BULLETIN OF MARINE SCIENCE. 88(3):745–754. 2012
http://dx.doi.org/10.5343/bms.2011.1070

USING A STOCK ASSESSMENT FRAMEWORK TO EXAMINE CIRCLE HOOKS: EXPLORING CHANGES IN CATCHABILITY AND IMPLICATIONS FOR MANAGEMENT

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ABSTRACT

A presumed conservation benefit of circle hooks is that they reduce catchability (*q*) and therefore bycatch of non-target species. While these changes may benefit a fish stock, they are difficult to incorporate in a stock assessment context, particularly for models that rely on fishery-dependent data, because few experiments exist that quantify the effects of circle hooks for a given species over appropriately large spatial scales. Consequently, to develop management advice, it may be necessary to model assumed changes in *q* within the adopted stock assessment model framework. Here we present a case study of bigeye tuna (*Thunnus obesus* Lowe, 1839), a highly migratory species managed by the International Commission for the Conservation of Atlantic Tunas (ICCAT), and explore the management implications of changes in *q* within a multi-fleet, age-structured assessment context. This study demonstrates that changes in *q* on the order of ±30% are sufficient to cause notable differences in the magnitude of common management reference points estimated by stock assessment models. Relative to a base model that assumed a constant *q*, models that incorporated a theoretical reduction in *q* produced higher estimates of spawning stock biomass and maximum sustainable yield, and lower estimates of fishing mortality while a theoretical increase in *q* had the opposite effect. The magnitude of the change was dependent on the number of fisheries affected. We conclude that carefully designed studies are essential to quantify the effects of a proposed gear change and to inform the appropriate parameterization of stock assessment models.

Commercial longline fisheries operate throughout the tropical, subtropical, and temperate oceans of the world, targeting a number of species including yellowfin tuna (*Thunnus albacares* Bonnaterre, 1788), bigeye tuna (*Thunnus obesus* Lowe, 1839), bluefin tuna (*Thunnus thynnus* Linnaeus, 1758), albacore (*Thunnus alalunga* Bonnaterre, 1788), and swordfish (*Xiphias gladius* Linnaeus, 1758). While some (e.g., Yamaguchi 1989) argue that longline gear can be more selective than other commercial gears, significant bycatch of non-targeted species often occur, including seabirds, billfishes, and sea turtles. Due to the perceived potential to enhance live release of bycatch species, particularly sea turtles and billfishes (NMFS 2004) and other fishes that must be released due to size or bag limits (GMFMC 2008, NMFS 2011), several management organizations mandate or promote the use of circle hooks in hook-based fisheries (ASMFC 2003).

Circle hooks appear to support substantially higher release survival for sea turtles (Watson et al. 2004, Gilman et al. 2006, Epperly et al. 2012), billfishes (Prince et al. 2002, Kerstetter and Graves 2006), and tunas (Curran and Bigelow 2011, Serafy et al. 2012) over conventional J-hooks or Japanese-style tuna hooks and may be an effective conservation tool (Cooke and Suski 2004, Serafy et al. 2009). However, as a substantive change in fishing practice, hook changes can have multiple consequences for the fishery and the ecosystem (Kaplan et al. 2007). To quantify the population-level impacts of the transition from traditional J-hooks (or tuna hooks) to circle hooks it is necessary to incorporate such changes into a stock assessment model.

When examined in this context, hook changes operate on at least three model inputs: (1) release mortality, (2) size or age selectivity of the fishing gear, and (3) catchability or q, the fraction of the population captured with one unit of effort. Due to the mechanical properties of circle hooks, they tend to lodge in the corner of the jaw rather than in deep tissues. This results in improved survival during the hooking process (Cooke and Suski 2004, Serafy et al. 2009), and since the entire hook must fit in the mouth and the gap between the point and the hook shank must also fit around the jaw, they tend to be size selective (Cooke et al. 2005). Lastly, circle hooks can potentially alter catch rates (Kerstetter et al. 2006); however, differences in catch rates between circle and J-hooks, when they exist, are often species, fishery, or situation specific (Cooke and Suski 2004, Serafy et al. 2009, Curran and Bigelow 2011).

While it is possible to estimate q, selectivity, and release mortality parameters before and after a change in hook type, the available data are seldom adequate to support this objective, particularly when stock assessments rely on fishery dependent data. Instead, it is generally preferable to obtain estimates of the effect of hook changes on these parameters from field studies, and to use these effects in the model without estimation, or to use informative priors.

The specific intention of this research was to explore, within a multi-fishery stock assessment framework, the sensitivity of commonly used management reference points to changes consistent with a switch from traditional J-hooks (or tuna hooks) to circle hooks. To simplify the analytical procedures, we chose to modify a single parameter, q. In the absence of clear guidance as to the magnitude and direction of expected changes in q, we examined a range of possibilities.

Methods

The use of circle hooks became mandatory for US pelagic longline vessels fishing in the Atlantic in August 2004 (NMFS 2004). To explore the potential implications of this gear change, we used a case study, the recent age-structured multi-fleet stock assessment of Atlantic bigeye tuna as accepted by the International Commission for the Conservation of Atlantic Tunas (ICCAT) in 2010 (Anon 2011). During this assessment, tuned virtual population analyses (VPA) were conducted using the VPA-2BOX software featured in the ICCAT Software Catalog (Porch 2003). All data inputs and parameter specifications are described in detail in the assessment report (Anon 2011), and will not be reiterated here. The specific run explored during the present study is referred to as "VPA Run 2" in Anon (2011).

Within the ICCAT convention area, bigeye tuna is a primary target species for many commercial longline and some baitboat fisheries. In addition, juvenile bigeye tuna are often caught by purse seiners in association with skipjack and juvenile yellowfin during fishing operations on natural or artificial floating objects such as fish aggregating devices (FADs). During the 2010 assessment, 9 fleets were considered, 7 longline fleets (Brazil, Japan, Uruguay, Taiwan, United States, Mexico, and Morocco), and 2 surface fishing fleets (Azorean baitboats and the European purse seine). Tuning indices were available for each of these fisheries, with the exception of the Mexican longline. Note that all indices were fishery dependent and no surveys were available for Atlantic bigeye tuna. Fleet-specific catch-at-age was used to estimate the selectivity of each fleet. These and the total catch-at-age were estimated from the available catch-at-size information using an age slicing procedure (Anon 2011).

During the 2010 assessment, the catchability coefficients for each index were assumed to be constant over the duration of the index and estimated using a concentrated likelihood formula (Anon 2011). For the present study, changes in catchability were applied as of January 1, 2005, to either the US pelagic longline fleet only, or to all longline fleets. The following changes were considered: 30%, 20%, and 10% reductions in q; constant q (as in the 2010 model); and 10%, 20%, and 30% increases in q. Because the VPA model, as currently programed, does not allow a change in q applied to a single year, changes in q were incorporated by adjusting the abundance indices directly using Equation 1.

$$I'_y = \frac{I_y}{1 + \Delta q} \quad \text{(Eq. 1)}$$

where I'_y is the adjusted annual index value, I_y is the unadjusted annual index value, and is the change in q expressed as a proportion (i.e., a 30% reduction is equivalent to a Δq of −0.3). The adjusted indices are shown in Figure 1. It was not necessary to adjust the Moroccan longline index as it began in 2005. No changes were made to the q coefficients of the baitboat or purse seine fleets.

Deterministic management reference points, including current stock status and MSY, were estimated using PRO2-BOX (Porch 2002), a related software package also available in the ICCAT software catalog. In stock assessment terminology, it is common to express the present stock status using the spawning stock biomass ratio [SSB/SSB_{MSY}: the present spawning stock biomass (SSB) relative to the level required to support long-term maximum sustainable yield (MSY)] and the fishing mortality ratio [F/F_{MSY}: the current fishing mortality rate (F) relative to the level required to support long-term MSY]. According to the ICCAT Convention (ICCAT 2007), stocks are designated overfished if SSB/SSB_{MSY} is <1.0. Likewise, stocks are undergoing overfishing is F/F_{MSY} if >1.0.

Results

Changes in q applied to the US pelagic longline fleet alone were sufficient to cause small differences in common management reference points estimated by the stock assessment model. The accepted base model, which did not specifically incorporate a change in q due to circle hooks, produced the following estimates: SSB_{2008}/SSB_{MSY} = 0.703, F_{2008}/F_{MSY} = 1.244, and MSY = 85,499 t (Table 1). When a theoretical 30% reduction in q was applied, the estimated metrics changed as follows: SSB/SSB_{MSY} increased by 7.8% to 0.757, F_{2008}/F_{MSY} decreased by 7.9% to 1.146, and MSY increased by 3.4% to 88,402 t (Table 1). A theoretical 30% increase in q had the opposite effect, SSB/SSB_{MSY} decreased by 4.9% to 0.668, F_{2008}/F_{MSY} increased by 5.8% to 1.316, and MSY decreased by 2.5% to 83,350 t (Table 1). As expected, less substantial changes in q had smaller effects (Table 1). The stock status results were also overlaid on a phase diagram which facilitates comparison of the estimated stock level relative to a commonly-used management reference (i.e., level at MSY). When the change in q was applied to a single fishery, the US pelagic longline, the estimated stock status in 2008 was located within a single quadrant of the phase diagram (overfished with overfishing occurring) across the examined changes in q (Fig. 2A).

When a theoretical 30% reduction in q was applied to all longline fleets, more substantial changes were noted. Relative to the base model described in the previous paragraph, the estimated metrics changed as follows: SSB/SSB_{MSY} increased by 42.4% to 1.001, F_{2008}/F_{MSY} decreased by 28.6% to 0.888, and MSY increased by 11.5% to 95,325 t (Table 2). A theoretical 30% increase in q had the contrary effect: SSB/SSB_{MSY} decreased by 22.4% to 0.545, F_{2008}/F_{MSY} increased by 42.8% to 1.777, and MSY decreased by 16.7% to 71,234 t (Table 2). Smaller changes in q had less substantial

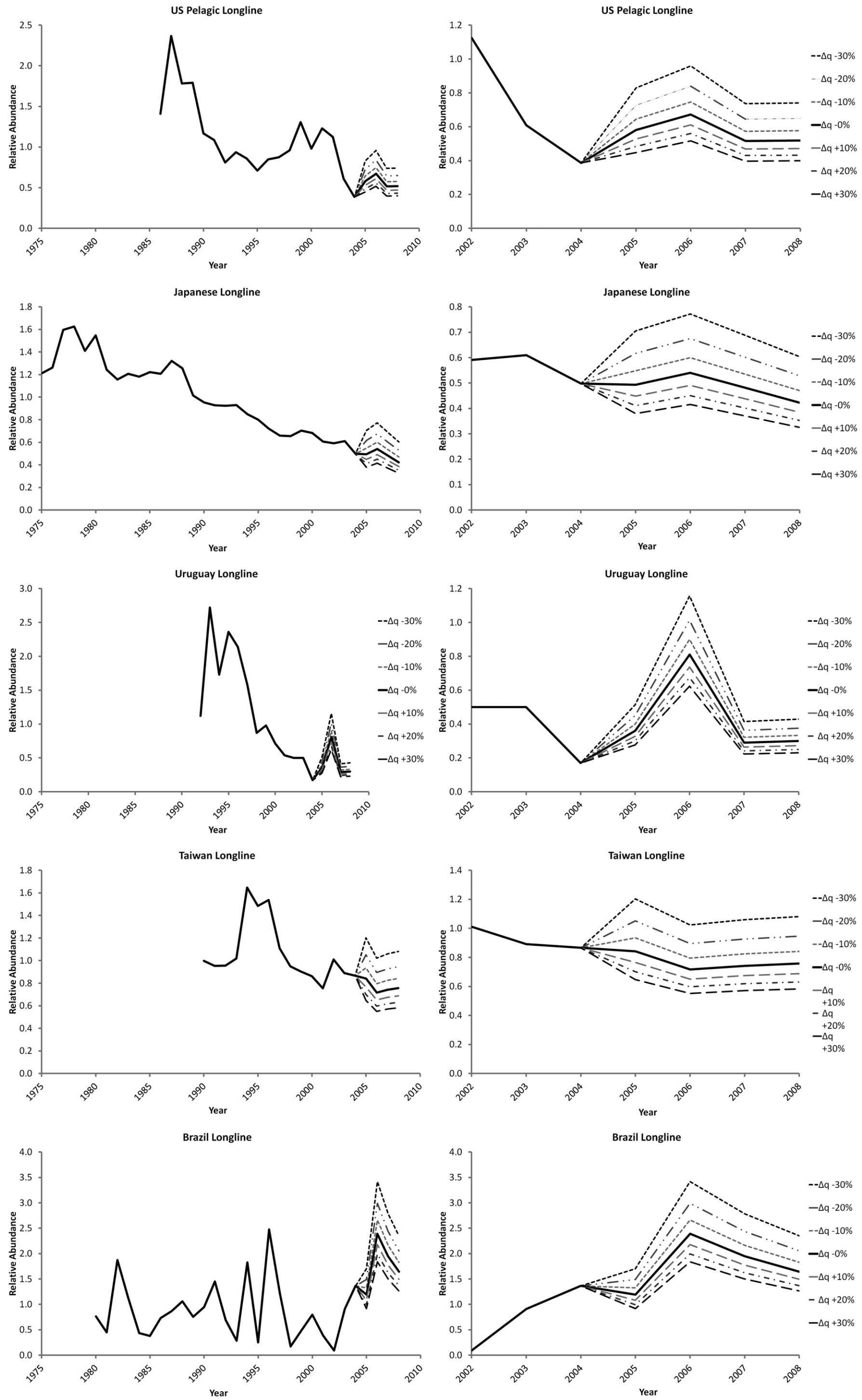

Figure 1. Bigeye tuna indices of abundance with constant q (bold solid line), and with changes in q applied to 2005 (see legend). Available time series are on the left, detailed views of 2002–2008 are on the right.

Table 1. Estimates of (and percent change) common management reference points, including SSB_{2008}/SSB_{MSY}, F_{2008}/F_{MSY}, and MSY with changes in q applied only to the US pelagic longline fishery. SSB = spawning stock biomass, F = fishing mortality, MSY = maximum sustainable yield, q = catchability.

Change in q	SSB_{2008}/SSB_{MSY} estimate (% change)	(F_{2008}/F_{MSY}) estimate (% change)	MSY estimate (% change)
Decrease 30%	0.757 (+7.8%)	1.146 (–7.9%)	88,402 (+3.4%)
Decrease 20%	0.738 (+5.0%)	1.179 (–5.3%)	87,451 (+2.3%)
Decrease 10%	0.719 (+2.4%)	1.210 (–2.7%)	86,378 (+1.0%)
No change	0.703 (+0.0%)	1.244 (+0.0%)	85,499 (+0.0%)
Increase 10%	0.690 (–1.7%)	1.268 (+1.9%)	84,597 (–1.1%)
Increase 20%	0.679 (–3.4%)	1.293 (+3.9%)	83,854 (–1.9%)
Increase 30%	0.668 (–4.9%)	1.316 (+5.8%)	83,350 (–2.5%)

effects. It is important to note that in this case, the phase diagram includes model results located in three quadrants, ranging from very poor stock condition to healthy stock condition (Fig. 2B).

Discussion

Here we demonstrate that failure to account for true changes in q, such as those caused by a change in gear configuration, can be sufficient to cause substantial inaccuracy in commonly estimated management reference points. This inaccuracy can have serious consequences for the success of fisheries management plans, which are often based on a specific probability of achieving a desired objective (e.g., 50% chance of recovery to SSB greater than SSB_{MSY} within 10 yrs). The problem is most severe when the changes are applied rapidly and simultaneously to a number of fleets. Rapid changes in gear configuration within a national fishery are not unusual as regulations generally have a single effective date across the fishery. Additional fleets may subsequently adopt the change if it has demonstrable conservation benefits and maintains a sufficient catch rate for the target species. During this experiment, changes in catchability were applied to (1) the US pelagic longline fleet alone or (2) to all longline fleets on a single date. These scenarios were intended to allow comparison of two extreme possibilities and to bracket the potential effect.

We chose to evaluate the implications of a change in q using a case study, the recent age-structured, multi-fleet stock assessment of Atlantic bigeye tuna. This was a useful and practical illustration as intentional releases of bigeye tuna are believed to be rare, and therefore, live releases could be assumed to be negligible (Anon 2011). For species with non-negligible live releases (e.g., marlins) the effect of hook type on releases and release mortality must also be considered.

Here we restricted our analyses to variations in q, and applied these changes directly to the US pelagic longline index alone, or to all longline indices. Other approaches are possible within a stock assessment modeling framework. For example, one could create two sets of indices broken at the gear change, and estimate additional index-specific q parameters. However, unless the magnitude of the change in q is known from scientific studies, or can be constrained with an informative prior, it is not likely that sufficient information will be available to obtain a defensible estimate of the change in q. This is particularly evident when gear changes are made across a

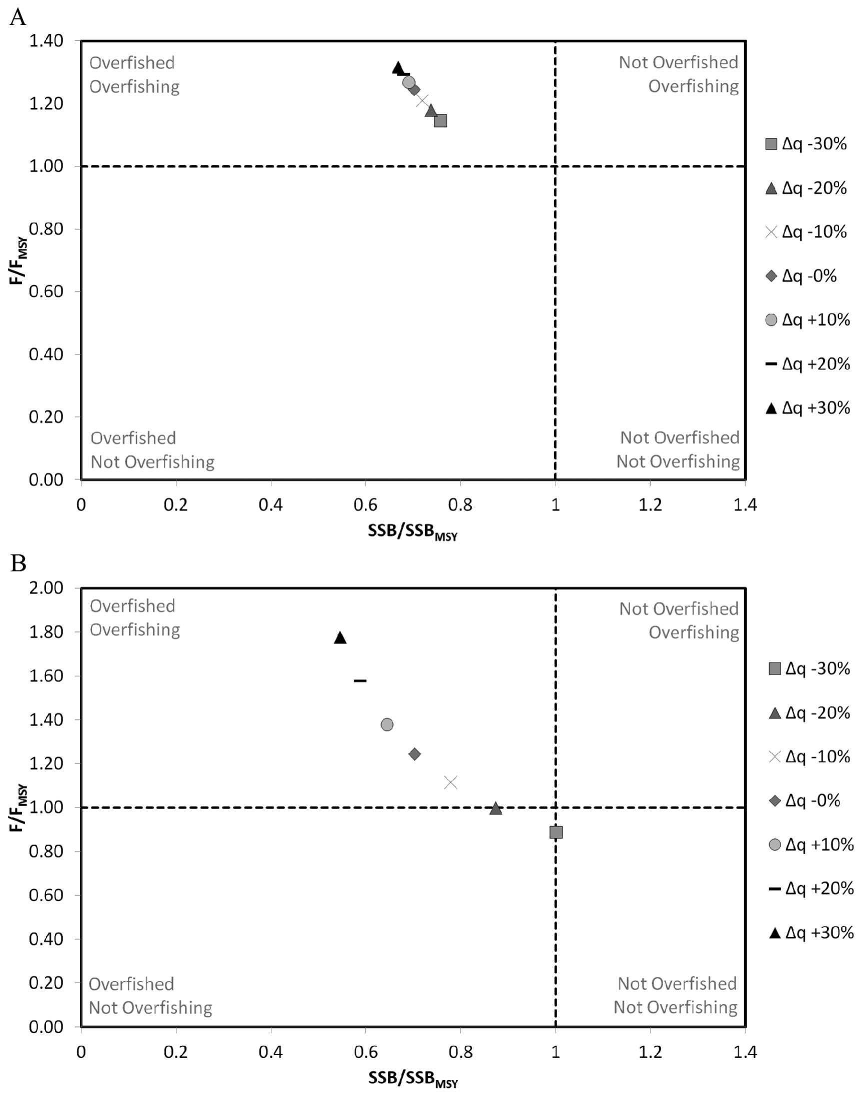

Figure 2. Phase plot of stock status relative to a common management reference level [i.e., maximum sustainable yield (MSY)] due to change in *q* applied to (A) US pelagic longline fishery only and (B) all longline fisheries.

fleet within a single calendar year because any change in *q* will be confounded by a concurrent change in abundance.

During the most recent years, 2005–2010, the US pelagic longline fishery comprised a small fraction (<1%) of the total catches of Atlantic bigeye tuna while the remaining longline fleets caught approximately 54%, and the baitboat and purse seine fleets were responsible for about 45% (Anon 2011). However, the indices of abundance were not weighted by the catch or by fishing effort in the 2010 stock assessment model. Rather, all indices were equally weighted. Therefore, the US

Table 2. Estimates of (and percent change) common management reference points, including SSB_{2008}/SSB_{MSY}, F_{2008}/F_{MSY} and MSY with changes in q applied to all longline fisheries. SSB = spawning stock biomass, F = fishing mortality, MSY = maximum sustainable yield, q = catchability.

Change in q	SSB_{2008}/SSB_{MSY} estimate (% change)	(F_{2008}/F_{MSY}) estimate (% change)	MSY estimate (% change)
Decrease 30%	1.001 (+42.4%)	0.888 (–28.6%)	95,325 (+11.5%)
Decrease 20%	0.873 (+24.3%)	0.999 (–19.7%)	92,402 (+8.1%)
Decrease 10%	0.778 (+10.8%)	1.114 (–10.4%)	89,202 (+4.3%)
No change	0.703 (+0.0%)	1.244 (+0.0%)	85,499 (+0.0%)
Increase 10%	0.645 (–8.3%)	1.379 (+10.9%)	81,742 (–4.4%)
Increase 20%	0.588 (–16.3%)	1.577 (+26.7%)	75,668 (–11.5%)
Increase 30%	0.545 (–22.4%)	1.777 (+42.8%)	71,234 (–16.7%)

pelagic longline index may have had more influence on the stock assessment results than the fleet-specific landings imply.

The extent of the examined change in q (±30%) was similar in magnitude to the reported change in catch rates of tunas from other studies. For example, Curran and Bigelow (2011) reported a 10% increase to 40% decline in the catch rates of many pelagic species captured by Hawaii-based tuna longliners, although some changes were more extreme. It is interesting to note that Curran and Bigelow (2011) report that hook type had no significant effect on the catch rates of bigeye tuna, which implies that the resulting change in catchability was low. Although that result may be applicable to the present study, the objective of our research was to explore the implications of failing to account for a change in catchability within a multi-fleet, age-structured stock assessment model. Thus, we expect that the general conclusion is applicable across modeling platforms and species whenever significant changes in catchability are not adequately accounted for within the model structure and/or inputs.

This evaluation would have been needless, even contraindicated, if the indices of abundance had been derived from scientific surveys that used a standardized gear configuration, or if the fishery-dependent indices had fully accounted for all changes in q. Although a standardized index was developed for the US pelagic longline fishery that accounts for a variety of variables including: year, area, season, fishing target, and some aspects of fishing operation (Ortiz and Cass-Calay 2011), hook type could not be fully accounted for due to the rapid transition to circle hooks, which caused a lack of contrast between year and hook type. Other unquantified changes in q may also have occurred in fisheries targeting bigeye (e.g., due to a change from shallow to deep sets, or from rope to monofilament gear). These changes may be of similar or even greater magnitude than those considered during our study and, like the change due to circle hooks, they are not thoroughly understood or accounted for by the stock assessment model or the index standardization process. Nonetheless, assessments of bigeye tuna, and other species, frequently consider the possibility that unspecified changes in q are reflected within the data inputs and attempt to account for these changes using a variety of techniques. Thus, the changes in q explored here should be interpreted as the potential unaccounted change in q rather than the total magnitude.

To fully characterize the effects of a change in gear configuration within a stock assessment model framework, it is necessary to examine the effects of gear changes on release mortality, and size and/or age based selectivity of the fishing gear in addition to changes in *q*. Furthermore, since these changes can operate simultaneously, the implications for management are difficult to predict. Studies of the effects of hook type on *q*, selectivity, and release mortality of bigeye tuna do not show consistent results. A recent study (Curran and Bigelow 2011) compared large-size 18/0 circle hooks against Japanese style tuna hooks and also against size 9/0 J-hooks and found no significant difference in *q* for bigeye tuna landed by Hawaii-based longliners. There was also no significant difference in the mean length of bigeye across hook comparisons. These results were generally consistent with an earlier study by Kim et al. (2006). In contrast, Pacheco et al. (2011) conducted longline field trials in the western equatorial Atlantic Ocean and demonstrated a significantly higher catchability for bigeye tuna on 18/0 circle hooks compared to J-hooks. Similar inconsistencies are also noted for other pelagic species including billfishes, sailfish, swordfish, and yellowfin tuna (Kerstetter and Graves 2006, Kerstetter et al. 2006, Kim et al. 2006, Diaz 2008, Serafy et al. 2009, Ward et al. 2009, Pacheco et al. 2011). Such comparisons among hook effect studies are fraught with difficulty, as results are often confounded by the use of different hook types and sizes, different bait selection and baiting techniques, insufficient samples sizes, and inadequate experimental designs that do not permit robust statistical inference (Curran and Bigelow 2011). Thus, carefully designed studies are essential to improve our ability to quantify the effects of a proposed gear change, and the potential implications for management.

Acknowledgments

We would like to thank three anonymous reviewers, as well as C Porch and C Brown of the NMFS Southeast Fisheries Science Center for constructive reviews and helpful suggestions.

Literature cited

ANON. 2011. Report of the 2010 Atlantic bigeye tuna stock assessment session (Pasaia, Spain—July 5 to 9, 2010). Collect Vol Sci Pap ICCAT. 66(1):1–186.

ASMFC. 2003. Circle hook definition and research issues. Special Report No. 77. Atlantic States Marine Fisheries Commission.

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 Eco. 14:299–326. http://dx.doi.org/10.1002/aqc.614

Cooke SJ, Barthel BL, Suski CD, Siepker MJ, Philipp DP. 2005. Influence of circle hook size on hooking efficiency, injury, and size selectivity of bluegill with comments on circle hook. N Am J Fish Man. 25:211–219. http://dx.doi.org/10.1577/M04-056.1

Curran D, Bigelow K. 2011. Effects of circle hooks on pelagic catches in the Hawaii-based tuna longline fishery. Fish Res. 109:265–275. http://dx.doi.org/10.1016/j.fishres.2011.02.013

Diaz G. 2008. The effect of circle hooks and straight (J) hooks on the catch rates and numbers of white marlin and blue marlin released alive by the US pelagic longline fleet in the Gulf of Mexico. N Am J Fish Manage. 28:500–506. http://dx.doi.org/10.1577/M07-089.1

Epperly SP, Watson JW, Foster DG, Shah AK. 2012. Anatomical hooking location and condition of animals captured in pelagic longlines: the Grand Banks experiments 2002–2003. Bull Mar Sci. 88:513–527. http://dx.doi.org/10.5343/bms.2011.1083

Gilman E, Zollett E, Beverly S, Nakano H, Davis K, Shiode D, Dalzell P, Kinan I. 2006. Reducing sea turtle by-catch in pelagic longline fisheries. Fish Fish. 7:2–23. http://dx.doi.org/10.1111/j.1467-2979.2006.00196.x

GMFMC. 2008. Final Amendment 30B to the Reef Fish Fishery Management Plan. Gulf of Mexico Fishery Management Council, 2203 North Lois Avenue, Suite 1100, Tampa, FL 33607. 427 p.

ICCAT. 2007. Basic texts (5th Revision). 117 p.

Kaplan IC, Cox SP, Kitchell JF. 2007. Circle hooks for Pacific longliners: not a panacea for marlin and shark bycatch, but part of the solution. Trans Am Fish Soc. 136(2):392–401. http://dx.doi.org/10.1577/T05-301.1

Kerstetter DW, Graves JE. 2006. Effects of circle versus J-style hooks on target and nontarget species in a pelagic longline fishery. Fish Res. 80:239–250. http://dx.doi.org/10.1016/j.fishres.2006.03.032

Kerstetter DW, Pacheco JC, Hazin FH, Travassos PE, Graves JE. 2006. Preliminary results of circle and "J" hook comparisons in the Brazilian pelagic longline fishery. Collect Vol Sci Pap ICCAT. 60(6):2140–2147.

Kim S, Moon D, Boggs C, Koh J, An D. 2006. Comparison of circle hook and J hook catch rate for target and bycatch species taken in the Korean tuna longline fishery. J Kor Soc Fish Tech. 42:210–216. http://dx.doi.org/10.3796/KSFT.2006.42.4.210

NMFS (National Marine Fisheries Service). 2004. Atlantic highly migratory species (HMS); pelagic longline fishery; final rule. Fed Reg. 69(128):40,733–40,758.

NMFS (National Marine Fisheries Service). 2011. Atlantic highly migratory species (HMS); bluefin tuna bycatch reduction in the Gulf of Mexico pelagic longline fishery. Fed Reg. 76:(65):18,653–18,661.

Ortiz M, Cass-Calay SL. 2011. Standardized catch rates for bigeye tuna (*Thunnus obesus*) from the US pelagic longline fleet 1986–2009. Collect Vol Sci Pap ICCAT. 66(1):298–307.

Pacheco J, Kerstetter D, Hazin F, Hazin H, Segundo R, Graves J, Carvalho F, Travassos P. 2011. A comparison of circle hook and J hook performance in a western equatorial Atlantic Ocean pelagic longline fishery. Fish Res. 107:39–45. http://dx.doi.org/10.1016/j.fishres.2010.10.003

Porch CE. 2002. Pro-2Box: Version 2.01 User's Guide. NOAA Southeast Fisheries Science Center, Sustainable Fisheries Division Contribution SFD-02/03-182. 40 p.

Porch CE. 2003. VPA-2BOX: Version 3.01. User's Guide. NOAA Southeast Fisheries Science Center, Sustainable Fisheries Division Contribution SFD/2003-0004. 101 p.

Prince ED, Ortiz M, Venizelos A. 2002. A comparison of circle hook and "J" hook performance in recreational catch-and-release fisheries for billfish. Am Fish Soc Symp. 30:66–79.

Serafy J, Kerstetter DW, Rice PH. 2009. Can circle hook use benefit billfishes? Fish Fish. 10:132–142. http://dx.doi.org/10.1111/j.1467-2979.2008.00298.x

Serafy JS, Orbesen ES, Snodgrass DJG, Beerkircher LR. 2012. Hooking survival of fishes captured by the United States Atlantic pelagic longline fishery: impact of the 2004 circle hook rule. Bull Mar Sci. 88:605–621. http://dx.doi.org/10.5343/bms.2011.1080

Ward P, Epe S, Kreutz D, Lawrence E, Robins C, Sands A. 2009. The effects of circle hooks on bycatch and target catches in Australia's pelagic longline fishery. Fish Res. 97:253–262. http://dx.doi.org/10.1016/j.fishres.2009.02.009

Watson JW, Foster DG, Epperly S, Shah A. 2004. Experiments in the Atlantic northeast distant waters to evaluate sea turtle mitigation measures in the pelagic longline fishery. Report on experiments conducted in 2001–2003. NOAA Fisheries. February 4, 2004. 123 p.

Yamaguchi Y. 1989. Tuna longline fishing (I–V): historical aspects, fishing gear and methods, selection of fishing ground, fish ecology, and conclusions. Mar Behav Physiol. 15:1–81. http://dx.doi.org/10.1080/10236248909378714

Date Submitted: 12 July, 2011.
Date Accepted: 4 April, 2012.
Available Online: 4 June, 2012.

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