

## AN OVERVIEW OF CIRCLE HOOK USE AND MANAGEMENT MEASURES IN UNITED STATES MARINE FISHERIES

*Jacqueline A Wilson and Guillermo A Diaz*

### ABSTRACT

We provide an overview of the use of, and management measures for, circle hooks in various marine fisheries of the United States. Circle hooks have long been known for their conservation benefits, such as reducing deep hooking, and therefore, reducing post-release mortality associated with this event. Some US commercial pelagic longline vessels voluntarily started using circle hooks due to increased catch rates for some target species and increased post-release survival of non-target species, whereas recreational anglers began using circle hooks to reduce post-release mortality in catch-and-release fisheries. Despite previous voluntary circle hook use, circle hooks have been a relatively new fishery management tool in US state and federal fisheries. However, the difference in jurisdiction between state and federal waters has resulted in some disparity in state and federal circle hook regulations. In general, consistent management regulations between state and federal waters should be more beneficial for fish stocks that have both state and federal fisheries. Finally, while state and federal circle hook regulations are documented, voluntary circle hook use by commercial and recreational fishers participating in different state and federal fisheries is more difficult to characterize. Thus, overall circle hook use is difficult to quantify.

The use of circle hooks in different fisheries is not a recent phenomenon. The original development of circle hooks occurred centuries ago in the Pacific (Hurum 1977, Johannes 1981). In fact, Polynesians and North Pacific indigenous and pre-Columbian aboriginal peoples used hooks that resemble modern circle hooks (Stewart 1977, Johannes 1981). In modern times, circle hooks in the United States have been used voluntarily since the 1980s by commercial halibut fisheries in the Pacific Northwest (IPHC 1998), as well as in the US American Samoa and Hawaii-based longline fleets (P Dalzell, National Marine Fisheries Service, pers comm). Similarly, data collected by the US Pelagic Observer Program indicate that some US longline vessels fishing in the Gulf of Mexico have also voluntarily used circle hooks since the 1990s. The voluntary use of circle hooks in commercial fisheries is linked to perceived increases in the catch rates of target species; otherwise, fishers likely would not adopt their use on a voluntary basis. However, management regulations mandating the use of circle hooks in commercial fisheries are not aimed at increasing landings of target species, but at protecting non-target/bycatch species by reducing their catch rates and/or increasing their post-release survival. For example, research has shown that the use of large (18/0 or larger) circle hooks in combination with finfish bait is an effective mitigation measure for sea turtle (Cheloniidae) bycatch (Watson et al. 2005). Based on this finding, the US pelagic longline (PLL) fleet operating in the Atlantic has been required to use circle hooks since 2004 (July 6, 2004, 69 Fed. Reg. 40734; NMFS 2004) and similar requirements are also in place in the Hawaii-based shallow-set longline fishery targeting swordfish (April 2, 2004, 69 Fed. Reg. 17329). Although the mandatory use of circle hooks in the US PLL fleets

was initially adopted to protect sea turtles, research has also shown that their use can benefit other bycatch species (Kerstetter and Graves 2006, Diaz 2008). This is particularly important for species such as white marlin, *Kajikia albidus* (Poey, 1860), and blue marlin, *Makaira nigricans* (Lacépède, 1802), which are an important component of bycatch in longline fisheries and for which Atlantic stocks are deemed to be overfished and still undergoing overfishing (ICCAT 2007, 2011).

Unlike commercial fishers, the voluntary use of circle hooks by recreational anglers is not necessarily due to increased catch rates associated with these hook types. Many anglers use circle hooks for their conservation benefits, particularly for catch-and-release fisheries. A larger proportion of fish caught on circle hooks tend to be hooked in the mouth instead of being deep-hooked as they tend to be with the traditional J-hook. Because mouth-hooking results in a higher post-release survival compared to deep-hooking (Grover et al. 2002, Lukacovic and Uhhoff 2002, Skomal et al. 2002), recreational anglers interested in releasing their catch alive are more willing to voluntarily use gear that will increase those chances.

Even though circle hooks have been used on a voluntary basis in both commercial and recreational fisheries for decades, mandatory use of circle hooks has been a relatively new management tool used by state and federal fisheries agencies. Some of the first recreational and commercial circle hook requirements were put into place in 1997 in marine federal and state waters in certain areas off California for salmon fisheries (Cal. Code Reg. § 27.80, Title 14). Federal circle hook measures in the Atlantic and Pacific PLL fisheries were implemented in 2004 to help reduce bycatch and mortality of sea turtles and non-target species [Title 50 of the *Code of Federal Regulations* (C.F.R.) § 635.21 and 50 C.F.R. 665.813], and some states, such as Maine and New Hampshire, have had circle hook regulations in marine state waters as of 2002 [Rule Chapter 34.10(1)(C)(4) of the *Code of Maine Rules* (C.M.R.) and New Hampshire Fish and Game Rules Part Fis 602.18(b)(1), respectively]. More recently, circle hook requirements for some state shark fisheries and state and federal snapper-grouper and reef fish fisheries have been implemented since 2008. A federal regulation requiring the use of a modified circle hook that permits the escape of large bluefin tuna, *Thunnus thynnus* (Linnaeus, 1758), from longlines in the Gulf of Mexico was recently implemented by the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS; April 5, 2011, 76 Fed. Reg. 18653; NMFS 2011).

Here we summarize the current US federal and state requirements for the mandatory use of circle hooks in commercial and recreational marine fisheries, as well as document the extent and incentives for voluntary use of circle hooks.

## CIRCLE HOOK REGULATIONS

State and federal requirements for the use of circle hooks and applications to highly migratory species (HMS) are organized according to regulations in state or federal waters in differing regions (Table 1). State waters generally extend from state's coastline and extend seaward 3 nmi (except in the Gulf of Mexico, where the jurisdictions of Florida and Texas extend seaward 9 nmi) and in the Commonwealth of the Northern Mariana Islands (CNMI) where federal waters extend to land (0–200 nmi). The US federal government has jurisdiction within the Exclusive Economic Zone (EEZ), which generally starts at the seaward limit of the state's or territory's jurisdiction and extends 200 nmi from the coastline.

Table 1. Summary of United States state and federal circle hook regulations in differing regions, HMS = highly migratory species, PLL = pelagic longline, LAP = limited access permit, USVI = US Virgin Islands, CNMI = Commonwealth of the Northern Mariana Islands, and PR/IA = Pacific Remote Island Areas.

State	State waters		Federal waters	
	Recreational	Commercial	Recreational	Commercial
<i>Atlantic HMS</i>			Require non-offset circle hooks with natural bait or a natural bait/artificial lure combination for anglers in Atlantic HMS billfish tournaments.	Require circle hooks for HMS permitted PLL vessels (limit on size and bait depending on area fishing); require safe handling and release equip, protocols, and attendance of workshops for sea turtle interactions.
<i>Northeast Region</i>				
Maine	Require circle hooks for halibut (limit on size and #); In 2013, will require circle hooks for striped bass and bluefish when fishing with bait.	Require circle hooks for groundfish and halibut (limit on size and #) for longline and tub trawl gear.	Atlantic HMS requirements.	Atlantic HMS requirements; require circle hooks with longline and tub trawl gear (limit on size and #) for NE multispecies LAP in certain areas; require dehooker.
New Hampshire	None; brochure to promote circle hook use.	Require circle hooks (limit on size and #) for hook gear using bait; require dehooker		
Massachusetts	None; brochure to promote circle hook use.	Require circle hooks (limit on size) for cod when using longline gear in certain areas and times.		
Connecticut	Discretionary tournament regulations dependent on circle hook use.	None.		
Rhode Island	None.	None.		

Table 1. Continued.

State	State waters		Federal waters
	Recreational	Commercial	
<i>Mid-Atlantic Region</i> New York	Recommend circle hooks for catch-and-release fishing and for striped bass when using natural bait.	Require corrodible circle hooks for shark shortlines; must use NMFS safe handling and release protocols and gear and attend workshops.	Atlantic HMS requirements. Atlantic HMS requirements.
New Jersey	Require non-offset circle hooks when using natural bait during striped bass spawning season (limit on size and #) in Delaware River and its tributaries.	None.	
Delaware	Require non-offset circle hooks during striped bass spawning season when using natural bait in Nanticoke and Delaware Rivers.	None.	
Maryland	Allow non-offset circle or certain sized J-hooks (limit on size) for striped bass in tidal waters during pre-spawning season.	None.	
Virginia	None; brochure to promote circle hook use.	Require corrodible circle hooks for shark shortlines (limit on #); must use NMFS safe handling and release protocols, gear and attend workshops for sea turtle interactions.	
North Carolina	Require circle hooks (limit on size) when using natural baits during certain times of year and time of day in tidal coastal waters of Pamlico Sound; brochure to promote circle hook use.	None	

Table 1. Continued.

State	State waters		Federal waters	
	Recreational	Commercial	Recreational	Commercial
<i>South Atlantic Region</i>				
South Carolina	Same as federal.	Same as federal.	Atlantic HMS requirements; require corrodible circle hooks with hook and line gear and natural baits for South Atlantic snapper-grouper north of 28°N; require dehooker.	Atlantic HMS requirements; require corrodible circle hooks with hook and line gear and natural baits for South Atlantic snapper-grouper north of 28°N; require dehooker.
Georgia	None; promotes circle hooks for catch-and-release fisheries.	None.		
Florida (east coast)	Charter/headboats that hold federal South Atlantic snapper-grouper permits must abide by federal regulations for circle hooks; require dehooker.	Same as federal.		
<i>Gulf of Mexico Region</i>				
Florida (west coast)	Same as federal except require non-offset circle hooks.	Same as federal except require non-offset circle hooks.	Atlantic HMS requirements; require corrodible circle hooks with hook and line gear and natural baits for Gulf reef fish; require dehooker and venting device.	Atlantic HMS requirements; require corrodible circle hooks with hook and line gear and natural baits for Gulf reef fish; require dehooker and venting device.
Alabama	None.	None.		
Mississippi	None; encourages use of corrodible circle hooks or barbless hooks.	None.		
Louisiana	Same as federal.	Same as federal.		
Texas	Require circle hooks and natural baits when using pole and line for red snapper.	Require circle hooks and natural baits when using pole and line for red snapper; require circle hooks (limit on size and #) for inland trophine fisheries.		
<i>Caribbean Region</i>				
Puerto Rico and USVI	None.	None.	Atlantic HMS requirements.	Atlantic HMS requirements.
<i>Pacific Region</i>				
California	Same as federal.	Same as federal.	Require barbless circle hooks anytime other than trolling when using bait in specific areas (limit on #).	Require barbless circle hooks anytime other than trolling when using bait (limit on #).
Oregon	None; encourages use of barbless hooks for catch-and-release fishing.	None.		
Washington	None.	None.		

Table 1. Continued.

State	State waters		Federal waters	
	Recreational	Commercial	Recreational	Commercial
<i>North Pacific Region</i>				
Alaska	None.	None.	None.	None.
<i>Western Pacific Region</i>				
Hawaii, Guam, American Samoa, CNMI, PRIA	None.	None.	None.	Require circle hooks for shallow-set longline gear north of the Equator (limit on size and bait); require use safe handling and release equip, protocols, and attendance of workshops for protected species and seabird interactions.

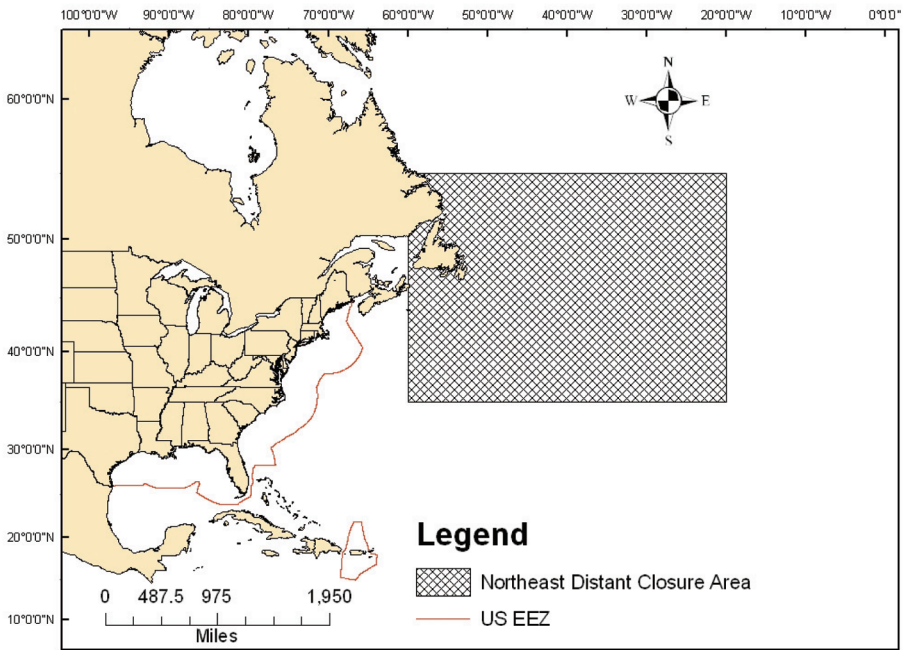


Figure 1. Map of the Northeastern United States Closed Area (NED) off the East Coast of the United States.

#### ATLANTIC HIGHLY MIGRATORY SPECIES

*Regulations in Federal Waters.*—Regulations that pertain to Atlantic HMS (tunas, sharks, billfishes, and swordfishes) apply to federal waters of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. Commercial vessels using PLL possessing a limited access swordfish, shark, or tuna longline category permit are restricted to using only (and possessing onboard) circle hooks that are 18/0 or larger with an offset not to exceed 10° while fishing within the Northeastern United States Closed Area (NED, see Fig. 1) per federal regulations at 50 C.F.R. § 635.21(c). Atlantic HMS PLL vessels fishing outside of the NED are restricted to using (and possessing) 18/0 or larger circle hooks with an offset not to exceed 10° or 16/0 or larger non-offset circle hooks. These vessels are also restricted in the types of baits that can be used within the NED, outside the NED, and within the Gulf of Mexico per 50 C.F.R. § 635.21 (July 6, 2004, 69 Fed. Reg. 40734). The only exception with regard to the requirement to possess circle hooks onboard PLL vessels is if greenstick gear (a type of trolling gear) is also onboard, in which case, a vessel may possess no more than 20 J-hooks (September 23, 2008, 73 Fed. Reg. 54721). Vessels using buoy gear are also not required to use circle hooks. In addition, PLL vessels must carry release equipment for the safe release of sea turtles and marine mammals that could be incidentally caught by longline gear. Vessel owners and operators must also attend workshops for the safe handling and release of these marine protected resources every 3 yrs to be issued the corresponding fishing permits (October 2, 2006, 71 Fed. Reg. 58166). Finally, as of May 5, 2011 (April 5, 2011, 76 Fed. Reg. 58058), PLL vessels fishing in the Gulf of Mexico are required to use “weak” circle hooks, or weak hooks. Weak hooks are constructed of

round wire stock that is thinner-gauge than the circle hooks required in the fishery as of 2004. Weak hooks can allow incidentally hooked bluefin tuna (and other large fishes) to escape capture because the hooks are more likely to straighten when a large fish is hooked, and therefore, reduce bycatch of large bluefin tuna in the Gulf of Mexico (NMFS 2011).

In terms of recreational HMS fisheries, as of January 2008 recreational anglers participating in an Atlantic billfish tournament are required to use non-offset circle hooks when using natural bait or a natural bait/artificial lure combination per 50 C.F.R. § 635.21(e)(2)(iii). J-hooks may only be used with artificial lures (May 11, 2007, 72 Fed. Reg. 26735).

#### NORTHEAST REGION

*Regulations in Federal Waters.*—Since 2004, regulations in federal waters in the Northeast (NE) Region require that all longline hooks not fishing for Atlantic HMS must be circle hooks of a minimum size of 12/0 (April 27, 2004, 69 Fed. Reg. 22906). Vessels fishing with a NE multispecies limited access permit (LAP) fishing under Days at Sea (DAS) and fishers fishing with a NE multispecies limited access Small-Vessel permit are limited to the number of hooks they can carry based on the fishing area in which they are operating [see 50 C.F.R. § 648.80(a)(3)(v), 50 C.F.R. § 648.80(a)(4)(v), and 50 C.F.R. § 648.80(b)(2)(v)]. Most fishers participating in fisheries other than those mentioned above (i.e., fisheries managed under sector management) are exempt from the hook limit, but are still required to use circle hooks (April 9, 2010, 75 Fed. Reg. 18262). Fishing vessels with tub trawls are limited to 250 circle hooks of size 12/0 or greater. The use of a dehooker or “crucifer” with <15.2 cm (6 in) spacing between the fairlead rollers is also prohibited (April 27, 2004, 69 Fed. Reg. 22906). There are no recreational requirements for the use of circle hooks in federal waters in the NE Region; however, anglers do use circle hooks when fishing for striped bass, *Morone saxatilis* (Walbaum, 1792), and using bait (P Perra, NMFS, pers comm).

#### *Regulations in State Waters.*—

Maine.—As of 2002, per Rule Chapter 34.10(1)(C)(4) of the CMR, commercial fishing vessels in Maine’s marine state waters using tub trawl or longline gear and fishing for any species of groundfish must use 12/0 or greater circle hooks. These vessels are currently limited to 250 hooks. As with the federal requirements, the use of a dehooker with <15.2 cm (6 in) spacing between the fairlead rollers is also prohibited. Per Rule Chapter 34.10(1)(B)(4)(b)(iv) of the CMR, commercial and recreational fishers must use 14/0, 15/0, or 16/0 circle hooks when fishing for Atlantic halibut, *Hippoglossus hippoglossus* (Linnaeus, 1758), and are limited to 450 circle hooks. Recreational or commercial fishers that do not have a halibut permit when using a tub trawl and fishing for personal use are limited to 100 hooks. Beginning in 2013, recreational anglers must use a circle hook when using bait and fishing for striped bass or bluefish, *Pomatomus saltatrix* (Linnaeus, 1766) (Rule Chapter 42.01(C) and Rule Chapter 43.01(C) of the CMR, respectively).

New Hampshire.—As of 2002, commercial fishing vessels in New Hampshire’s marine state waters have been required to use 12/0 circle hooks when using bait, are limited to deploy no more than 800 circle hooks, and are required to use a dehooker with at least 15.2 cm (6 in) spacing between the fairlead rollers per New Hampshire Fish and Game Rules Part Fis 602.18(b)(1). Currently, there are no recreational



regulations requiring circle hooks; however, the Marine Fisheries Division of the New Hampshire Fish and Game Department promotes the use of circle hooks in their publication "Take Me Fishing!" available at [http://www.wildlife.state.nh.us/marine/marine\\_PDFs/seacoast\\_TMF\\_guide.pdf](http://www.wildlife.state.nh.us/marine/marine_PDFs/seacoast_TMF_guide.pdf).

Massachusetts.—Commercial vessels fishing in Massachusetts' marine state waters are restricted to hooks that must be >17.5 mm (0.689 in) in gape or circle hooks that must measure at least 12.7 mm (0.5 in) inside when longlining for cod, *Gadus morhua* (Linnaeus, 1758), within winter flounder, *Pseudopleuronectes americanus* (Walbaum, 1792), spawning closure area from February 1 to May 31 of each year, provided the area is open to groundfish per 322 of the *Code of Massachusetts Regulations* § 8.09(3). There are currently no recreational regulations requiring circle hooks in marine state waters of Massachusetts; however, the Massachusetts Division of Marine Fisheries has several brochures explaining the conservation benefits of circle hooks in recreational fisheries available at [http://www.mass.gov/dfwele/dmf/spotlight/fish\\_responsibly.htm](http://www.mass.gov/dfwele/dmf/spotlight/fish_responsibly.htm).

Connecticut.—There are currently no circle hook regulations in place for commercial fishing in Connecticut's marine state waters. However, in January 2007, as part of an exemption from the prohibition on culling or high-grading during tournaments, Conn. Code § 26-159a-26 of the Regulations of Connecticut State Agencies requires tournament participants to use non-offset circle hooks when using baits or lures. The Connecticut Department of Environmental Protection also publishes a guide for recreational anglers on ways to increase catch and reduce mortality using circle hooks that can be found at [http://www.ct.gov/dep/lib/dep/fishing/anglers\\_guide/anguide\\_part4.pdf](http://www.ct.gov/dep/lib/dep/fishing/anglers_guide/anguide_part4.pdf).

Rhode Island.—Currently there are no circle hook regulations in commercial or recreational fisheries operating in marine state waters of Rhode Island.

#### MID-ATLANTIC REGION

*Regulations in Federal Waters.*—Currently there are no additional circle hook requirements in federal fisheries of the mid-Atlantic Region besides the regulations for Atlantic HMS fisheries as described above. However, there is voluntary use of circle hooks of varying sizes in recreational fisheries operating in federal waters for summer flounder, *Paralichthys dentatus* (Linnaeus, 1766), scup, *Stenotomus chrysops* (Linnaeus, 1766), black sea bass, *Centropristis striata* (Linnaeus, 1758), bluefish, and striped bass (M Ruccio, National Marine Fisheries Service, pers comm).

#### *Regulations in State Waters.*—

New York.—As of 2010, as a bycatch reduction measure, all hooks attached to shortline gear must be corrodible circle hooks when commercially fishing for sharks in state waters per Chapter 1 Part 40.7(d)(10) of the New York Department of Environmental Conservation Regulations. Commercial shark fishers must also practice the protocols and possess the federally required release equipment for pelagic and bottom longline gears for the safe handling, release, and disentanglement of sea turtles and other non-target species. All captains and vessel owners must be certified in using handling and release equipment through workshops offered by NMFS. In addition, many fishers in the commercial tilefish fishery out of Montauk, New York, voluntarily use 13/0 circle hooks (MAFMC 2009). Currently there are no

recreational circle hook requirements in New York's marine state waters, but the New York Department of Environmental Conservation promotes their use when fishing for striped bass as well as when using natural baits and conducting catch-and-release fishing at <http://www.dec.ny.gov/outdoor/31427.html>.

New Jersey.—Since 2007, the State of New Jersey requires non-offset circle hooks for hooks size 2/0 and larger in its recreational fishery (as there is no commercial fishing for striped bass) while fishing with any natural bait during striped bass spawning season (April 1–May 31 of each year) in the Delaware River and its tributaries per New Jersey's Administrative Code 7:25-18.1(h)1. There are no commercial circle hook or any other recreational regulations in New Jersey's marine state waters. However, many fishers in the commercial tilefish fishery voluntarily use small circle hooks (MAFMC 2009).

Delaware.—Similarly, in 2005 the State of Delaware required the use of non-offset circle hooks in its recreational striped bass fishery during the spawning season (April 1–May 31 of each year) with the use of natural baits when hook measurements are >9.5 mm (0.375 in) per Delaware Administrative Code Title 7 3502 § 6.0. These regulations apply in areas of the Nanticoke and Delaware Rivers and their tributaries. There are no other recreational circle hook regulations or any commercial circle hook regulations in Delaware's marine state waters; however, there is some voluntary use of circle hooks by Delaware's anglers (R Cole, Delaware Division of Fish and Wildlife, pers comm).

Maryland.—As of 2009, in tidal waters of Maryland, regulations in state waters require the mandatory use of non-offset circle hooks or J-hooks with a gap of <12.7 mm (0.5 in) when using bait in the recreational catch-and-release striped bass fishery during the prespawn time period as defined by the Code of Maryland Regulations Title 8.02.05.02 and 8.02.15.03E. In general, the use of circle hooks is increasing in Maryland's recreational fisheries (M Gary, Maryland Department of Natural Resources, pers comm) and careful catch-and-release techniques can be found online (<http://carefulcatch.com>). There are no commercial circle hook regulations, or any other recreational circle hook regulations, in Maryland's marine state waters.

Virginia.—Currently there are no recreational circle hook regulations in Virginia's marine state waters. However, Virginia's Marine Resources Commission puts out an angler guide that promotes circle hook use, especially in catch-and-release fisheries and when using bait, which can be found at [http://www.mrc.state.va.us/vswft/Angler\\_guide/angler\\_web\\_waters.pdf](http://www.mrc.state.va.us/vswft/Angler_guide/angler_web_waters.pdf). In addition, recreational anglers tend to use circle hooks when using live bait inshore targeting large red drum, *Sciaenops ocellatus* (Linnaeus, 1766), striped bass, or cobia, *Rachycentron canadum* (Linnaeus, 1766), and when fishing with live bait offshore for amberjack, *Seriola dumerili* (Risso, 1810) (L Gillingham, Virginia Marine Resources Commission, pers comm).

Since 2009, commercial fishers are required to use corrodible circle hooks in state waters when fishing for sharks using shortlines per Chapter 4 of Virginia Administrative Code (VAC) 20-490-30. Per 4 VAC-20-490-30 fishers are also limited to 50 hooks per shortline and only allowed two shortlines per vessel. In addition, fishers are required to practice the protocols and possess the federally required release equipment for pelagic and bottom longline gears for the safe handling, release

and disentanglement of sea turtles and other non-target species in commercial fisheries operating in state waters. All captains and vessel owners must also be certified in using handling and release equipment.

North Carolina.—Currently, the only circle hook regulations in place in North Carolina's marine state waters apply to the internal coastal fishing waters of Pamlico Sound and its tributaries south of the Albemarle Sound Management Area. As of 2009, recreational anglers are required to use circle hooks when using natural bait that must meet certain requirements if they are fishing with a hook larger than 4/0 in these areas during July 1–September 30 from 19:00 to 07:00 hrs per Title 15A of North Carolina Administrative Code Title 03J.0306. The North Carolina Division of Marine Fisheries also puts out an angler guide that promotes circle hook use, which can be found at <http://www.ncfisheries.net/recreational/downloads/2010EthicalAnglingNCDMF-web.pdf>, and notes that there is voluntary use of circle hooks among its state anglers (D Taylor, North Carolina Division of Marine Fisheries, pers comm).

#### SOUTH ATLANTIC REGION

*Regulations in Federal Waters.*—As of March 2011, the use of non-stainless steel circle hooks (offset or non-offset) have been required on any vessel (commercial or recreational) using hook-and-line gear with natural baits to fish for South Atlantic snapper-grouper north of 28°N in federal waters of the South Atlantic per 50 C.F.R. § 622.41(n)(2) (75 Fed. Reg. 76874, December 9, 2010). The South Atlantic Fishery Management Council (SAFMC) limited the circle hook requirement to South Atlantic areas north of 28°N to help rebuild red snapper, *Lutjanus campechanus* (Poey, 1860), by reducing discard mortality but to not affect fishing for species such as yellowtail snapper, *Ocyurus chrysurus* (Bloch, 1791), and gray snapper, *Lutjanus griseus* (Linnaeus, 1758), which fishers report are not easily caught with circle hooks (SAFMC 2010). As of July 2009, fishers have been required to carry an approved de-hooking device to remove hooks from South Atlantic snapper-grouper per 50 C.F.R. § 622.41(n)(1) (74 Fed. Reg. 30964, June 29, 2009).

#### *Regulations in State Waters.*—

South Carolina.—*South Carolina Code of Laws* § 50-5-2730 specifies that regulations in federal waters apply in South Carolina's marine state waters unless state law indicates otherwise. Thus, the federal requirements for circle hooks per 50 C.F.R. § 622.41(n)(2) in the recreational and commercial South Atlantic snapper-grouper fisheries and the federal requirement to carry an approved dehooking device per 50 C.F.R. § 622.41(n)(1) as explained above apply to South Carolina's state water fisheries. These are currently the only circle hook requirements in place for South Carolina's marine state waters.

Georgia.—Currently, there are no circle hook regulations in Georgia's marine state waters in its commercial or recreational fisheries. The South Atlantic snapper-grouper that benefit from the circle hook regulations in federal waters are not caught in Georgia's state waters (P Greer, Georgia Department of Coastal Resources, pers comm). However, the Georgia Department of Coastal Resources publishes an angler guide that promotes circle hook use, especially in catch-and-release fisheries and when using bait, which can be found at [http://knowtheconnection.com/index.php?option=com\\_zoo&task=item&item\\_id=19&category\\_id=10&itemid=10](http://knowtheconnection.com/index.php?option=com_zoo&task=item&item_id=19&category_id=10&itemid=10).

East Coast of Florida.—Since 2010, Florida's regulations in state waters per Florida Administrative Code (FAC) 68B-14.005 have required commercial and recreational fishers to possess a dehooker device to remove hooks from South Atlantic snapper-grouper. In addition, since the State of Florida requires a federal commercial permit for commercial harvest in Florida's marine state waters, as of 2011, commercial South Atlantic snapper-grouper fishers in Florida's state waters have been required to follow federal circle hook regulations in the Atlantic per 50 C.F.R. § 622.41(n)(2) as explained above. Persons fishing aboard charter boats and headboats that hold federal South Atlantic snapper-grouper permits are also required to follow federal circle hook regulations, even while fishing in state waters. Private recreational anglers fishing for South Atlantic snapper-grouper in Florida's state waters are not required to use circle hooks.

#### GULF OF MEXICO REGION

*Regulations in Federal Waters.*—As of 2008, recreational and commercial fishers must possess non-stainless steel circle hooks when using natural bait and fishing for Gulf of Mexico reef fish in federal waters per 50 C.F.R. § 622.41(m) (73 Fed. Reg. 5117, January 29, 2008). These regulations also require fishers to have an approved venting tool to reduce barometric trauma and an approved dehooking device to remove hooks from reef fish.

#### *Regulations in State Waters.*—

West Coast of Florida.—Since 2008, recreational and commercial fishers fishing for Gulf of Mexico reef fish in Florida's state waters must fish with non-stainless steel circle hooks that are not offset when fishing for Gulf of Mexico reef fish, must possess a dehooking tool to remove hooks embedded in Gulf reef fish, and must possess an approved venting tool per FAC 68B-14.005. Florida regulations in marine state waters are more stringent than the regulations in federal waters as the state requires non-offset circle hooks.

Alabama and Mississippi.—Currently, there are no circle hook regulations for commercial or recreational fisheries in Alabama or Mississippi marine state waters. In addition, regulations in federal waters regarding Gulf of Mexico reef fish do not apply in these two states' waters. However, the Mississippi Department of Marine Resources in their Guide to Mississippi Saltwater Fishing does encourage the use of non-stainless steel circle hooks or barbless hooks when participating in catch-and-release fisheries. The guide can be found at <http://www.dmr.ms.gov/images/publications/reg-book.pdf>.

Louisiana.—Since 2008, recreational and commercial fishers fishing for Gulf of Mexico reef fish in the Gulf of Mexico EEZ must fish with non-stainless steel circle hooks when using natural bait, must possess and use a dehooking tool to remove hooks embedded in Gulf reef fish, and must possess and use an approved venting tool per Louisiana Administrative Code 76:VII.335.I.2.

Texas.—In 2007, Texas restricted fishing for red snapper to pole-and-line angling using only circle hooks per Texas Parks and Wildlife Proclamations § 57.981. In 2011, an amendment was made to Texas Code § 57.981 to clarify that only natural bait may be used when fishing for red snapper by means of a circle hook. These regulations are meant to mirror regulations in federal waters in the Gulf of Mexico as outlined

above. In addition, there are circle hook requirements for commercial fishers using trotlines targeting channel catfish, blue catfish, and flathead catfish per Texas Parks and Wildlife Proclamations § 57.973(c)21(d)(iv)(5). Fishers are limited to circle hooks comparable to Mustad 11/0 circle hooks and are limited to no more than five hooks per trotline.

#### CARIBBEAN REGION

*Regulations in Federal Waters.*—Currently, there are no additional circle hook requirements in federal fisheries of the Caribbean Region besides the regulations for HMS fisheries as described above.

##### *Territorial Regulations.*—

US Virgin Islands and Puerto Rico.—Currently, there are no commercial or recreational circle hook regulations for hook and line fisheries in US Virgin Islands or Puerto Rico's territorial waters. However, deep water snapper fishers in the US Virgin Islands tend to use circle hooks (J Brown, USVI Division of Fish and Wildlife, pers comm).

#### PACIFIC REGION

*Regulations in Federal Waters.*—Since 1997, circle hooks have been required in federal commercial and recreational components of the salmon fishery to reduce deep-hooked fish (C Tracy, Pacific Fishery Management Council, pers comm). Federal commercial salmon fishers from the Oregon-California border to the US-Mexico border are limited to no more than six lines per vessel, and barbless circle hooks are required when fishing with bait by any means other than trolling. In federal recreational salmon fisheries, anglers fishing with bait and angling by any other means than trolling between Horse Mountain and Point Conception are required to fish with no more than two single-point, single-shank barbless circle hooks. The distance between the two hooks must not exceed 127 mm (5 in) when measured from the top of the eye of the top hook to the inner base of the curve of the lower hook, and both hooks must be permanently tied in place (hard tied). Each year, management measures are implemented for the salmon fishery through NMFS and the Pacific Fishery Management Council. Salmon regulations in 2011 were implemented on May 4, 2011 (76 Fed. Reg. 25246). There are no other circle hook requirements in marine commercial and recreational federal fisheries in federal waters adjacent to the states of California, Oregon, and Washington; however, NMFS does encourage the use of circle hooks in the recreational thresher shark fishery to decrease tail hooking (H Hermsmeyer, NMFS, pers comm).

##### *Regulations in State Waters.*—

California.—Since 1997, circle hook requirements apply to salmon fishing per Calif. Code § 27.80, Title 14. Recreational anglers fishing with bait and angling by any other means than trolling between Horse Mountain and Point Conception are required to follow the same regulations in federal waters explained in the previous section. In the commercial salmon fishery, barbless circle hooks are required when fishing with bait and fishing by any means other than trolling. There are no other circle hook requirements in marine commercial and recreational fisheries in California's marine state waters.

Oregon and Washington.—Currently, there are no circle hook regulations for commercial or recreational fisheries operating in Oregon and Washington's marine state waters. However, in Oregon most commercial fishers using longline gear for sablefish, halibut, and nearshore groundfish species use circle hooks (C Schmitt, Oregon Department of Fish and Wildlife, pers comm), and they are also commonly used in the recreational halibut fishery. In Oregon, anglers have also been experimenting with the effectiveness of circle hooks in the recreational albacore tuna fishery (C Schmitt, Oregon Department of Fish and Wildlife, pers comm). Oregon's Department of Fish Wildlife also encourages the use of barbless hooks when participating in catch-and-release fisheries in their *Catch and Release* guide that can be found at <http://www.dfw.state.or.us/resources/fishing/docs/CatchReleaseBrochure.pdf>.

#### NORTH PACIFIC REGION

*Regulations in Federal Waters.*—Currently, there are no circle hook regulations in place for any federally managed fisheries in the North Pacific Region. However, based on 2009 logbook data for most of the commercially landed Pacific halibut *Hippoglossus stenolepis* (Schmidt, 1904) in the North Pacific (from the United States and Canada), 97% of the commercial halibut vessels (26 ft or larger) reported using circle hooks (G Williams, International Pacific Halibut Commission, pers comm). In addition, a 2007 survey of the halibut sport fishery done by Alaska's Department of Fish and Game also indicated that circle hook use by charter and private anglers was very high (G Williams, International Pacific Halibut Commission, pers comm).

#### *Regulations in State Waters.*—

Alaska.—Currently there are no circle hook regulations for commercial or recreational fisheries operating in Alaska's marine state waters. However, groundfish longline fishers and recreational halibut anglers are known to voluntarily use circle hooks due to their effectiveness (S Kelley, Alaska Department of Fish and Game, pers comm).

#### WESTERN PACIFIC REGION

*Regulations in Federal Waters.*—Since 2004, US PLL vessels in the Hawaii-based PLL fleet have been managed under two different management regimes; a shallow-set longline fishery, which targets swordfish, and a deep-set longline fishery, which targets tunas. Each fleet has observer coverage requirements and different hook requirements. All vessels with shallow-set longline gear north of the Equator (0° lat.) are required to use only circle hooks sized 18/0 or larger, with an offset not to exceed 10°, with only mackerel-type bait per 50 C.F.R. 665.813 (April 2, 2004, 69 Fed. Reg. 17329). The deep-set fishery does not have hook or bait requirements; however, between 30% and 40% of the Hawaii deep-set PLL vessels also use circle hooks. Similarly, the American Samoa longline fishery does not have circle hook requirements, but most vessels use circle hooks (P Dalzell, National Marine Fisheries Service, pers comm). As in the Atlantic, the Western Pacific Region (i.e., Hawaii-based and American Samoa-based fisheries) also has regulations regarding workshops for protected species, seabirds, and safe handling and release gear for PLL vessels (May 14, 2002, 67 Fed. Reg. 34408). In addition, longline fishing is regulated through spatial management zones within the United States' EEZs of the United States' Pacific Islands. Requirements for longline fishing in these areas can be found on the NMFS Pacific Islands Regional Office's webpage at <http://www.fpir.noaa.gov/>

SFD/SFD\_regs\_2.html. There are no circle hook requirements for other commercial and recreational fisheries operating in the Western Pacific Region.

*State/Territorial Regulations.*—

Hawaii, American Samoa, Commonwealth of the Northern Mariana Islands, and Guam.—State/territorial waters extend from the shoreline and extend seaward 3 nmi, except in the CNMI where federal waters extend to land (0–200 nmi, WPRFMC 2005). In addition, all fisheries operating within the Pacific Remote Island Areas (PRIAs) are covered via federal regulations (WPRFMC 2005). There are no additional commercial circle hook requirements in the state and territorial waters of the Western Pacific besides the regulations in federal waters pertaining to shallow set longlines as described above. In addition, there are no recreational requirements for circle hooks in any of these areas; however, circle hooks are the standard hook that is used for recreational shoreline fishing in Hawaii when using bait. A Hawaiian initiative encourages the proactive use of barbless circle hooks for recreational fisheries use during specific situations to reduce post-hooking injuries of any accidental bycatch of protected resources (K Kawamoto, NMFS, pers comm).

## DISCUSSION

In the United States, the difference in jurisdiction between state and federal waters can result in the implementation of different management measures between these two adjacent areas. In general, consistent management regulations between state and federal waters should be more beneficial for fish stocks that occur in areas where both federal and state fisheries may overlap. In some cases, there are complementary circle hook regulations in both state and federal waters. However, this is not always the case. Currently, there is consistency between circle hook regulations in federal and state waters of Maine, South Carolina, Louisiana, Texas, California, and the east coast of Florida. In some cases, state waters have more restrictive circle hook measures, such as New York and Virginia, which require circle hooks in state water shark fisheries; however, such regulations are not mandatory in federally-managed shark fisheries. On the west coast of Florida, state water regulations do not allow offset circle hooks for the Gulf reef fish fishery whereas regulations in federal waters allow circle hooks to be offset or non-offset for the same fishery. In other cases, states' waters may have circle hook regulations where regulations in federal waters are lacking, either because the fisheries do not exist in federal waters, such as New York, Maryland, and Delaware's striped bass fisheries, or because different circle hook regulations in state waters are implemented to address unique state water fishery concerns, such as circle hook requirements for catfish trotlines in Texas inland bay waters. Conversely, some states and territories may not have circle hook regulations consistent with adjacent federal waters because the same fisheries do not exist in both state and federal waters, such as a non-existent South Atlantic snapper-grouper fishery in Georgia's state waters.

While circle hook regulations may exist for both commercial and recreational fisheries, the management goals behind these regulations often differ between the fisheries. Concerns regarding catch and post-release mortality of bycatch, such as protected resources and non-target species, have been the driver for circle hook regulatory changes in commercial fisheries. NMFS' decision to require the mandatory

use of circle hooks in commercial Atlantic and Pacific PLL fisheries was based on findings by Watson et al. (2005) that showed the conservation benefits of this terminal gear for sea turtles through experiments conducted in the North Atlantic. In fact, the use of circle hooks in combination with other gear modifications for commercial fisheries, such as many PLL fisheries, has maintained the catch rate of many target species while significantly reducing bycatch rates and bycatch mortality (Watson and Kerstetter 2006, Gilman et al. 2007). However, the effect of circle hooks is not the same for all species. Some studies have indicated increased shark catch rates due to circle hook use whereas other studies have indicated decreased shark catch rates; therefore, the conservation benefit for some species, such as pelagic sharks, may be mixed (Afonso et al. 2011, Curran and Bigelow 2011, Swimmer et al. 2011). In addition, in the South Atlantic studies on the effects of circle hooks and J-hooks on retention and survival on reef fish are limited to a handful of snapper grouper species (SAFMC 2010). Some studies indicate beneficial effects, while others are inconclusive as not all species in the snapper-grouper complex have the same mouth morphology, and it is possible that circle hooks could negatively impact survival (SAFMC 2010). Thus, the SAFMC limited the area where circle hooks were required under Amendment 17A (SAFMC 2010). For recreational fisheries, the reduction of post-release mortality has been the important factor driving circle hook regulations, as many of these fisheries tend to be more catch-and-release oriented (Prince et al. 2002, Horodysky and Graves 2005). Cooke and Suski (2004) have shown that overall mortality rates in recreational fisheries were lower for circle hooks compared to J-hooks.

Overall, circle hook use may be difficult to quantify due to the voluntary use of such hooks in both commercial and recreational fisheries. For instance, many fishers in the Western Pacific and Pacific regions voluntarily use them. American Samoan longliners use only circle hooks despite having no requirements for their use (P Dalzell, National Marine Fisheries Service, pers comm). Commercial and recreational halibut fisheries in the Pacific Northwest use circle hooks not because of mandatory requirements, but because of increased catch efficiency (G Williams, International Pacific Halibut Commission, pers comm), and Hawaiian recreational fisheries commonly use circle hooks, and more recently barbless circle hooks, despite no recreational circle hook requirements in the State of Hawaii (K Kawamoto, NMFS, pers comm). Circle hooks are even becoming considered in freshwater fisheries based on conservation benefits relative to conventional J-hooks (Montrey 1999). Thus, circle hook use may be more prevalent than the number of circle hook regulations suggest.

#### ACKNOWLEDGMENTS

We thank the staff of various state and federal fishery agencies who took the time and effort to help clarify and verify circle hook regulations for commercial and recreational marine fisheries around the United States. We are also grateful to those that helped characterize the voluntary use of circle hooks by commercial fishers and recreational anglers. We thank P Cooper for help with maps and manuscript preparation and M Schulze-Haugen, K Brewster-Geisz, and four anonymous reviewers for helpful suggestions and criticisms during the development of the manuscript. This work was funded by the HMS Management Division and Office of Science and Technology of NMFS.



## LITERATURE CITED

- Afonso AS, Hazin FHV, Carvalho F, Pacheco JC, Hazin H, Kerstetter DW, Murie D, Burgess GH. 2011. Fishing gear modifications to reduce elasmobranch mortality in pelagic and bottom longline fisheries off Northeast Brazil. *Fish Res.* 108(2–3):336–343.
- Cooke SJ, Suski CD. 2004. Are circle hooks an effective tool for conserving marine and freshwater recreational catch and release fisheries? *Aquat Conserv: Mar Freshwat Ecosyst.* 14:299–326.
- Curran D, Bigelow K. 2011. Effects of circle hooks on pelagic catches in the Hawaii-based tuna longline fishery. *Fish Res.* 109(2–3):265–275.
- Diaz GA. 2008. The effect of circle hooks and straight (J) hooks on the catch rates and numbers of white marlin and blue marling released alive by the US pelagic longline fleet in the Gulf of Mexico. *N Am J Fish Manage.* 25:500–506.
- Gilman E, Kobayashi, D, Swenarton T, Brothers N, Dalzell P, Kinan-Kelly I. 2007. Reducing sea turtle interactions in the Hawaii-based longline swordfish fishery. *Biol Conserv.* 139(1–2):19–28.
- Grover AM, Mohr MS, Palmer-Zwahlen ML. 2002. Hook-and-release mortality of Chinook salmon from drift mooching with circle hooks: management implications for California's ocean sport fishery. *In: Lucy JA, Studholme AL, editors. Catch and release in marine recreational fisheries.* Bethesda, Maryland. *Am Fish Soc Symp* 30. p. 80–87.
- Horodysky AZ, Graves JE. 2005. Application of pop-up satellite archival tag technology to estimate postrelease survival of white marlin (*Tetrapterus albidus*) caught on circle and straight-shank (“J”) hooks in the western North Atlantic recreational fishery. *US Fish B-NOAA.* 103:84–96.
- Hurum HJ. 1977. A history of the fish hook. New York: Winchester Press.
- ICCAT (International Commission for the Conservation of Atlantic Tunas). 2007. Report of the ICCAT 2006 billfish stock assessment. *Collect Vol Sci Pap ICCAT.* 60(5):1431–1546.
- ICCAT (International Commission for the Conservation of Atlantic Tunas). 2011. Report of the 2011 blue marlin stock assessment and white marlin data preparatory meeting. SCRS. Available from: [http://www.iccat.int/Documents/Meetings/Docs/2011\\_BUM\\_ASSESS\\_ENG.pdf](http://www.iccat.int/Documents/Meetings/Docs/2011_BUM_ASSESS_ENG.pdf)
- IPHC (International Pacific Halibut Commission). 1998. The Pacific halibut: biology, fishery, and management. IPHC Technical Report 40, Seattle, Washington.
- Johannes RE. 1981. Words of the lagoon: fishing and marine lore in the Palau District of Micronesia. Los Angeles: University of California Press.
- Kerstetter DW, Graves JE. 2006. Survival of white marlin (*Tetrapterus albidus*) released from commercial pelagic longline gear in the western North Atlantic. *Fish Bull.* 104(3):434–444.
- Lukacovic R, Uphoff JH. 2002. Hook location, fish size, and season as factors influencing catch-and-release mortality of striped bass caught with bait in Chesapeake Bay. *In: Lucy JA, Studholme AL, editors. Catch and release in marine recreational fisheries.* Bethesda, Maryland. *Am Fish Soc Symp* 30. p. 97–100.
- MAFMC (Mid-Atlantic Fishery Management Council). 2009. Amendment 1 to the Tilefish Fishery Management Plan. Mid-Atlantic Fishery Management Council, 300 South New Street, Room 2115, Dover, DE 19904.
- Montrey N. 1999. Circle hooks ready to boom - design pierces fish through jaw, promotes conservation. *American Sportfishing.* 2(1):6–7.
- NMFS (National Marine Fisheries Service). 2004. Final supplemental environmental impact statement. Reduction of sea turtle bycatch and bycatch mortality in the Atlantic pelagic longline fishery. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Highly Migratory Species Management Division, Silver Spring, MD 20910.

- NMFS (National Marine Fisheries Service). 2011. Final rule to require the use of weak hooks on pelagic longline vessels in the Gulf of Mexico with final environmental assessment, final regulatory impact review, and final regulatory flexibility analysis. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Highly Migratory Species Management Division, Silver Spring, MD 20910.
- Prince ED, Ortiz M, Venizelos A. 2002. A comparison of circle hook and “J” hook performance in recreational catch-and-release fisheries for billfish. *In*: Lucy JA, Studholme AL, editors. Catch and release in marine recreational fisheries. Bethesda, Maryland: Am Fish Soc Symp 30. p. 60–79.
- SAFMC (South Atlantic Fishery Management Council). 2010. Amendment 17A to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region with Final Environmental Impact Statement, Initial Regulatory Flexibility Act Analysis, Regulatory Impact Review, and Social Impact Assessment/Fishery Impact Statement. South Atlantic Fishery Management Council, 4055 Faber Place, Ste 201, North Charleston, SC 29405.
- Skomal GB, Chase BC, Prince ED. 2002. A comparison of circle hook and straight hook performance in recreational fisheries for juvenile Atlantic bluefin tuna. *In*: Lucy JA, Studholme AL, editors. Catch and release in marine recreational fisheries. Bethesda, Maryland. Am Fish Soc Symp 30. p. 57–65.
- Stewart H. 1977. Indian fishing — early methods on the Northwest Coast. Seattle, Washington: University of Washington Press.
- Swimmer Y, Suter J, Arauz R, Bigelow K, Lopez A, Zanela I, Bolanos A, Ballestero J, Suarez R, Wang J, et al. 2011. Sustainable fishing gear: the case of modified circle hooks in a Costa Rican longline fishery. *Mar Biol.* 158(4):757–767.
- Watson JW, Epperly SP, Shah AK, Foster DG. 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. *Can J Fish Aquat Sci.* 62:965–981.
- Watson JW, Kerstetter DW. 2006. Pelagic longline fishing gear: a brief history and review of research efforts to improve selectivity. *Mar Technol Soc J.* 40(3):5–10.
- WPRFMC (Western Pacific Regional Fishery Management Council). 2005. Fishery ecosystem plan for the Pacific Remote Island Areas. Western Pacific Regional Fishery Management Council 1164 Bishop Street, Suite 1400, Honolulu, Hawaii 96813.

DATE SUBMITTED: 11 July, 2011.

DATE ACCEPTED: 17 February, 2012.

AVAILABLE ONLINE: 23 May, 2012.

ADDRESSES: (JAW) *National Marine Fisheries Service, Highly Migratory Species Management Division, 1315 East West Highway, Silver Spring, Maryland 20910.* (GAD) *National Marine Fisheries Service, Southeast Fisheries Science Center, 1315 East West Highway, Silver Spring, Maryland 20910.* CORRESPONDING AUTHOR: (JAW) *Telephone: (240) 338-3936. Email: <Jackie.Wilson@noaa.gov>.*

