SCIENTIFIC COMMITTEE
SEVENTEENTH REGULAR SESSION

Electronic Meeting
11-19 August 2021

Improving on deck best handling and release practices for sharks in tuna purse seiners using hopper with ramp devices

WCPFC-SC17-2021/EB-IP-13

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KEYWORDS: Silky shark, purse seiner, hopper, bycatch reduction devices

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Executive summary

A possible bycatch reduction device (BRD) that tuna purse seiners could employ to promote safer and faster release of vulnerable bycatch, such as sharks, are hoppers with ramps. These selective hopper trays can take many shapes and sizes depending on the vessels' top deck configuration. Not all hoppers are equally valuable for bycatch release as some are either too small to access the bycatch or act as funnels with no stop mechanism to allow for time to detect and take out non-target species. In this study four class A purse seiners operating in the Pacific Ocean and fitted with mobile hoppers were examined for shark release efficiency. Observer data results indicated that when hoppers were used on the vessels between 92% and 98% of the sharks were released from the top deck, against 21% to 46% with no hopper. Hoppers can increase shark survival because their mortality greatly increases once they reach the lower deck, where release times are delayed if there is no release exit from this area, resulting in sharks having to be carried manually upstairs. In addition, release ramps were built and trialled with the hoppers, which acted as wet slides to facilitate faster and safer release of sharks and other bycatches with minimal handling. While designs of hopper and ramps for bycatch release can still be improved, they offer a promising tool for fleets to implement best release practices of vulnerable species. Future trials will employ satellite pop-up tags to properly assess survival rates with and without hoppers. We recommend that tuna RFMOs concerned with best bycatch mitigation and crew safety practices consider the implementation of hoppers with ramps as an efficient BRD in tropical tuna purse seiners which would be in line with shark protection recommendations in CMM-2019-04 paragraph 17.

1. Introduction

In many fisheries BRDs such as turtle excluder devices (TEDs), Tori lines, Medina panels, etc. have been successfully developed and implemented to maximize survival of non-target catches (Jenkins, 2012; Hall et al., 2017). Given enough research, selective fishing gear improvements could drastically diminish bycatch mortality in most fisheries (Gilman, 2011). Industrial tropical tuna class A purse seiners have an array of technological aids on onboard to help with fishing efficiency (e.g., sonars, echo-sounders, bird radars, power blocks, heavy duty winches, echo-sounder buoys, etc.). However, despite this strong technological investment by "super-seiners", bycatch selectivity and release equipment remain poorly developed. This can lead to poor handling practices, crew safety injury risks, and lower overall survival of released species. In recent years tropical tuna purse seiners have been working on mitigating fish aggregating device (FAD) impacts including mortality reduction of vulnerable associated species like turtles, sharks, or mobulids, by adopting non-entangling FADs and developing a series of bycatch release protocols in cooperation with skippers (Poisson et al., 2016; Murua et al., 2017). In addition, multiple tuna purse seine fleets (e.g., Spain, France, Ecuador, etc.) have voluntarily adopted "codes of best practices" for bycatch releases (Goujon et al., 2018; Grande et al., 2020).

The principal focus of these bycatch release practices for purse seiners has been during the brailing phase on the vessel's deck, rather than before sacking up (but see Restrepo et al., 2018 for trials of shark release from the net with escape windows and fishing in the net). Today, many of the best release practices in purse seiners involve manual handling, especially for safer species (e.g., turtles) or juvenile individuals (e.g., small sharks or rays). Meanwhile, for larger heavier species like adult mobulids release options have involved lifting them with canvases or cargo nets (Poisson et al. 2014) or more recently with manta shorting grids (Murua et al., 2020). With larger sharks which are typically lifted out of the brailer from the tail with lassos, new less abrasive padded velcros are being tested (Grande et al., 2020). While these recent devices are facilitating faster and safer evacuation of bycatches to increase their survival, there is still room for improvement of on deck release methods.

A particularly important limitation when trying to release bycatch on deck directly from the brailer is that many individuals, especially juvenile sizes, cannot be easily detected. As brailers continue to increase in size (i.e., some reaching 12 t capacity) many times small sharks and other bycatches may be buried in between tonnes of tunas in the middle of the brailer and go unnoticed until the contents are emptied down in the lower deck. However, once bycatches reach the lower deck release is more complicated and mortality rates almost double for sharks if the lower deck is not adapted for a quick bycatch release (e.g., bycatch conveyor belt or specific gateway for bycatch release) (Filmalter et al., 2015). As most of the sharks bycaught in FAD sets are juveniles of small size (Clavareau et al. 2020; Hall and Roman 2013) a very large proportion of them end up in the lower deck despite crew efforts to apply best practice protocols. A potential tool to help prevent this problem could be the hopper, a generic term used to describe a large metallic selector tray on deck into which the contents of the brail are emptied to help discard non-target species, and from which the target tuna then spills into the lower deck (Poisson et al. 2016). Because the contents of the brail are spread out on the hopper, spotting bycatch species is easier and can potentially be released immediately from the upper deck.

2. Hopper design diversity

Hoppers have been used in some purse seiners since the 1970s and historically have been more prevalent in the Pacific Ocean fleets (e.g., USA, Ecuador, Mexico, Korea, etc.) (Hutchinson et al., 2015; Murua et al., 2019) but other fleets like the French in the Indian Ocean and the Atlantic also use them (Poisson et al. 2016). In the early days, the hopper's function was to facilitate discards of bycatch (and unwanted tunas) from deck and help regulate the flow of catch into the wells, as many vessels did not have conveyor belts. The design characteristics of hoppers (i.e., size, capacity, shape) and disposition on the deck (i.e., starboard, portside) and mobility (i.e., removable, static) can vary greatly as they must adapt to the available deck space and operational restrictions of each vessel. Different designs are likely to influence the efficiency of each hopper type with regards to release of bycatch species.

Some hopper trays are very small and narrow, with high lateral walls, which prevent the catch from the brail spreading out for inspection and act as mere "funnels" (Figure 1). These hoppers add little value to bycatch release as sharks and other bycatches are not readily visible and the brail contents move down too quickly to the lower deck before they can be detected and taken out.

Figure 1. Small sized hopper with high walls, which prevents effective bycatch detection and release during brailing.

Other hopper types may have enough surface area to spread the brail contents, however, if the catch falls from the tray into the lower deck too fast, there is not enough time to get hold of the bycatch species and release them. This is especially true in some static or semi-integrated designs (i.e., hoppers in which the catch contents go down through an opening in the tray fitted directly on the unloading hatch), which lack a stoppage mechanism to slow down the flow of individuals into the lower deck if vulnerable bycatch species are detected (Figure 2). While this kind of hopper enables partial sorting of the catch, some individuals will still go down to the lower deck if the unloaded catch is moving too fast.

Figure 2. Large hopper tray lacking a stoppage door to prevent bycatch going down to quickly into the unloading hatch opening to the lower deck.

In addition to the design, the positioning of the hopper on deck can facilitate bycatch release speed. For example, mobile hoppers may be placed on starboard or port side. Because most bycatch is released from the starboard, if hoppers are located on the portside fishers must travel longer distances (5-6 m) carrying the animals until they are released (Figure 3). With small individuals this might not be a problem, but with medium to large, heavier, and more dangerous animals it can cause safety issues and release delays. For their own safety fishers might be reluctant to manually handle energetic adult sharks and may leave them on the side of the deck until they appear to calm down or die.

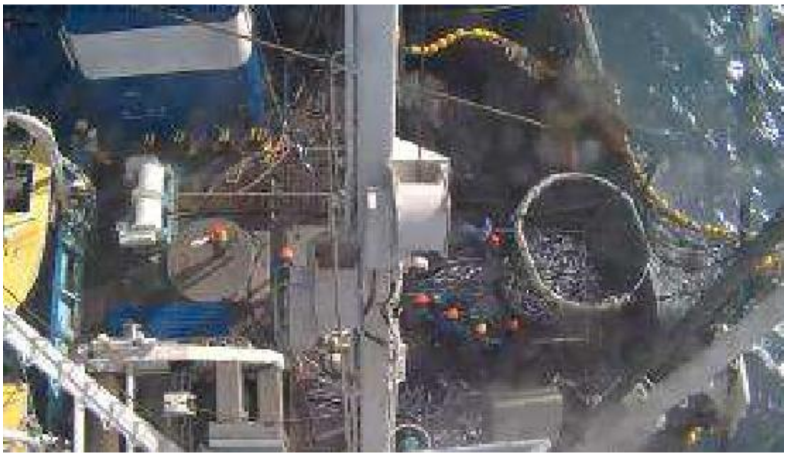

Figure 3. Crow nest's view of brail being unloaded on hopper located on the portside with fisher carrying a small shark by hand towards the starboard for release.

3. Hopper with ramp data collection

In the present study shark releases were evaluated using electronic monitoring systems (EMS) in four tuna purse seiners belonging to Garavilla (Bolton Group), operating in the IATTC and WCPFC areas. Out of the four vessels, three had hoppers at the time of the study during 2018-2019, and a fourth one was added subsequently in late 2020. The size and capacity of each hopper varied for each vessel to adapt to the space on deck and the capacity of each brailer but all had a similar shape (Figure 4). The lengths of the hoppers varied between 4.2 m and 4.5 m and width between 2.4 and 2.7 m, while the capacities of the hoppers (4.3-5.2 tonnes) were about half of the maximum capacities of the brailers (8.2-10.5 tonnes).

Figure 4. Hopper from a vessel studied stored at port during unloading.

The EMS recorded for each vessel data including date, position, and time of the sets, set duration, set size, time per brail, and number of individuals per species released, and release location in the vessel (i.e., upper deck, lower deck). Condition of the animals released (i.e., dead, poor, fair, good) was not collected as it was difficult to assess with confidence this information through EMS images. While some groups such as turtles, marlins or manta rays were sporadically found and released, the study focused on shark releases as they formed the bulk mass of the vulnerable species bycaught.

At a later phase of the study in 2020 release ramps were added to the hoppers of three of those vessels to try facilitating shark release on deck and a last fourth ramp has been recently built in June 2021. The ramps connected the hopper to the starboard opening so that animals could go directly back to sea with minimal manual handling. Few EMS disks of the trips of hoppers with ramp have been fully processed at the time of this report, but preliminary data and skippers' feedback suggests the ramps are being a useful device to ensure faster and safer shark releases.

4. Shark releases from top deck with hoppers

During the first part of the study with the hoppers with no ramps, a total of 15 fishing trips by four purse seiners were analysed using EMS. Over this period a total 231 sets with hopper and 133 without hopper were examined (Table 1). Excluding the one purse seiner (vessel C) that did not have a hopper at the time of the study, the overall number of sets examined for the rest of the three vessels carrying a hopper was majorly with hopper (71% sets) compared to those sets without hopper (29% sets).

Table 1. Number of trips and sets with and without hopper examined with EMS in four purse seiners operating in the Pacific Ocean during 2018-2019.

Vessel	Trips	Sets with hopper	Sets with no hopper
A	5	128	14
B	6	96	3
C	2	0	71
D	2	7	45

Inspection of the numbers of sharks released in each vessel, with the same crew trying to apply best practices at all times, revealed very marked differences between proportions of sharks released from the top deck when using or not the hopper (Table 2; Figure 5). For example, according to EMS data between 92.8 % and 98.6 % of sharks were released from the top deck in the sets when hoppers were employed, while only 21.1 % to 46.5% of sharks were released from the top deck when the hopper was not used.

Table 2. Number of sharks released from the top deck and the lower deck of four purse seiners in sets with hopper and sets without hopper.

Vessel	With hopper		With no hopper	
	Top deck	Lower deck	Top deck	Lower deck
A	748	34	7	26
B	1,141	89	73	84
C	0	0	72	203
D	69	1	114	167

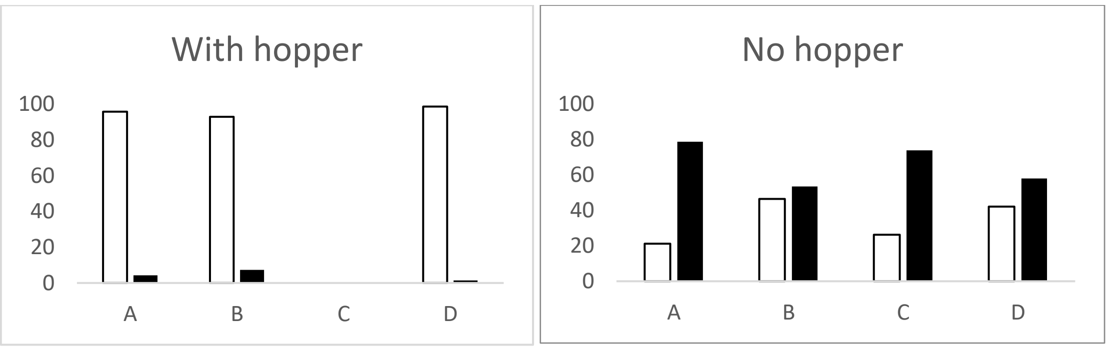

Figure 5. Percentage of sharks released from the top deck (white bars) and lower deck (black bars) when sets were performed with or without the use of the hopper in each of the four purse seiners (A-D).

5. Brailing times with hoppers

The average time per brail when using or not the hopper was estimated using EMS footage (Figure 6). There appeared to be little difference between brail times between both kind of sets, only in vessel D was the brail on average 13 seconds slower when using the hopper.

Vessel	With hopper (min)	No hopper (min)
A	1:39	1:41
B	1:58	1:56
C	-	1:37
D	2:11	1:48

Figure 6. Average time per brail (min) in sets using and without the hopper.

6. Hopper with ramp releases

At the time of this report, few trips have been analysed for the hoppers in which release ramps were incorporated between late 2020 and mid-2021. Out of the four vessels examined, all hoppers are mobile, with three vessels keeping the hopper stored near the chimney towards the stern of the top deck when not used and move it to the port side when brailing (taking approximately 3-4 minutes to put it in place). Because bycatch is released from the starboard, the release ramp must be fairly long (5-6 m) crossing over half of the deck width (Figure 7). As the ramp's maximum height must remain low enough to facilitate fishers depositing the sharks on it, these longer ramps have a lower gradient and at times sharks have to be helped pushing by hand to reach the lower end at the starboard from where they fall back into the sea. Using the vessels' hose to water the ramp aids with animals sliding down, plus keeps them moist and irrigates their gills. Once the brailing process is finished, the ramps which are composed of three sections are dismounted for storage and the hopper repositioned near the chimney until the next set.

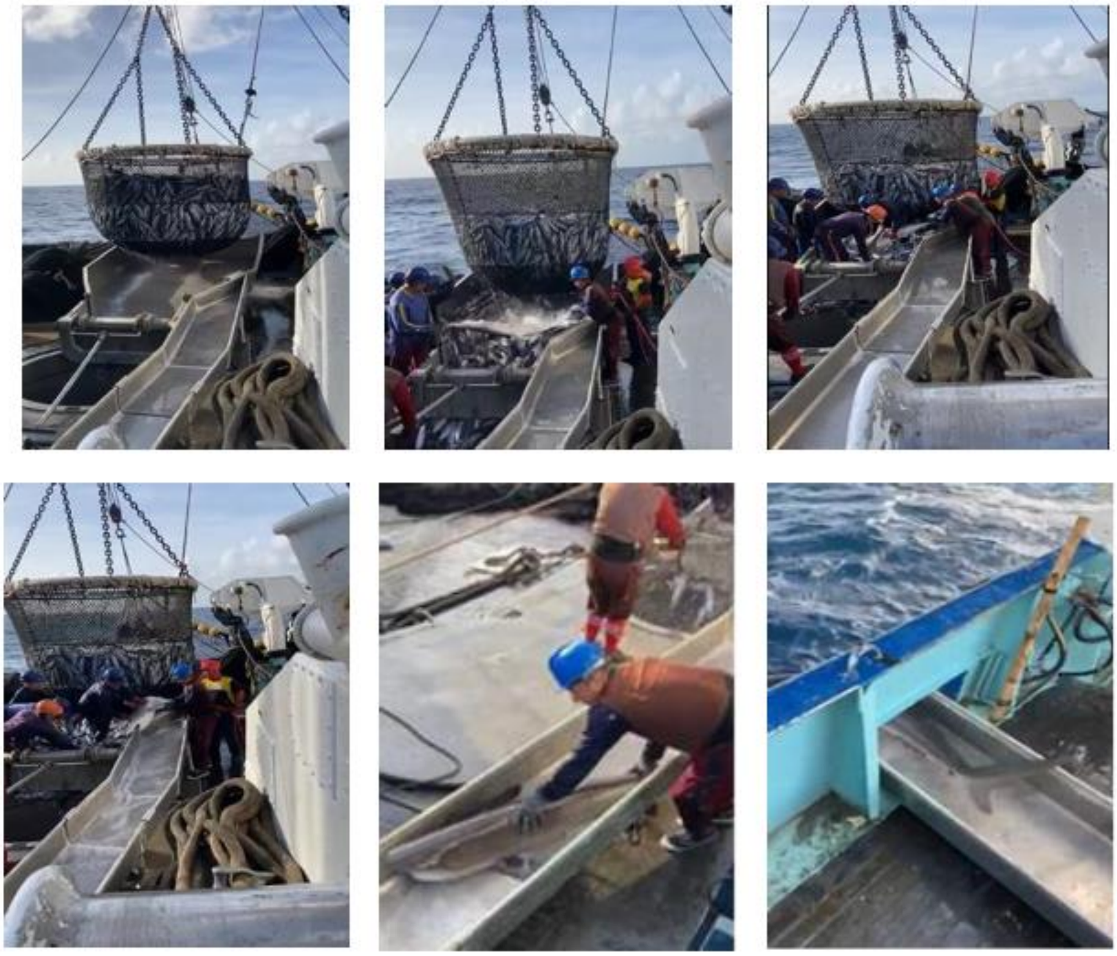

Figure 7. Sequence of brailing and shark release using hopper with ramp in the top deck port side.

For the one vessel that had the hopper over the starboard side of deck, the ramp was much shorter (2-3 m), enabling more steepness for released animals to slide down (Figure 8). In addition, although both the hopper and ramp were mobile, unless necessary, they both remained in this location of deck for the duration of the trip until dismounted when going to port.

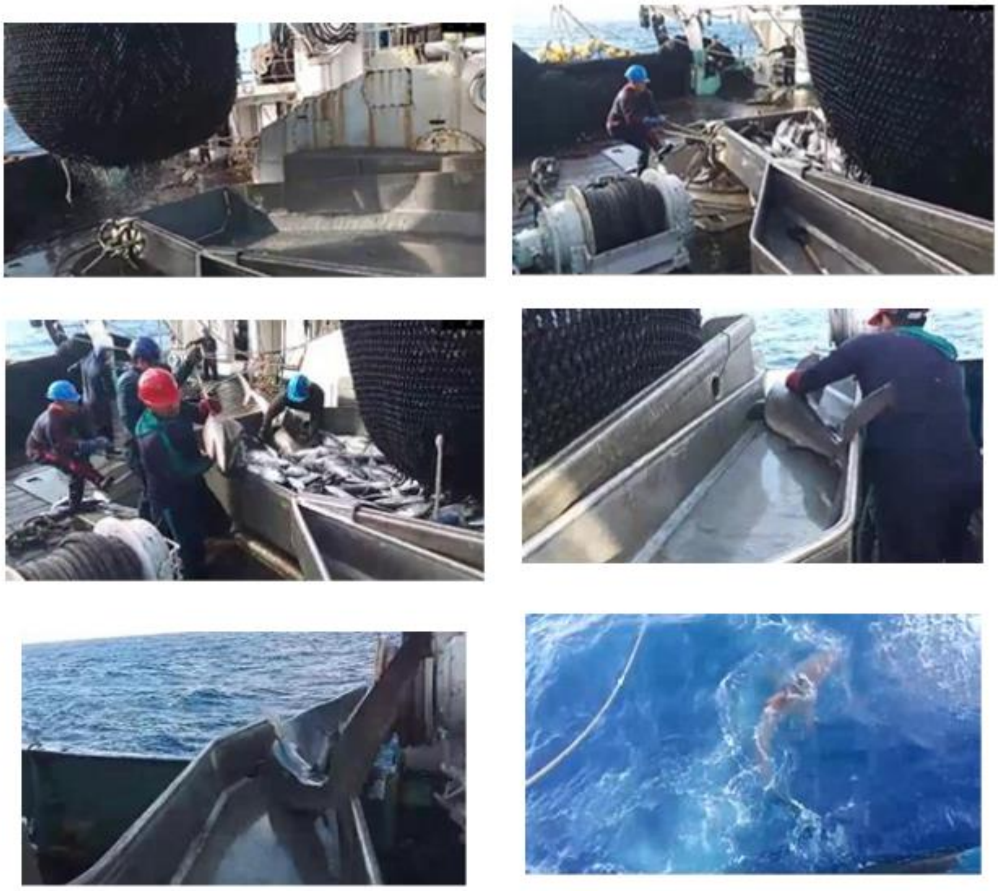

Figure 8. Sequence of brailing and shark release using hopper with ramp in the top deck starboard.

7. Discussion

This work highlights the benefits of hoppers with ramps in commercial tuna purse seiners to maximize detection and rapid release of sharks and other bycatches at the top deck level. Conspicuous animals such as large mobulids are easily detected when brought onboard in the brailer. However, bycatch detection, especially with smaller individuals (e.g., juvenile sharks), can be difficult if hidden away in between several tonnes of fish in large brailers. A large proportion of shark bycatch is thought to go unnoticed into the lower deck, where release is delayed, or individuals can accidentally end up in the wells. Releasing animals after being dumped to the lower deck almost doubles their mortality (Filmalter et al., 2015), likely due to stress associated with the extra physiological trauma of being dumped down from the unloading hatch with tonnes of catch and added time out of the water (i.e., the bycatch must be picked up and carried up the stairs to the upper deck again before release). Only if the vessel has a double conveyor belt fitted to rapidly release sharks from the lower deck can this mortality rate be partially reduced (Onandia et al., 2021). Note, however, that only a very small minority of tuna purse seiners around the world have a double conveyor belt installed. In fact, the number of vessels which do not have a single conveyor belt and rely on a system of chutes to move the catch from the unloading hatch to the well is probably much larger. In vessels with chutes, lower deck bycatch release is almost impossible due to the high speed at which the catch shoots into the wells. In these cases, a hopper would not only be critical to release bycatch species, but also would help regulate the flow of the catch into the lower deck, preventing overspilling of fish from the chutes. Another added value of hoppers on deck is that by spreading the catch of each brailer on its wide tray, the catch composition evaluation is more accurate, both in terms of tuna and bycatch species and sizes. Fishers gain a better estimation of the types and quantities of tunas they are loading, and observers obtain better bycatch estimates, as the number of sharks that accidentally go to the lower deck undetected is reduced.

While several purse seine fleets have been using hoppers for decades, not all devices are well suited for bycatch release. Two critical hopper design elements to maximize effective release of unwanted catches are: 1) a wide enough and accessible tray to detect and reach bycatch individuals for release, and 2) a stoppage system (e.g., regulated door) to allow enough time to collect the bycatch before going down through the unloading hatch. Both hopper requirements are necessary, as for example, the data from the French fleet's code of best practices, shows that despite having an ample and accessible hopper tray in many of their vessels, the lack of a stoppage door results in the brailer contents moving too fast into the unloading hatch, with a high proportion of sharks (>50%) ending up in the lower deck (Maufroy 2020). In our study, all hoppers had a door at the lower end of the tray which was manually operated by deck crew. When sharks were observed the deck crew would pull from a lever to stop fish flowing into the unloading hatch, until bycatches were picked up and released.

Brailing times recorded with EMS revealed similar brailing speeds when unloading fish with the brailer with the hopper and without it. This finding was supported by skippers' views, who commented that fish loading times are not greatly influenced by the presence of the hopper. The only time these skippers would consider not using the hopper was in very small sets (e.g., < 10 t) in which for one or two brailers they might not bother moving the hopper to the port side, or in very large sets (i.e., > 150 tonnes) in which quick catch loading is necessary to prevent histamine build up and bycatch release becomes secondary. For the rest of the sets, which are the majority, the hopper was voluntarily used by skippers as observed in the trials. In the case of the integrated or static hoppers (i.e., non-mobile; see example in Fig. 2), the device remains in position during all sets. Combining the best characteristics from integrated (e.g., used in all sets, wide accessible tray) and mobile hoppers (e.g., stoppage doors) in future designs might prove a valuable approach.

Another improvement to hopper designs is the addition of release ramps. These ramps connecting the hopper to the opening in the starboard deck enable a faster and less stressful transport of the animal from the brailing zone to the sea. With ramps sharks do not require being carried by hand for several meters (sometimes with poor practices such as held by the gills, tail, or dragged though the floor if heavy), instead sliding down in a water-sprayed medium. Releases with hopper and ramp presumably increase shark survival rates, but no shark condition nor satellite tags were collected in these trials. Future research with these BRDs envisages obtaining satellite tag data to compare survival rates in sets with and without hoppers. Regardless of bycatch survival, the hopper with ramp represents an important safety improvement for crew, as it greatly reduces handling interactions between crew members' and dangerous sharks (i.e., minimizes need to carry upstairs sharks found in the lower deck, or manually transport sharks from the brail to the waters' edge). Integrated or mobile hoppers oriented towards starboard appear to enable a ramp with a shorter distance to the water and a greater inclination degree to facilitate bycatch release. In addition, they do not require extra storage space thus not having move them for each set, as the hoppers on the portside do. The disposition of the hopper and ramp for each vessel will depend on the space on deck and the type of fish loading operation it employs, but these devices can be adapted to the requirements of each purse seiner. These initial trials can shed light on design options to maximize fishing efficiency and bycatch releases. Planning the installation of these BDRs in future built purse seiners would greatly facilitate their integration as top deck elements (e.g., winches, chockers, etc.) can be easily configurated to enable room for the hoppers with ramps.

Hoppers with ramps can help fishing companies seeking to reduce their impact on vulnerable species, such as those fleets adopting best bycatch mitigation practices and pursuing eco-certification. The adoption of hoppers in purse seiners could also be considered by national or international fisheries management bodies in charge of ensuring the protection of sharks and other threatened species within their jurisdiction. For other tuna gears specific bycatch mitigation equipment is already required (e.g., hooked circles, Tori lines; CMM-2018-03, CMM-2018-04). As elasmobranch populations continue to decline, use of selective equipment, like hoppers with ramps, contributing towards increased release survival should remain a priority for managers, scientists, and fishers.

Acknowledgements

Special thanks are due to Garavilla (Bolton Group) fleet manager, inspectors, and fishers for their collaboration with the hopper trials at sea, particularly Joseba Blanco for logistics coordination. Thanks to Josu Apraiz from Murueta Shipyard for help with hopper and ramp designs. This research was funded by the Fishing Department of the Basque Country. Thank you also to the International Seafood Sustainability Foundation (ISSF) for financial contribution towards this work.

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