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Draft best practice mitigation guidelines for sharks and rays taken in purse-seine and long-line fisheries

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Activity 8 of the CMS Sharks MOU Programme of Work (2016-18) is to "Promote research focusing on the identification of species-selective fishing gear and bycatch mitigation measures". This document briefly sets out options for mitigating the capture of sharks and rays listed by the two major pelagic fishing gears managed by the five tuna Regional Fisheries Management Organizations (RFMOs): purse-seines and long-lines. The impacts and mitigation of trawling and gill netting, the two other fishing gears with a significant effect upon shark and ray populations, are not considered here.

This review is undertaken in the context of the CMS Migratory Sharks MOU and the shark and ray species listed in Annex I, but also takes into account other taxa. This is particularly important where techniques that mitigate the impact of a fishery on Annex I species may increase the impact of that fishery on other vulnerable species, including those listed in the CMS Appendices and other CMS agreements.

Mitigating (lessening the severity of) the impacts of purse seines and long lines can be addressed in three ways:

- Indirect mitigation;
- Capture avoidance;
- Improved escape from fishing gear, handling techniques, and post-release survival.

Recent literature and other sources of information were reviewed to identify recommendations for best practice in these areas. These results were compared with the Conservation and Management Measures (CMMs) that have been adopted by RMFOs. Bycatch mitigation methods are relatively straightforward and consistent for purse seine fisheries. In comparison, studies and reviews of long line capture mitigation for sharks (e.g. Ardill et al. 2011, Favaro and Côté 2013, Gilman et al. 2008, Howard 2015, Patterson et al. 2014) have identified numerous techniques that may potentially reduce bycatch rates for sharks and rays, but very few that are effective across several species and fisheries. Many reduce bycatch rates for some species but increase them for others, requiring a case-by-case approach to longline fishery mitigation.

In all cases, it is essential to involve industry bodies in the development of best practice for bycatch mitigation measures. Furthermore, best practice guides (several already exist) must be disseminated as widely as possible among crews, and the crews be trained in the use of the techniques recommended. Without these measures, even the simplest best practice options are

unlikely to be adopted. Given their adoption, further research is urgently needed into the efficacy of all mitigation measures for reducing mortality and improving stock status.

1. Indirect mitigation

Indirect methods for mitigating the impacts of fisheries on non-target species may be very successful. For example, the International Seafood Sustainability Foundation (ISSF) has mitigated for seabird and turtle bycatch mortality by identifying and protecting nesting grounds for these taxa. Improved breeding success at bird colonies (e.g. by eradicating rats from islands) and at turtle beaches (e.g. through wardening and education) increases juvenile and adult survival and hence population growth rates. By improving the overall status of the population, the relative impact of bycatch mortality is reduced.

1. 1.1. Identification and protection of critical habitats

The FAO IPOA-Sharks urges States to adopt national shark plans and suggests that these should *inter alia* "determine and protect critical habitats". Most tuna RFMOs (ICCAT, IATTC, IOTC, GFCM) have adopted CMMs that encourage their Members to identify nursery grounds. IATTC Resolution C-2016-04 goes further, asking Members to "undertake research to… identify key shark mating, pupping and nursery areas". However, none of the RFMOs recommend that these areas, once identified, be protected. The IATTC Secretariat (IATTC-90-04d (Rev)) recommends that fishing with steel leaders should be prohibited within silky shark pupping grounds, once these have been identified.

Best practice for management of critical habitats

Regional Fisheries Bodies to encourage their Members to report on the location of nursery grounds and other critical habitats and to take appropriate actions to mitigate bycatch in these locations.

Best practice could include:

- Spatial closures: the permanent or seasonal closures of critical habitats,
- Prohibition of fishing with steel leaders in critical habitats,
- Permanent or seasonal gear restrictions in other fisheries that exploit these areas.

Recommendation:

The CMS Sharks MOU Conservation Working Group to consider additional indirect mitigation measures that could be applied to improve population growth rates for Annex 1 shark and ray species, and thereby reduce the impact of bycatch mortality.

2. Capture avoidance

The single most important mitigation measure that can be adopted for sharks and rays is to avoid catching them in the first place. Several RFMOs have prohibited the retention of species listed in Annex I and require their live release (see section 3). It is easier to adopt prohibitions on retention than it is to agree to mandate techniques to avoid capture.

2. 2.1. Capture avoidance in Purse seines

The use of Fish Aggregating Devices (FADs) is the single greatest risk factor for high levels of shark bycatch. FADs can also catch sea turtles.

IATTC defines a Fish Aggregating Device (FAD) as an anchored, drifting, floating or submerged object deployed and/or tracked by vessels, including through the use of radio and/or satellite buoys, for the purpose of aggregating target tuna species for purse-seine fishing operations. The WCPFC definition includes "any object or group of objects, of any size, that has or has not been deployed, that is living or non-living, including but not limited to buoys, floats, netting, webbing, plastics, bamboo, logs and whale sharks floating on or near the surface of the water that fish may associate with" (CMM 2008-01). IOTC distinguishes between Drifting (DFAD) and Anchored (AFAD) FADs when recommending FAD management measures.

The greatly increased use of artificial FADs during the past decade has resulted in a huge rise in shark mortality. This has taken two forms: hidden mortality through entanglement in nets hung under drifting FADs (which are used to increase biomass associated with FADs, and hence tuna catch rates); and bycatch mortality in seine nets set on FADs. Industry-led research (ISSF 2016) suggests that shark bycatch in sets on floating objects (natural and man-made) tend to be 2 to 6 times higher than they are when set on free-swimming schools. If sets were only made on free-swimming schools of tuna, this could reduce silky shark capture in the western and central Pacific by 83% (Peatman and Pilling 2016). Furthermore, the numbers of sharks associated with FADs are independent of the numbers of tuna present. Hence, avoiding setting on FADs with only low numbers of tuna present will reduce the proportion of shark bycatch to tuna catch. A reduction of 21-41% of the shark catch (depending upon ocean area) could be achieved through a 3-10% reduction in tuna catch (Dagorn et al. 2012).

These issues are recognised and RFMOs have, since 2012/2013, begun to address the management of FADs. ICCAT, IOTC and IATTC now require fleets to transition to non-entangling FADs to reduce hidden mortality. WCPFC may adopt this measure at the December 2016 Commission meeting.

In 2013, the IOTC (Res 2013/08, amending Res 2012/04) required CPCs using FADs to develop FAD Management Plans and called for improved FAD designs to be developed to reduce the incidence of entanglement of non-target species. Resolution 2015/08, which

superseded 13/08, set an upper limit on the number of instrumented DFADs per vessel, asked for more detailed management plans to be developed, and set principles for the design and deployment of FADs. Resolution 15/09 established an ad hoc FADs Working Group to assess the consequences of the increasing number and technological developments of FADs in tuna fisheries and their ecosystems, in order to inform and advise on future FAD-related management options. The IOTC Secretariat was asked to liaise with the ICCAT Secretariat to determine whether their respective FAD WGs could work together.

ICCAT's FAD Working Group (Recommendation 2015-02) is charged with, *inter alia*, identifying management options and common standards for FAD management, including management plans, deployment limits, characteristics and use of FADs, and evaluating their effect on ICCAT managed species and pelagic ecosystems, based on scientific advice and the precautionary approach. The ICCAT FAD WG is reporting and making recommendations to the 2016 ICCAT Commission meeting in November 2016.

In 2016, the IATTC also resolved to establish a multi-sectoral *ad hoc* Permanent Working Group on FADs (Resolution C-2016-01 amending C-2015-05, which had amended C-2013-04). The objectives of this group include, *inter alia*, FAD data collection and compilation, compilation of information regarding developments on FADs in other tuna RFMOs and the latest scientific information on FADs (including non-entangling FADs), and identifying priority areas for research. The Working Group will identify and review possible FAD management measures and make recommendations to the Commission.

Best practice for Fish Aggregating Devices (FADs)

While best practice currently includes the following, these and other measures are under review by RFMO working groups and best practice is likely to develop rapidly.

- Avoid FADs: set on free-swimming tuna schools.
- Use chum to attract sharks away from FADs before the set is made.
- Remove and destroy entangling FADs.
- Avoid setting on FADs when less than 10t of tuna are present.
- Improve FAD design.
- Minimise the use of non-biodegradable materials in FAD construction.
- Vessels to report all interactions with FADs to the relevant RFMO.
- All FADs used by CPC vessels to be clearly identified with alpha-numeric codes.
- Regulate the total number of FADs deployed.
- Spatial closures, where FAD deployment is prohibited.
- Develop national and fishery-wide FAD Management Plans.

Recommendation:

CMS to seek opportunities to become involved in the RFMO FAD working groups on behalf of the Sharks MOU and Bycatch Group. This issue is important not only for shark and ray species, but also for other CMS migratory species impacted by FADs.

3. 2.2. Capture avoidance in long lines

While numerous techniques and devices for reducing shark bycatch in long line fisheries have been trialled and reviewed (e.g. Favaro and Côté 2013; Godin et al. 2012; Gilman et al. 2016; Howard 2015; Patterson et al. 2014), only a few have been found to be effective across several species and fisheries. Several may reduce bycatch rates for one shark species, but increase it for other sharks, or reduce shark catch rates at the expense of other vulnerable species. In almost all cases, therefore, it is necessary to tailor mitigation measures to specific fisheries.

Favaro and Côté (2013) examined bycatch reduction devices (BRDs) for longlines, including different hook types and repellents (electropositive and magnetic), dyed bait, various materials for hook leaders made from various materials and the use of floats to raise lines off the seabed (thus reducing catches of benthic species). The last of these was the only BRD that yielded a statistically-significant reduction in capture rates/increase in capture avoidance across all studies, although other BRDs were apparently effective to some extent in individual studies. Howard (2015) concluded that large hooks reduce capture rates for some species.

Favaro and Côté (2013) did not consider changes to fishing techniques, such as switching baits, deep-setting and night setting. Switching bait can reduce shark catches, but the effect is species-specific and may also increase bycatch of other CMS species, such as turtles.

Night setting in the southwest Indian Ocean minimises shark bycatch on shallow sets, while maximizing catch of target swordfish (Auger et al. 2015). However, night setting does not necessarily reduce shark bycatch in some other fisheries and regions.

Longlines set at depths >100m catch significantly fewer sharks than shallow hooks. ICCAT has, from 2018, prohibited the use of shallow "shark lines" (individual lines attached to the floatline or to the floats directly, and used to target sharks) by longline vessels. WCPFC gives vessels the choice between either not using wire branch lines and leaders, or not using shallow set shark lines that run directly off longline floats (CMM 2014-05). Sharks caught on shallow set monofilament lines may be able to bite off the line to escape, but sharks are less likely to be caught in the first place on deep set lines.

The use of monofilament leaders results in lower catch rates, but this is not due to capture avoidance, it's because sharks are more likely to bite off the leaders and escape. "J" hooks do not reduce shark bycatch, they increase escape; deep-hooked sharks are more likely to bite off monofilament lines than sharks caught on circle hooks, but post-escape survival will be lower.

Best practice for avoiding capture on longlines

- Set tuna longlines deeper than 100m; do not use shallow shark lines.
- Avoid setting lines on the bottom; use floats to raise demersal lines.
- If shallow lines are needed (e.g. for swordfish), set longlines overnight.
- Monofilament lines and large circle hooks maximize escape and post-release survival.
- Other mitigation techniques and BRDs may be species- and fishery-specific and should be tested with industry.

3 Improved release and post-release survival

Improved techniques for releasing bycatch alive and in good condition has been an important mitigation measure for many years. All RFMOs require prohibited species to be released promptly, unharmed. Pregnant females and juveniles are often also priorities for live release, and current CMMs require that all sharks retrieved alive and not retained should be released unharmed. The most recent CMMs provide detailed instructions for release of bycaught sharks (e.g. IATTC Resolution C-2016-05, specifies safe release requirements for all sharks except those retained aboard the vessel, to take effect from 1 January 2018).

RFMOs have relatively recently started to consider the potential scale of post-release mortality for non-target species. Research is being commissioned to take this into account when developing best practice for release of bycatch, to minimise mortality and improve stock status.

3.1 Release from purse seines

4. Release from the net

Sharks that have been encircled by purse seine nets survive best if they can be released from the net before being brailed[1] on board the vessel. The industry has tested several methods, with variable success (ISSF 2016, Poisson et al. 2012). The least damaging method is to use a brailer to scoop sharks and rays straight out of the bunt and release them into the ocean, as specified in IATTC Resolution C-2016-05. Using baited hooks to fish the sharks out of the bunt and release them outside the net has been successful, with low bycatch mortality because of the short period between hooking and release and an estimated 21% increase in shark survival (ISSF 2016). Efforts to attract sharks out of the net by towing the FAD through a gap between the net and the hull of the fishing vessel have not worked. Research into the use of shark escape panels in the seine net has had mixed results and is ongoing. Sharks entangled in the walls of the seine net can have high survival rates, particularly if they are released before being taken on board the vessel. Sharks that are brought on board after the net has been hauled (which takes up to an hour) have much lower survival rates, particularly if they have been compressed in the sack with the rest of the catch (e.g. Poisson et al. 2012 and 2014).

1 The brail is the scoop used to lift fish from inside the bunt (the sack formed by the purse seine) to the deck for sorting.

WCPFC SC8 (2012) decided that it was not possible to determine the "best" practical method for release of encircled animals, such as whale sharks. Ropes should not be used to tow whale sharks out of a purse-seine net.

5. Release from the deck

Filmalter et al. 2015 found that simple best practice could reduce direct mortality of silky sharks released from the deck by up to 20%. Speed of release is essential for sharks and rays that have been brought on deck from the seine net, if mortality is to be minimised. IATTC Resolution C-2016-05 notes that, if it is not possible for safety reasons to release sharks directly into the ocean, sharks landed on deck must be returned to the water as soon as possible, either utilizing a ramp from the deck connecting to an opening on the side of the vessel, or through escape hatches. If ramps or escape hatches are not available, the sharks must be lowered with a sling or cargo net, using a crane or similar equipment, if available. It is prohibited to use gaffs and hooks to handle sharks. Sharks cannot be lifted by their head, tail, gill slits or spiracles or with wire, nor can holes be punched through their bodies to help to lift them.

Poisson et al. (2013) identify two opportunities to return sharks and rays to the sea. The first is when the catch is brailed onto the upper deck and sorted by the crew. Some 60% of sharks are still alive at this point. The authors recommend using a hopper to sort the catch when it arrives on the upper deck, to make it easier for crew to separate sharks and rays from the target catch, and adapting the design to make it easier to sort out the smaller sharks. Small sharks that are not removed on the upper deck pass down a chute to the lower deck for further sorting. Fewer than 30% of sharks were still alive when handled on this deck. Shark bycatch can still be released at this point if the vessel is equipped with a bycatch conveyor belt and a waste chute with a sufficient water flow to evacuate the shark through the drain pipe.

Best practice for releasing bycatch from purse seines

- Whenever possible, release shark bycatch before it reaches the deck.
- Cut the net to allow large whale sharks to swim out, or roll them over the float line and out of the bunt. Do not use ropes to tow them.
- Use a brailer to lift sharks <3m long out of the bunt, over the float line, and into the sea.
- Release sharks entangled in the walls of the bunt back into the sea as the net is being hauled, by reducing the haul rate to reduce tension and if necessary cutting the net.
- Use hooks and lines to fish sharks out of the bunt and release them into the sea.
- Test the use of an escape hatch to allow sharks to swim out of the bunt.

Best practice for releasing bycatch from purse seiner decks

- Return bycatch to the water as quickly as possible.
- Use hoppers to facilitate the rapid sorting and release of sharks and rays landed on deck from the brailers.
- Ensure that crews are trained to handle bycatch carefully; it must not be lifted by the head, gill slits, spiracles or tail, be thrown or dropped onto the deck, or trodden on.
- Do not use gaffs, hooks or wire to punch holes in, handle, or move sharks and rays.
- Provide ramps or escape hatches from the deck to openings on the side of the vessel to allow sharks and rays to be returned rapidly and safely to the sea. Small animals can be dropped headfirst into the water.
- Use a crane with a sling or cargo net to lower large sharks and rays into the sea, if no ramp or escape hatch is available.
- Shark bycatch may be released alive from the lower deck if there is a bycatch conveyor belt and a waste chute with a sufficient water flow to carry the shark through the drain.

3.2 Release from longlines

Scientific and industry advice is consistent about the importance of using circle, rather than 'J' hooks. This is because circle hooks usually lodge in the mouth, where they are much easier to release, while J-hooks are more likely to result in gut-hooking and mortality either before the longline is hauled, or after the shark has been released. Larger sized circle hooks also select against the capture of some species of shark and ray.

The use of monofilament instead of wire leaders is also agreed to be best practice; some sharks will bite off monofilament lines before they are hauled, and those that are brought to the side of the vessel can easily and safely be released by cutting the snoods, even if the hooks cannot be removed.

The length of the set, or soak time, has a major impact on survivorship. Longer sets result in higher mortality rates.

Post-release survival is higher if sharks and rays are not stressed and physically damaged by being hauled on deck. It is always best to release sharks in the water. If the hook cannot be removed easily and safely, a line cutter should be used to cut the line as close to the hook as possible to minimise trailing line. If the shark must be brought on board, it is essential to minimise the length of time that it spends out of the water.

Best practice for reducing mortality of sharks and rays caught on longlines

- Use large circle hooks and monofilament lines.
- Use as short a soak time as practical.
- If possible, release sharks without removing them from the water.
- If hooks cannot be removed, use a line cutter to cut the line as close to the hook as possible.
- If sharks must be brought on deck, minimise the time they spend out of the water.
- Train crew to handle sharks carefully on deck (see best practice handling technique for purse seine catches).
- Exclude longlining from critical habitats, or mandate best practice in these areas.
- Undertake research with industry to identify other longline mitigation measures and best practices for particular species, fisheries, and regions.

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