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Minimising Unwanted Shark Interactions and Mortalities in CCSBT Longline Fisheries

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Abstract

This paper provides a brief overview of techniques and strategies that can serve to minimize unwanted interactions with sharks in longline fisheries, including those fishing for southern bluefin tuna. Mitigation is a complex subject and the conclusions drawn in this or any overview paper from available studies may not be representative of performance across all fisheries. Nevertheless, in order to provide a framework for understanding the range of available options, this paper summarizes ways of modifying fishing behaviour (setting hooks deeper, reducing soak time, and fleet communication to avoid hotspots); ways of modifying fishing gear (using circle hooks, using nylon (not wire) branchlines, and using fish (not squid bait); applying repellents or deterrents (electrical or magnetic, olfactory or chemical, and artificial bait); and options for safe handling (cutting sharks free in water or removing gear from sharks). Promising options are identified although in each case it will be necessary to further consider the mitigation's effectiveness for the fishery in questions as well as the acceptability to fishers in terms of impacts to target species catches, crew safety, operational costs and environmental effects.

1 Introduction

Fishers' skill is often judged by the degree to which they catch the fish they intend to catch. In many fisheries, however, the gear types used are inherently unselective and thus despite the skill of the fishers, there will be unintentional and unwanted catches of associated species such as sharks, sea turtles, seabirds, marine mammals or other fishes.

In tuna fisheries, sharks are among the most ubiquitous, abundant and problematic of the associated species. Sharks are found throughout the ranges of the major commercial tuna species, and, as similarly high trophic level predators, are attracted to the same baits used to catch target species (or to dense concentrations of target species themselves). In some longline fisheries blue shark (*Prionace glauca*) alone may account for more than 50% of the total fish catch (Coelho et al. 2012). Sharks can also bite off terminal tackle, depredate hooked tuna and create a safety risk for crew attempting to handle them on deck (Clarke et al. 2014). If unintentional shark catch is retained, there may not be a ready, profitable market for the carcasses nor, with reported downturns in the shark fin trade, for their fins (Dent and Clarke 2015). Compounding all of this, shark conservation and management measures such as prohibitions on retention and restrictions on trade have steadily expanded to cover many of the most commonly encountered species.

Technologies and techniques for mitigating shark interactions and mortalities have proliferated in the past two decades but there are still many questions to be answered regarding the efficacy, as well as the economic and operational consequences, of their use. It is also important to note that mitigation performance may vary between areas and fisheries, and in many cases trials have not been conducted widely enough to understand this thoroughly (Clarke et al. 2014). The following sections provide a concise review of techniques for minimising shark interactions and mortalities in longline fisheries. This paper is designed to provide a brief introduction to this potentially voluminous topic and to point the reader to other sources for more information.

2 Prospects for Avoiding Shark Interactions

In general, there are three types of approaches for avoiding shark interactions in longline fisheries: modification of fishing behaviour, modification of fishing gear, and use of repellents. Each of these approaches is introduced below.

2.1 Modification of Fishing Behaviour

Some fishers report that they will either shift fishing grounds or change the way they operate their gear (by changing hook depth, soak time or set start time) in order to reduce shark interactions (Gilman et al. 2007). These techniques can undoubtedly be effective but are likely to require pre-existing knowledge, or considerable trial and error in a given fishing ground, before perfecting. There may also be trade-offs between reduced shark interactions and lower catches of target species when normal fishing behaviours are modified.

Two often-cited methods are setting hooks deeper and reducing soak time. In two recent studies focused on these techniques, minimising the presence of hooks in shallow surface waters was suggested as useful for reducing bycatch in general. However, in the major study of setting hooks deeper, removing branchlines fishing shallower than 100 m did not demonstrate any significant reduction in shark catch rates (Beverly et al. 2009). Similarly, a study focused on exploring the effect of longer soak times found that longer soak times did not increase catches of the target species, and so argued by default that shorter soak times might reduce bycatch (Carruthers et al. 2011). As these were single studies, their applicability across fisheries is not known.

A recent review of these and other potential mitigation measures (Poisson et al. 2016) noted that deep setting can be technically difficult to achieve, and though it has the potential to be effective, it might simply replace catches of shallow-dwelling sharks with those that inhabit deeper waters. It considered that reduced soak time could decrease shark catches as well as the mortality rates for released sharks, but might also reduce catches of target species and disrupt typical crew schedules. Overall the review considered that developing a real-time fleet communication programme to assist fishers to avoid known hotspots would be one of the most effective fishing behaviour modification approaches, equal in its potential effectiveness to deep setting.

2.2 Modification of Fishing Gear

Another type of approach to avoiding shark interactions is to modify the fishing gear componentry, for example the hook types, branchline materials or baits. Although there have been a considerable number of studies published on these types of techniques, the results are highly variable. A recent meta-analysis assessed the relative risk of capturing an elasmobranch with different bycatch reduction "devices" including circle hooks, nylon branchlines and dyed bait. Each of these devices had 95% confidence interval extending from reduced risk through no change in risk to greater risk meaning that none of them were effective in reducing risk in all of the situations studied (Favaro & Coté 2013).

Circle hooks have been examined in a wide variety of locations, and their use is mandatory in some fisheries. Many studies have found no difference in hooking rates for sharks between circle hooks and other hook types, or have found higher hooking rates for circle hooks. There is also evidence that circle hooks are more likely to engage in the shark's jaw and this may provide less opportunity for the shark to bite through the branchline and escape. However, these types of "bite-offs" are only likely if nylon, rather than wire branchlines, are used so the decreased likelihood of "bite-offs" is less relevant in fisheries using wire branchlines. Bait type has also been shown to have variable effects on shark catch rates in different fisheries and may also influence hooking position. Therefore, it is important to consider hook type, branchline (leader) type and bait type combinations, as well as their actual properties (e.g. the width, gape and offset of hooks; and the characteristics and lengths of the nylon) when examining gear modification options (Serafy et al. 2012, Clarke et al. 2014).

The most recent review of fishing gear modification techniques concluded that the effectiveness of circle hooks in reducing shark interactions was unproven and requires more study (Poisson et al. 2016). In contrast, the review considered that prohibiting wire branchlines would be effective and have no major drawbacks, but it is not clear that the reasons for preferring wire branchlines in some longline fisheries (i.e. to support line weighting mitigation for seabirds) were taken into account. The review also recommended prohibiting light sticks and the use of live bait but these seem unlikely to be used when fishing for southern bluefin tuna.

2.3 Use of Repellents

The final type of approach is to use techniques that repel sharks away from fishing gear or deter them from approaching. A considerable amount of laboratory research has been conducted into finding ways to exploit the differences in sensory systems between sharks and teleost (bony) fishes, but to date field testing has been limited. Research has been reported on ferrite magnets, rare earth electropositive metals, rare earth electropositive metal/magnet combinations, electrical currents and chemical surfactants (Clarke et al. 2014).

Most studies involving electrical currents or olfactory chemicals have failed to demonstrate a clear deterrent effect across species, and attraction (rather than repulsion) and habituation may be problematic (Jordan et al. 2013). Using these techniques at sea may be even less effective than in a laboratory setting due to range and dispersion issues, and the potential for adverse environmental effects is poorly understood. Results with magnets and electropositive metals are more promising in some cases but appear to vary across shark species, perhaps as result of species-specific sensory system differences (Hutchinson et al. 2012).

The most recent review (Poisson et al. 2016) considered the current state of information about electrical, magnetic, olfactory and auditory deterrents. It concluded that more investigation of all of these options is necessary but suggested that olfactory and auditory deterrents appear slightly more promising. Habituation, environmental effects, cost, and effects on target species were all identified as issues requiring further study. Poisson et al. (2016) also considered artificial baits in this category, as such baits could in theory be tailored to selectively repel certain species. Artificial baits were deemed to be preferable to the other repellents and deterrents considered, but still face many of the same issues regarding practicality and unintended consequences.

3 Prospects for Minimising Shark Mortalities

We can expect that even optimum mitigation measures will still result in the hooking of sharks on some sets. Therefore, in the event that shark interactions are not completely avoided it is also important to consider how to handle sharks to both protect the health and safety of the crew and to maximize the survival of the sharks. Although mortality rates for some sharks can be reduced through safe handling and release techniques, resilience to capture and some sharks will benefit more than others (Dapp et al. 2016, Gallagher et al. 2014).

In the Atlantic, Indian and Pacific Oceans tuna regional fisheries management organizations (t-RFMOs) have adopted no-retention measures for some of the most vulnerable shark species. CCSBT members are required to comply with all applicable measures adopted by the International Commission for the Conservation of Atlantic Tunas (ICCAT), Indian Ocean Tuna Commission (IOTC) and Western and Central Pacific Fisheries Commission (WCPFC) when operating in southern bluefin tuna fishing grounds overlapping any of these three Convention Areas. While the requirements to release the sharks are clear, in most cases there are few, if any, guidelines or required procedures when doing so. Difficulties in adopting such procedures arise from the lack of information available to scientifically determine which methods are better than others, or alternatively, which methods meet a threshold of acceptability. These issues are further complicated by the diversity of operational configurations for which there is probably no one-size-fits-all best practice recommendation.

In general, there are two options for dealing with unwanted hooked sharks: release the shark in the water by cutting the branchline, or haul the shark to the vessel and attempt to remove the gear. There is a lack of scientific evidence on the relative effects on survival of these two methods, though it is likely that release in the water will be less detrimental to live sharks. Nevertheless, even if a live shark is released in the water it may still not survive. Such sharks may succumb to either the stress from hooking and haulback, or to the potential chronic effects of entanglement or ingestion of trailing gear. Some fishers may resist releasing sharks in the water as it results in the loss of the terminal tackle. In fact, retrieval of the terminal tackle may be one of the prime motivating factors in bringing unwanted sharks to the vessel. Although gear removal seems more likely to injure the shark than cutting it free, the degree of injury will depend on the equipment and skill used and can be expected to range from minimal to traumatic. As noted by Poisson et al. (2016) tools, training and, perhaps, incentives may be necessary for gear removal options to minimize shark mortality.

Several guides have been produced recently which explain safe release techniques for sharks and rays caught by longline fisheries:

- Patterson and Tudman (2009) reviews a variety of mitigation options specifically for pelagic sharks caught by longline fisheries in Australia;
- A report by the Safina Center (2014) provides do's and don'ts for Pacific longline fisheries practicing safe release of sharks and rays; and
- Poisson (2016) provides a fully-illustrated handbook based on France's longline fisheries in the Mediterranean (in French).

The WCPFC's Scientific Committee will discuss guidelines for the safe release of encircled and non-encircled animals at its next meeting in August 2017.

4 Conclusions

An array of options are available for fishers who seek to minimize interactions with sharks. This paper attempts to provide a brief introduction to these options with the caveat that the situation in each fishery is likely to lead to a different optimal approach. A summary of the preceding sections on modification of fishing behaviour, modification of fishing gear, and repellent/deterrent approaches is provided in Table 1. Fleet communication has the advantage of using real-time information and fishers' own solutions to adapt to a dynamic environment. It also appears to be better able to avoid many of the disadvantages of the other approaches, which may work well in some situations but prove unworkable in others. Poisson et al. (2016) highly recommended the use of nylon branchlines as a means of reducing shark interactions, but the analysis of Favaro and Coté (2013) suggested this method is less, or not, effective in some cases particularly when multifilament rather than monofilament is used. Furthermore, it seems unlikely that all fishers currently using wire branchlines wish to catch sharks. Thus there may be other reasons for preferring wire branchlines for non-shark target species in some fisheries, and these may prevent ready adoption of nylon branchlines. Cutting sharks free seems clearly preferable to attempting to remove the gear, although it is noted that the cost to fishers of lost gear and the effects of the trailing gear on the sharks may not be negligible.

It should also be noted that shark interactions are not a new problem, and many fishermen have undoubtedly already found ways to avoid unwanted shark catches when targeting other species. The recommendations of Poisson et al. (2016) are based on a combination of effectiveness and acceptance by fishers, and though this mixes two very different types of evaluations onto one scale, the most useful approaches will necessarily score high in both. That study ultimately grouped approaches into those that are "supported by fishers as they have no impact on the yield of target species", "accepted by all longline fisheries because they are easy to implement at relatively low costs", or "theoretically attractive but not successfully tested in the field". Use of nylon branchlines was placed in the first group, whereas fleet communication was placed in the second. These conclusions should be treated as generic (as should those in Table 1) because the effects of most mitigation measures on target species are poorly studied, and it is quite possible that if there were such target species effects, the mitigation measures would not be used and there would be no data to report. Similarly, what is considered to be low cost will vary among fisheries based on profitability, the cost of not mitigating shark interactions, and potentially other factors.

Previous work on shark mitigation in the WCPFC may also be useful when considering mitigation options for southern bluefin tuna fisheries. A series of analyses by the Pacific Community (SPC) explored the effects of operational variables such as the use of shark lines (branchlines running directly off the longline floats), the use of wire branchlines, bait type and hook type on catch rates and condition of several species of sharks across a variety of fisheries (Bromhead et al. 2013, Caneco et al. 2014, Harley et al. 2015). These results identified that the use of wire leaders and shark lines result in higher shark catches, and contributed to the adoption of a WCPFC Conservation and Management Measure (CMM 2014-05) requiring that members ensure that their vessels either do not use wire branchlines, or do not use shark lines. Also in the WCPFC, a study is being conducted to investigate shark post-release mortality rates in several species and fisheries (Common Oceans 2017). Estimates obtained from this study are expected to assist with quantifying total mortality in stock assessments and informing assessments of the effectiveness of shark no-retention measures (currently applicable in the WCPFC to oceanic whitetip, silky and whale sharks).

Optimal shark minimization strategies for southern bluefin tuna fisheries, as well as for most other tuna fisheries, will need to be tailored to individual circumstances. In order to facilitate stakeholder access to a wide range of bycatch information, and provide tools to interpret it, the Western and Central Pacific Fisheries Commission is further developing its Bycatch Management Information System (BMIS) with support from the Areas Beyond National Jurisdiction (Common Oceans) Tuna Project. The aim of the re-developed BMIS is to provide a global platform to support outreach and management decision-making (Fitzsimmons et al. 2015). The original system is available at http://www.wcpfc.int/bmis and will be relaunched soon with new interfaces, updated content, and a broader range of bycatch-related topics. (Any users interested in using a beta-test version of the new BMIS website incorporating the expanded content, please contact the author of this paper for login details.) More information on the mitigation approaches introduced here, including the cited literature, is available through the BMIS.

Table 1. Summary of shark interaction and mortality approaches described in this paper. √=a positive feature of the approach; ?=a potential positive feature of the approach. Please refer to text and cited references for more information noting that this table generalizes from an often complex situation and may not apply across all fisheries and variations of the listed approaches.

Approach	**Strong Evidence of Effectiveness for Reducing Shark Interactions**	**No Major Technical Barriers**	**No Reduction in Target Species Catch Rates?**	**No Increased Risk to Crew Safety**	**No Major Increased Costs**	**No Major Environmental Effects**
Modifying Fishing Behaviour						
Set Hooks Deeper				√		√
Reduce Soak Time		√	?	?	√	√
Fleet Communication to Avoid Hotspots	√	√	√	√	?	√
Modifying Fishing Gear						
Use Circle Hooks		√	?	√	√	√
Use Nylon (not Wire) Branchlines (Leaders)	?	√	?	√	√	√
Use Fish (not Squid) Bait		√	?	√	?	√
Repellents/Deterrents						
Electrical or Magnetic			?	√		?
Olfactory or Chemical			?	√		?
Artificial Bait			?	√		?
Safe Handling						
Cut Sharks Free in Water	√	√	√	√	?	√
Remove Gear from Sharks	?	?	√			√

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