2nd AD-HOC WORKING GROUP ON FADS MEETING

6.2.1. Methods to reduce the incidental mortality of FADs

Developing solutions to increase survival rates of vulnerable bycatch species in tuna purse seiner FAD fisheries

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ABSTRACT

One of the principal impacts of FAD fishing is accidental catch of vulnerable species like sharks, mobulid rays, or turtles. In the last decade, scientists and purse seine industry have been collaborating to test diverse fishing tactics, tool configurations, fishing manoeuvre modifications and new release devices for bycatch mitigation. Prevention of ghost fishing by transitioning to non-entangling FADs, with the support of RFMOs, is one example. Possible options to avoid endangered species bycatch include near-real time fleet communication systems of bycatch habitat preferences and the use of dynamic ocean models and acoustic technology to discriminate target species from undesired ones. Once encircled in the net, fishing sharks with hook and line to release them out could be evaluated, even if applied only at peak shark zones or seasons. For those animals captured that arrive on deck, bycatch release devices are being developed and evaluated including shark velcros, manta sorting grids, or hoppers with ramps. These tools are built considering crew safety and also the reduction of time of release of sensitive bycatch into the water with minimum stressful handling. The implementation of most promising bycatch mitigation strategies and tools, in close collaboration with the fishery sector, can strongly accelerate change towards better practices that help reduce current elasmobranch bycatch in the purse seine fishery contributing to a more sustainable fishery.

INTRODUCTION

While purse seiners' bycatch percentage relative to target tuna are low compared to other fishing gears, the impact is still significant due to the large volumes caught annually by this fishery (Dagorn et al., 2013; Hall and Roman, 2013). Bycatch in FADs is higher than in free schools as floating objects aggregate numerous species apart from tuna (Taquet et al., 2007). In the Indian Ocean bycatch per ton of target tuna catch in free school sets averages 0.8%, while in floating objects is around 3.0 % (Murua et al., 2021). These statistics are below those of other tuna fishing gears such as longline or gillnets, which depending on the fishery, can show discards exceeding 25 % and generate the majority of shark bycatch in the Indian Ocean (Kelleher, 2005;

Ardill et al., 2015; MRAG, 2012; Aranda, 2017). With regards to bycatch composition at FADs, the largest proportion are minor tuna species like the Auxis group (e.g., bullet tuna, frigate tuna), followed finfish (e.g., triggerfish, dolphinfish, rainbow runner), which are not considered threatened due to their fast growth and reproduction rates. Live release or utilization of these species are considered valid options. However, other groups like sharks, mobulids, or turtles are of greater concern to scientists and managers due to the poor status of some of these slow growing species (Lewison et al., 2014; Pacoureau et al., 2021).

In recent years various scientific groups have conducted research aiming to mitigate bycatch in FAD fishing. For example, ISSF, in coordination with other research institutions (e.g., AZTI, IRD, SPC, IATTC, etc.) and multiple fleets, has conducted numerous research cruises to test new techniques and best practices in FAD fisheries (Restrepo et al., 2018). Some of the mitigation activities tested are challenging as developing and refining new selective fishing operations and technology under real commercial operations at sea is complicated and requires considerable trial and error. Key for some of the most promising bycatch solutions has been the collaboration of fishers with scientists, both in bycatch mitigation workshops and in research cruises (Murua et al., 2014; Poisson et al., 2014).

In fisheries there are several stages at which bycatch mitigation can take place. The hierarchical preference is: 1) to prevent bycatch entering into contact with the gear before the set to ensure full survival, 2) to release bycatch from the water if caught/encircled in the gear, and if not 3) release the animals as soon as possible once they arrive on deck. In the following sections some of the latest bycatch mitigation work are described and possible options discussed both in terms of efficiency and practicality for its implementation in commercial vessels. The recommendations in this document are focused on purse seiners as they are the principal users of FADs.

BYCATCH MITIGATION IN FADS

1. AVOIDANCE BEFORE THE SET

One of the most successful initiatives to date to reduce shark and turtle mortality caused by "ghost fishing" of FADs has been the move to non-entangling FADs. Filmalter et al. (2013) documented the alarming estimate of sharks entangled in the Indian Ocean when using high risk entanglement FADs with wide mesh open netting. Since then, scientists, industry and managers have been working on transitioning towards FADs that pose minimum enmeshment risk. Industry first through voluntary agreements and later following RFMO regulations (Table 1) have moved to FADs with small mesh and tied netting (i.e., lower risk entanglement FADs in ISSF's classification), or FADs with no mesh at all (Murua et al., 2017). Since 2020, through Res-19/02, the IOTC was the first RFMO to prohibit the use of net material in FADs construction which will greatly reduce, if not eliminated, shark ghost fishing.

Aiming to avoid bycatch before setting the net is the preferred bycatch mitigation option as it would prevent interaction with the fishing gear and, hence, being caught. Ideally, the information of whether a FAD is likely to have underneath a considerable amount of vulnerable species bycatch should be available to skippers remotely before they start the trip towards a

FAD. There are several ways in which bycatch can be potentially avoided. The simplest one is communication between skippers alerting of areas with high abundance of unwanted catches, so they can redirect efforts towards less sensitive areas. This system can be either coordinated by fishers within a company or code group, or more formally through an external coordinator relaying information to the fleet (e.g., a trusted scientific agency) (Gilman et al., 2006; Barnes et al., 2016). This near-real time communication for bycatch hotspot avoidance has been employed in small (Alfaro-Shigueto et al., 2012) and large fisheries (O´Keefe et al., 2013).

Acoustic instruments, like echo-sounder buoys attached to FADs used to track their trajectories and provide an estimate of the biomass aggregated remotely, also hold potential to estimate quantities of bycatch species (Moreno et al. 2019; Mannocci et al., 2021). Some bycatch species have strong acoustic backscattering, as is the case for pelagic triggerfish (*Canthidermis maculatus*) and rainbow runner (*Elagatis bipinnulata*), two species commonly found at FADs. In order to discriminate them from tuna species, knowledge on the vertical distribution of the different species found at FADs is necessary. Most non-tuna species are found consistently shallower than target species (Moreno et al. 2007; Forget 2015) which would allow monitoring their presence and abundance in real time.

Other more sophisticated ways of identifying bycatch hotspots include fine-scale spatiotemporal dynamic ocean models based on real-time catches and oceanographic conditions which could help predict vulnerable species areas at any given time (Lewison et al., 2015; Hazen et al., 2018; Lezama-Ochoa et al., 2020). These models should also consider the economic repercussions, in terms of target catch wins or losses of closing or moving away from these bycatch hotspots relative to other alternatives such as total closures (Watson et al., 2009; Dunn et al., 2016). In isolation or combined, the use of communication systems, hotspot models and remote sensing tools could help managers decide on dynamic “move on” spatial closures.

Another way of reducing bycatch is to target FADs with larger tuna aggregations and avoid small FAD sets because the amount of bycatch in most FADs is similar. Therefore, limiting FAD sets to those with large tuna aggregations and avoiding many low productivity small FAD sets, would slightly reduce target catch (3-10%) but greatly diminish bycatch (23-43%) (Dagorn et al., 2012). This approach would be difficult to implement especially in high-vessel concentration regions, like the Indian Ocean, with high probability of FAD theft as often pushes them to quickly set on small school FADs for fear of losing them to other competitor vessels (Murua et al., 2018).

Once the purse seiner has arrived at a FAD there are ways fishers could try to attract the sensitive bycatch away from the FAD before setting. For example, using attractors such as bait to entice sharks to swim away from the floating object. However, the few trials conducted in the Indian Ocean by slowly moving away from the FAD in a speedboat dragging a bag full of fish as bait only partially attracted some sharks, most moving back to the FAD after following the bait for a few hundred meter maximum (Restrepo et al., 2018). Also, fishers might be reluctant to routinely carry out this procedure as it would take time and often be conducted in the dark before sunrise or in rough seas.

Important research gaps exist on the characterization of elasmobranch senses (i.e., sight, hearing, smell, taste) and to some extent of tunas as well. This prevents the development of better targeted deterrents or attractants that could keep sharks away from FADs. For example, if silky sharks were able to detect certain wavelengths that tunas cannot, lights fitted to the FAD or echo-sounder buoys could be remotely activated the night before a set to scare them away. These alternatives have not been trialled due to lack of fundamental knowledge on the physiological principles driving the behaviour of FAD fauna groups.

2. RELEASE IN THE NET

Releasing bycatch from the net has been tested in different ways in the last decade (Restrepo et al, 2018). For example, Ecuadorian purse seiners are required to use sorting grids in the sac (e.g., Arrue, Eliseo, Salica models; Figure 1a). Bycatch species are able to swim away through this grid with wider mesh. The mix of target and bycatch species and sizes at FADs complicates the use of size-selective gear. For example, bycatch like sharks will be larger than skipjack, which can result in escapes of target tunas though the grid. Records of Ecuadorian fishers lifting the section of the sac with the sorting grid, so it remains out of the water to prevent potential tuna escapes, are not uncommon. Workshops between scientists and fishers have been held in recent times to improve the design of the sorting grids (IATTC, 2019).

Other interesting experiments to release sharks from the net were the shark release panels trialled in various ISSF research cruises (Figure 1b). At the start of the set tunas tend to dive deeper in the net, while bycatch like finfish and sharks remain nearer to the surface. This temporary large spatial separation in the net and the observation that sharks often accumulated in a bend or “pocket” of the net, led to testing a release window to allow sharks escape before the sacking up operation (Itano et al., 2012). Unfortunately, not many sharks escaped through the window in the limited trials. Moreover, oceanographic features like currents and thermoclines had a strong influence on results (Itano et al., 2015), but this idea or similar ones providing escape openings in the net merit further consideration.

One of the most successful trials to release sharks from the net has been by fishing them with hook and line inside the net and releasing them outside of it. The idea was initially suggested by fishers in an ISSF Skippers Workshop. This activity takes place at the start of the net hauling process, during the initial 45 minutes approximately. Results in two cruises, one in the Atlantic and another in the Indian Ocean, showed that between 15 % and 30 % of the sharks present in the net could be captured and released alive following this procedure. Satellite tagged released sharks showed 100 % survival rates (Sancristobal et al., 2016; Restrepo et al., 2018). Thus, this option could partially help to reduce shark bycatch and, hence, overall shark mortality. As the fishing line can be cut with the biodegradable hook still attached to the animal, the activity does not entail risky crew shark handling. However, crew safety considerations might be necessary in cases where the activity needs to be conducted in adverse weather conditions (e.g., monsoon season). While most fishers will prefer not to conduct extra activities like this during the set, they would prefer this mitigation option to stricter measures such as area closures to protect sharks (Murua et al., 2018).

In the case of accidental encirclement of whale sharks, release takes place from the net. Fishers have developed manoeuvres enabling these large animals to escape over the corkline or cutting an opening in the net. Satellite tagging in the Atlantic Ocean indicated that almost 100% of the whale sharks released in this manner during the studies survived (Escalle et al., 2015, 2017).

3. ON BOARD RELEASE

Once the net hauling reaches the final stage of sacking up and brailing of the catch onboard commences there are several methods to release the animals from the top deck. It is important to point out that there is a strong relationship between release time and bycatch survival at this stage (Onandia et al., 2021). Animals released in the earlier stages of the fishing operation, such as enmeshed sharks liberated when the net is being hauled or in the first few brails, showed higher survival rates (Hutchinson et al., 2015; Onandia et al., 2021). On the other hand, individuals in the later brails or that end up in the lower deck and must be transported back to the working deck for release when there are no quick releasing mechanisms in the lower deck, result in lower survival chances. Therefore, developing methods that ensure a safe and fast release from deck are key.

Collaborative work between French scientists and the fleet helped develop the first guide of good practices to release sharks and mobulids from deck (Poisson et al., 2012). This was a first step towards creating new release protocols and some low-cost hand-made tools were proposed such as stretcher beds for sharks and cargo net/canvases to lift heavy manta rays. These basic tools while practical, are still subject to improvement. For example, cargo nets for mobulids, still require time consuming and risky manual handling to extract the animal out of the brailer and small canvases might result in excessive folding of the mobulid's wings when they are lifted (Figure 2).

Maufroy et al., (2020) report that good practices are less easily applicable for larger and more dangerous individuals (e.g., adult mobulids and sharks) and also for less detectable small individuals (e.g., juvenile sharks). At present AZTI scientists are working with industry to develop and trial new devices to release vulnerable species by increasing animal detectability and reduction of handling time, and crew safety (Grande et al., 2019; Murua et al., 2021; Table 2). Prototype tools include padded leashes with velcros to lift large sharks out of the brail and release them into the water. These shark velcros are intended to substitute current lifting practices with ropes, which abrade and damage the sharks' tail (Figure 3). Another prototype device is the manta sorting grid, which consists of a metallic frame with a series of ropes placed on top of the unloading hatch enabling at brailing tuna to go through while retaining the mobulid on top. The manta grid is then lifted with a crane towards the starboard where the animal is released (Figure 4; Annex 1). Experimental trials have shown several benefits such as sorter release times (1-2 minutes) than other techniques, no manual handling requirement, release of more than one mobulid at once while the brail can continue to operate during release (Murua et al, 2020; Table 3). Several Spanish vessels, including some in the Indian Ocean, have started in 2021 to build manta sorting grids and using them in commercial fishing trips.

A third type of on deck devices tested have been bycatch release ramps. The ramps start near the brailing area and connect all the way to the starboard, where many vessels have a bycatch release door. These ramps speed up release and minimize handling risks as once the animal is deposited on the top end of the ramp it slides down unassisted towards the water's edge (Figure 5; Annex I). Although some vessel will have less space on the top deck than others, the size and design of the devices described above can be adapted in most cases to suit those specific working conditions.

Another bycatch reduction device that has been used in the past by some fleets are hoppers, which is a generic term to describe some kind of metallic container on which the brailer contents are emptied to sort out unwanted catches before they go down to the lower deck. Traditional hoppers were more widely utilized in the 1970s, before purse seiners had conveyor belts in the lower deck, to help “clean” the catch before it went into the wells. Many kinds and designs of hopper exist (e.g., mobile, fixed on deck, on the starboard, on the portside, etc.) and some are better for releasing bycatches than others. Two conditions appear to be important to maximize hopper selective efficiency: 1) they should have a wide enough “tray” or surface area so brailed contents can be spread out and bycatches located, and 2) must have a stoppage mechanism (e.g., door) to prevent bycatch spilling down too fast to the lower deck without being detected and released. For example, French fleet style hoppers have a wide base but lack of a stop door resulting in many sharks, especially the smaller ones which are harder to spot, going to the lower deck (Maufroy et al., 2020; Figure 6). A recent study with four vessels that had removable hoppers with a wide tray and a stop door revealed that these vessels were able to release over 95% of the sharks from deck compared to only about 50% when there was no hopper (Murua et al., 2021; Figure 7). To further improve the release efficiency of these hoppers, custom-built ramps were added to the hoppers to assist with fast releases (Figure 8). In 2021-2022 several new hoppers with ramps will be tested in the Atlantic, Pacific and Indian Oceans. Manta releasing devices to be integrated in hoppers are also starting to be developed in the Spanish fleet in 2021 and similar projects with the French and USA fleet are programmed for 2022.

In addition to these devices, some vessels are equipped with a double conveyor belt and waste chute to release bycatches from the lower deck. Although top deck releases are preferrable, if bycatch is released quickly directly from the lower deck into the water (i.e., instead of having to handle it up the stairs to the upper deck for release) it is likely to increase their survival rates. For example, a recent study by Onandia et al. (2021) in the Indian Ocean showed higher levels of shark release survival (43%), compared to previous studies ranging between 15 and 20% (Poisson et al., 2014; Hutchinson et al., 2015; Eddy et al., 2016). The application of best practices together with devices like waste chutes might help understand better these results. A new Indian Ocean shark release tagging campaign in a different vessel with a waste chute is being planned for the last trimester of 2021 to validate previous findings. Note that constructing a double conveyor belt and waste chute in a vessel can be very expensive or might not even be permitted due to vessel safety concerns.

In recent years tuna RFMOs have adopted several conservation measures regarding vulnerable species bycatch in FADs (Table 4), some of which deal with retention requirements and others with bycatch releases. At present, none of them regulate bycatch avoidance options, and mostly deal with best practices for release handling methods (i.e. prohibition of use of gaffs, lifting with hooks, etc.). Only a few simple tools, like stretcher beds, or cargo net/canvas to lift manta rays are recommended, but not obliged. New advances with more refined bycatch release devices that improve safety and survival are necessary to reduce ecological impacts. The coproduction with fishers of these tools and trial and error is paramount to reach agreed solutions that will be fully implemented at sea. However, for already built vessels, fisheries technology must adapt the larger release devices (e.g., hoppers with ramps) to each working deck space characteristics. In the future, newly built purse seiners should allow for inclusion of release devices in the same way other fishing equipment like winches, power blocks, or cranes are. Customized deck configurations that integrate release devices from the start would enable improved deck distribution and greater functionality of these tools.

CONCLUSIONS

Bycatch mitigation by tuna purse seiners working with FADs has been advancing in the last decade thanks to several factors such as increased pressure by consumers, retailers, and NGOs for more sustainable seafood. This has led to increase scientific research to find solutions with the collaboration of fishing industry, and adoption of relevant conservation measures by RFMOs such as the prohibition of entangling FADs. Having said this, many challenges remain such as increasing the survival rate of caught sharks and manta rays, and urgent progress is needed given the status of some of these vulnerable species.

In the mid- to long-term fundamental science investigating the physiology of threated species to exploit sensory characteristics that keeps them away from FADs and technological developments that remotely monitor species presence should be supported to obtain smarter mitigation solutions before the bycatch interacts with the fishing gear. In the meantime, bycatch avoidance systems like near real-time fleet communication programs and dynamic ocean models have already proven their value in other fisheries and could be adapted to tropical tuna fisheries. Dynamic “move on” bycatch avoidance schemes work better but are difficult to implement without incentives.

Operational protocols to release bycatch species once in the net or when they arrive on the vessel are also necessary as all FAD sets will have certain amount of bycatch. For now, fishing sharks in the net from the speedboat with a hook and line to immediately release them outside the net, has shown to be one of the simplest, cheapest, and most effective mitigation options. This action ensures on average full survival of 15-30% of all sharks present in the net (Restrepo et al., 2018). However, the action was guided by scientific staff which were fully dedicated to it and its extrapolation to the fishing operations should further be evaluated.

Most purse seiners in the Indian Ocean take part in Good Practice programs. The adoption of new release devices would help advance in the objectives of these programs and pricewise as it is relatively inexpensive. Even the most expensive equipment such as hoppers with ramps are the price equivalent of 15-30 echosounder buoys. The design of the hoppers (e.g., size, shape) must be accommodated to the space configuration on deck, and in some types of vessels might be more difficult to integrate than others. In the future it is suggested that new purse seiners are built already with options to incorporate these or other bycatch reduction devices integrated in their deck configuration to afford better distribution and operational efficiency. Recommendations supporting the incorporation of these bycatch release devices in best release practice measures (e.g., IOTC Res. 19-03; Res. 17-05) would promote the implementation of these tools. Finally, many of these bycatch release actions would greatly benefit from skipper and crew best practice training programs to raise bycatch awareness and encourage socialization of these measures to improve implementation (Airaud et al., 2020).

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TABLES

Table 1 – Resolutions and Recommendations on non-entangling FADs by tuna RFMOs

RFMO	Resolution(s)	Non-entangling material
ICCAT	REC. 16-01 REC. 19-02	Replace existing FADs with non-entangling* FADs (2016-2021)
IOTC	RES. 15-08 RES. 16-01 RES. 17-08 RES. 18-08 RES. 19-02	Non-mesh material (2020-2021)
IATTC	RES C-17-02 RES C-19-01 RES-20-06	If open mesh is used the mesh size is restricted to 7 cm and if it is above 7 cm it must always be well rolled in coils to minimize the entangling potential both in the submerged and floating part (2019)
WCPFC	CMM-17-01 CMM-18-01 CMM-20-01	If open mesh is used the mesh size is restricted to 7 cm and if it is above 7 cm it must always be well rolled in coils to minimize the entangling potential both in the submerged and floating part (2020)

Table 2 – Tuna purse seiner bycatch release device options. * High durability devices that would only require a one-off purchase, ** Fitted with mobulid release adaptations.

Bycatch release device	Target species/size	Price unit (USD)	Implementability
Padded velcros	Large sharks	50-80	High
Manta sorting grid	Large mobulids	500-2,000*	High
Release ramps	All except mobulids	500-3,000*	High
Hoppers with ramps	All species**	15,000-60,000*	Medium
Cargo net/canvas	Mobulids	< 50	High
Stretcher beds	Sharks	< 50	High
Double conveyor belt	All except mobulids	> 200,000*	Low

Table 3. Mobulid releases with sorting grid in Atlantic Ocean at sea trials on a purse seiner

SET TYPE	DATE	TONS PER SET	SET NUMBER	BRAIL NUMBER	NUMBER MOBULIDS	SPECIES	DISC WIDTH (cm)	RELEASE TIME (min)	CONDITION
FAD	05/10/19	15	11	4	1	*M. tarapacana*	240	2:11	Dead
FAD	13/10/19	15	31	1	1	*M. tarapacana*	250	2:00	Dead
FAD	13/10/19	15	31	3	1	*M. tarapacana*	300	1:40	Dead
FAD	13/10/19	15	31	5	3	*M. tarapacana*	300,300,300	2:14	Alive
FAD	06/11/19	30	65	3	1	*M. tarapacana*	330	1:13	Alive
FAD	06/11/19	30	65	6	1	*M. tarapacana*	300	1:02	Alive

Table 4 – Tuna purse seiner bycatch related RFMO conservation measures

RFMO	Turtles	Sharks	Mobulids	Whale sharks	Marine Mammals	Others
IOTC	Res.12/04	Res.12/09 Res.13/06 Res.17/05	Res. 19/03	Res. 13-05	Res. 13-04	Res. 19/05 Res. 18/05
ICCAT	Rec. 10/09 Rec. 13/11	Rec. 04/10 Rec. 8/06 Rec.09/07 Rec.10/06 Rec.10/07 Rec.10/08 Rec.11/08 Rec.18/06 Rec.19/06				
CIAT	C-04-05 C-04-07	C-16-05 C-19-05	C-15-04	C-19-06	APICD	
WCPFC	CMM 2018-04	CMM 2019-04	CMM 2019-05	CMM 2019-04	CMM 2011-03	

FIGURES

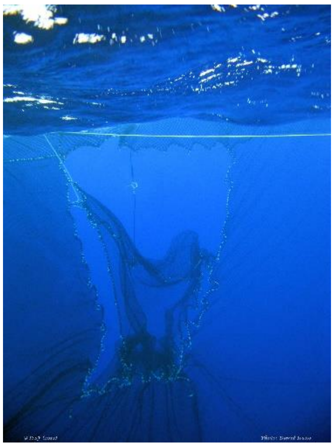
(a)  (b) 

Figure 1. (a) Sorting grid fitted in the purse seine net of an Ecuadorian vessel, (b) shark escape panel trialled in ISSF research cruise in the WCPO.

(a)  (b) 

Figure 2. (a) Mobulid being pulled out of the brail to deposit on the release canvas, and (b) mobulid filted for release with home-made net too small.

(a)  (b) 

Figure 3 – (a) AZTI shark velcro prototype, (b) shark released with shark velcro

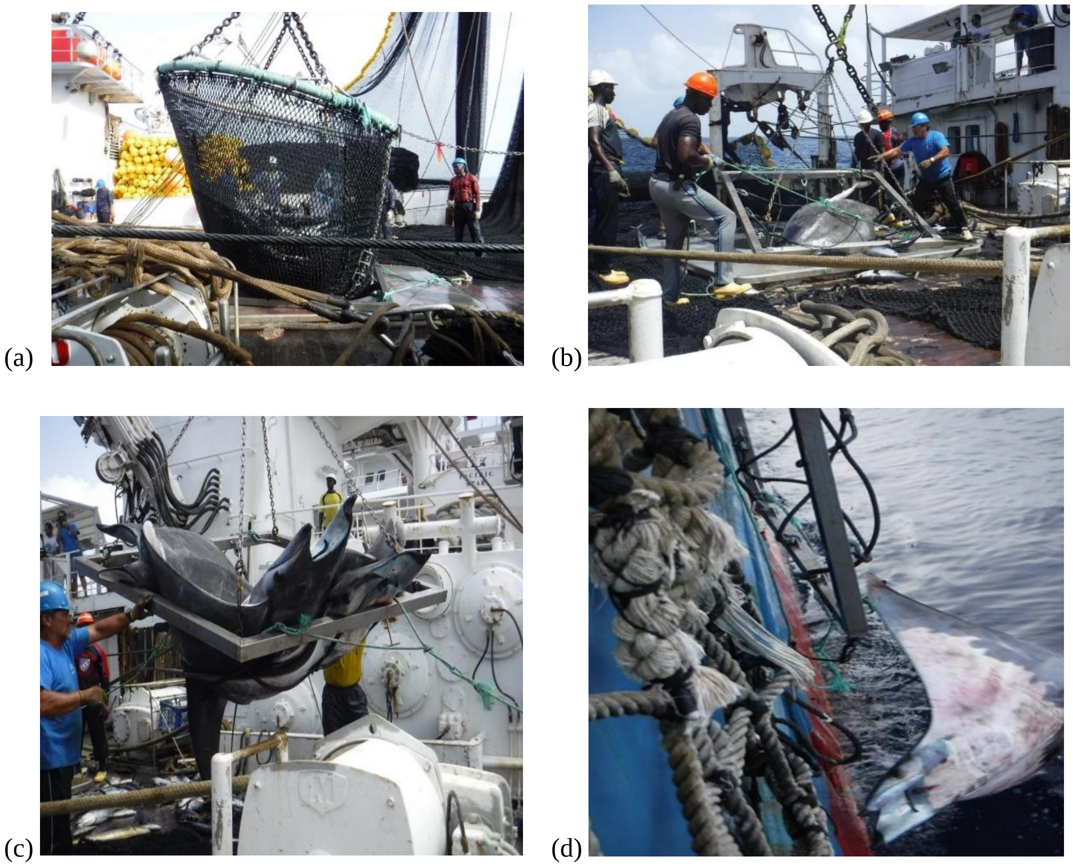


Figure 4. AZTI manta sorting grid use release steps: (a) empty brail contents into unloading hatch, (b) connect grid frame with chains to deck crane, (c) move sorting grid towards starboard railing, and (d) release animals into the water.

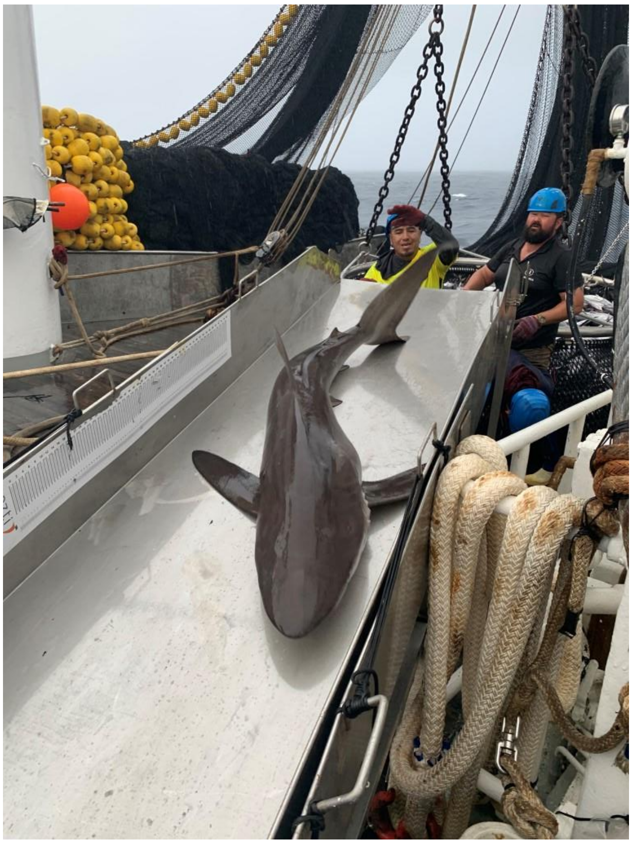


Figure 5 – Shark extracted from brailer and deposited on release ramp for release

Figure 6. Large hopper tray lacking a stop door to avoid bycatch moving too quickly into the lower deck.

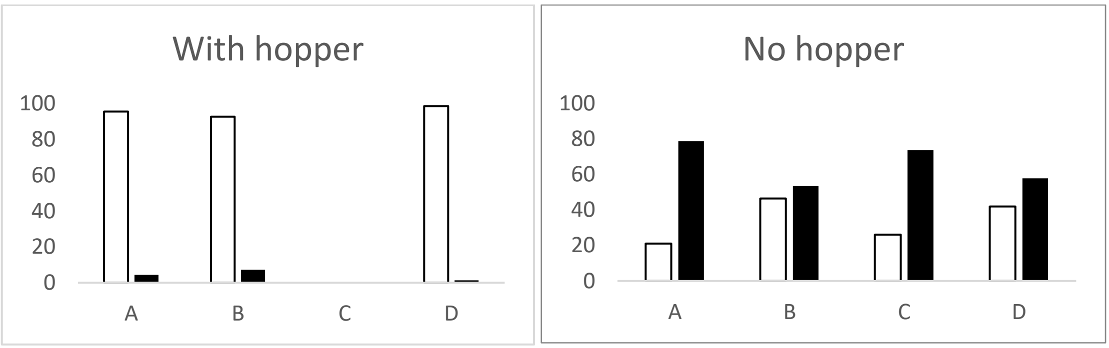


Figure 7. Percentage of sharks released from the top deck (white bars) and lower deck (black bars) in sets performed with or without hopper in four purse seiners (A-D) of the Eastern Pacific.

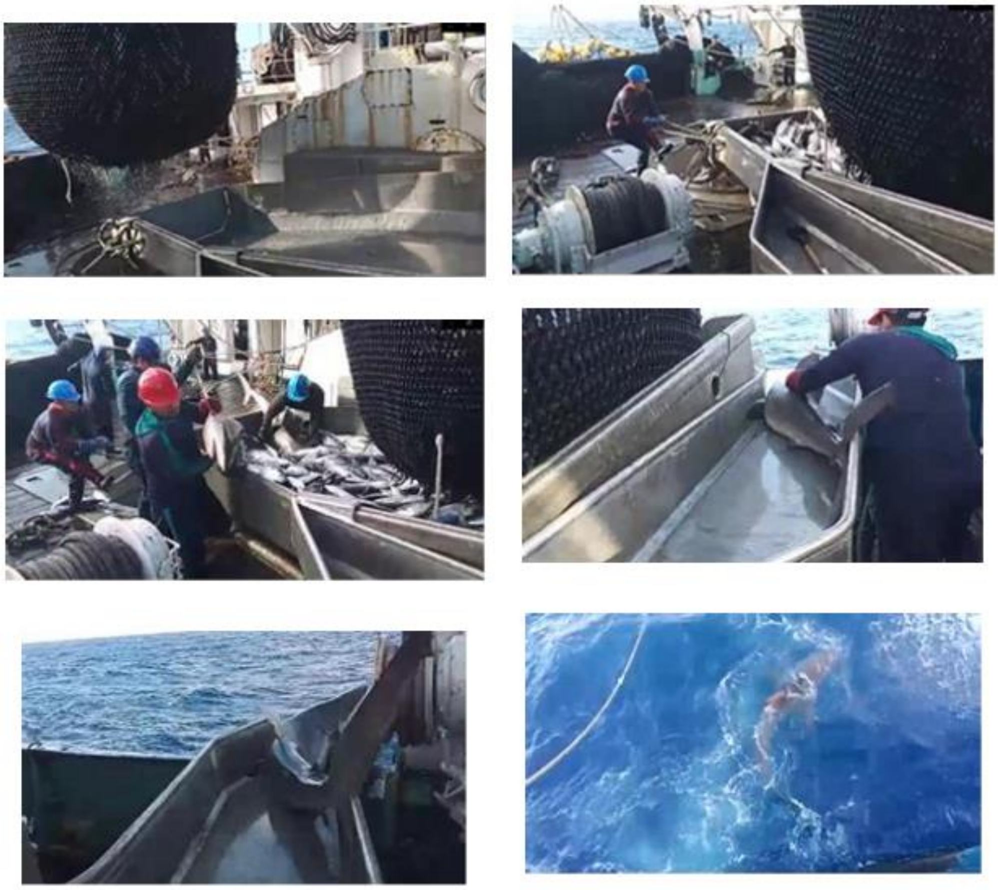
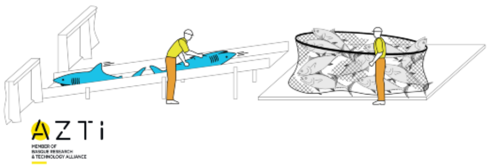
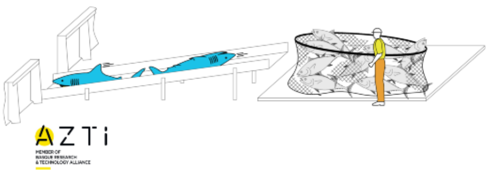


Figure 8. Sequence of brailing and shark release using hopper with ramp in the top deck on the starboard.

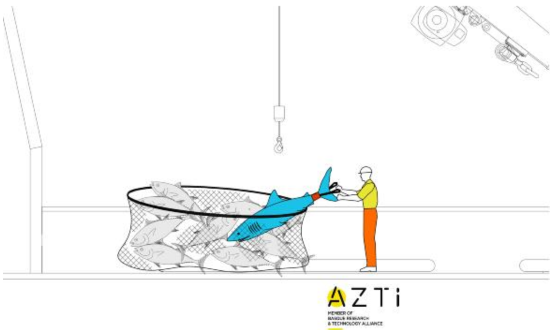
ANNEX 1 – Illustrations of best on deck release practices with bycatch release devices

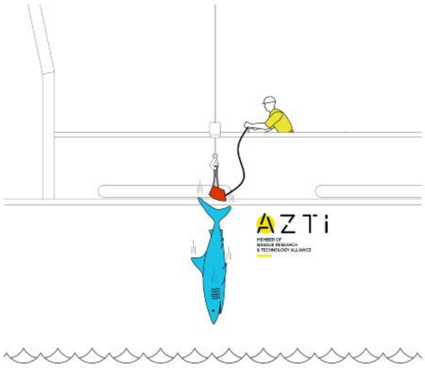
Deck release ramp



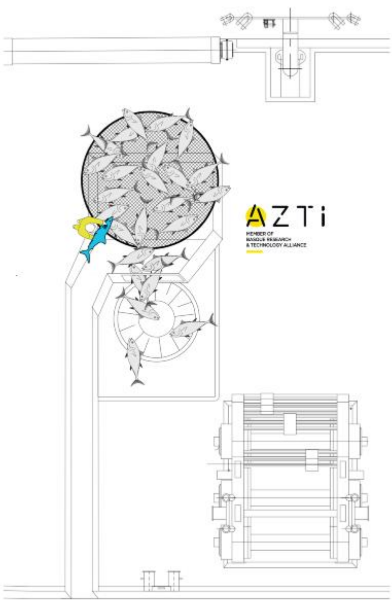


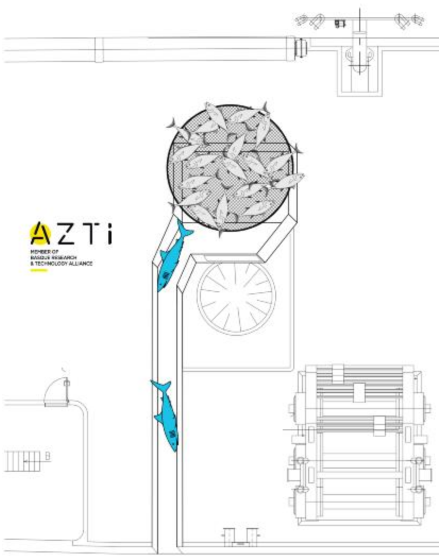
Shark Velcro





Hopper with ramp





Manta sorting grid