A Review of Marine Recreational Hook Regulations in the United States: Accessibility, Incorporation of Science, and Recommendations

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Abstract: The effects of fish-hook type on hooking location and post-release mortality of recreationally and commercially targeted fish species have been well studied. We examined how fisheries management agencies along the coastal United States had incorporated fish-hook data into fisheries regulations and how visible and accessible those regulations were to anglers. We reviewed state recreational hook regulations on natural resource agency websites of 23 states. To assess the accessibility of hook regulations to anglers, we conducted an online survey that was distributed by email to participants throughout the United States including fishing enthusiasts, fishing clubs, conservation organizations, state agency officials, and students and faculty in resources departments at multiple universities. Survey participants ranged from non-anglers to experienced recreational anglers. State regulations varied; 69% of states had regulations and/or recommendations regarding the use of various hook types and the remaining states had no regulations. Survey results suggested that website design was a key factor to increase accessibility of hook regulations. Survey participants found that accessibility to hook regulations was generally moderate to difficult in most states; only two states had easily accessible regulations. Resource agencies should make hook regulations more visible and readily available to anglers to promote sustainable fishing practices.

Key words: management, marine fishes, survey, anglers

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In fisheries management, regulation of gear types is an effective tool to control the capture of targeted and bycatch species. One of the most popular of these gears is the fish hook. Humans have used hooks to ensnare fish for nearly 42,000 years (O'Connor et al. 2011). Hooks are designed in many different ways to effectively catch various species and sizes of fish. Managers regulate hook size, numbers, and type in hook-and-line fisheries to reduce bycatch and increase catches of target species/sizes of fish. In the United States, hook regulations for fisheries within state waters are enforced by both state and federal agencies, while the National Marine Fisheries Service controls hook regulations in federal waters.

In hook and line fisheries, fish can experience post-release injury and mortality from gut hooking and bleeding (Cooke and Suski 2004). Many studies have reported on the effects of different hook types on the post-release fate of recreational and commercial fish species (e.g., Matlock et al. 1993, Muoneke and Childress 1994, Serafy et al. 2012, Sullivan et al. 2013). We reviewed the scientific literature on the effects of various hook types on post-release injury and mortality: traditional J hooks, circle hooks, multiple and treble hooks, and barbless hooks. In general, studies encompass three basic types of comparisons: traditional J hooks with circle hooks, single hooks with treble hooks, and barbless versus barbed hooks. Fish caught with circle hooks, compared to conventional J hooks, generally have: 1) lower hooking mortality, 2) higher occurrences of jaw hooking, 3) lower occurrences of deep/gut hooking, and 4) less instances of bleeding (Cooke and Suski 2004). The effects of treble hooks versus single hooks on post-release fate of fish vary among species. Brook trout experienced significantly higher release mortality when caught with treble hooks than with single hooks (Nuhfer and Alexander 1992). Striped bass experienced higher mortality when caught with single hooks versus treble hooks (Muoneke and Childress 1994). Matlock et al. (1993) found no significant difference in red drum and spotted sea trout hook mortality between single hooks and treble hooks. Barbless hooks have been used to simplify dehooking of angled fish, reducing handling time and incidence of injury and ultimately resulting in lower fish mortality (Muoneke and Childress 1994).

Along with hook type, angling method and bait type can have significant effects on injury and mortality of released fish. Sullivan et al. (2013) showed that stream-dwelling trout were nearly twice as likely to be deep hooked with inline circle hooks when anglers fished passively (i.e., no sharp hook set) verses actively (sharp hook set). Fish typically experience higher mortality when caught with natural bait than with artificial lures (Bartholomew and Bohnsack 2005) which may be a result of deeper hooking. For instance,

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Table 1. Listing of state agency websites and designations of difficulty of use. The designations were based on results from the user survey, where survey participants scored the ease of access to hook regulation on four random state agency websites with regulations. States labeled "NR" have no hook regulations or recommendations. Alabama (*) has no direct hook regulations, though it does have snagging regulations as does Washington.

State	Agency	Weblink	Difficulty
AK	Dept. of Fish and Game	www.adfg.alaska.gov/index.cfm?adfg=fishingSport.main	Difficult
AL*	Marine Resources Div.	www.outdooralabama.com/fishing/saltwater/regulations/	NR
CA	Dept. of Fish and Wildlife	www.dfg.ca.gov/marine/sportfishing_regs2013.asp	Moderate
CT	Dept. of Energy and Env. Protection	www.ct.gov/deep/cwp/view.asp?A=2696&Q=322740	N/A
DE	Div. of Fish and Wildlife	www.dnrec.delaware.gov/fw/Pages/FWPortal.aspx	Difficult
FL	Fish and Wildlife Conservation Com.	http://myfwc.com/fishing/saltwater/recreational/	Moderate
GA	Coastal Resources Div.	www.georgiawildlife.com/fishing/regulations	Easy
HI	Div. of Aquatic Resources	http://hawaii.gov/dlnr/dar/regulated_fish_mfv.html	NR
LA	Dept. of Wildlife and Fisheries	www.wlf.louisiana.gov/fishing/regulations	Easy
MA	Dept. of Fish and Game	www.mass.gov/dfwele/dmf/recreationalfishing/rec_index.htm	NR
MD	Dept. of Natural Resources	www.eregulations.com/maryland/fishing/striped-bass/	Moderate
ME	Dept. of Marine Resources	www.maine.gov/dmr/recreational/rechomepage.html	Moderate
MS	Dept. of Marine Resources	www.dmr.state.ms.us/images/publications/reg-book.pdf	Moderate
NC	Dept. of Env. and Natural Resources	http://portal.ncdenr.org/web/mf/rules-and-regulations	Moderate
NH	Fish and Game Dept.	www.eregulations.com/newhampshire/fishing/saltwater/	Moderate
NJ	Div. of Fish and Wildlife	http://www.njfishandwildlife.com/njregs.htm#fishing	Difficult
NY	Dept. of Env. Conservation	www.dec.ny.gov/outdoor/7894.html	NR
OR	Dept. of Fish and Wildlife	www.dfw.state.or.us/resources/fishing/	Moderate
RI	Dept. of Env. Management	www.dem.ri.gov/pubs/regs/regs/fishwild/rimftoc.htm	NR
SC	Dept. of Natural Resources	www.dnr.sc.gov/siteindex.html	Moderate
TX	Parks and Wildlife	www.tpwd.state.tx.us/regulations/fish_hunt/	Moderate
VA	Marine Resources Commission	http://mrc.virginia.gov/regulations/swrecfishingrules.shtm	NR
WA	Dept. of Fish and Wildlife	http://wdfw.wa.gov/fishing/saltwater.html	Moderate

striped bass caught with live bait were hooked deeper and experienced greater mortality than fish caught with other gear (Diodati and Richards 1996).

Hook-type regulations have the potential to reduce fishing mortality more effectively than size limits, bag limits, and closed seasons (Bacheler and Buckel 2004). Some countries have mandated the use of circle hooks as a way to reduce fishing mortality of target species (Graves et al. 2012). Our objectives in this study were to 1) document and describe hook regulations of 23 states along the coastal United States to compare hook regulations among saltwater recreational fisheries, and 2) determine the availability and accessibility of these regulations to anglers as a means to assess their effectiveness. We hypothesized that hook regulations should be an integral part of state fisheries management strategies as indicated by existing scientific body of evidence. Additionally, we expected these hook regulations to be easily accessible and readily available on agency websites and within outreach material disseminated by a given state.

Methods

Assessment of State Hook Regulations

In 2013, we reviewed the saltwater recreational fishing regulations of 23 states in the United States for patterns and trends. We examined state agency websites for information on fish hook regulations, as these websites provide recreational anglers with access to the latest regulations (Table 1). All regulations or recommendations regarding fish hook type were noted and separated into five categories: 1) no regulations or recommendations (NR), 2) hook recommendations (HR), 3) circle-hook regulations (CH), 4) multiple and treble hook regulations (M/T), and 5) barb regulations (BR). The states in the NR category had no mention of fish hooks anywhere within their websites. The HR category was defined as state agency websites that mentioned fish hooks using terms such as 'recommends' or 'suggests' or contained outreach documents advocating the use of certain hook types. States categorized as CH had rules that specifically mentioned circle hooks with the terms: "requires," "prohibits," "shall," or "must." The M/T category was defined as any regulations that mentioned treble or multiple hooks with the terms: "prohibits," "unlawful," or "requires." States assigned to BR were those that included any mention of barbs/

barbless hooks while containing the terms: "must" or "only" along with any phrase such as "pinch down" or "flatten barbs." These categories were not mutually exclusive except NR.

Survey Design and Dissemination

We determined the accessibility of state fish hook regulations and or recommendations through the use of a survey which asked participants to rate their experience in locating fish hook regulations in state agency websites using the following categories: 1 (easy), 2 (moderate), or 3 (difficult). We used a combination of snowball sampling and convenience sampling methods. Snowball sampling is a non-probability sampling approach where the study subjects recruit from their acquaintances and the sample members are not randomly selected (Goodman 1961). Convenience sampling is another non-probability method where people are selected because they are convenient sources of data (Babbie 2001). Our surveys were distributed via email to a variety of participants throughout the United States including: natural resources department undergraduate students and graduate students, fishing enthusiasts, fishing clubs, conservation organizations, state and federal resources agency officials, and faculty from multiple universities. Survey participants ranged from non-anglers to experienced recreational anglers. We initially distributed our survey to approximately 75 people. We encouraged the survey recipients to distribute the survey to other interested groups. Because we used a simple random survey approach we do not know how many people ultimately received the survey and therefore could not estimate return rates; the survey population was not defined. We conducted a preliminary review of each state's website and designated seven states in the NR category (Table 1). These states were excluded from the survey, resulting in 16 states surveyed (Table 1). After a pilot survey, we concluded that including more than four states on each survey discouraged participation because of the time needed to complete the survey (>30 min). Each survey therefore contained only four randomly-assigned states with their respective website links for review. Participants were also encouraged to provide comments on their survey experience.

Results

State Regulations

Hook Recommendations (HR).—As noted, there were seven states lacking both regulations and recommendations; whereas, seven more had only recommendations published with their posted regulations (Table 2). Flattening barbs or using barbless hooks was recommended by six of those seven states, with the exception of Delaware, whose sole recommendation was that circle hooks should always be used when fishing with natural bait and that treble hooks should be avoided when practical. Along with Delaware, four states (Alaska, Georgia, Louisiana, and Mississippi) also recommended use of circle hooks when fishing with bait either for specific species or all species. Alaska further recommended using the proper size hooks to avoid unnecessary damage to fish, and Georgia recommended that anglers use non-stainless steel hooks that dissolve easily.

Circle-hook Regulations (CH).—Ten of the 23 states had hook regulations directly requiring the use of circle hook (Table 3). Eight states had circle-hook regulations for specific species, such as striped bass or the snapper-grouper complex, a group that includes 59 species of sea basses, groupers, wreckfish, snappers, porgies, grunts, jacks, tilefishes, triggerfishes, wrasses, and spadefishes (Table 3). Delaware required use of non-offset circle hooks with a

Table 2. State fish hook management categories: No Regulations or Recommendations = no mention of fish hooks on website; Recommendations = "recommends" or "suggests" or advocates the use of a particular fish hook type; circle hook = any mention of circle hooks with the terms: "requires,""prohibits," or "must"; multiple hook = terms: "prohibits,""unlawful," or requires "multiple or treble hooks"; barbs = any mentions while using the terms "must" or "only" or any phrase such as "pinch down" or "flatten barbs." A state may be listed under multiple categories if both regulations and recommendations are present on state websites. Alabama* and Washington have regulations against snagging;

		Recommendations / Regulations		
No regulations or recommendations		**Circle hook**	**Multiple hook**	**Barbs**
Alabama*	Alaska	California	Alaska	California
Connecticut	Delaware	Delaware	Florida	Maryland
Hawaii	Louisiana	Louisiana	Maine	Oregon
Massachusetts	Mississippi	Maine	Mississippi	Washington*
New York	New Jersey	Maryland	New Hampshire	
Rhode Island	Georgia	Mississippi	Oregon	
Virginia	Oregon	New Jersey	Washington*	
		North Carolina		
		South Carolina		
		Texas		

Table 3. Species or area specific circle-hook regulations by state. The asterisks represent location specific rules that include all species within the given location.

State	Species
California	All species*
Delaware	Striped bass
Louisiana	All reef species
Maine	Bluefish and striped bass
Maryland	Striped bass
Mississippi	All reef species including red snapper
New Jersey	Striped bass, weakfish, and sea bass
North Carolina	All species*
South Carolina	Snapper grouper species
Texas	Red snapper

≥0.95-cm gap during the striped bass spawning season when fishing with natural bait. Maryland regulated use of bait to fish for striped bass all year and required use of non-offset circle hooks or J hooks with a gap < 1.27 cm. Maine required circle hooks when fishing with bait for bluefish in addition to striped bass and New Jersey required use of non-offset circle hooks for species that bite and flee weakfish and black sea bass. Louisiana, Mississippi, and South Carolina required use of non-stainless steel circle hooks when fishing with natural bait for all snapper/grouper species and/or all reef fish species. Texas required use of circle hooks only when targeting red snapper, but did not regulate hook type for the rest of the snapper-grouper complex.

California and North Carolina were the only coastal states that had hook regulations based upon time and/or location rather than species. California restricted anglers to a maximum of two single-point, barbless circle hooks while bait fishing in certain areas. This rule was consistent with the rules that existed in federal waters off of California's coast. North Carolina restricted use of any hook other than a circle hook larger than 4/0 within Pamlico Sound and its tributaries south of the Albemarle Sound Management Area from 1 July to 30 September during the hours from 1900–0700 hours.

Multiple and Treble Hook Regulations (M/T).—Regulations varied widely among states. Maine and Mississippi had regulations directly detailing the use of treble hooks, while Alaska, Florida, New Hampshire, and Oregon had regulations for multiple hooks (Table 3). Washington had regulations specific only to snagging with multiple hooks. Maine prohibited use of treble hooks with bait or lures but only when fishing for certain species. Alaska allowed use of multiple hooks with a gap > 1.27 cm for all species except salmon with exception for drainage-specific regulations. In contrast, Oregon allowed salmon to be caught with multiple hooks provided the hooks had a gap < 1.43 cm. Florida banned use of any multiple-tined hooks (double or treble) with live or dead bait. In contrast, New Hampshire only restricted multiple hooks from one specific system, and only when fishing for sea-run brook trout. Mississippi prohibited use of treble hooks when fly fishing.

Barb Regulations (BR).—California, Maryland, Oregon and Washington had regulations on the use of barbs (Table 3). In California, use of barbless hooks was mandatory when fishing for certain species or in federal waters off California's coast for circle-hook regulations. Maryland required barbless hooks only when trolling for striped bass. Oregon anglers were restricted to a single-point, barbless hook when fishing for sturgeon, but when fishing for salmon, no more than two single-point, barbless hooks could be used; single point hooks with > 25-mm gap were prohibited. In Washington, anglers were restricted to only single-point, barbless hooks when fishing for salmon or sturgeon.

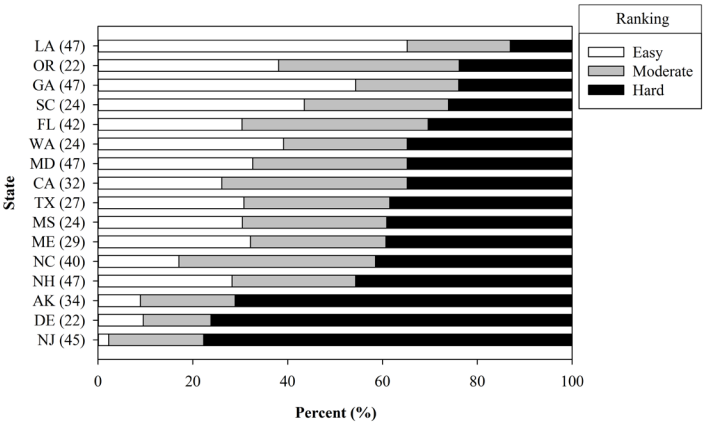

Figure 1. Results from the hooking regulations survey. Participants were asked to rate their experience in location fish-hook regulations on state agency websites as easy, moderate, or hard. Number in the parentheses represents the responses for each state.

Survey Results

We received 135 completed survey responses. Survey participants consistently ranked the accessibility of Georgia and Louisiana's hook regulations as the most accessible (ranked "Easy" in more than 54% of surveys), while New Jersey, Alaska, and Delaware's were ranked as "Easy" less than 10% of the time (Figure 1). The remaining 11 states received "Easy" rankings in 17% to 44% of surveys.

Discussion

We found that recreational hook regulations throughout the coastal United States were fishery/species specific and generally concurred with scientific data that demonstrates benefits associated with the use of one hook type over another (Bacheler and Buckel 2004, Cooke and Suski 2004). However, 30% of states report no regulations and 30% only have recommendations regarding hook use. Furthermore, there were some inconsistencies in hook management between neighboring states that share common fisheries. For example, North Carolina specifies explicit hook regulations, while Virginia has none. Some states report laws that reflect or reiterate federal regulations, while others do not. Regulation inconsistencies pose problems with management and enforcement of migratory and anadromous fishes because these fish move across state borders and are subject to different management strategies.

There were several general themes in circle-hook regulations within states. Circle-hook requirements only exist for natural bait fishing. These requirements follow research findings that show in-

creased gut hooking with natural baits versus lures (Diggles and Ernst 1997). As circle hooks reduce gut hooking and release mortality, states may require circle hooks when fishing with natural bait in an attempt to mitigate fishing mortality (Cooke and Suski 2004). Also, species with intense and lucrative fisheries (e.g., striped bass, salmon, and snapper-grouper) usually have explicit circle-hook regulations. Delaware, Maine, Maryland, and New Jersey have regulations that require circle hooks when fishing for striped bass during the spawning season. These regulations are consistent with the information regarding the efficacy of circle hook use in striped bass management (Cook and Suski 2004). Interestingly, the Chesapeake Bay supports a large recreational striped bass fishery shared by Maryland and Virginia, but the circle-hook regulations are inconsistent between the two states as Virginia does not have any hook regulations.

The snapper-grouper complex and reef fisheries have explicit circle-hook regulations in state and federal rulebooks. Florida, Louisiana, and South Carolina require corrodible circle hooks when fishing with natural baits for these species, which correlates with federal rules in the Gulf and South Atlantic Economic Exclusion Zones. Texas, which also supports a snapper-grouper fishery, only requires circle hooks when fishing for red snapper with natural baits. This rule applied to a single species within a complex that is fished in a similar location and method causes an enforcement issue. It also increases the probability that a red snapper will be caught with bait on a J hook or treble hook because anglers can target other species in the same location with bait and those types of hooks. However, the rule (when followed) should give some benefit to the red snapper fishery compared to not having the rule.

We found that hook management in the United States focused mainly on snapper-grouper species, as they typically experience heavy fishing pressure and many species are depleted. These fishes are usually slow-growing and late-maturing; therefore, they are particularly susceptible to overharvest (Coleman et al. 2000). Additionally, these species are mostly caught using bottom fishing techniques that also usually involve live or natural bait. Circle hooks significantly reduce gut hooking incidences (Bacheler and Buckel 2004), which has been found to reduce post-release mortality for grouper species in North Carolina (Overton et al. 2008). Despite these findings, and the existence of regulations in federal waters bordering these states, North Carolina, Georgia, Alabama, and Mississippi lack any hook regulation for the snapper-grouper complex or reef fishes in state waters.

Hook regulations sometimes follow the scientific evidence regarding the efficacy of using certain hook types to achieve management goals. For example, North Carolina has a very specific and detailed rule that requires the use of circle hooks when fishing in certain areas of Pamlico Sound during summer months. This rule specifies a time and location that coincides with critical red drum spawning aggregations (Bacheler et al. 2009) and was implemented to protect ecologically important spawning populations. Beckwith and Rand (2005) found that large circle hooks reduced incidences of deep hooking in adult red drum in the Neuse River estuary in North Carolina.

Barb regulations exist predominantly in states along the Pacific Ocean. All three states along the west coast of the continental United States have very popular and lucrative recreational salmon fisheries. Similar to the situation in Pamlico Sound, North Carolina, regulations requiring the use of barbless hooks reflect findings from studies (Milne and Ball 1956, Gjernes et al. 1993, Orsi et al. 1993) that found lower hooking mortality in salmon caught with barbless hooks. Maryland was the only state outside of the west coast that required barbless hooks in their management plans; however, other east coast states recommended use of barbless hooks by distributing outreach material (e.g. fliers and decals).

Alabama prohibited snagging of mullet from 24 October to 31 December. As snagging often involves multiple hooks we considered categorizing Alabama as M/T because this could be considered an indirect multiple/treble hook regulation. However, we classified Alabama as NR because snagging can occur with single hooks. Washington specifically prohibited the use of multiple hooks when snagging, and as such was placed into M/T category. Georgia recommended that anglers use non-stainless steel hooks that dissolve easily, non-offset circle hooks should be used when fishing with natural bait, and barbs should be removed or flattened for easier removal. However, none of these were legally restricted.

We focused primarily on hook regulations in this manuscript, because line and hooks are the most common gear used by recreational fishermen. We are not suggesting that hook regulations should be more accessible or are more important than other regulations to recreational and commercial anglers. Other important regulations, such as opened and closed seasons, minimum size, prohibited species, necessary permits, and authorized gears are all important components in the success of fisheries management. Our study could have easily be expanded to determine how accessible that these other regulations are to anglers. However, it should be noted that accessibility of regulations may not ensure compliance. Anglers' risk preference is a major determinant of their response to a fishing regulation (Mistiaen and Strand 2000). Increased visibility may increase awareness and encourage fishermen to follow regulations. Seven states that we reviewed had no hook regulations or recommendations. Reasons behind the lack of regulations were unclear; however, there are often social and fiscal considerations associated with any management protocol (Helvey

2004). Also, it is likely that many fisherman are resistant to change. Many people don't plan on releasing fish and do not consider the damage they are doing to the "bycatch" fish.

Management Recommendations

While the basis for existing recommendations and regulations are scientifically sound, we offer potential strategies for management agencies to make hook regulations more visible. The boundary between state and federal waters is not always clear to recreational anglers. These anglers may be in compliance with state rules while fishing in state waters but may cross into federal waters unknowingly and unintentionally violate federal rules. We recommend that state agencies mention federal rules within state rulebooks and remind anglers of state-federal boundaries. Currently many hook regulations are not readily available and can be difficult to locate on agency webpages. Recreational anglers may not abide by these regulations because they may be unaware of them. Anglers can also be encouraged to comply with regulations through education and outreach. For example, North Carolina Division of Marine Fisheries distributes decals to encourage the use of circle hooks and pinching down barbs.

We also recommend making hook requirements more visible on agency websites by listing any hook regulations possibly along with the catch limits in a table format. Listing hook regulations with bag and catch limits will allow anglers to gather all relevant information from one location. The accessibility of this information for anglers was surprisingly low; of the 16 states surveyed, respondents classified the regulations of only two states (12.5%) as easy to locate, whereas 68.75 % were classified as moderate and 18.75% were considered difficult to locate. Because state agency websites are likely one of the first places anglers attempt to locate fishing regulations, we recommend that state agencies consider the design of their websites and incorporate webpage designs similar to those of Georgia and Louisiana, states identified by survey respondents as ones where hook regulations and bag limits were easily located.

Agencies should also consider using various social media outlets, such as Facebook and Twitter, to inform anglers of regulations and recommendations, with links to proper agency website locations. The use of mobile applications to find fishing regulations should also be considered. While websites are commonly the first place for anglers to look for information, a growing number of state agencies have developed mobile apps to outline their fishing regulations. Some of the mobile apps are free, while others can be downloaded for a nominal fee. Most agencies that have these apps also have links to them on their websites. Anglers are increasingly utilizing information technology to access regulation information, including gear regulations. If state agencies make hook (and other important) regulations more visible and easily accessible to the average angler, regulations may be followed more stringently and the ecological benefits of mandated hook types will be further realized.

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