Circle Hook Requirements in the Gulf of Mexico: Application in Recreational Fisheries and Effectiveness for Conservation of Reef Fishes

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CIRCLE HOOK REQUIREMENTS IN THE GULF OF MEXICO: APPLICATION IN RECREATIONAL FISHERIES AND EFFECTIVENESS FOR CONSERVATION OF REEF FISHES

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ABSTRACT

In 2008, recreational anglers in the US Gulf of Mexico were required to use circle hooks when catching federally managed reef fishes (50 C.F.R. 622.41). From June 2009 through November 2010, we observed recreational hook-and-line fishing during for-hire trips off the west coast of Florida. Anglers used circle hooks and other hook types in a wide range of sizes from a variety of manufacturers. The present study evaluated the effectiveness of circle hooks toward reducing potentially lethal hooking injuries and the number of undersized reef fishes caught in the Florida recreational fishery. For seven out of 10 species evaluated, there were significant reductions in potentially lethal injuries for fish caught with circle hooks compared to all other hook types. Overall, reductions ranged from 30% to 93%. Potentially lethal injuries for red snapper [*Lutjanus campechanus* (Poey, 1860)] were reduced to 6.3% with circle hooks (from 17.1% with other hook types), which was a 63.5% reduction. For gag [*Mycteroperca microlepis* (Goode and Bean, 1879)] and scamp (*Mycteroperca phenax* Jordan and Swain, 1884) potentially lethal injuries were <5.5% for both circle hooks and other hook types and differences were not significant. There was no clear evidence that circle hooks reduced bycatch of undersized fishes when compared to J-hooks. There was an increase in mean fish length with increasing circle hook size for multiple species; however, r^2 values were low and much of the explained variance was unrelated to circle hook size.

The US Gulf of Mexico supports substantial, year-round recreational fisheries that are vital to local economies. In 2009, more than 23 million recreational fishing trips were made by residents and visitors to the region (NMFS 2010). For many fish stocks in the Gulf, recreational harvest constitutes a significant portion of total removals and can surpass commercial landings (Coleman et al. 2004). A primary target group for offshore recreational anglers in the Gulf of Mexico is the reef fish complex, which includes an assemblage of snappers (family Lutjanidae), groupers (Serranidae, subfamily Epinephilinae), triggerfishes (Balistidae), amberjacks (Carangidae), and other associated finfish species. Recreational fisheries for reef fishes historically have been regulated through harvest-control measures that include a suite of size limits, bag limits, and seasonal closures. In recent years, annual catch limits for federally managed stocks have required substantial adjustments in harvest controls to keep recreational landings within mandated limits. Harvest control measures, combined with sustained high levels of recreational fishing effort in the Gulf of Mexico, have resulted in increasing numbers of regulatory releases (Bartholomew and Bohnsack 2005, Hanson and Sauls 2011). In recent years, the released portion of the recreational catch of red snapper [*Lutjanus campechanus* (Poey, 1860)], gag [*Mycteroperca microlepis* (Goode and Bean, 1879)], and red grouper [*Epinephelus morio* (Valenciennes, 1828)] has exceeded 80% of total recreational catch from state and federal jurisdictions in the region (NMFS 2010). Recent research suggests that release mortality rates for reef fishes may be high due to a combination of factors, including hooking injuries and barotrauma (Burns et al. 2002, Burns and Wilson 2004, McGovern et al. 2005, St. John and Syers 2005, Rudershausen et al. 2007, Rummer 2007). When the released portion of total catch is high, post-release mortality has the potential to lead to recruitment overfishing (Coggins et al. 2007).

Amendment 27 to the Gulf of Mexico Reef Fish Fishery Management Plan (GMFMC 2007) explored several management options for minimizing catch-and-release mortality. In 2008, the Gulf of Mexico Fishery Management Council adopted the preferred management alternative requiring recreational anglers fishing in federal waters to use non–stainless steel circle hooks when catching reef fishes with natural bait (50 C.F.R. 622.41). A circle hook was defined by this regulation as "a fishing hook designed and manufactured so that the point is turned perpendicularly back to the shank to form a generally circular, or oval, shape." A minimum hook size to potentially reduce bycatch of undersized red snapper was also considered as an alternative management option but was not adopted. The State of Florida matched federal regulations for state territorial seas in the Gulf of Mexico in 2008, with the added specification that a circle hook must have 0° of offset (Florida Administrative Code § 68B-14.005).

The preferred management alternative in Amendment 27 was supported by a comprehensive meta-analysis, which reviewed 43 studies for 25 species and concluded that mortality rates were reduced by approximately 50% overall when circle hooks are used compared with J-hooks (Cooke and Suski 2004). Circle hooks had a greater tendency to set in the lip or jaw, resulting in fewer internal injuries for the majority of species studied. Amendment 27 cited additional studies suggesting circle hooks may be more size-selective than J-hooks, which could provide the added benefit of reducing regulatory discards of undersized fish. Cooke and Suski (2004) cautioned that management strategies should not incorporate circle hooks unless studies confirmed that their use had benefits for the particular species of concern. At the time when regulations were being considered in the Gulf of Mexico, studies to evaluate the potential benefits of circle hook use for reef fishes were limited and most available studies compared only select numbers of hook brands and sizes.

In the present study, we directly observed reef fishes caught in for-hire recreational fisheries that operate off the west coast of Florida. We compared hooking injury rates for fish caught with circle hooks and other types of hooks used in the recreational fishery. We evaluated size-selectivity of reef fishes captured with circle hooks and J-hooks in similar size categories to determine if circle hooks reduce bycatch of undersized fish. Additionally, we explored the potential for increasing size selectivity of reef fishes through the use of larger circle hooks in the recreational fishery. Analyses were conducted for eight species in the Gulf of Mexico reef fish complex that were most frequently encountered: red grouper, gag, scamp (*Mycteroperca phenax* Jordan and Swain, 1884), gray snapper [*Lutjanus griseus* (Linnaeus, 1758)], red snapper, vermilion snapper [*Romboplites aurorubens* (Cuvier, 1829)], greater amberjack [*Seriola dumerili* (Risso, 1810)], and gray triggerfish (*Balistes capriscus* Gmelin, 1789). Two unregulated species that are frequently targeted in the recreational fishery were also evaluated: white grunt [*Haemulon plumieri* (Lacépède, 1801)] and red porgy [*Pagrus pagrus* (Linnaeus, 1758)].

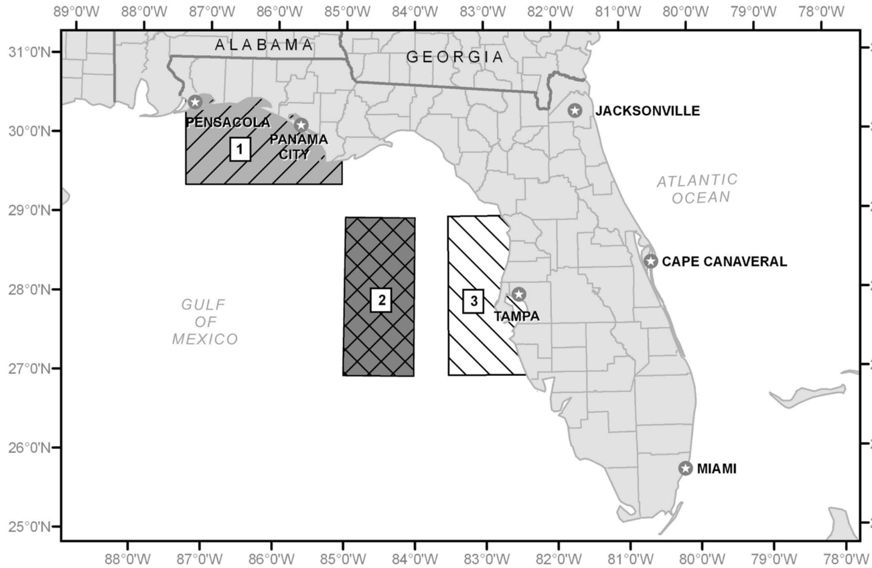

Figure 1. Study area in the Gulf of Mexico. 1 = area where single-day headboat, charter, and research trips from the Panhandle region took place; 2 = area where multi-day trips from Tampa Bay region took place; 3 = area where single-day charter and headboat trips from Tampa Bay region took place.

Methods

In June 2009, the State of Florida implemented a cooperative research project with operators of for-hire fishing vessels that offer recreational fishing trips in the Gulf of Mexico. A total of 166 private charter, large-party (headboat), and multi-day vessels from two regions were recruited into the voluntary study (Fig. 1). In each region, biologists were assigned to randomly selected vessels each week to observe recreational anglers during hook-and-line fishing. Biologists had no influence on recreational fishing during this fishery-dependent study. Between June 2009 and November 2010, 127 single-day trips (4–12 hrs) from headboat and charter vessels and 17 multiday trips (>24 hrs) were sampled in the Tampa Bay region, and 153 single-day trips from headboat and charter vessels were sampled in the Panhandle region. Included in this analysis are an additional 21 single-day research trips that targeted red snapper from charter vessels in the Panhandle region. During each research trip, four volunteer anglers fished with tackle chosen by the charter vessel operators and two volunteer anglers fished with circle hooks provided by the research team. Vessel operators provided bait and chose fishing locations without guidance from the research team.

During both research and randomly sampled trips, biologists visually inspected hooked fish prior to release or harvest and recorded the species, length at the fork or midline (mm), type of terminal tackle used for capture, and location where the hook was embedded (lip, mouth, gills, esophagus, stomach, or externally). Hook type was recorded as circle, J-type, or other (e.g., kahle, treble). Circle hooks and J-hooks from various manufacturers were sized by matching hooks to a printed chart of standard hook sizes (Fig. 2). Width of the bend, which is the curved section of the hook between the point and the shank, was used to group circle hooks and J-hooks into three similar-sized categories (small, medium, and large; Fig. 3).

We tested the hypothesis that circle hooks embedded in the lip or jaw (lip-hooking) more frequently than other hook types. Lip-hooking injuries were classified as non-lethal, whereas hook injuries in all other locations, including the eyes, gills, esophagus, stomach, or external

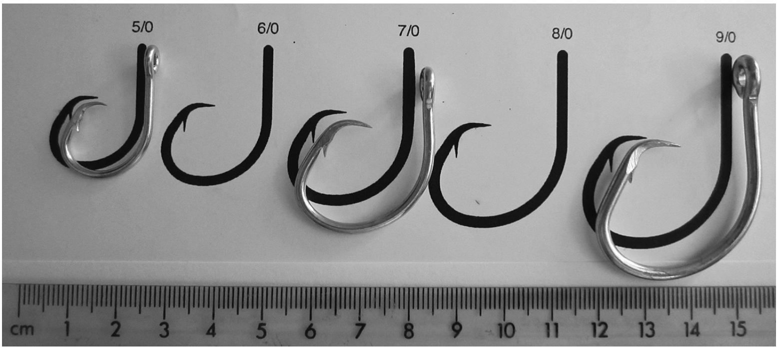

Figure 2. Example of a small, medium, and large circle hook matched to a chart used to record a standard size for different brands of hooks. For multiple comparison analyses, hook size categories included small (5/0 or smaller), medium (6/0, 7/0, and 8/0), and large (9/0 or larger).

areas of the body, were categorized as potentially lethal hooking injuries. For each species evaluated, we constructed a two-by-two contingency table to compare lip-hooking rates for circle hooks compared to the full range of other hook types observed in the recreational fishery. SAS software was used to calculate relative risks (RR) and 95% confidence intervals around RR values (Cody and Smith 2006). Relative risk for each species was calculated as the probability that circle hooks embed in the lip or jaw divided by the probability that other hook types embed in the lip or jaw. A RR value >1.0 indicated a positive effect for circle hooks and <1.0 indicated a negative effect for circle hooks. A RR value = 1.0 and/or a confidence interval that contained 1.0 indicated no effect for circle hooks.

The second hypothesis tested was that circle hooks caught larger fish than similar-sized J-hooks for each species evaluated. Only circle hooks and J-hooks were compared since other hook types could not be grouped into similar size categories. Differences in how hooks were baited to target different species could not be controlled in this study. Comparisons of mean fish length among hook type and hook size categories were made within similar trip types. Since the majority of J-hook observations were from the Tampa Bay region, we ran simple *t*-tests to determine whether mean fish length was significantly different between the two regions. For species that differed significantly in length between regions, observations from the Panhandle region were not included. Research trips were excluded because there were no J-hook observations. Multiday trips were also excluded, because two or more J-hooks were sometimes used together (with a single bait) during these trips and such observations could not be distinguished in our data. Due to low numbers of cell-level observations for large J-hooks, the large hook size category could not be included in multiple comparisons. To test for significant differences in mean fish lengths for each species, we used a general linear model (GLM) and adjusted for multiple comparisons using the Tukey-Kramer method (Cody and Smith 2006). Model parameters included hook type and size (medium circle, medium J, small circle, and small J), trip type (single-day headboat or single-day charter), and an interaction term.

The third hypothesis tested was that larger circle hooks were more selective and caught larger fish than smaller circle hooks. Separate GLMs using all circle hook observations from the Tampa Bay and Panhandle regions were used to compare mean lengths for fish caught with large, medium, and small circle hooks within four different trip types (single-day headboat, single-day charter, multiday, and red snapper research trips). Research trips were only evaluated for red snapper and gag, since numbers of observations for other species during those trips were low.

Hypotheses were developed to test the potential benefits of hook type and hook size for individual species within a multi-species fishery. A conservative, a priori alpha level (0.01) was selected that was sufficient to detect significant effects for a single species and minimize the probability of falsely concluding (by random chance) that the effects extend across multiple species.

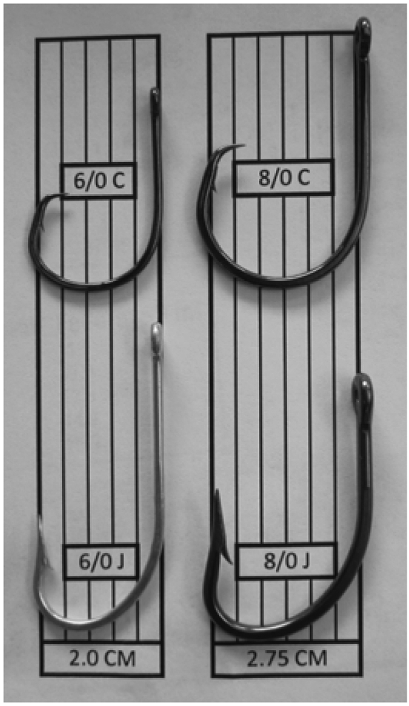

Figure 3. Examples of 6/0 and 8/0 circle hooks (top) and J-hooks (bottom) observed in the fishery. Width of the curved section between the point and the shank of the hook was used to group circle hooks and J-hooks into similar size categories.

Results

For seven out of 10 species evaluated, evidence was consistent with the hypothesis that circle hooks embed in the lip more often and result in fewer potentially lethal injuries than other hooks. The majority of observations for other hook types were made up of J-hooks (96%). For gag, scamp, and red porgy, potentially lethal hooking injuries were low (<5.5%) for both circle hooks and other hooks, and there was no appreciable difference in hooking injuries between hook types (Table 1). Results for the remainder of the 10 species evaluated were significant and RR indicated that fish were 1.04–1.13 times more likely to be exposed to a non-lethal injury (lip-hooked) when caught with circle hooks (Table 1). Across all species, there was a 30%–93% reduction in potentially lethal injuries for fishes caught with circle hooks compared to other hook types (Fig. 4). Potentially lethal injuries for red snapper decreased from 17.1% with other hook types to 6.3% with circle hooks (63.5% reduction), gray snapper decreased from 15.2% to 11.2% (29.7% reduction), and greater amberjack decreased from 13.9% to 3.5% (57.8% reduction). The percentage of potentially lethal injures with circle hooks was still relatively high for gray snapper and red snapper (11.2% and 6.3%, respectively) when compared with other species (5.4% for red grouper and from 0.3% to 3.8% for all other species).

There was no evidence to support the hypothesis that circle hooks are more selective and catch larger fish than J-hooks. For five species, mean fish lengths were

Table 1. Number of fishes observed (n) and percentage hooked in the lip or jaw area (lip-hooked) for circle hooks and other hook types. Values for relative risk (RR) and 95% confidence intervals (CI) around RR is the ratio of lip-hooked fish caught with circle hooks divided by lip-hooked fish caught with other hook types. RR values >1.00 indicate circle hooks have a positive effect. The effect of circle hooks is not significant when the 95% CI includes 1.00 (values in parentheses). Numbers of fish are not weighted with respect to fishing effort and should not be interpreted as a measure of compliance with circle hook requirements.

	Circle hooks		Other hooks		Relative risk	
	n	Lip-hooked	n	Lip-hooked	RR	95% CI
Red grouper	5,675	94.52%	1,969	90.66%	1.04	1.03, 1.06
Gag	1,433	96.23%	772	94.56%	1.02	(1.00, 1.04)
Scamp	363	97.80%	115	94.78%	1.03	(0.99, 1.08)
Gray snapper	770	88.83%	1,114	84.11%	1.06	1.02, 1.10
Red snapper	7,449	93.74%	589	82.85%	1.13	1.09, 1.17
Vermillion snapper	2,510	97.69%	795	94.21%	1.04	1.02, 1.06
Greater amberjack	693	96.54%	309	86.08%	1.12	1.07, 1.18
Gray triggerfish	593	99.66%	352	95.45%	1.04	1.02, 1.07
Red porgy	1,379	99.35%	465	97.85%	1.02	(1.00, 1.03)
White grunt	2,282	98.90%	1,346	89.75%	1.10	1.08, 1.12

significantly different between the Panhandle and Tampa Bay regions (Fig. 5). For those species, observations from the Panhandle region were not included in GLMs due to the low number of J-hook observations from that region. Among multiple comparisons for all species, only one significant difference in mean fish length between circle hooks and J-hooks was detected for gag caught with small hooks from headboats (Table 2). Model r^2 values were low for all species, and P values were not significant (alpha = 0.01) for gray snapper, vermilion snapper, and white grunt (Table 2). Hook type and size was not a significant factor for red snapper or gray triggerfish. Red porgy could not be evaluated due to a low number of J-hook observations.

There was a detectable increase in mean fish length with increasing circle hook size for multiple species (Fig. 6). However, r^2 values were low for all species and for all but three species (gray snapper, greater amberjack, and white grunt), trip type accounted for the largest proportion of explained variance (high F, Table 3). Circle hook size was a significant factor ($P < 0.01$) influencing fish length for red grouper, scamp, red snapper, vermilion snapper, white grunt, greater amberjack, and red porgy. However, the interaction term was significant for six species ($P \leq 0.01$), which may be attributed to differences in species targeted on headboat, charter, and multiday trips. For headboat trips, there were no significant differences among circle hook size categories for any species (Table 3). Headboat trips tended to target smaller fishes that are unregulated in the Gulf, including white grunt and red porgy, and squid was the primary bait type observed (57.2% of baits vs 40% on charter). For charter trips, mean size of fish increased significantly with increasing circle hook size for red grouper, scamp, red snapper, vermilion snapper, greater amberjack, and red porgy. Live baits and whole dead fish baits were more prevalent on charter trips (22.2% of baits vs 9.4% on headboats). Research trips were conducted similarly to charter trips and results of hook comparisons were consistent with those from charter trips. Multiday trip comparisons yielded conflicting results (smaller hooks caught significantly larger fish for some species). There was a smaller size range of circle hooks used on multiday trips compared to other trip types (Fig. 6), and >70% of baits were cut fish (vs <40% on charter and headboat), 13.8% were squid, and 11.8% were live.

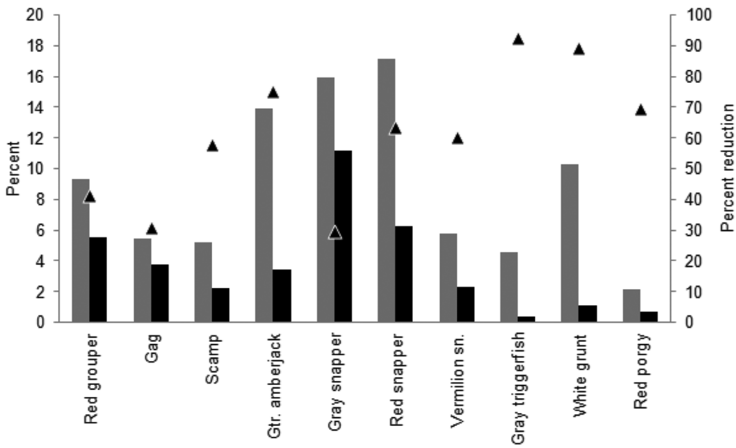

Figure 4. Percentage of fish, by species, that were hooked in the eyes, mouth, esophagus, gills, gut, or externally for circle hooks (black bars) and all other hook types (gray bars). Black triangles denote the percent reductions in potentially lethal hooking injuries for fish caught with circle hooks compared to other hook types. Note that differences between hook types for gag, scamp, and red porgy were not significant.

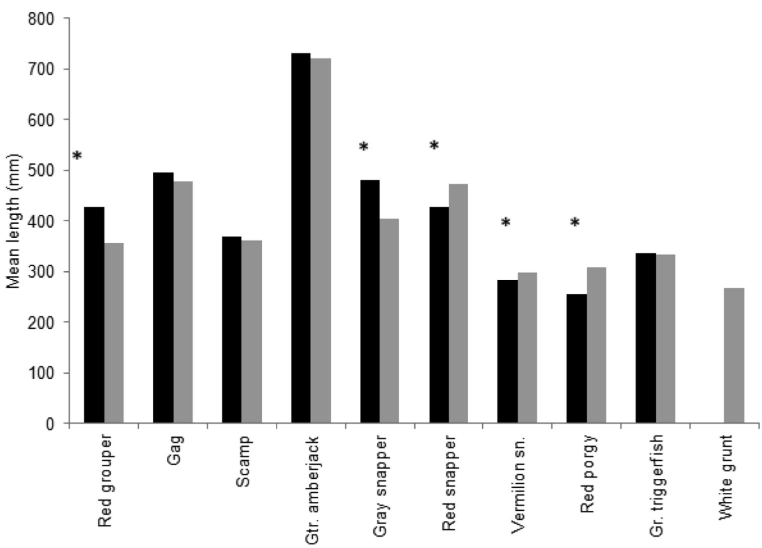

Figure 5. Mean length (mm at fork or midline) for the 10 most frequently encountered reef fish species in the Panhandle region (black bars) and Tampa Bay region (gray bars). Asterisks indicate *t*-test comparisons that were significant (alpha = 0.01).

Table 2. Results of general linear model analyses (r^2 = explained variance, P = significance) of fish length (mm fork or midline). Variables included in the model were hook type (small circle, small J, medium circle, medium J), trip type (charter, headboat) and interaction of hook type and trip type (H × T). Values for P in parentheses are not significant (alpha = 0.01). Multiple comparisons for each trip type among medium and small hooks indicate whether mean length of fish caught with circle hooks (C) was greater (>), less (<), or not significantly different (=) than mean length of fish caught with similar sized J-hooks (J). Comparisons were not made for hook types with fewer than 10 observations.

							Headboat		Charter	
Species	n	r^2	P	Hook type	Trip type	H × T	Med.	Small	Med.	Small
Red grouper	4,932	0.03	<0.0001	<0.0001	(0.94)	<0.0001	C = J	C = J	C = J	C = J
Gag	1,297	0.08	<0.0001	<0.01	<0.0001	(0.83)	C = J	C > J	C = J	C = J
Scamp	210	0.16	<0.0001	0.01	(0.04)	<0.01	C = J	C = J	C = J	C = J
Gray snapper	114	0.13	(0.04)	(0.02)	(0.19)	(0.18)	C = J	C = J	C = J	C = J
Red snapper	163	0.19	<0.0001	(0.29)	(0.05)	(0.16)	C = J	C = J		
Vermillion snapper	92	0.12	(0.09)	(0.12)	(0.93)	(0.54)	C = J			
Greater amberjack	136	0.15	<0.001	<0.01	(0.23)	(0.10)			C = J	C = J
White grunt	812	0.01	(0.13)	(0.08)	(0.74)	(0.30)		C = J	C = J	C = J
Gray triggerfish	701	0.02	<0.01	(0.92)	(0.27)	(0.41)				C = J

Discussion

For species that are susceptible to high levels of fishing effort and strict harvest restrictions, reductions in release mortality rates may equate to meaningful conservation benefits (Coggins et al. 2007). The present study indicates that multiple species within the managed reef fish complex potentially benefit from circle hook use in the Gulf of Mexico, including red grouper, greater amberjack, and red snapper. Should measures become necessary for species with fewer harvest restrictions, such as gray snapper, gray triggerfish, vermilion snapper, white grunt, and red porgy, results from our study may serve to guide future management. Before we can definitively conclude that circle hooks increase survival rates for released reef fishes, further studies are needed to evaluate internal injuries before hooks are set. A study by Aalbers et al. (2004) found for a sciaenid [*Atractoscion nobilis* (Ayres, 1860)] that 32% of all mortalities (circle and J-hooks combined) were from internal damage to the esophagus caused before the hook ultimately embedded in the lip or mouth. The study also found that fewer fish were hooked in the viscera with circle hooks, but a higher proportion of those fish incurred latent mortality (circle hooks, 69%; J-hooks, 42%). Internal injuries in the present study were evaluated based on visual observations of embedded hooks prior to fish being released alive, and other potential internal injuries could not be examined.

For two managed grouper species in our study, gag and scamp, potentially lethal hook injuries were low (<5.5%) for both circle hooks and other hook types, and there were no significant differences in hook injuries between hook types. However, vessel operators that participated in our study expressed concern for the increased difficulty of removing circle hooks that are embedded deeply, particularly in the gills, esophagus, and stomach. A review of hooking studies found that circle hooks in general are more difficult to remove than J-hooks (Cooke and Suski 2004). Cooke et al. (2003) also noted anecdotally that removing circle hooks caused more tissue damage to fish, even when hooks were easy to remove, and warned that deep-set circle hooks may cause more internal damage. If circle hooks do cause more internal

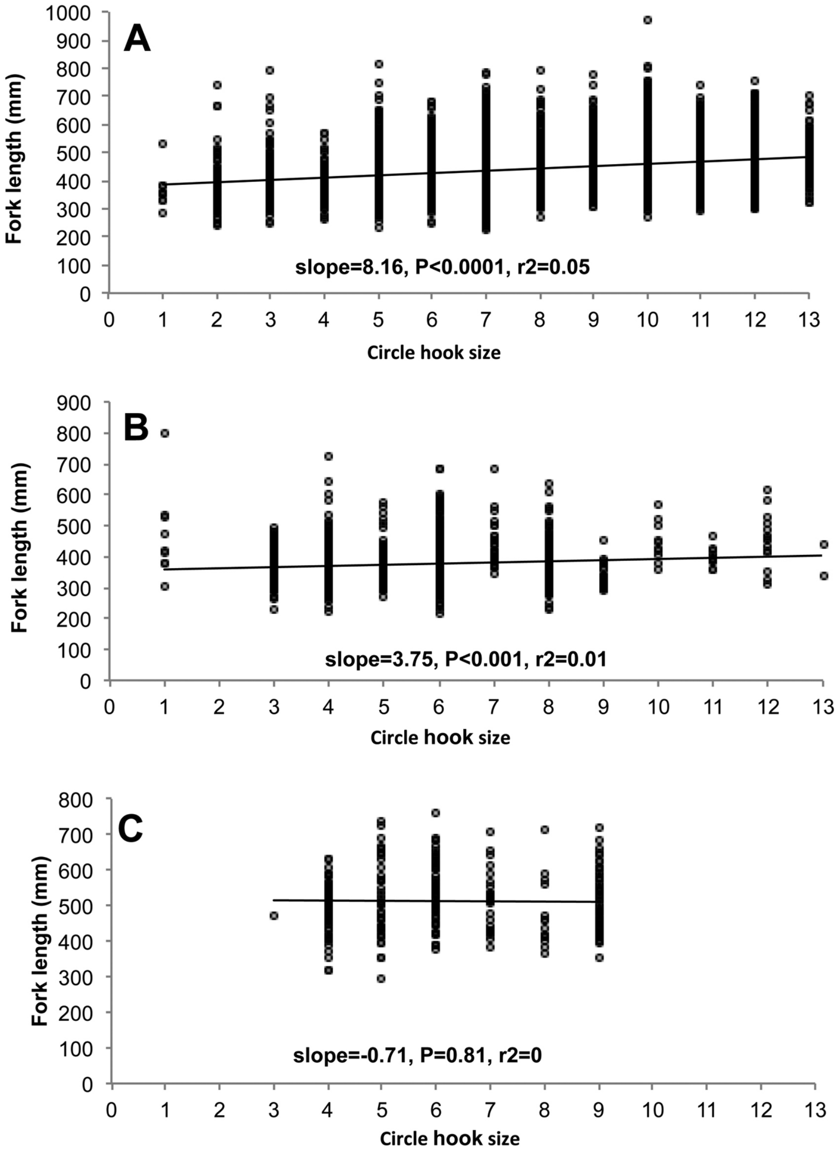

Figure 6. Fork length (FL) for red snapper (*Lutjanus campechanus*) caught using small (1–5), medium (6–8), and large (≥9) circle hooks during (A) charter, (B) headboat, and (C) multiday trips (see Fig. 2). Red snapper caught during research trips on charter vessels are included in (A). The minimum size limit for red snapper is equivalent to approximately 378 mm FL.

damage during removal, then gag and scamp may incur greater release mortality as a cost of protecting other species. The potential for greater injury during removal of circle hooks is also a concern for other species evaluated in our study. For gray snapper and red snapper, hooks that embedded in the eyes, mouth, gills, esophagus, gut, and externally were significantly reduced with circle hooks. However, compared to the other species evaluated, proportions of potentially lethal injuries for these two species remained high with circle hooks. Rummer (2007) cited several references

Table 3. Results of general linear model analyses (r^2 = explained variance, P = significance) of fish length (mm fork or midline). Variables included in the model were circle hook size (L = large, M = medium, and S = small), trip type (headboat, charter, multiday, red snapper research), and interaction of circle hook size and trip type, with F and P values for each. Values for P in parentheses are not significant (alpha = 0.01). Multiple comparisons for each trip type among different sized circle hooks indicate whether mean fish length in the larger hook size was greater (>), less (<), or not significantly different (=) than fish compared to the next smaller hook size. Comparisons were not made for hook sizes with fewer than 10 observations.

			Hook size		Trip type		Interaction		Multiple comparisons			
Species	r^2	P	F	P	F	P	F	P	Headboat	Charter	Multiday	Research
Red grouper	0.08	<0.0001	29.6	<0.0001	94.1	<0.0001	11.2	<0.0001	L = M = S	L > M > S	L < M > S	
Gag	0.13	<0.0001	0.1	(0.88)	40.1	<0.0001	5.0	<0.0001	M = S	L = M = S	L = M = S	L = M
Scamp	0.21	<0.0001	4.7	0.01	15.8	<0.0001	6.7	<0.0001	L = M = S	L = M > S	L = M = S	
Gray snapper	0.06	<0.001	3.6	(0.03)	1.5	(0.22)	1.1	(0.38)	M = S	L = M = S	L = M = S	
Red snapper	0.14	<0.0001	36.5	<0.0001	130.0	<0.0001	5.7	<0.0001	L = M = S	L > M > S	L = M = S	L > M > S
Vermillion snapper	0.11	<0.0001	24.6	<0.0001	48.5	<0.0001	7.8	<0.0001	L = M = S	L = M > S	L > M = S	
Greater amberjack	0.23	<0.0001	4.6	0.01	2.2	(0.11)	4.4	<0.01	L = M = S	L > M = S	L = M < S	
White grunt	0.02	0.01	5.1	0.01	1.3	(0.25)	1.4	(0.26)	L = M = S	L = M = S		
Red porgy	0.39	0.0001	4.6	0.01	51.4	<0.0001	2.7	(0.03)	M = S	L > M = S	L = M = S	
Gray triggerfish	0.06	<0.0001	0.9	(0.41)	16.1	<0.0001	1.2	(0.29)	M = S	L = M = S		

for aggressive feeding behavior in red snapper, which could explain higher deep-hooking rates for this species. An action that could mitigate internal injury resulting from circle hook removal is to release deep-hooked fish with the hook left in place. Aalbers et al. (2004) found higher survival rates when deep-set hooks were cut from the leader and left in the fish (41% mortality) compared with fish for which hooks were removed (65%), regardless of hook type. For fish in our study that were not lip-hooked and were caught with circle hooks, we observed that 7% of red snapper and approximately 4% of red grouper, gag, and gray snapper were released with hooks left in place.

There was no clear evidence that circle hooks result in reduced bycatch of undersized fish than J-hooks under the conditions observed in the present study. These results are consistent with Cooke and Suski (2004), who reviewed 14 published studies and found no evidence to support differential size selectivity between circle hooks and J-hooks. An alternative management option that was not implemented in the Gulf of Mexico was to regulate hook size to reduce bycatch of undersized red snapper. Circle hook size was a significant factor related to mean fish length for a majority of species in our study, including red snapper. However, r^2 values for all models in this analysis were low and much of the explained variance was unrelated to circle hook size. We did not measure morphological characteristics beyond length; however, relationships between fish length and hook size are less evident for species with large mouth gapes (Cooke et al. 2005). In a study that compared four hook sizes from a single hook manufacturer, Patterson et al. (2012) found declining catch rates with increasing circle hook size for multiple reef fish species in the Gulf of Mexico. While our results were less equivocal, an important point to be made from this and other observational studies is that conditions are highly variable in real-world fisheries and maximum conservation benefits may not be attained.

The prevalence of circle hook use across all segments of the recreational fishery for reef fishes must also be determined to assess their true conservation benefits. Prior to the circle hook requirement in 2008, Burns et al. (2002) and Burns and Wilson (2004) attempted to recruit volunteer anglers from headboats in the Tampa Bay region to use circle hooks for a comparison study with J-hooks. Initially, the researchers experienced difficulties convincing anglers to switch to circle hooks, even when hooks were provided free. Based on conversations with vessel operators whom we have come to know over the course of our study, the use of circle hooks has gained acceptance since the requirements for reef fishes were implemented. However, it was not uncommon for individual anglers to bring their own gear on large-capacity vessels and target unregulated species without circle hooks. Rules specify that circle hooks must be used when catching reef fishes; however, identifying an unintentional act of noncompliance is not practical and generally not the best use of enforcement resources. A better approach for reducing unintended reef fish interactions with J-hooks and other hook types is to increase anglers' awareness of the problems and regulations through outreach.

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