INTER-AMERICAN TROPICAL TUNA COMMISSION

SCIENTIFIC ADVISORY COMMITTEE

15TH MEETING

La Jolla, California (USA)
10-14 June 2024

SAC-15-11

BEST HANDLING AND RELEASE PRACTICE GUIDELINES FOR SHARKS IN IATTC FISHERIES

Melanie Hutchinson, Jon Lopez and Alexandre Aires-da-Silva

CONTENTS

EXECUTIVE SUMMARY

In the Inter-American Tropical Tuna Commission (IATTC), there's a growing emphasis on employing Best Handling and Release Practices (BHRP) for sharks to mitigate the impacts of fishing. To facilitate the development of shark BHRP guidelines, the IATTC Commission requested (under Resolution C-23-07) the IATTC staff to develop and recommend, in collaboration with the EBWG and the SAC, a set of best handling guidelines for the safe release of sharks for consideration in the 2024 meeting of the Commission. Therefore, the IATTC staff prepared the present document, which is structured by fishing gear types and aims to provide a comprehensive background for the adoption of practical, effective, and implementable BHRPs for reducing shark mortality resulting from bycatch. Specific recommendations are outlined for purse seine, longline, and gillnet fisheries, addressing various stages of fishing operations. For purse seine fisheries, strategies include avoiding shark interactions, releasing entangled sharks promptly, and minimizing handling time onboard. Longline fisheries are advised to leave sharks in the water, remove trailing gear, and minimize handling stress to improve post-release survival. Gillnet fisheries require further data collection to inform effective BHRP guidelines but methods to reduce harm are provided. The draft guidelines for integration into Resolution C-23-07 are provided in Annex 1. Feedback from the EBWG and the SAC will be taken into consideration by the staff in the preparation of the final list for consideration at the 102nd Commission meeting.

1. BACKGROUND

Concerns about the incidental capture (i.e., bycatch) of vulnerable marine species, including marine mammals, seabirds, sea turtles, and elasmobranchs, have resulted in increased efforts to develop conservation and management measures that avoid interactions with fishing fears and reduce mortality. In the Inter-American Tropical Tuna Commission (IATTC), currently, these measures often require, among others, that no retention takes place and that the best handling and release practices (BHRP) are employed to reduce the impacts of fishing on these populations. Although most of these IATTC measures allude to the use of best practices, ban certain practices, or provide general common-sense recommendations, they lack specific guidance that has been tested for efficacy and measurable impacts on survival. Thus, BHRP guidelines still need to be developed and adopted into the regulatory framework for several species and fishing gears domestically, regionally, and globally.

The development of BHRPs is often an iterative process. It requires *a priori* knowledge of: i) the fishery specific operational characteristics (e.g., vessel sizes and designs, free board, gear availability and composition, mitigation tool availability, handling and releasing practices used); ii) behavior and physiology of the bycatch species; iii) data that validates the efficacy of the practice (i.e., post release survival studies); and iv) the engagement of the fleet, and other stakeholders, to assist with the development and testing of practices that are endorsed by fishers, feasible and practical, in other words, practices that can be implemented operationally.

In response to this need, the IATTC staff conducted a review of available literature, knowledge, research and data relevant to the development of BHRP guidance (EB-01-01). The document identified knowledge and data gaps and reviewed the current vulnerable species Resolutions to identify where BHRP guidelines can be implemented into the regulations and where additional research is required in the IATTC Convention area of the eastern Pacific Ocean (EPO). The paper was presented to the IATTC's permanent Working Group on Ecosystem and Bycatch (EBWG; Res. C-22-06) at its first meeting and the Scientific Advisory Committee (SAC) at its 14th meeting (SAC-14-16). Accordingly, the SAC endorsed the EBWG recommendation that: a) the development of BHRP guidelines for vulnerable species are addressed and, b) CPCs and other relevant stakeholders support the IATTC staff in a survey to gather details of national efforts or programs that can help elucidate post-release survival rates of vulnerable species captured in the various fisheries under the purview of the IATTC. In recognition of the above recommendations, the 101st Commission adopted Resolution C-23-07 on sharks with paragraph 12 requiring '*the IATTC scientific staff, in collaboration with the IATTC SAC and EBWG, shall develop and recommend to the Commission a set of best handling guidelines for the safe release of sharks for inclusion in this measure in 2024*'.

To meet these requirements, a Memorandum was sent by the Director of the IATTC to all CPCs (Reference: 0473-410) requesting any existing guidelines or regulations on best handling and release practices for vulnerable species and existing data that elucidates the post release fate of marine mammals, seabirds, sea turtles, sharks, and rays for tuna and tuna-like fisheries under the purview of the IATTC. The memo also requested that Members and Cooperating non-Members (CPCs) identify and designate subject matter experts that could potentially assist the IATTC staff with the development of the guidelines referred to above for each taxa and fishery.

Following the request made under Resolution C-23-07 paragraph 12 for the staff to work in collaboration with the IATTC SAC and EBWG to derive BHRP guidelines, this paper presents all the necessary background, context, and scientific evidence to support the proposed draft BHRP guidelines (Annex 1) for consideration at the EBWG and the SAC meetings. Feedback from the EBWG and the SAC will be taken into consideration by the staff in the preparation of the final list to bring to the 102nd Commission meeting. In addition to the proposed draft guidelines for BHRP, the staff reviews additional relevant content below on practices that could also reduce the impacts of tuna fishing on shark populations, including avoidance

and gear configuration. These practices will be further considered by the staff in the future but are provided here for comprehensiveness and to assist in the discussions by the EBWG and the SAC.

1.1. Objectives

This document synthesizes all the available scientific evidence and data, including the information provided by CPCs in response to the Memorandum 0473-410, in support of the development of BHRP guidelines for sharks, as required by Resolution C-23-07. It also provides an update to the review of available literature and current BHRP guidelines for sharks that began with EB-01-01. The combined content was used to inform the draft BHRP guidelines for sharks captured in IATTC fisheries presented in this document. The recommended guidelines are separated by the main fishing gears used in the EPO for tuna fisheries (purse seine, all hook and line fisheries and gillnet) and the following sections are constructed with the background rationale justifying the recommendations throughout the text. The resultant proposed BHRP guidelines for consideration at the 102nd meeting of the Commission are summarized in Annex 1 and formatted to ensure the framework and minimum set of standards for BHRP development, introduced in EB-02-03 are consistent. Where appropriate, the text was maintained from language previously adopted in Resolutions C-23-07 and C-23-08. Special effort was made to ensure that all recommendations throughout this document are reasonable, practical, effective, and implementable in each fishery setting with crew safety prioritized.

2. PURSE SEINE

IATTC purse seine fisheries interact with several species of sharks, but species composition of the elasmobranch bycatch is dominated by juvenile silky sharks (*Carcharhinus falciformis*, SAC-14-11). Several studies have been conducted across ocean basins to investigate post release survival (PRS) rates and handling and release methods that improve survival of silky and other shark species captured in purse seine fisheries (Table 1). The following recommendations are listed in order of the progression of the purse seine fishing operation: from avoidance of encirclement to the net hauling stage, the sacking up stage, and finally, the brailing stage, where fish are brought on board - because the methods for BHRPs are somewhat specific to fishing stage.

2.1. Avoidance

There is overwhelming scientific evidence (Table 1) that survival is compromised once sharks have been confined to the sack portion of the net. Therefore, the most effective means of reducing shark mortality in this fishery is to either remove sharks from the net prior to sacking up or to avoid shark interactions altogether. However, current practices to remove sharks from the net seem impractical and methods to avoid or reduce interaction are in development, especially those based on ecoinformatics and environmental modelling, e.g., dynamic ocean management (SAC-10 INF-D). Studies have indicated that the smallest set sizes have the highest proportion of shark to tuna ratios (Dagorn et al. 2012). Avoiding sets on small schools of tuna would reduce shark and other bycatch rates while improving fishing efficiency (Dagorn et al. 2012), especially on floating objects, hereafter called fish-aggregating devices (FADs) for simplicity. Shark bycatch rates are in general significantly higher in sets made around drifting FADs than on sets on tuna schools associated with dolphins (~3-3.5 times higher) and sets on unassociated schools (~ 4.5 times higher; EB-02-01). If sharks are encircled, efforts to remove them from the net while they are still free-swimming should be promoted (i.e., prior to sacking up), as post-release survivorship has been shown to be 100% (Hutchinson et al. 2015, Sancristobal et al. 2016; Restrepo et al. 2018, Hutchinson et al. 2019).

Specific considerations to reducing interaction rates & to reduce shark mortality in the purse seine fishery:

- Avoid, to the extent possible, sets on small schools (< 10 mt).

- Remove sharks from the net while they are still free-swimming.

2.2. Sharks entangled in the net during haul back

After a tuna school is encircled and the net has been pursed, the crew begins hauling the net back on board and gets the catch next to the vessel for brailing onboard. Some sharks become entangled in the main purse seine net during this net hauling and restacking process. Research has shown that survival rates of entangled sharks can be high (80-84%) when BHRP are used, likely because these individuals were never subjected to confinement in the sack and are released early in the operation (Poisson et al. 2014; Hutchinson et al. 2015; Onandia et al. 2021).

BHRP Recommendations:
To maximize post release survival of sharks entangled in the purse seine net during the net hauling process:

- Do not roll sharks with mandatory release requirements through the power block.
- Drop the net to the deck and allow crew to safely cut the net away from the animal.
- Maneuver the animal into a stretcher or cradle immediately and release it on the port side of the working deck.

Tools Required:

- Stretcher or cradle (See Figure 1 for example).

2.3. If sharks are present and visible on top of the sack

Once most of the net has been hauled in, the crew begins 'sacking up' the net manually (pulling the net up) to reduce the volume of net, condensing the catch into a tight sausage-like 'sack' at the side of the vessel for more effective 'brailing'. Brailing is the process of bringing the catch onboard using a winch operated large dipnet (volume can reach ~8 metric tons) called a 'brailer'. The brailer is dropped into the sack and pulls the catch from the sack onto the main deck of the vessel in a sequence of brails. Survival rates of sharks that are present on the top of the sack and brought on board during the first few brails have been shown to be higher (13-57%) than for those sharks that are brought on board in later brails (6-30%) (Hutchinson et al. 2015, Onandia et al. 2021). Therefore, the release of visible sharks on top of the sack at the commencement of brailing operations should be prioritized.

BHRP Recommendations:
To maximize post release survival of sharks that are visible on the top of the sack:

- When sharks are visible on top of the sack, the vessel should conduct a 'skimming scoop' with the brail to move as many sharks as possible from the sack to the deck, bycatch sorting device or directly to the ocean for immediate release.
- Maneuver the animal into a stretcher or cradle immediately and release it on the opposite side of the working deck.

Tools Required:

- Stretcher or cradle (See Figure 1 for example).

2.4. Sharks brought on board via brailing

All PRS studies (Table 1) show that survival rates are seriously compromised once the animals have entered the loading hatch and release is initiated from the lower (well) decks (Eddy et al. 2016; Onandia et al. 2021; Poisson et al 2014a). Vessels should separate bycatch on the working/main deck so that sharks are released back to the sea prior to going down the loading hatch to the lower deck, to significantly improve PRS probabilities. Effective bycatch separation methods include the use of Bycatch Reduction Devices (BRDs: e.g., hopper with a controlled door) detailed in Murua et al. (2023). Smaller vessels that do not have space for a hopper on the working deck should allow sharks to be separated from the catch on the main working deck. For larger vessels with hoppers, a hopper with a ramp extension is the safest, quickest, and most effective method for returning sharks to the sea (Murua et al. 2023; Poisson et al. 2014b). Where possible, the installation of a waste/bycatch chute in the lower decks is recommended to facilitate and expedite the release of animals that may need to be released from the lower/well decks directly back into the ocean (Onandia et al. 2021: Poisson et al. 2014a). Otherwise, stretchers should be used for crew safety, and to release sharks as quickly as possible.

Crew safety is paramount and should always be prioritized. The safest way to handle a shark is to 'not handle' it directly and or reduce the amount of time the animal is being handled. For this reason, ramps attached to hoppers on the main/working deck and or on the well deck are the preferred release method. When sharks must be released manually, the use of a stretcher or cradle is recommended to improve the safety of the crew and reduce injury to the animals. Sharks should be carefully maneuvered into a stretcher or cradle and carried by crew to the opposite side of the vessel for release. Releasing sharks off the opposite side of the vessel reduces the risk of the shark becoming 're-entangled' in the purse seine net.

BHRP Recommendations:
To maximize post release survival of sharks subject to brailing:

- Require BRDs (e.g., hoppers, ramps) to ensure sharks are sorted on the work deck and do not go down the loading hatch.
- In case that passage of sharks through the loading hatch cannot be avoided, sharks should be released via a bycatch chute, or using stretchers (following recommendations on shark handling below) to return animals to the ocean as quickly as possible.

Tools Required:

- Bycatch sorting BRD for work/main deck (e.g., hopper with a door, ramp).
- Bycatch/waste chute on lower/well deck.
- Stretcher or cradle (See Figure 1 for example).

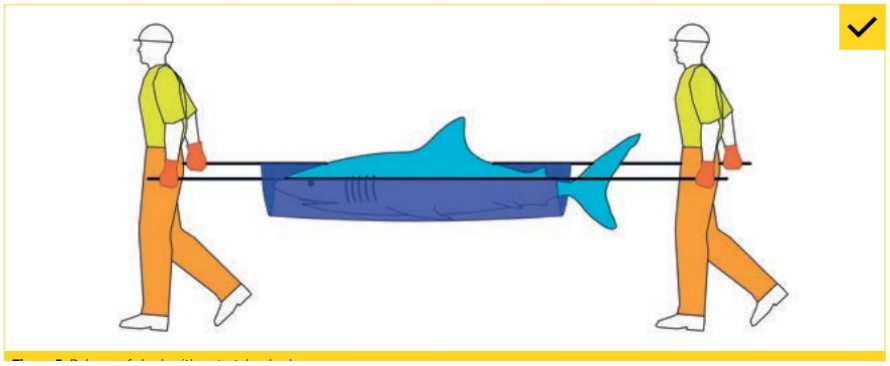

FIGURE 1. Example of a stretcher/cradle for handling and releasing sharks. The important components of stretchers/cradles include the material, size, and frames. The material needs to be soft and pliable to accommodate and not injure the animal, but also rigid enough to protect the crew from the shark. They need to be large enough to completely encapsulate larger animals. The frames need to be strong enough to support the weight of larger sharks but light enough for two crew members to carry it. Figure borrowed from the AZTI Best Practices handbook: https://www.azti.es/wp-content/uploads/2024/02/AZTI_BBPP_guide_EN-low.pdf

2.5. Whale Sharks

Deliberate encirclement of whale sharks for the purposes of setting purse seine gear was banned in the IATTC in 2019 (Resolution C-19-06). However, incidental interactions do occur rarely when whale sharks are not sighted prior to commencement of the set. When incidental interactions happen, Resolution C-19-06 requires CPCs to ensure that all reasonable steps are taken to ensure its safe release. Here, we detail acceptable safe release practices based on the generally recognized practices developed by Poisson et al. (2014b) and existing PRS data validating the efficacy of these practices (Table 1: Escalle et al. 2016 & 2017; Hutchinson et al. 2019).

BHRP Recommendations:

To maximize post release survival of whale sharks accidently encircled during purse seine sets:

Do not:

- Land or bring a whale shark on board the purse seine vessel regardless of size.
- Pull or tow a whale shark by the tail.

Do:

- Leave whale sharks in the water for release.
- Prioritize release of whale sharks prior to brailing.
- If the whale shark is at the side of the vessel and its head pointed towards the stern of the boat, a crewmember can cut a few meters of net in front of the shark's mouth to release it.
- If the head of the whale shark is pointed towards the bow of the boat, the crew in charge of the net hauling operation can maneuver the winch and the capstan to bring the whale shark close to the hull, then stand the animal on the net and to roll it outside the bunt.
- A rope placed under the animal and attached to the float line could help to roll the whale shark out of the net.

TABLE 1. Shark post release survival studies conducted in purse seine fisheries (modified from EB-01-01_Rev1 Table 2c). Regions: IO = Indian Ocean, WCPO = Western Central Pacific Ocean, EPO = Eastern Pacific Ocean, EAO = Eastern Atlantic Ocean. Flags: FRN=France, US = United States, ECU = Ecuador, EU = European Union. Species: FAL = Silky shark (*Carcharhinus falciformis*), SPL = Scalloped hammerhead shark (*Sphyrna lewini*), RHN = whale shark (*Rhincodon typus*), OCS = Oceanic whitetip shark (*C. longimanus*). BRD = Bycatch Reduction Device, BHRP = Best Handling and Release Practices.

Region	Flag	Species	Sample size	Release practices used / BRDs	Post-release mortality rate	Citation	Key Conclusions
IO	FRN	FAL	221 sharks, 48 sets, 3 trips, 31 tags	Release practices: manual release BRDs used in study: Hopper	Total mortality = 81% Mortality by fishing stage: Entangled in the net = 18% mortality, landed via brailing = 85% mortality.	Poisson et al. 2014	Used satellite tags to assess survival rates in sharks that were entangled and sharks that were brought on board via the brail. Mortality was significantly higher for sharks that were removed from the lower well decks than those that were sorted and removed from the hopper (on working deck). It also showed high PRS for entangled animals and emphasized the importance of best handling practices.
WCPO	US	FAL	295 sharks, 31 sets, 1 trip, 26 tags, 87 blood chemistry	Release practices: manual release BRDs used in study: Hopper	Total mortality = 84%. Mortality by fishing stage: released while free swimming = 0% mortality, entangled in net = 31.6% mortality, sharks on top of the sack (i.e., first 3 brails = 83.3 % mortality, sharks from later brails or bottom of sack = 93.3% mortality.	Hutchinson et al. 2015	Used both blood chemistry and satellite tags to validate fate for mortality prediction by release condition and landing stage. Found a large proportion of sharks are brought on board in the last few brails (75%). Study also showed no relationship between set size (tonnage) and shark mortality rates. Indicating injuries that led to mortality occurred once they'd been confined in the sack. To reduce mortality, avoidance or removing sharks from the net while they are still free swimming will be most effective.

EPO	ECU	FAL	53 sharks, 2 trips, 13 tags	Release practices: manual release BRDs used in study: None. Most sharks sorted on the lower well deck & brought to the upper/working deck for release.	Total mortality = 91.5% (62% post release mortality)	Eddy et al. 2016	Used satellite tags and release condition indices to estimate total mortality for silky (FAL) and scalloped hammerhead sharks (SPL). Showed animals released in better condition when entangled. Mortality was higher for sharks that were sorted from lower deck. Found lower at vessel mortality when set sizes were smaller.
		SPL	6 sharks, 2 trips, 3 tags		75% = Total mortality (100% post release mortality)		
EAO	EU	FAL	11 tags, 1 trip	NA	0%	Sancristobal et al. 2016	Tested efficacy of catching and releasing sharks from inside the net using hook and line. Caught 11 of 53 sharks encircled during 7sets and released them outside the corks. All survived to 21 days
EAO	EU	RHN	11 sharks, 3 trips	Released using recommendations in Poisson et al. 2014, 1 towed by tail	0%	Escalle et al. 2016; 2017	Of 11 tags, 7 individuals survived at least 21 days after release, 3 tags detached after 3 - 7 days and fates were unknown, one tag failed to report.
EAO	EU	RHN	2 tags, 1 trip	Released using recommendations in Poisson et al. 2014	0%	Hutchinson et al. 2019	2 sharks tagged; 3 sharks released using best practices from Poisson et al (2014b).
		FAL	5 tags, 1 trip, tested on 9 sets, (3 FAD, 6 Free school),	NA	0%		Sharks were fished (hook & line) out of the net while still free swimming and released outside the net. Only 7 sharks were hooked of the 106 sharks present in those sets. Of the 5 sharks that were tagged, all survived.

IO	EU	FAL	526 sharks, 71 sets, 2 trips, 60 tags, 45 blood samples	BRDs used in study: None Most sharks released from the lower deck waste/bycatch chute	Total mortality = ~61% [Sharks entangled in net while hauling = ~13% mortality, sharks brought on board from the top of the sack in first 3 brails (1st brail =~43%, 2nd brail =~61-69%, 3rd brail =~86% mortality, later brails = ~61%)]	Onandia et al. 2021; 2022	Used survival tags, blood lactate and condition indices to predict survival rates by release condition (vitality index). This study did not tag animals brought on board in later brails. Survival was set to 15 days. Ships had conveyer belt on lower deck for faster release from well decks
IO	EU	OCS	19 tags, 9 vessels	Unknown	18.75% PRM (3 mortality, 2 tags did not report)	Sabarros et al. 2023	Tagged animals in 'alive', 'alive good' & 'alive injured' conditions. Larger animals in good condition had higher survival than smaller animals in poor or compromised condition at the vessel. Release condition also directly related to time on deck. No data on landing stage, release location or BRDs was collected.

3. LONGLINE FISHERIES

Several studies have been conducted across ocean basins to assess shark bycatch PRS rates in longline fisheries (Table 2). Several of these studies also analyzed the impacts of handling and release methods on PRS rates and provided guidance for BHRPs (e.g., Francis et al. 2023; Hutchinson et al. 2021). Throughout the available scientific literature, PRS rates were shown to be species-specific and dependent on the condition of the animal at capture, the handling and release methods used, the amount of trailing gear[1] left on the shark, and the gear composition (e.g., hook shape, leader material) (Bowlby et al. 2020; Francis et al. 2023; Hutchinson et al. 2021; Musyl & Gillman 2018). The following sections provide an overview of options for operational adjustments for either avoidance of interactions or mortality mitigation and BHRP guidelines.

3.1. Avoidance

Many species of sharks aggregate in areas of biological significance for feeding, mating, parturition and or nursery habitats. Several of these areas are consistent in space and/or time and, if identified, could be avoided by fishers while others may be more relative to environment variables, and thus, harder to predict. The Commission has adopted several Resolutions with measures aimed at mitigating bycatch mortality in areas and/or times of reproductive significance and include recommendations for improving our understanding of habitat use requirements for bycatch avoidance (see Resolutions C-23-07 and C-23-08). However, the exact locations of these areas of biological significance remains unknown for some species.

Specific considerations to reduce interaction rates and mortality during important life stages in the longline fisheries:

- CPCs and IATTC Scientific Staff to continue research as per paragraph 18 of C-23-07 and paragraph 14 of C-23-08.
- When practical, avoid fishing in areas that have high shark catch rates.
- When identified, avoid fishing in known nursery areas.

3.2. Gear considerations

Bycatch mortality mitigation has a long history of gear configuration changes to either reduce catch rates of non-target species, reduce injury or mortalities. Below, we review the available scientific literature for applicable options under Resolutions C-23-07 and C-23-08, which include buoy (shark) lines, shallow hooks, leader material, hook shape and trailing gear. This section on gear considerations broadens the scope and objectives of this document. Our primary goals of developing Best Handling and Release Practice (BHRP) guidelines for sharks are expanded to explore alternative strategies for mitigating shark mortality resulting from bycatch. Additionally, it aims to furnish a thorough background on shark mortality mitigation for reference purposes and to facilitate informed discussions during the EBWG and SAC meetings.

[1] Trailing gear is the fishing gear left on the animal after release. It includes the hook, where it is attached to the animal and any materials between the hook and where the line is cut. Trailing gear is often in excess of 20 m and may include weights in some fisheries (Hutchinson et al. 2021).

3.2.1. Buoy (Shark) Lines

Resolution C-23-07 prohibited vessels targeting tuna and/or swordfish from using 'buoy lines[2]' (sometimes called shark lines in other regions) in IATTC fisheries. Analyses of potential management measures and mitigation options with the goal of reducing shark mortality in longline fisheries in the WCPO demonstrated that banning buoy (shark) lines could reduce fishing mortality by 2.6 – 14.7% and 5.4 – 23.3% for silky shark and oceanic whitetip (*Carcharhinus longimanus*) shark respectively (Bigelow and Carvalho 2022; Harley et al. 2015).

3.2.2. Shallow Hooks

Vertical habitat preferences are often temperature dependent where some bycatch species spend most of their time above the thermocline (e.g., green sea turtles, silky and oceanic whitetip sharks). When the thermal preferences of the target species (e.g., albacore or bigeye tuna) are broader (i.e., cooler) and they occupy deeper water (i.e., below the thermocline), the elimination of the shallower hooks can reduce fishery vulnerability and catch rates of some non-target species. For example, the initial interaction of silky shark and oceanic whitetip shark with longline gear can be significantly reduced by the removal of "shallow hooks", defined as the three hooks closest to the start/end of the basket (Harley et al. 2015). Research conducted in this field noted that fishing deeper than the thermocline (e.g., ~100 m in the WCPO) has the potential to reduce shark catch rates – where catches on the 3 shallowest hook positions accounted for 18.3% of all bycatch (Watson and Bigelow 2014). The study demonstrated that catch on the shallow hooks was species-specific, accounting for 45.5% of green sea turtle (*Chelonia mydas*), 37.3% of silky shark and 42.6% of oceanic whitetip shark interactions in a U.S. tuna longline fishery.

3.2.3. Leader Material

Several scientific studies have noted that shark retention rates (i.e., sharks are brought to the vessel - they do not bite through the line and self-release) are significantly lower (~33-40%) when wire leaders are not used (e.g., Afonso et al. 2012; Scott et al. 2022; Ward et al., 2008). While leader material is unlikely to influence interaction rates, but they allow sharks to bite-through the line and free themselves, with bite-off rates being significantly higher when J-hooks are used (see section below for details in hook shape) (Afonso et al. 2012; Ward et al., 2008). Accordingly, at-vessel mortality (dead on haul-back) rates are known to be higher in paired trials when wire leaders are compared to mono/nylon leaders (Afonso et al. 2012; Coelho et al. 2013; Scott et al. 2022; Ward et al., 2008). Leader material may also affect post release survival for animals released with trailing gear, with 2-4% higher survival rates on mono leaders (Hutchinson et al., 2021). Banning wire leaders has been identified as the most effective method for reducing shark mortality in simulation studies of management and mitigation options, with reductions in fishing mortality of 28.2% and 35.8% for silky shark and oceanic whitetip shark, respectively (Bigelow and Carvalho 2022). Combined, banning both shark (buoy) lines and wire leaders has the potential to reduce shark fishing mortality by 29.4-30.8% and 40.5% for silky shark and oceanic whitetip shark, respectively (Bigelow and Carvalho 2022; Harley et al. 2015). Similarly, recent simulations of 42 potential CMMs for silky and hammerhead sharks using EASI-Fish by the IATTC staff (SAC-14-12) showed that the use of wire leaders was among the most effective measure in reducing vulnerability when applied to industrial and/or artisanal longlines fleets. However, the use of wire leaders was only effective when combined with non-retention measures and effectiveness was further increased when combined with best handling practices.

[2] Buoy lines: individual lines or leaders that are attached to the float line or to the floats directly, and that are constructed of steel, metal, wire trace, or other materials, and are deployed in the water column at depths shallower than the mainline. These are also known as 'shark lines'.

3.2.4. Hook shape

The evaluation of circle hooks versus J-hooks as a mitigation strategy to reduce fishing mortality and enhance post-release survival of sharks in fisheries with no-retention policies has revealed promising results. Many scientific studies have reported circle hooks to have a lower gut-hooking rate than J-hooks (Carruthers et al. 2009; Epperly et al. 2012; Watson et al. 2006), and consequently, significantly lower at-vessel mortality rates (e.g., Cooke and Suski 2004; Gilman et al. 2006; Kerstetter and Graves 2006; Sales et al. 2010; Coelho, Santos, and Amorim 2012; Godin et al. 2012; Serafy et al. 2012; Gilman et al. 2016).

Some scientific studies have reported higher catch rates of sharks on circle hooks, potentially attributed to lower retention rates of sharks captured on J-hooks. This discrepancy arises from a substantial portion of sharks captured on J-hooks being foul or gut hooked, allowing them to bite off the line and artificially inflating the "catch" rates on circle hooks (Afonso et al., 2012). One of the key benefits of circle hooks lies in their ability to minimize foul or gut hooking (Carruthers et al. 2009; Epperly et al. 2012; Watson et al. 2006). Given that hooking location is a primary factor influencing injury (Campana et al., 2009; Coelho et al., 2020), data on hooking location provides a crucial indicator of the extent of injury and the probability of post-release survival (Gilman et al., 2016). As such, the adoption of circle hooks across all IATTC 'hook and line' fisheries emerges as a potential option to reducing shark mortality (IATTC 1st Circle Hook Workshop: Chair's Report).

Specific considerations to reducing interaction rates and mortality of bycaught sharks:

To reduce interaction rates and mortality to sharks there are several gear configuration options that have been shown to be effective:

- Avoid the use of buoy (shark) lines (already adopted Res C-23-07).
- Avoid the use of shallow hooks when targeting species with cooler/deeper thermal preferences.
- Avoid the use of wire leaders.
- Consider the use of circle hooks in no retention fisheries.

3.3. Best Handling and Release Practices

The BHRP guidance below are derived from the studies outlined in Table 2 and are data driven, robust recommendations with measurable impacts on shark mortality reduction in longline fisheries. Most of these studies have shown that removing sharks from the water for gear removal reduces survival rates and increases time to recovery (Bowlby et al. 2020, Campana et al. 2016, Hutchinson et al., 2021). In some PRS studies, sharks that were left in the water for tagging and release from the fishing gear had lower mortality rates by 50% as opposed to sharks brought on board (Bowlby et al. 2020). In the Pacific Ocean, PRS studies on silky sharks in the industrial longline fleets showed higher survival rates for sharks tagged in the water (Francis et al. 2023; Hutchinson et al. 2021) than in studies where silky sharks were brought on board for tagging (Musyl & Gilman 2018). Leaving sharks in the water decreases stress and air exposure but is particularly important for vessels with high freeboard[3], where the difficulty of lifting sharks to the deck is often mediated using multiple gaffs. This not only adds physical trauma to the animal but often gaff wounds penetrate organs and can cause lethal and sublethal injuries. While two studies conducted in small-scale longline fisheries where vessels are smaller and the freeboard height is lower, found high

[3] Freeboard refers to the distance between the waterline and the main deck of a ship and the waterline to the rail of a small boat.

survival rates for sharks brought on board for tagging and removal of fishing gear (Schaeffer et al. 2019 & 2021). In these studies fishers developed a safe method to bring sharks onboard for tagging and gear removal using a lasso (gaffs were not used), and most animals survived, even with the additional handling and air exposure on deck.

Across fisheries the removal of trailing gear is necessary. Scientific studies have shown that the amount of trailing gear left on an animal has a negative effect on post-release survival for multiple species (Francis et al. 2023; Hutchinson et al. 2021) and is correlated with high delayed mortality rates of blue sharks (*Prionace glauca*), bigeye thresher sharks (*Alopias superciliosus*) and oceanic whitetip sharks (Hutchinson et al. 2021). Leaving large quantities of trailing gear is not only energetically costly for the animal, but may also introduce infection, present an entanglement hazard, and increase susceptibility to predation (reviewed in Hutchinson et al. 2021). Bringing sharks to the side of the vessel for gear removal will not only improve post release survival probabilities but will also facilitate accurate identification to species and aid in the determination of condition (alive, injured, dead), key information to improve assessment capabilities, efficacy of mitigation measures and data quality of observer and electronic monitoring programs. If fishers remove as much trailing gear as possible, ideally leaving less than 1 meter, survivorship can be improved by as much as 40% (Francis et al. 2023; Hutchinson et al. 2021).

BHRP guidance for longline fisheries (both industrial and small-scale) are similar and applicable to other hook and line fisheries but may depend on the size of the vessel and how far the deck is from the waterline (freeboard). Thus, the BHRP recommendations in the next sections are separated by freeboard height as opposed to fishery classification.

3.3.1. Vessels with freeboard higher than 2 m

When sharks are captured on vessels with a high freeboard, sharks must be left in the water for release from the gear. The vessel should slow to safely bring the shark close to the vessel for identification (C-23-07), assessment of condition (C-23-07) and to remove the animal from the fishing gear. Ideally and when the hook is visible, fishers will have a long-handled de-hooker and are able to remove the hook safely. If the hook is not visible (i.e., swallowed) attempts to retrieve/remove the hook must be avoided. Fishers may need to cut the line to free the animal from the fishing gear. Fishers shall cut the line as close to the hook (or mouth) as possible, ideally leaving no more than 1 meter of trailing gear and ensuring any weights or other terminal tackle are removed.

BHRP Recommendations

To improve post release survival rates of discarded sharks captured in longline vessels with a high (>2m) freeboard:

- Leave sharks in the water for gear removal.
- Use long handled de-hookers if attempting to remove hooks.
- Do not attempt to remove hooks if they are not visible.
- Use long handled line cutters to cut the line as close to the hook (or mouth) as possible leaving no more than 1 meter of gear attached and ensuring that weights are removed.

Tools Required:

- Long-handled de-hooker
- Long-handled line cutter

3.3.2. Vessels with freeboard lower than 2 m

Sharks should be left in the water to remove them from the fishing gear as delineated in the section above. In the small-scale fleets, however, many fishers remove the hooks from sharks to retrieve their gear. Often this requires fishers to hoist the sharks onboard for gear removal. In these cases, fishers should use a dipnet or lasso to lift sharks onboard because the soft cartilaginous bony tissues of sharks are not robust to the lifting forces under the weight of the body in air. If the hook is not visible, fishers shall not attempt to remove the hook or lift the shark onboard using the line attached to the hook. If the hook is clearly visible, fishers should use a de-hooker or pliers to remove the hook. Fishers shall not cut into the jaw or damage the cartilage of the jaw during hook removal. Fishers should also take care to reduce the amount of time sharks are exposed to air on deck during gear removal and return animals to the sea promptly.

Handling sharks on deck is dangerous. To reduce the risk of injury to the crew and to the sharks brought on board, fishers should carry and utilize stretchers/cradles to manually restrain sharks. Fishers should maneuver sharks by the pectoral fins and caudal peduncle (for large sharks, two crew members are required for safe manual restraint of a shark on deck: one on the pectoral fins and one on the caudal peduncle; small sharks can be manually restrained by one person). Placing a wet cloth over the eyes of sharks also calms them for easier and safer handling. Fishers shall not lift or maneuver sharks by the gill slits, or spiracles. Fishers shall not punch holes in the bodies of sharks (e.g., to pass a cable through or for lifting or manipulating the shark with a gaff).

BHRP Recommendations

To improve post release survival rates of discarded sharks captured in small-scale and artisanal vessels with a low (<2m) freeboard:

- Leave sharks in the water and remove trailing gear.
- If animals are brought on board for gear removal, use a secondary point of attachment (e.g., dip net or lasso) to help support their weight while lifting them onboard.
- Use de-hookers if attempting to remove hooks. Do not cut into the jaw to remove hooks.
- Use line cutters to cut the line as close to the hook or mouth as possible leaving no more than 1 meter of gear attached to the animal and ensuring that weights are removed.
- Maneuver sharks using manual restraint of the pectoral fins and at the caudal peduncle. Do not lift or maneuver sharks by the gill slits, or spiracles. Fishers shall not punch holes in the bodies of sharks (e.g., to pass a cable through or for lifting the shark with a gaff).
- Return animals to the sea immediately.

Tools Required:

- Dipnet
- Short handled de-hooker
- Pliers
- Line cutter
- Long-handled de-hooker
- Long-handled line cutter
- Stretcher/cradle

TABLE 2. Shark post release survival studies conducted in commercial longline fisheries (modified from EB-01-01 Table 2d). Regions: NWA = Northwest Atlantic Ocean, EPO= Eastern Pacific Ocean, IO = Indian Ocean, AS = American Samoa, CPO = Central Pacific Ocean. Species are listed by 3-alpha FAO codes: BSH = blue shark, SMA = shortfin mako shark, POR = porbeagle shark, FAL = silky shark, OCS = oceanic whitetip shark, BTH = bigeye thresher shark. Notes contain the estimated PRS rates and influential factors in each study. Where possible we used the data reported to 30-days (tag deployment period) which should comprise 90% of mortalities that are directly due to the fishery interaction in pelagic sharks (Musyl and Gilman 2018).

Region	Flag	Species	Sample size	Handling practices	Target species/ gear configuration	Post- release mortality rate	Citation	Key Conclusions
NWA	Canada, 71 trips, 513 sets	BSH	40	Some sharks were hauled on deck for tagging and gear removal.	Swordfish, 55% circle hooks, 45% J hooks, leader material not reported	19%	Campana et al. 2009	All surviving sharks exhibited recovery behavior for 2 to 7 d after release. All healthy sharks survived, while 33% of injured or gut hooked died. Overall BSH bycatch mortality was 35%, estimated discard mortality for sharks that were released alive was 19%. 95% of the mortality occurred within 11 d of release. Hook type (circle hooks vs J hooks) influential on at vessel condition.
NWA	Canada, 76 trips, 496 sets	BSH	37	Some sharks were hauled on deck for tagging and gear removal.	Tuna & Swordfish, 88% circle 12% J hooks, leader material not reported	24%	Campana et al. 2016	AVM ranged from 15 to 44%, POR and SMA had higher mortality than BSH. PRM rate of all three species differed with condition at release. BSH & POR tagged on deck, some SMA tagged in water-no difference in survival for tagging location for SMA
		SMA	26			30.8%		
		POR	33			18.2%		
S. Pacific	Palau 13 trips, 1 vessel	FAL	35	Sharks were hauled on deck for tagging and gear removal.	Tuna, circle hooks, sardine bait, leader material not reported	20%	Musyl & Gillman 2018	Mean PRM rates were 0.17 [95% CI 0.09–0.30] for BSH and 0.20 [95% CI 0.10–0.36] for FAL. 87% of mortalities occurred within 2 days of release. PRM rate was 31% (.12-.59) for injured sharks (n = 13) & 11% (.04-.27) for healthy sharks (n = 35). Random sample, animals brought onboard for tagging some were gaffed. Released with trailing gear (0-2 m). Close

		BSH	48			16.7%		correspondence (~83% accuracy) between condition at capture and survival outcomes. Reliable methods to classify at-vessel condition represent an inexpensive and simple metric for estimating PRM rates.
EPO	Ecuador, 4 trips, 1 vessel	FAL	21	Sharks were hauled on deck for tagging and gear removal using lasso method.	Multi-species including sharks, Japanese tuna hook, mono leader	11.1%	Schaeffer et al. 2019	PRS rate estimated from Kaplan–Meier survival analyses for combined dataset was 94.3% (95% CI: 87.0%–100%) to 20 days. All sharks tagged onboard vessel. Crew developed lasso method to haul sharks onto the deck for tagging and release. They did not use gaffs.
	Costa Rica, 3 trips, 3 vessels		17		Multi-species including sharks, circle hook, wire leader	0%		
NWA	Canada	POR	18	Some hauled on deck for tagging and gear removal and irrigated with seawater, some tagged in water and line cut as close to hook as possible.	Swordfish & scientific shark surveys, circle hooks, leader material not reported	14%	Bowlby et al. 2020	Tag data was combined with data from Campana et al. 2016. Sample sizes were 48 healthy and 15 injured POR and 41 healthy and 7 injured SMA. Estimated mortality rates were 14% for porbeagle (6% for healthy and 40% for injured), 28% for shortfin mako (27% for healthy and 33% for injured), which is ~ ½ of the previous estimate for POR and the same for SMA (from Campana et al.2016). The difference for POR is likely due to handling during tagging, which switched from bringing animals on board to tagging in the water. Median recovery times for surviving animals was 1 day (shortfin mako) or 1.5 days (porbeagle) but longer when the shark was tagged onboard as compared to in the water even though gills were irrigated during tagging on deck.
		SMA	15		Swordfish, circle hooks, leader material not reported	28%		

EPO	Mexico, 6 trips, 3 vessels	FAL	63	Sharks hauled on deck for tagging and gear removal using lasso method, gear removed or cut as close to hook as possible	Multi-species including sharks, circle hooks & J hooks, wire leaders.	15.2%	Schaeffer et al. 2021	The PRS rate estimated using Kaplan - Meier survival analyses: 84.8 % (95 % CI: 71.0 %–100 %).
IO	European Union	OCS	9	No handling data in report	No fishery information available in report.	0%	Bach et al. 2021	1 mortality after 58 days but it was not considered a mortality in the study. Animals were only tagged in alive or alive good condition. This figure will be the most optimistic estimate of PRS. 2 premature tag releases on days 9 & 14.
AS	USA 128 trips, 76 vessels	FAL**	30	Small sharks brought on deck, most tagged in water, trailing gear shorter	Tuna, circle hooks, mono leaders	3%	Hutchinson et al. 2021	This study was designed to test the effects of handling on survival. Most sharks were tagged in the water by observers and fishers were instructed to release sharks however they normally release them. Bayesian methods were used project survival rates across several metrics over time. At vessel condition, handling method. leader material, and trailing gear were all influential on survival outcomes. Leaving sharks in the water and removing as much trailing gear as possible by cutting the line improves survival. **All silky sharks were tagged in American Samoa where leader materials are mono, trailing gear lengths are shorter and weighted swivels are not used. All FAL were in good condition, so this PRM rate should be considered a 'most optimistic scenario' and not representative of reality.
CPO		OCS	62	Observers tagged sharks in water, fishers used various methods to release sharks from gear.	Tuna, circle hooks, 45-gram weighted swivels, wire leaders and a regulatory change to mono leaders during the study.	15%		
		BSH	69			37.7%		
		SMA	20			6%		

		BTH	43			18%		
S. Pacific	New Zealand 35 trips, Fiji 58 trips, New Caledonia 10 trips, Marshall Is. 14 trips	FAL	57	Most sharks were tagged in the water and lines cut with different lengths of trailing gear.	Tuna, circle hooks	10.5%	Francis et al. 2023	Predicted survivorship at 60 days for the WCPFC tagged sharks was considerably higher for uninjured sharks (mako: 88.4%, CI: 74.0– 95.2%; silky shark: 90.5%, CI: 82.5–94.9%) than for injured sharks (mako: 36.8%, CI: 6.3–69.1%; silky shark: 44.3%, CI: 14.3–71.5%) when FL and trailing branchline ratios were fixed at their median values. Kaplan Meier survival estimates: FAL= 92.3% (CI: 85.3–99.9%), SMA= 90.2% (CI: 82.3–98.9%). Factors affecting survival: Size, catch condition, trailing gear lengths. Total mortality: 47.7% FAL: 51.4% SMA
		SMA	60			11.6%		

4. GILLNET

The gillnet fisheries across IATTC are typically small-scale, seasonal, mixed target fisheries and sharks captured using this gear are often retained (SAC-11-13). For those that may be released either because of low market value or retention prohibitions there is limited information available on the at-vessel condition of sharks captured in this fishery and their PRS rates (Bach, 2019). In the few existing studies, PRS rates appear to be species-specific and depend on the soak time (see review by Ellis et al. 2016). Most studies of commercial gillnet catch composition show high at vessel mortality rates for elasmobranchs, with particularly high mortality rates for species from the family Sphyrnidae: 62% (Braccini et al., 2012) - 98.3% (Reid & Krogh, 1992). In scientific gillnet studies, soak times were shorter, and at-vessel mortality rates were correspondingly lower for Sphyrnidae: 30.8%-71.5% (Hueter et al., 2006; Manire et al., 2001; Thorpe and Frierson, 2009). At-vessel mortality rates will help us infer how effective a no-retention measure and concomitant BHRP guidelines may be for sharks captured in this fishery. Thus, data on interactions and condition are needed for this fishery.

Presently, and in the absence of detailed data, the IATTC staff can offer general BHRP guidance for sharks captured in this fishing gear. If the IATTC implements an overarching code of conduct to reduce harm for incidental vulnerable species captured in the IATTC fisheries (as proposed in the workplan for vulnerable species, see EB-02-03), the following practices may help improve PRS for sharks that are alive when released from gillnets.

BHRP Recommendations

To improve post release survival rates of discarded sharks captured in gillnet fishing gear:

- Prioritize release of live non-target sharks.
- Leave sharks in the water for gear removal.
- Carefully cut the net away from the animal, allowing it to swim away from the gear.

Tools Required:

- Line cutter

5. DISCUSSION

Efforts to mitigate the post release mortality of vulnerable marine species, including sharks, have encouraged the development of BHRP guidelines within the IATTC. While existing measures emphasize the importance of employing best practices and avoiding detrimental techniques, specific guidelines backed by efficacy studies were lacking. The iterative process of developing BHRPs necessitates a comprehensive understanding of fishery characteristics and operations, species behavior and physiology, validated practices, and stakeholder engagement. In response to this need, the IATTC initiated a review of available literature and data to identify gaps and opportunities for integrating BHRP guidelines into regulatory frameworks (EB-01-01). The 101st Commission endorsed efforts to develop BHRP guidelines, prompting collaborative action among CPCs to gather relevant information and designate subject matter experts to assist with the development of the BHRP guidelines for sharks presented in this document.

The directive in Resolution C-23-07, which mandates the development of BHRP guidelines for sharks captured in IATTC purse seine and longline fisheries by 2024, underscores the importance of ensuring safe handling and release practices across the various fishing gears under the purview of the IATTC. The staff took the opportunity to also include guidance for the small-scale and artisanal fisheries that also interact with sharks (hook and line and gillnet). Recommendations for each gear type are informed by scientific studies and aim to minimize stress and injury to captured sharks while maximizing post-release survival rates. Additionally, there is some discussion on options for further reducing interactions and mortality of

non-target sharks across fisheries including options for avoidance and optimizing fishing gears and configurations. For convenience, the specific BHRP guidelines that are available for discussion and ultimately consideration for adoption by the Commission are provided in Annex 1.

While the adoption of BHRP guidelines is a step in the right direction for shark mortality mitigation, BHRPs must be accompanied by consistent and regular training of captains and crews, illustrated guidelines that are posted where they are clearly visible to crew members and that fishers carry the required tools. By prioritizing crew safety and adherence to practical, effective guidelines, the IATTC seeks to enhance conservation efforts and mitigate the impacts of fishing activities on vulnerable shark populations in the eastern Pacific Ocean.

6. ACKNOWLEDGEMENTS

We would like to acknowledge and thank the following CPCs for responding to Memo (Ref: 0473-410) and providing content used in this document and for identifying subject matter experts to facilitate helpful reviews of earlier drafts (Canada, Colombia, Ecuador, European Union, French Polynesia, Panama, Peru, United States). We are also very grateful to Dr. Jefferson Murua, Dr Francois Poisson, Dr. Nick Wegner, Amanda Munroe, and Kristen Cote for their reviews of previous versions that ultimately strengthened the document.

7. REFERENCES

Bach, P., Sabarros, P. S., Romanov, E., Coelho, R., Guillon, N., Massey, Y., & Murua, H. (2021). Third progress report on tag deployments to investigate the post release mortality of the oceanic white tip sharks (POREMO project) discarded by EU purse seine and pelagic longline fisheries in the Southwest Indian Ocean. IOTC-2021-WPEB17(AS)-26_Rev1.

Bigelow, K. and Carvalho, F., 2022. Review of potential mitigation measures to reduce fishing-related mortality on silky and oceanic whitetip sharks (Project 101). WCPFC-SC17-2021/EB-WP-01 https://doi.org/10.25923/10gt-as86

Bowlby, H., Joyce, W., Benoit, H. and Sulikowski, J., 2020. Evaluation of post-release mortality for porbeagle and shortfin mako sharks from the Canadian pelagic longline fishery. *Collective Volumes of Scientific Papers*, *76*, pp.365-73.

Bowlby, H.D., Benoît, H.P., Joyce, W., Sulikowski, J., Coelho, R., Domingo, A., Cortés, E., Hazin, F., Macias, D., Biais, G., Santos, C., Anderson, B., 2021. Beyond Post-release Mortality: Inferences on Recovery Periods and Natural Mortality From Electronic Tagging Data for Discarded Lamnid Sharks. Front. Mar. Sci. 8, 619190.

Campana, S.E., Joyce, W. and Manning, M.J., 2009. Bycatch and discard mortality in commercially caught blue sharks Prionace glauca assessed using archival satellite pop-up tags. *Marine Ecology Progress Series*, *387*, pp.241-253.

Campana, S.E., Joyce, W., Fowler, M. and Showell, M., 2016. Discards, hooking, and post-release mortality of porbeagle (Lamna nasus), shortfin mako (Isurus oxyrinchus), and blue shark (Prionace glauca) in the Canadian pelagic longline fishery. *ICES Journal of Marine Science*, *73*(2), pp.520-528.

Capietto, A., Escalle, L., Chavance, P., Dubroca, L., de Molina, A.D., Murua, H., Floch, L., Damiano, A., Rowat, D. and Merigot, B., 2014. Mortality of marine megafauna induced by fisheries: Insights from the whale shark, the world's largest fish. *Biological Conservation*, *174*, pp.147-151.

Carruthers, E.H., Schneider, D.C. & Neilson, J.D. (2009). Estimating the odds of survival and identifying mitigation opportunities for common bycatch in pelagic longline fisheries. *Biological Conservation*, **142**(11), 2620–2630.

Coelho, R., Fernandez-Carvalho, J., Lino, P.G. & Santos, M.N. (2012). An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. *Aquatic Living Resources*, **25**(4), 311–319.

Coelho, R., Fernandez-Carvalho, J., Lino, P.G. & Santos, M.N. (2012). An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. *Aquatic Living Resources*, **25**(4), 311–319. https://doi.org/10.1051/alr/2012030

Cooke, S.J. & Suski, C.D. (2004). Are circle hooks an effective tool for conserving marine and freshwater recreational catch-and-release fisheries? *Aquatic Conservation: Marine and Freshwater Ecosystems*, **14**(3), 299–326. https://doi.org/10.1002/aqc.614

Dagorn L, Filmalter JD, Forget F, Amandè MJ, Hall MA, Williams P, Murua H, Ariz J, Chavance P, Bez N. Targeting bigger schools can reduce ecosystem impacts of fisheries. Canadian Journal of Fisheries and Aquatic Sciences. 2012 Sep;69(9):1463-7.

Eddy, C., Brill, R. and Bernal, D., 2016. Rates of at-vessel mortality and post-release survival of pelagic sharks captured with tuna purse seines around drifting fish aggregating devices (FADs) in the equatorial eastern Pacific Ocean. Fisheries Research, 174, pp.109-117.

Epperly, S.P., Watson, J.W., Foster, D.G. & Shah, A.K. (2012). Anatomical hooking location and condition of animals captured with pelagic longlines: the grand banks experiments 2002–2003. *Bulletin of Marine Science*, **88**(3), 513–527. https://doi.org/10.5343/bms.2011.1083

Escalle, L., Murua, H., Amande, J.M., Arregui, I., Chavance, P., Delgado de Molina, A., Gaertner, D., Fraile, I., Filmalter, J.D., Santiago, J. and Forget, F., 2016. Post-capture survival of whale sharks encircled in tuna purse-seine nets: tagging and safe release methods. Aquatic Conservation: Marine and Freshwater Ecosystems, 26(4), pp.782-789.

Escalle, L., Amandé, J.M., Filmalter, J.D., Forget, F., Gaertner, D., Dagorn, L. and Mérigot, B., 2018. Update on post-release survival of tagged whale shark encircled by tuna purse-seiner. Collect. Vol. Sci. Pap. ICCAT, 74(7), pp.3671-3678.

Francis, M.P., Lyon, W.S., Clarke, S.C., Finucci, B., Hutchinson, M.R., Campana, S.E. et al., 2023. Post-release survival of shortfin mako (Isurus oxyrinchus) and silky (Carcharhinus falciformis) sharks released from pelagic tuna longlines in the Pacific Ocean. Aquatic Conservation: Marine and Freshwater Ecosystems, pp.1-13.

Gilman, E., Chaloupka, M., Swimmer, Y. & Piovano, S. (2016). A cross-taxa assessment of pelagic longline by-catch mitigation measures: conflicts and mutual benefits to elasmobranchs. *Fish and Fisheries*, **17**(3), 748–784. https://doi.org/10.1111/faf.12143

Godin, A.C., Carlson, J.K. & Burgener, V. (2012). The effect of circle hooks on shark catchability and at-vessel mortality rates in longlines fisheries. *Bulletin of Marine Science*, **88**(3), 469–483. https://doi.org/10.5343/bms.2011.1054

Harley S, Caneco B, Donovan C, et al (2015) Monte Carlo simulation modelling of possible measures to reduce impacts of longlining on oceanic whitetip and silky sharks. WCPFC-SC11-2015/EB-WP-02(Rev 2). Pohnpei, Federated States of Micronesia

Hutchinson, M., Itano, D., Muir, J., LeRoy, B., and Holland, K. 2015. Post-release survival of juvenile silky sharks caught in a tropical tuna purse seine fishery. Marine Ecology Progress Series, 521:143 -154. doi: 10.3354/meps11073

Hutchinson, M., Justel-Rubio, A. and Restrepo, V.R., 2019. At-Sea Tests of Releasing Sharks from the net of a Tuna Purse Seiner in the Atlantic Ocean. https://doi.org/10.25923/60ej-m613 SCRS/2019/029. Collect. Vol. Sci. Pap. ICCAT, 76(9): 61-72 (2020)

Hutchinson M., Siders Z., Stahl J., Bigelow K. 2021. Quantitative estimates of post-release survival rates of sharks captured in Pacific tuna longline fisheries reveal handling and discard practices that improve survivorship. United States. National Marine Fisheries Service; Pacific Islands Fisheries Science Center (U.S.). PIFSC data report; DR-21-001. DOI : https://doi.org/10.25923/0m3c-2577

Kerstetter, D.W. & Graves, J.E. (2006). Effects of circle versus J-style hooks on target and non-target species in a pelagic longline fishery. *Fisheries Research*, **80**(2–3), 239–250. https://doi.org/10.1016/j.fishres.2006.03.032

Murua, J., Moreno, G., Dagorn, L., Itano, D., Hall, M., Murua, H. and Restrepo, V., 2023. Improving sustainable practices in tuna purse seine fish aggregating device (FAD) fisheries worldwide through continued collaboration with fishers. *Frontiers in Marine Science*, *10*, p.141.

Musyl, M.K. and Gilman, E.L., 2018. Post-release fishing mortality of blue (Prionace glauca) and silky shark (Carcharhinus falciformes) from a Palauan-based commercial longline fishery. Reviews in Fish Biology and Fisheries, 28(3), pp.567-586.

Onandia, I., Grande, M., Galaz, J.M., Uranga, J., Lezama-Ochoa, N., Murua, J., Ruiz, J., Arregui, I., Murua, H. and Santiago, J., 2021. New assessment on accidentally captured silky shark post-release survival in the Indian Ocean tuna purse seine fishery. IOTC-2021-WPEB17 (DP)-13.

Poisson, F., Filmalter, J.D., Vernet, A.L. and Dagorn, L., 2014a. Mortality rate of silky sharks (Carcharhinus falciformis) caught in the tropical tuna purse seine fishery in the Indian Ocean. Canadian Journal of Fisheries and Aquatic Sciences, 71(6), pp.795-798.

Poisson, F., Séret, B., Vernet, A.L., Goujon, M. and Dagorn, L., 2014b. Collaborative research: Development of a manual on elasmobranch handling and release best practices in tropical tuna purse-seine fisheries. Marine Policy, 44, pp.312-320.

Sabarros P.S., Mollier, E., Tolotti, M., Romanov E.V., Krug, I., Bach, P. 2023. Post-release mortality of oceanic whitetip sharks caught by purse seiners – POREMO project. IOTC-2023-WPEB19-18_Rev1 Presented at the 19th Session of the IOTC Working Party on Ecosystems and Bycatch, La Réunion, France, p. 19.

Sancristobal, I., U. Martinez, G. Boyra, J. Muir, G. Moreno and V. Restrepo. 2016. ISSF bycatch reduction research cruse on the F/V MAR DE SERGIO in 2016. ICCAT SCRS/2016/156.

Schaefer, K.M., Fuller, D.W., Aires-da-Silva, A., Carvajal, J.M., Martínez-Ortiz, J. and Hutchinson, M.R., 2019. Postrelease survival of silky sharks (Carcharhinus falciformis) following capture by longline fishing vessels in the equatorial eastern Pacific Ocean. *Bulletin of Marine Science*, *95*(3), pp.355-369.

Schaefer, K., Fuller, D., Castillo-Geniz, J.L., Godinez-Padilla, C.J., Dreyfus, M. and Aires-da-Silva, A., 2021. Post-release survival of silky sharks (Carcharhinus falciformis) following capture by Mexican flag longline fishing vessels in the northeastern Pacific Ocean. Fisheries Research, 234, p.105779.

Ward, P., Lawrence, E., Darbyshire, R., and Hindmarsh, S. (2008). Large-scale experiment shows that nylon leaders reduce shark bycatch and benefit pelagic longline fisheries. Fisheries Research, 90:100–108

Watson, J.T. and Bigelow, K.A., 2014. Trade-offs among catch, bycatch, and landed value in the American Samoa longline fishery. *Conservation Biology*, *28*(4), pp.1012-1022.

ANNEX 1. RECOMMENDED BEST HANDLING AND RELEASE PRACTICE GUIDELINES FOR SHARKS CAPTURED IN IATTC FISHERIES

To maximize efficacy and utility of adopted BHRPs, CPCs must ensure fleets are educated and trained on these requirements regularly and have access to illustrated guidelines available in the languages spoken by the crews and are to be clearly posted on the vessels. CPCs must also require vessels to carry the necessary BHRP tools.

For all fisheries

Do:

- Leave shark in the water as much as possible and remove from gear.
- Ensure sharks are released immediately.

Do not:

- Leave sharks on deck.
- Pull or drag sharks by the tail or caudal peduncle.
- Use drag lines or drag sharks behind the vessel.
- Gaff or kick a shark or insert hands into gills.
- Lift and drop sharks from the vessel height.
- Strike shark against surface.
- Cut any part of, or punch holes through the shark.
- Expose shark to sun or air for extended periods of time.

Purse seine

Encourage CPCs to avoid shark interactions and develop strategies for removing sharks from the net while it is open, and they are still free-swimming.

Tools Required:

- Bycatch sorting/releasing devices for working/main deck (e.g., hopper with a door, ramp)
- Stretcher/cradle

Do:

For sharks entangled in the net:

- Drop the net to the deck and allow the crew to safely cut the net away from the animal.
- Maneuver the animal into a stretcher/cradle or ramp immediately and release it on the opposite side of the vessel.
- Use a stretcher or cradle to ensure the safety of the crew and the animal.

For sharks that are on top of the sack:

- When sharks are visible on top of the sack, the vessel should conduct a ‘skimming scoop’ to move as many sharks as possible from the sack to the sea (if possible) or the main deck for immediate release.

When brailing sharks on board:

- Utilize bycatch sorting devices (e.g., hoppers) to ensure sharks are sorted on the main deck and do not go down the loading hatch.
- Maneuver sharks into a stretcher/cradle or ramp immediately and release it on the opposite side of the vessel.
- Vessels should install a bycatch/waste chute on the lower decks to facilitate faster and safer release of sharks that were not sorted on the main/working deck.

Do not:

- Roll sharks and or any bycatch species with mandatory release requirements through the power block.
- Leave sharks on deck. Ensure that they are released immediately.
- Use gaffs, hooks, or similar instruments to punch holes or drag sharks.
- No shark may be lifted by the head, tail, gill slits, or spiracles, or by using bind wire against or inserted through the body, and no holes may be punched through the bodies of sharks (*e.g*., to pass a cable through for lifting the shark). Use a stretcher/cradle or ramp to ensure the safety of the crew and the animal.

Whale sharks

Do:

- Leave whale sharks in the water.
- Prioritize release of whale sharks prior to brailing.
- If the whale shark is at the side of the vessel and its head is pointed towards the stern of the vessel, a crewmember can cut a few meters of net in front of the shark's mouth to release it.
- If the head of the whale shark is pointed towards the bow of the boat. The crew in charge of the net hauling operation can maneuver the winch and the capstan to bring the whale shark close to the hull, then stand the animal on the net and roll it outside the bunt.
- A rope placed under the animal and attached to the float line could help to roll the whale shark out of the net.

Do not:

- Land a whale shark on deck regardless of size.
- Start a brailing process when a whale shark is still in the net.
- Pull or drag whale sharks out of the net by the tail or caudal peduncle.

Longline (also applicable to surface fleet fisheries)

Tools Required:

- Dipnet.
- Short handled de-hooker (for sharks brought onboard).
- Line cutter.
- Short-handled de-hooker (vessels with low [< 2m] free-board).
- Long-handled de-hooker (equal or greater in length than the vessel's freeboard).
- Long-handled line cutter (equal or greater in length than the vessel's freeboard).

Do:

For sharks captured by vessels with high freeboard (>2m):

- Slow the vessel to bring the sharks in.
- Leave sharks in the water and remove gear.
- Use de-hookers if attempting to remove hooks.
- Use line cutters to cut the line as close to the hook or mouth as possible leaving no more than 1 meter of gear attached and ensuring that weights are removed.

For sharks captured by vessels with low freeboard (<2m):

- Slow the vessel to bring the sharks in.
- Leave sharks in the water and remove gear.
- If animals are brought on board for gear removal use a dip net or lasso to help lift them onboard.
- If animals are brought on board for gear removal use a stretcher or cradle to improve safety of the crew and to reduce injury to the animal.
- If animals are brought on board for gear removal, sharks should be maneuvered using manual restraint of the pectoral fins and the caudal peduncle (this may require two crew members depending on the size of the animal).
- Return the animals to the sea as quickly as possible.

Do not:

For all vessels:

- Use drag lines or drag sharks behind the vessel until the hook rips free of the jaw.
- Use gaffs for lifting or maneuvering sharks.
- Lift and drop sharks from the vessel height to rip the hook from the shark's jaw.
- Lift sharks onto the deck without the use of a dipnet and or second point of attachment to support the weight of the animal.
- Lift or maneuver sharks by the gill slits, or spiracles.
- Attempt to remove a hook if it is not visible.
- Cut into the jaw for removal of the hook.

ANNEX 2. EXAMPLE SPECIFICATIONS FOR SELECT RECOMMENDED TOOLS

The framework and minimum standards for BHRP guidelines includes recommendations for specifying the tools that fishing vessels need to carry onboard to facilitate safe release of vulnerable species (EB-01-01; EB-02-03). While being too prescriptive with tool specification requirements may risk inhibiting innovation, ensuring that tools meet the minimum requirements for efficacy is necessary. Below are some examples of specifications for some of the tools that were identified in this document to aid discussions surrounding tool requirements.

Long-handled line cutter
The minimum design standards are as follows:

1. A protected cutting blade. The cutting blade must be curved, recessed, contained in a holder, or otherwise afforded some protection to minimize direct contact of the cutting surface with animals or users of the cutting blade.
2. Cutting blade edge. The blade must be capable of cutting 2.0-2.1 mm monofilament line and nylon or polypropylene multi-strand material commonly known as braided mainline or tarred mainline.
3. An extended reach holder for the cutting blade. The line clipper must have an extended reach handle or pole of at least 6 ft (1.82 m).
4. Secure fastener. The cutting blade must be securely fastened to the extended reach handle or pole to ensure effective deployment and use.

Long-handled dehooker (for externally visible hooks).
The minimum design and performance standards are as follows:

1. Construction. The device must be constructed of 5⁄16 inch (7.94 mm) 316 L stainless steel rod. A 5-inch (12.70 cm) tube T-handle of 1 inch (2.54 cm) outside diameter is recommended, but not required. The dehooking end must be blunt with all edges rounded. The device must be of a size capable of securing the range of hook sizes and styles used by the vessel.

2. Handle. The handle must have a length equal to or greater than the vessel's freeboard or 3 ft (0.91 m), whichever is greater.

Short-handled dehooker (for externally visible hooks).
The minimum design and performance standards are as follows:

1. Hook removal device. The hook removal device must be constructed of 5⁄16 inch (7.94 cm) 316 L stainless steel, and the design must be such that a hook can be rotated out without pulling it out at an angle. The dehooking end must be blunt, and all edges rounded. The device must be of a size appropriate to secure the range of hook sizes and styles used by the vessel.

2. Shaft and handle. The shaft must be 16 to 24 inches (40.64 to 60.69 cm) in length and must have a T-handle 4 to 6 inches (10.16 to 15.24 cm) in length and 3⁄4 to 11⁄4 inches (1.90 to 3.18 cm) in diameter.

Dip net
The minimum design standards for dip nets are:

1. An extended reach handle. The dip net must have an extended reach handle of at least the freeboard height of the vessel, and composed of wood or other rigid material able to support a minimum of 100 lb (34.1 kg) without breaking or significant bending or distortion.

2. The dip net must have a net hoop of at least 31 inches (78.74 cm) inside diameter and a bag depth of at least 38 inches (96.52 cm). The bag mesh openings may be no more than 3 inches by 3 inches (7.62 cm by 7.62 cm).