/fishing methods in some jurisdictions.

The synthesis by Cooke and Suski (2004) identified a number of apparent challenges with expanding the use of circle hooks into a wider range of fisheries. Most notably was the need for anglers to modify their behavior, moving away from a traditional and often aggressive hook set upon feeling a fish strike their lure, to a more gentle pressure and slow retrieval of a hooked fish. Another challenge was simply identifying the situations for which circle hooks work, and those where they are ineffective. Given that the early adoption of circle hooks was driven by anglers (e.g., billfish tournaments moved to circle hooks before government regulation; J Vernon, The Billfish Foundation, pers comm), it would be useful to better understand angler perspectives on the use of circle hooks to facilitate expanding their use, when appropriate. The perspective of anglers could be useful determining future research priorities, and identifying barriers to gear adoption. Indeed, human dimensions of fisheries (Ditton 2004) and conservation social science (Mascia et al. 2003) are now regarded as critical components of fisheries management and conservation.

The objective of the present study is to quantify angler perceptions and use of circle hooks in recreational fisheries. In particular, we were interested in surveying anglers to identify the general characteristics under which circle hooks facilitate shallow hooking while maintaining acceptable capture rates. The existing synthesis on circle hooks (i.e., Cooke and Suski 2004), along with more recent literature, provide useful information on the biological aspects of circle hook effectiveness emanating from field research studies. What is lacking is a parallel social science exploration of stakeholder perspectives on the use of circle hooks, an activity that could yield useful information on the application of circle hooks in fisheries management and conservation. To that end, we conducted an online snowball-style survey (i.e., meaning that anglers were encouraged to forward the survey to other potential participants) targeting North American anglers that had used circle hooks. Combining scientific data (i.e., an updated literature review building on Cooke and Suski 2004) with stakeholder perspectives has the potential to reveal issues and opportunities regarding circle hook use in recreational fisheries, and to identify and direct future research activities and management options.

Methods

Literature Review.—To build upon the earlier review by Cooke and Suski (2004), we conducted a review of existing literature that involved the use of circle hooks in recreational fisheries. Using similar methods to Cooke and Suski (2004), we located research materials published post-2004 using the library article databases Aquatic Sciences and Fisheries Abstracts A© (2004–January 2011) and Web of Science© (2004–January 2011). Web-based searches were also conducted using the search engine Google Scholar©. We also used the Cited Reference function in Web of Science to identify all papers that had cited the Cooke and Suski (2004) synthesis (it had been cited >65 times as of March 2011). Since the focus of our study was on catch-and-release angling, we excluded studies related to commercial bycatch reduction. However, where appropriate, we comment on commercial bycatch issues in the discussion. We expanded the tabular database from Cooke and Suski (2004) and used that to extract basic summary information. Unlike Cooke and Suski (2004), our goal was not to

conduct a meta-analysis. Instead, we wished to inform our analysis of the human dimensions data to see the extent to which opinions conformed or diverged from scientific findings.

Survey.—We implemented an online snowball-style survey to target recreational anglers in North America (i.e., Canada and the United States) that had used circle hooks. We excluded those anglers that had not used circle hooks, given that we felt their perspectives would be based entirely on hearsay rather than first-hand experience. The survey was hosted by FluidSurveys (Ottawa, Ontario, Canada) and was tested on 10 anglers prior to official launch. The survey portal was open from March 25, 2011, to April 6, 2011. Snowball-style internet surveys have a number of advantages over conventional survey designs, but also some important limitations (Fricker and Schonlau 2002, Beidernikl and Kerschbaumer 2007). One advantage is that they can reach large numbers of potential respondents very quickly. However, the nonrandom sampling-based survey design precludes generalized insights.

The web link for this survey, along with a brief preamble and invitation, were posted to social networking sites and online fishing blogs, angler discussion boards, and outdoor media sites. Some fishing clubs and organizations also distributed the survey via email. We attempted to post the survey on at least one angling website in each state and province in North America. Web-based fishing boards and groups were monitored to evaluate respondent comments regarding the survey and to watch for potential calls of abuse (Norman and Russell 2006). Because access to the survey was limited by one survey per Internet protocol (IP) address, as per the recommendations by Bowen et al. (2008), we assume that limited bias due to repeated survey response by individuals occurred. The survey was only available in English and the survey protocol was approved by the Ethics Committee at Carleton University. We are aware that our sampling was not conducted using principles of random sampling, meaning that it is not possible to accurately quantify the number of stakeholders that were presented with the opportunity to participate in this survey, nor was it possible to calculate response rates or other metrics of survey quality and representativeness.

The survey was divided into three parts: warm-up, Likert scale, and short answer questions. Warm-up questions were used to characterize angler experience with and exposure to circle hooks, their fishing experience and avidity, as well as fishing location preference. The first two questions in the survey were intended to screen participants that fell outside of our sample group. The first question asked whether participants had ever used circle hooks before; if a response of "no" was entered, the survey ended. The second question asked for the state or province of residence of the participant; if the participant selected a jurisdiction outside of North America the survey also was terminated. At the end of the survey, anglers had the opportunity to withdraw such that their responses would not be recorded. The majority of survey questions were based on a five point Likert scale asking respondent to rate their agreement on statements about circle hooks. There were also some free form questions including two broad open-ended questions related to circle hooks. The first question was "provide any additional comments on circle hooks with specific reference to their benefits for fish conservation and as a fisheries management tool" and the second was "provide any additional comments regarding your opinions of circle hooks." We randomly selected 300 surveys to analyze and thematically code individual responses to identify patterns with respect to positive, neutral, or negative perspectives for the first question. The second question was used only to generate quotes which are presented anonymously.

Results and Discussion

Characteristics of Literature on the Scientific Perspective.—Cooke and Suski (2004) found 43 recreational circle hook studies. Based on our internet searches in March 2011, we located an additional 28 papers yielding a total of 71 recreational circle hook studies, reflecting a general increase in such research through time (Fig. 1). Fifty-two of the 71 papers were marine in focus while 17 took place in

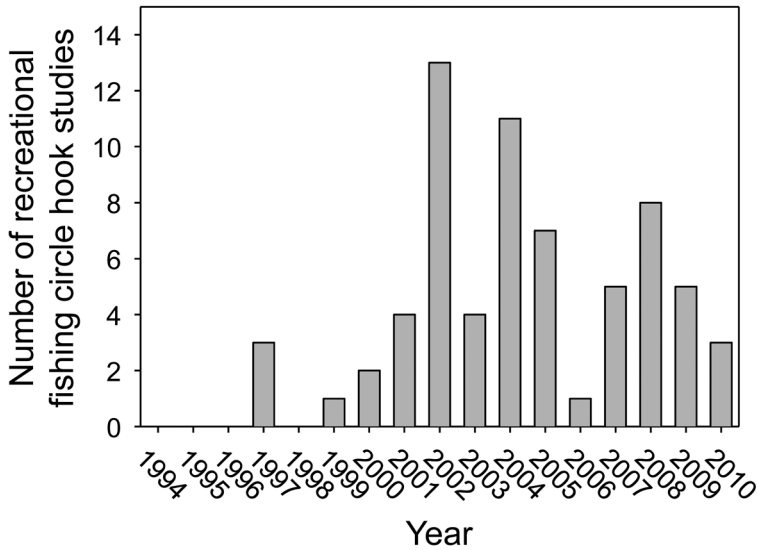

Figure 1. Progression of recreational angling circle hook research evidenced by publication rate. Data from Cooke and Suski (2004) are updated with current literature.

fresh water. Interestingly, there were no new freshwater papers since 2005. There are now also three "synthesis" or "review" type papers on circle hooks in recreational fisheries (i.e., Cooke and Suski 2004, Serafy et al. 2009, Graves and Horodysky 2010). The majority of the research post-2004 (i.e., since Cooke and Suski 2004) has focused on coastal marine fishes in Australia (e.g., Mapleston et al. 2008, Grixti et al. 2010), coastal marine fishes in Spain (e.g., Alós 2008, Alós et al. 2009), and marine fishes off the eastern seaboard of the United States (e.g., Graves and Horodysky 2008). The level of uncertainly with respect to the condition-dependent nature of circle hook effectiveness does not appear to have been resolved since the Cooke and Suski (2004) study. There are certainly a growing number of studies that have found conservation benefits of circle hooks; however, there are still a number of challenges. To summarize, not unlike Cooke and Suski (2004), the state of catch-and-release science with respect to circle hooks is as follows: (1) compared to J-style hooks, circle hooks almost always result in fewer instances of deep hooking; most often circle hooks hook in the jaw; (2) circle hooks tend to reduce hooking mortality by 50% compared to conventional style hooks (on average, Cooke and Suski 2004), recognizing that there are certainly exceptions; (3) subtle differences in circle hook configuration can obfuscate the potential benefits of circle hooks (e.g., offset; Prince et al. 2002); (4) catch rates for circle hooks can be similar to J-style hooks, but do require a change in angler behavior; and (5) circle hooks tend to work best in situations where live/organic bait is used or lures are used to fish passively. However, the question remains as to whether there is congruence between scientific perspectives and stakeholder perspectives.

Characteristics of Respondents in Social Science Survey.—In total, we had 1354 completed surveys (80% of participants) on which data analyses were based. The majority (82.9%, n = 1123) of survey respondents had been fishing for >20 yrs (<5

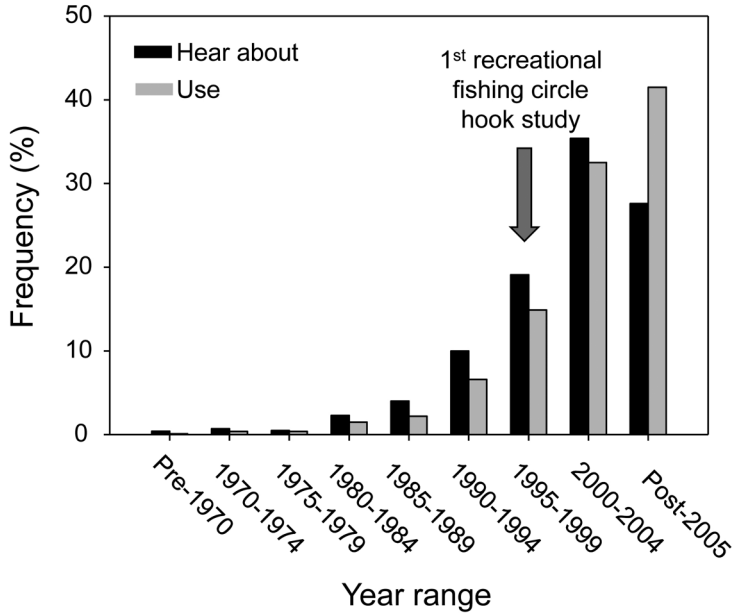

Figure 2. Progression of the number of recreational anglers who have heard about circle hooks vs those who use them.

yrs, n = 16; 5–10 yrs, n = 51; 10–15 yrs, n = 66; 15–20 yrs, n = 98). In general, the majority of respondents had spent many days per year fishing with nearly 47% (n = 635) reporting in excess of 50 fishing days per year (<10 d yr^{-1}, n = 7; 10–20 d yr^{-1}, n = 75; 21–30 d yr^{-1}, n = 255; 31–50 d yr^{-1}, n = 382). The majority of respondents fish in both marine and fresh water (i.e., n = 608, 45%), with fewer fishing in exclusively marine (n = 469, 35%) or fresh water (n = 277, 20%). Respondents were from both Canada (n = 179, 13.2%; representing six provinces and one territory) and the United States (n = 1175, 86.8%; representing 45 states). The top ten states/provinces in terms of number of respondents were New Jersey (n = 271), Massachusetts (n = 139), Ontario (n = 118), New York (n = 82), Pennsylvania (n = 79), Rhode Island (n = 76), California (n = 61), Connecticut (n = 58), Nebraska (n = 52), and Maine (n = 49).

Trends in Circle Hook Knowledge and Use.—Overall, there has been a steady increase in circle hook use from the 1970s through post-2005. Patterns in circle hook knowledge compared to circle hook use suggest a lag between when anglers learned about circle hooks compared to when they used circle hooks while fishing (Fig. 2). When asked about how they first heard about circle hooks, most respondents suggested that they learned primarily from fishing and outdoor media (n = 577), tackle shops (n = 179), fishing-related websites (n = 159), and government regulations (n = 50). Fewer respondents learned about circle hooks from the hook manufacturer (n = 38), government outreach (n = 7), charter boats/guides (n = 16), clubs/associations (n = 15), or commercial fishers (n = 14).

Recently (i.e., post-2005), it appears that anglers who have learned previously about circle hooks are trying them more frequently (Fig. 2). When respondents were asked how often they used circle hooks, 17.4% indicated that they rarely or never (after

trying them at least once) used circle hooks. Similarly, few (11.3%) respondents indicated that they always use circle hooks.

Conservation Effectiveness.—The majority (86.6%) of respondents were in agreement with the statement that, when using circle hooks, fish are almost always hooked in the jaw. Only 7.0% of respondents were in disagreement with the statement. Similarly, 87.4% of respondents were in agreement with the statement that circle hooks reduce instances of deep hooking relative to conventional hook designs. In general, this finding is consistent with scientific literature (i.e., Cooke and Suski 2004). Indeed, the entire premise of circle hooks is that when gentle pressure is applied, that the hook rotates over the jaw region, and avoids deep hooking. Overall, 76.9% of respondents were in agreement with the statement that circle hooks are an important fish conservation tool.

From the randomly sampled 300 respondents, we extracted 562 different responses that could be thematically coded. We identified three perspectives regarding the conservation benefits of circle hooks [i.e., positive (75.9%), neutral (12.6%), and negative (11.5%)]. The most common benefits (n = 455 responses) listed were the fact that circle hooks reduce deep hooking (18.5%), tend to hook fish in a shallow location (11.4%), and reduce mortality (8.9%) and stress/injury (8.0%), thus facilitating easy release (8%). A number of respondents emphasized their utility for bait fishing (8.2%), or for a specific species (7.8%), and that circle hooks typically yielded a good catch rate (9.6%). The most common challenges identified (n = 107) were associated with circle hooks simply being ineffective at both capture and reduction of deep hooking (17.6%), the fact that they are difficult to use (11.2%), and that there is a need for more research on circle hooks as well as promotion (14.9%). Although not specifically asked as part of the question, 16.8% of the challenge comments were specific to the fact that circle hooks should not be mandated (typically associated with a general lack of tolerance for more government regulation).

Responses from participants were mixed in their reaction to the statement that circle hooks are useful for novice anglers (Table 1). This finding likely reflects the fact that circle hooks may reduce deep hooking, which can be more common in novice anglers, but that there is also some expertise needed in terms of how to gently set a circle hook. We are unaware of any literature that has directly compared performance of circle hooks relative to level of angler experience. Indeed, there are only a few papers that have compared novice vs expert anglers in the context of catch-and-release science (i.e., Dunmall et al. 2001, Meka 2004). There is need for research on how circle hooks perform when used by novices along with strategies for educating novices on how to use circle hooks.

When asked to comment on which fish species/groups circle hooks work best (combination of conservation benefit and catch rate), respondents provided more than three times the number of responses for the species/groups for which circle hooks work quite well (n = 2705) compared to the number of species/groups for which circle hooks do not work well (n = 851, Table 2). Four groups (including the top three) on the "best" list also appeared on the "worst list," emphasizing the divergent perspectives of respondents regarding circle hook performance. Although the groups listed as being particularly effective were largely marine or anadromous, there were some exclusively freshwater groups also listed [e.g., black bass (*Micropterus* spp.), ictalurids]. This observation is consistent with the response to another question where

Table 1. Responses to statements as judged by a 5-point Likert scale. Percent of respondents are presented alongside the (*n*) for each response.

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Circle hooks are difficult to find in local stores	41.2% (556)	36.5% (494)	9.3% (126)	10.7% (145)	2.3% (31)
Circle hooks must be ordered by phone or internet	56.0% (756)	28.8% (390)	7.3% (99)	5.8% (78)	2.1% (29)
I make my own circle hooks by bending J-style hooks	77.3% (1,037)	12.8% (173)	6.3% (85)	1.1% (15)	2.5% (34)
Circle hooks tend to reduce my catch	34.0% (458)	31.0% (419)	19.3% (261)	9.9% (133)	5.8% (78)
To be effective the size of a circle hook has to be matched to the size of the fish	4.8% (66)	8.2% (111)	17.0% (230)	47.4% (640)	22.6% (302)
Circle hooks are more difficult to remove from a fish than a J-style hook	35.6% (480)	40.5% (546)	12.0% (162)	9.6% (129)	2.2% (31)
I have to adjust my fishing techniques when using circle hooks	8.2% (110)	12.7% (172)	8.9% (120)	49.0% (659)	21.1% (284)
Circle hooks are only for marine fish	32.5% (435)	39.7% (531)	22.9% (307)	4.0% (53)	0.9% (13)
Circle hooks are only for use with live/organic baits	24.9% (335)	34.9% (470)	14.9% (201)	20.6% (277)	4.6% (62)
Circle hooks are useful for novice anglers	7.7% (104)	12.2% (165)	27.1% (365)	42.0% (564)	11.0% (149)
Circle hooks reduce incidences of deep hooking relative to J-style hooks	2.0% (27)	3.4% (46)	7.2% (97)	46.4% (624)	41.0% (551)
When using circle hooks, fish are almost always hooked in the jaw	1.9% (26)	5.1% (68)	6.3% (85)	53.2% (716)	33.4% (450)
Circle hooks are an important fish conservation tool	3.2% (43)	4.4% (59)	15.5% (208)	38.9% (521)	38.0% (510)
Fisheries management agencies should consider mandating circle hook use for recreational fishing	17.3% (232)	16.7% (225)	18.8% (252)	27.0% (363)	20.2% (272)

Table 2. Ordered list of the most frequent responses to the questions of fish groups for which circle hooks are particularly effective and ineffective. The subjective volume of scientific understanding on circle hooks for each group is denoted as well-studied (W), moderately-studied (M), or poorly-studied (P).

Effective			Ineffective		
Fish group	*n*	Studied	Fish group	*n*	Studied
Moronids	771	W	Salmonids	171	M
Black bass	303	M	Flatfishes	156	M
Pomatomids	283	P	Panfishes	90	W
Flatfishes	258	M	Labrids	86	M
Catfishes	249	P	Black bass	73	M
Salmonids	225	M	Esocids	72	P
Tunas	189	M	Percids	67	M
Sciaenids	178	M	Moronids	53	W
Billfishes	141	W	Pomatomids	49	P
Sharks	108	P	Sparids	34	P

72.2% of respondents were in disagreement with the statement that circle hooks are only for marine fish. It is also worth noting that the relative ranking of these families partly reflects the extent to which they are targeted. For example, black bass are the most popular gamefish in North America, thus despite the lack of clear scientific evidence of the utility of circle hooks (i.e., circle hooks vs J-style hooks; see Cooke et al. 2003b), black bass was ranked second-most frequently as species for which circle hooks are effective. Conversely, tuna, billfish, and sharks represent more specialized fisheries where the comparative fishing effort would be reduced, so their lower ranking in the list of effective fish should not be taken as suggesting that the absolute ranking is meaningful. Indeed, circle hooks have been demonstrated to be particularly effective for billfish (Prince et al. 2002). Circle hooks were also deemed to be most effective for moronids, in particular, striped bass [*Morone saxatilis* (Walbaum, 1792)]. Consistent with the perspective of the respondents, all of the published work on circle hooks and striped bass has found consistent shallow hooking and hooking rates that are comparable to J-style hooks (e.g., Millard et al. 2003, Lukacovic and Uphoff 2007). Management agencies also seem to agree with this sentiment in that one of the first fisheries for which circle hooks were both recommended and mandated was the striped bass fishery. Together, we suggest that these data are representative of the respondent group and should be interpreted with caution. More meaningful evaluation of stakeholder perspectives on circle hook effectiveness could be obtained on a regional basis.

When subjects were asked which techniques were particularly effective for circle hooks, the majority of responses (n = 1241) pointed to natural/organic baits, with fewer responses providing examples of techniques and approaches that use artificial baits (n = 268). Specific examples of the four most common generalized responses were baitfishing, anchored bottom fishing, drifting, and fly fishing. Conversely, when asked about techniques that were ineffective for circle hooks, artificial baits (n = 394) were more commonly reported than natural/organic baits (n = 116). Trolling, jigging, casting, and fly fishing, all rather active techniques, were the most common types of ineffective techniques. The majority of respondents (59.8%) were in

disagreement with the statement that circle hooks are only for use with live/organic baits. Interestingly, there are relatively few accounts in the literature where circle hooks have been evaluated with artificial baits such as plastic worms or jigs, although they are mentioned anecdotally in Cooke and Suski (2004).

Capture Efficiency.—If circle hooks resulted in noticeable reductions in catch rate of target fish, it would likely be difficult to expect stakeholder "buy in" to their use. When asked to state their opinion regarding the phrase "circle hooks tend to reduce my catch rate," the majority (65%) of respondents disagreed or strongly disagreed. In addition, more respondents were neutral than in agreement with the statement. This finding is in general agreement with the scientific literature. There certainly are examples of where circle hooks have reduced capture efficiency relative to other hook types (reviewed in Cooke and Suski 2004). In those instances, it is usually a function of lower hookup rates rather than loss of fish during the fight (i.e., hookup rate is often lower in circle hooks while landing rate for hooked fish is higher for circle hooks; Cooke and Suski 2004). That sentiment was stated several times by anglers in free-form questions where some respondents noted that their "hooking percentage is way down compared to J-style hooks."

Ease of Hook Removal.—The majority (76.1%) of respondents reported disagreement with the statement that circle hooks are more difficult to remove from a fish than a J-style hook. To our knowledge, there are few studies that have recorded hook removal time when using circle hooks. Previous research that contrasted the sublethal physiological consequences of using barbed vs barbless J-hooks revealed that barbed hooks took longer to remove and this was associated with greater air exposure and hence greater cardiovascular disturbance (Cooke et al. 2001). Knowing whether circle hooks are indeed more difficult to remove would be useful to fully understand the biological consequences of different gear choices.

Regulation and Education.—There is an increasing trend toward resource management agencies mandating use of circle hooks as part of recreational fisheries management. When asked whether fisheries management agencies should consider mandating circle hook use for recreational fisheries, respondents were mixed in their responses (47.2% were in agreement with the statement). A common perspective voiced in the open-ended questions was that "circle hooks should be highly recommended...but not mandated...". One of the challenges with a regulatory approach is that there needs to be solid scientific basis for proposing mandated changes. Moreover, there needs to be a strategy for educating anglers on the basis for a regulatory approach, as well as how to ensure that they use circle hooks properly. For example, there is belief among the scientific community that circle hooks only function when gentle pressure is applied rather than a traditional hook-set. The majority (70.1%) of respondents were in agreement with the notion that they had to adjust their fishing techniques when using circle hooks. One responded noted that "once you adjust to how to fish circle hooks—and it is an adjustment—I found that the catch rate was comparable, and the kill rate from gut hooking was almost eliminated using the circle hooks." Some anglers also noted that they simply disliked fishing with circle hooks because "part of the thrill of fishing is setting the hook." There are inherent challenges with how to teach anglers about how to properly set the hook.

Respondents were also asked about the sources that they thought would be the best for information on circle hooks if they wanted to learn more about their proper use. Fishing-related websites (non-government, 68%), tackle/sport shop (59%), fishing media (56%), and internet searches (i.e., Google) were the most popular responses. Some respondents also reported interaction with peers (31%), government websites (7%), and fishing guides/clubs (6%). Several respondents provided comments that video clips that demonstrated proper hooksets would be helpful. This information should be useful for those agencies interested in promoting circle hooks and their proper use.

Availability of Circle Hooks.—Prior to conducting the study, we had predicted that one of the potential barriers to angler use of circle hooks was their availability. As researchers that are based largely inland, we have had a difficult time locating circle hooks for research at local tackle stores. Nonetheless, in our survey, over 77% of respondents either disagreed or strongly disagreed that circle hooks were difficult to find in local stores. Similarly, nearly 85% of respondents disagreed or strongly disagreed that they had to rely on ordering circle hooks online or via telephone from specialized stores outside of their area. Less than 4% of respondents agreed or strongly agreed that they make their own circle hooks by bending other hook types. However, from our general comment question, we identified that some respondents found it difficult to find small circle hooks for fly fishing.

Synthesis.—Our survey was the first to specifically focus on circle hooks and their use by the recreational fishing community. We were able to evaluate angler perspectives on circle hooks and document the level of agreement between their perspectives and the current circle hook science. Our survey identified that respondent perspectives tended to be consistent with the scientific literature. Most respondents reported that circle hooks are useful (in terms of enabling capture and shallow hooking) for certain species and types of fisheries/methods, but useless for others (i.e., very low hookup rates). However, a number of respondents identified the need for additional education, particularly related to hook sets. Most respondents were apprehensive about the use of broad-scale regulations requiring circle hooks, but felt that they could be used for some specific instances.

Identifying the factors that influence when circle hooks are effective and the barriers to angler adoption of circle hooks in instances where they are deemed effective represent key research needs for moving forward. Two other surveys have asked similar questions about circle hook use within the context of a broader survey on angler perspectives on recreational fishing. In a 1999 survey of specialized muskellunge anglers in Wisconsin, Margenau and Petchenik (2004) determined that most (93%) respondents had no experience with circle hooks. Nonetheless, 51% said they would support the use of circle hooks for live bait. Another 40% of anglers indicated uncertainty about the use of circle hooks until they tried them. More recently, Lynch et al. (2010) conducted a survey of elasmobranch recreational anglers in and around the Great Barrier Reef Marine Park (GBRMP) in Australia. None of the 309 elasmobranch anglers surveyed in the GBRMP reported using circle hooks despite the fact that the majority of respondents suggested that they would change behavior/gear if it would increase survival. The authors noted that "further research into fishers' knowledge and attitudes regarding the use of circle hooks would help inform education efforts."

Although the present study represents the first focused survey on circle hook use by recreational anglers, there were some inherent limitations. Due to the nonrandom sampling design, the findings are discussed in the context of the presumably biased respondents rather than the broader angling community. In addition, we do not dispute that it is likely that the respondents of this survey have either a particular avidity bias and/or strong opinions (either positive or negative) toward use of circle hooks. Regardless, we hope that our work stimulates more rigorous assessments of circle hook use in the recreational fishing community on a more focused (regional or fishery) basis and using survey instruments where one can better evaluate response rate and obtain a random (or specific non-random) sample.

Research Needs and Implementation Needs.—Cooke and Suski (2004) concluded their circle hook synthesis paper with a research agenda. Here we revisit their research agenda (italic) and provide comments (roman) on the advances on those points in the last 8 yrs.

1. *Need for additional research on circle hooks and their utility for minimizing injury and mortality in recreational fisheries.*—There have been a number of studies on a growing range of species that provide important information on injury and mortality rates of fish captured on circle hooks.
2. *Need for studies that vary the degree to which the hook forms a circle, the gap between the point of the hook and the shank, and the size of the hook relative to the size of the fish.*—There have been relatively few studies that have explored the role of hook size of circle hook performance (but see Cooke et al. 2005).
3. *Need for studies on the influence of off-set configurations on circle hook effectiveness.*—This topic has been studied rather extensively, particularly for marine pelagic fish.
4. *Need for examination of different fishing methods (e.g., fly fishing).*—There have been no published studies that examine the use of circle hooks for fly fishing. In general, there have been few studies that have compared and contrasted different types of fishing techniques with respect to circle hook performance.
5. *Need to compare the performance of circle hooks relative to swift and forceful hook sets vs slow and steady hook sets.*—There have been no published studies on this topic although some work on small stream salmonids is forthcoming (D Schill, Idaho Fish and Wildlife, unpubl data).
6. *Need for human dimension studies related to how anglers respond to new gear technologies with conservation benefits.*—There have been no focused human dimension studies published on circle hooks.

As evident from above, there has been relatively little progress on addressing some important detail-oriented questions associated with circle hooks in recreational fisheries. Nearly all of the work in the past 8 yrs has focused on the testing of circle hooks on new species (usually compared to conventional J-style hooks) with a decidedly marine focus. There still remain many opportunities for research on the topics outlined in Cooke and Suski (2004). For anglers and managers to fully understand when circle hooks work and when they do not, it is necessary to tease apart all aspects of circle hook use. We suggest that much effort has focused on the simple gear-oriented

questions but failed to tackle the more complex aspects of angler behavior and techniques and how those influence circle hook performance. That is clearly an important and timely research topic and emphasizes the need for additional human dimensions studies.

Our survey also revealed some insight that is relevant to the implementation and use of circle hooks. For example, some respondents noted that some hooks labeled as circle hooks are not (i.e., the point does not aim at the shank of the hook; that is, they do not form a sufficient circle to avoid deep hooking). Also noted was that there seemed to be a lack of convention with respect to size of circle hooks. Clearly there is a need for industry standards for labeling and sizing. Also related to packaging of circle hooks, some anglers suggested that instructions for circle hook use should be provided in or on packages containing circle hooks. There were also a number of comments that circle hooks were more expensive than comparable-sized J-style hooks, which if true could influence angler adoption. Opinions were mixed on mandating circle hook use. Some respondents suggested that regulation was necessary for some fisheries; others were opposed to the idea and suggested that education was the logical path forward. There is need for continued and expanded outreach efforts to educate anglers about circle hooks and their proper use and these efforts should precede and accompany any efforts to regulate their use. One of the respondents provided a balanced perspective that seems to reflect the scientific and management realities of circle hooks. Given that the present study is about stakeholder perspectives, the angler should be given the last word… *"Circle hooks are a beneficial tool, but further education is needed, and they aren't a silver bullet—they don't work for every species or in every angling situation."*

Acknowledgments

We thank the organizers of the International Symposium on Circle Hooks (in particular J Serafy) for their support. This research was supported financially by the Canada Research Chairs Program, the Ontario Ministry of Research and Innovation, and the Natural Sciences and Engineering Research Council of Canada. V Nguyen was also supported by an NSERC Canada Graduate Scholarship. L MacDonald-Hicks of the Carleton University Ethics Office assisted with obtaining necessary ethical clearances. Several referees kindly provided comments to improve the manuscript. We thank the members of the angling community that helped us to disseminate the survey or participated in the survey.

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Date Submitted: 7 July, 2011.
Date Accepted: 13 October, 2011.
Available Online: 2 December, 2011.

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