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Can lifting large sharks by the tail with bycatch release devices be a best practice for improved crew safety and shark survival?

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Abstract

Lifting sharks by the tail to release them from deck in purse seiners is currently prohibited because it is considered a poor practice. However, because large active sharks arriving on deck should be released manually, fishers are exposed to unreasonable danger if they decide to handle them and if they opt to wait until the shark becomes moribund for a safer release this will result in high post release mortality. With the feedback from fishers, we have developed two new bycatch release devices (BRDs), the “shark velcros” and “shark harnesses”, to quickly and safely lift heavy sharks out of the brailer with the crane and back into the water. These devices are easy to use and are constructed with a wide padded support area to prevent injury to the caudal peduncle of sharks when being lifted. Preliminary physiological and satellite data indicate high post-release survival (PRS) of sharks using these release methods. More research needs to be conducted to unequivocally confirm that these tools are effective in order to be incorporated into the best handling and release practices (BHRPs) for sharks.

Introduction

Minimizing impacts on threatened bycatch species like sharks is among the principal objectives of tuna regional fisheries management organizations (tRFMOs). One way of achieving this is through fishers applying BHRPs for elasmobranchs accidentally caught in these fisheries (Gilman et al., 2023). Most sharks incidentally caught in the tropical tuna purse seine nets are brought on deck in the brailer before they are released back into the water. Often sharks encountered in FAD sets are juveniles (Amande et al., 2010; Hall and Roman, 2013) and can be extracted manually out of the brailer or the hopper by one or two crew members with relative safety. While there are still risks associated with manipulating juvenile sharks, experienced crew can usually handle them satisfactorily, especially if they have tools to assist them in reducing direct contact time (e.g., stretchers, ramps) (Murua et al., 2025).

However, dealing with active large adult sharks is a completely different situation. Even if these large individuals are found on the upper layers of the brailer, with most of their body readily available for holding, fishers need to be extremely cautious, as a single bite can result in a severe injury or even a fatality (Maufroy et al., 2020). There have been numerous reported cases of deck crew being seriously wounded by shark bites when attempting to release large dangerous sharks manually. In other cases, during brailing, only part of the body (e.g., the tail) will be accessible, as often sharks will be embedded in between the large mass of tuna filling up the brailer, which range from 5 to 12 tonnes in capacity (Poisson et al., 2014). Pulling these heavily embedded large sharks by hand is not only dangerous but also difficult as the weight covering them is substantial (i.e., hundreds to thousands of kilograms of fish surrounding them). For this reason, in the past, fishers have resorted to using rope nooses around the tail of these animals to lift them out of the brailer with the help of the crane on deck.

It has been suggested that lifting sharks by the tail is detrimental to their survival as it can result in vertebral damage (Poisson et al., 2014). Although this might be true, revising the literature we could not find any shark physiology study testing and verifying this theory. We believe that the practice of using narrow ropes to make loops or nooses to lift sharks by the tail is clearly detrimental, as with its small diameter the rope can cut through the shark's skin when pulling strongly. However, unless the security of the crew is put aside trying to grab directly these large animals, the alternative is to either wait for the active shark to become lethargic until it is safer to handle or not pull it out of the brailer and let it fall to the lower deck, where release time is greatly delayed. In both instances, these protocols extend the time a shark remains in an anaerobic state out of the water and will likely reduce its chance of survival. It is well documented that time out of the water is one of the most critical factors leading to mortality in elasmobranchs (Stewart et al., 2024), especially since at this point of the fishing operation their respiratory capabilities have already been compromised due to the time spent in the sac, when these obligatory ram ventilators are unable to freely swim to breathe adequately (Hutchinson et al., 2015).

Currently IATTC Resolution C-24-05 paragraph 11 requires CPCs to promptly release unharmed all sharks to "the extent practicable, as soon as they are seen on the line, entangled in the net, or brailed on the deck, taking due consideration the safety of any person on board using the following procedures". Within such procedures for purse seiners, in point 11.d. it prohibits "the lifting of sharks by the head, tail, gill slits, or spiracles, or by using bind wire against or inserted through the body". We hypothesise that if lifting large sharks by the tail with the crane could be executed smoothly and quickly (e.g., < 1 minute) using non-incisive equipment, then this would ensure crew safety (i.e., no direct contact required) while increasing chances of post release survival of adult sharks due to reducing their time out of the water. To test this theory, we first developed bycatch release devices (BRDs) that could be easily placed around the shark's caudal peduncle without harming its skin and musculature and that enabled quick and safe release once the animal was close to the water. To assess if the sharks survived after being lifted and released using the BRDs, we tagged several individuals with pop-up survival satellite tags to learn about their fate. Here we present the prototype designs of these BRDs and preliminary PRS results.

Methods

1. Shark sizes

To better understand what fishers must deal with when releasing very large sharks on deck we checked in the database of Fishbase (https://www.fishbase.org/) the maximum sizes and weights of some of the principal species of sharks that can be encountered in tuna purse seine sets including silky sharks (*Carcharhinus falciformis),* oceanic whitetip sharks *(Carcharhinus longimanus),* blue sharks (*Prionace glauca*), hammerhead sharks (*Sphyrna* sp.), thresher sharks (*Alopias sp*.), and mako sharks (*Isurus sp*.). This information can provide a scale of the sizes and weights of sharks that fishers must manipulate with the upper percentile of large adult sharks.

We also checked 6 fishing trips in purse seiners of the Atlantic Ocean (prior to the development of velcros or harnesses), to examine the size of the sharks in particular cases when nooses had been employed to lift and remove sharks from deck. In the comparison we utilized two categories, small/medium sharks (<1.80 m) and large sharks (≥ 1.80 cm).

2. BRD prototypes

To lift large sharks from the caudal peduncle with methods that prevent harmful injuries two different BRDs were designed. Both have a wide padded holding surface to avoid marking or cutting the skin when lifting the animals. The design of these BRDs is described below.

2.1. Shark Velcro

We have been working on a series of “shark velcro” prototypes to lift large sharks by the caudal peduncle while minimizing potential damage to the animal. The basic concept of the shark velcro is creating a device with and wide enough padded surface that can be quickly wrapped around the shark’s caudal peduncle when it is still in the brailer and secured safely with a strong velcro. The device is then connected to the hook of the crane for lifting. Once the shark is transported to the water’s edge, the velcro can be opened remotely by pulling from a rope that connects to the device. The first shark velcros were produced in 2020 and given for testing to some Spanish fleet vessels (OPAGAC and ANABAC) in the Indian and Atlantic Oceans (Fig. 1).

Figure 1. Early shark velcro prototype.

While these early prototypes worked in some cases, there were a few events according to fishers in which the fabric accidentally ripped or the velcro’s sides separated due to the pressure exerted when lifting very large animals. We also found that the size of the standard prototype velcros was not large enough to adequately wrap around the tail of the largest specimens, particularly very large hammerhead sharks which have a wide caudal peduncle diameter.

We also tried to employ commercial big wave surf leashes modified with straps to connect to the crane for lifting. While very practical to apply around the perimeter of the tail, the breaking resistance of these commercial leashes (approx. 300 kg force) was not strong enough for the demanding conditions experienced during brailing in purse seiners (Fig 2).

Figure 2. Adapted big wave surf leashes breaking during laboratory tests.

With this feedback we continued to develop stronger velcros, still with the shape of surf leashes but this time with the core part of the device constituted by a heavy-duty sling on which the inner side was covered by a significant layer of shock absorbing padding to prevent injury to the animal’s skin. On the outer side adhesive velcro was stitched to secure the device in place. The velcro also has two sling loops oriented vertically to secure the device to the hook of the crane. We have produced velcros in two sizes, both with the same total length 106 cm but with 6 cm and 12 cm width bands (Figure 3,4).

Figure 3. Small shark velcro extended (above) and closed (below).

Figure 4. Large (left) and small (right) shark velcros.

2.2. Shark Harnes

A second device was recently developed following similar principles as those of the velcros, trying to create a lifting equipment that has an easy application and sufficiently wide and padded to prevent injury to the shark's caudal peduncle. In this case the device has on one end a loop to connect to the crane and on the other a paddled sling that has two reinforced loops (Figure 5). One of the loops is free, while the other is connected to by a strap to the crane's loop. In between there is a trigger release system to which a fine and long rope is attached to open it remotely when pulling from it. The way the shark harness is applied is by passing the free loop through the loop with the strap and then inserting it in the releaser. In this way, once the crane starts to pull up, the padded sling narrows and holds the caudal peduncle, and the animal can be lifted towards the starboard. Once it reaches the water, the fisher pulls the long rope connecting to the releaser to let the loop free. Thus, the sling holding the tail becomes loosened and the animal is immediately released. Two harness prototypes were initially constructed, both with a 6 cm wide padded strap, but one shorter (68 cm) than the other (103 cm).

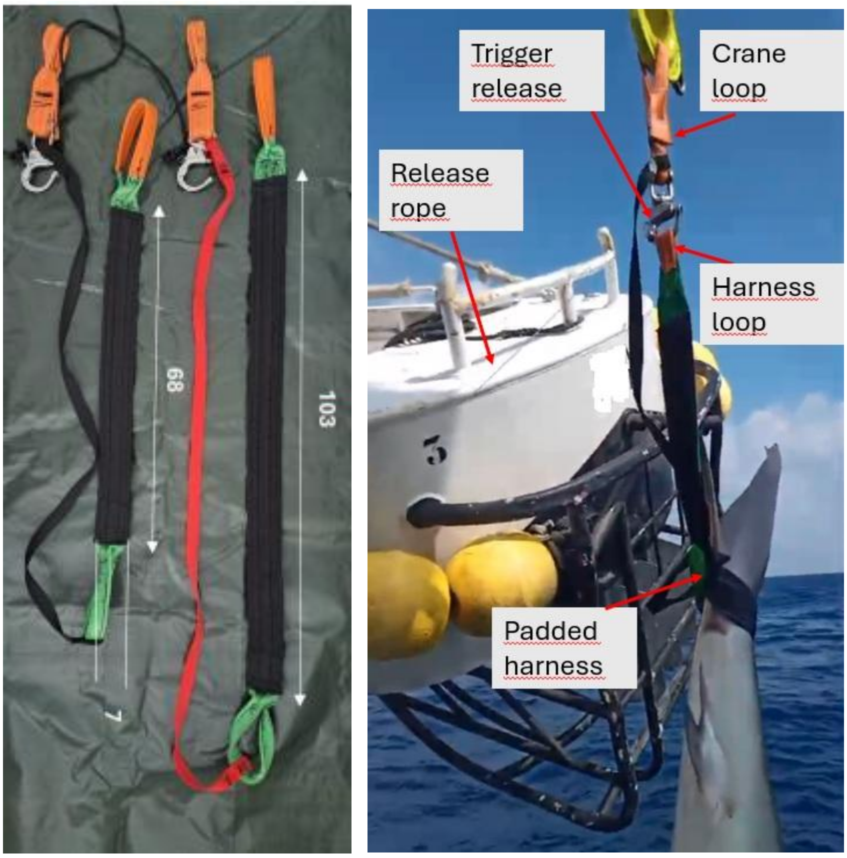

Figure 5 – Shark harnesses of different padded strap lengths (left) and description of its components (right).

3. At Sea Trials

In 2021 three silky sharks were released with shark velcros and satellite tagged during two experimental campaigns onboard tuna purse seiners Jai Alai and Euskadi Alai (Echebastar) and one more was tagged in 2024 in the Itsas Txori (Inpesca), all in the Indian Ocean. In the 2024 cruise additionally the condition of three sharks released with velcros were recorded. Over recent years we have provided experimental velcros and harness prototypes to fishers to test and receive feedback to improve them. We have also received multiple videos recorded by fishers of sharks released with the velcros in the Atlantic and Indian Oceans, in which it can be observed how sharks swim away actively after their release. However, we have not included this circumstantial evidence in the survival analysis of this work.

3.1. Pop-up satellite tags

In 2021 and 2024 during three opportunistic trips in the Indian Ocean four sharks were tagged and released with shark velcros. To estimate the survival of these sharks, survivorship pop-up archival tags (sPATs) (Wildlife Computers, Inc.), were programmed for detachment 60 days post-deployment for sPATs to record maximum and minimum daily depths and temperatures as well as depth at 10-minute intervals during the final four days of deployment. The sPAT release was also triggered if a tag exceeded 1,400-1,700 meters or remained at a constant depth for more than three consecutive days. In all cases, tags were attached using a 10 cm monofilament tether encased in an alimentary-grade silicone tubing. A Domeier-style anchor was used for tag attachment to sharks. To ensure proper insertion of the tag, a 2 cm incision was made at the base of the dorsal fin using a sterilized scalpel. All tagging equipment (tether, anchor, and scalpel) was treated with 5% povidone-iodine (Betadine Antiseptic Cream) to minimize the risk of infection. We considered an individual to have survived the release event if the tag remained on the animal for 10 days or longer and showed typical movement patterns during that period, following protocols employed in other shark tagging studies (e.g., Hutchinson et al., 2015).

3.2. Blood lactate

To assess physiological stress, blood samples were collected from the caudal peduncle of the four sharks tagged and of some released with velcro but no tag in the 2024 trip. Samples were taken and checked for lactate concentrations measured in situ using a portable lactate meter[1] (Lactate Plus, Nova Biomedical).

3.3. Vitality Index

To determine the state of the animal at release based, we used a vitality index following the states proposed by Hueter and Manire (1994) which include: (1) excellent (i.e., very active and energetic, strong signs of life on deck and when returned to water); (2) good (i.e., active and energetic, moderate signs of life on deck and when returned to water); (3) correct (i.e., tired and sluggish, limited signs of life, moderate revival time required when returned to water, slow or atypical swimming away); (4) poor (i.e., exhausted, no signs of life, bleeding from gills, jaw or cloaca, long revival time required when returned to water, limited or no swimming observed upon release); and (5) very poor or death (i.e.,

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[1] *https://www.laktate.com/producto/lactate-plus/*

moribund, no signs of life, excess bleeding from gills, jaw, or cloaca, unable to revive upon return to water, no swimming movement, sinks).

Results

Revising the literature the maximum sizes and weights of some of the most frequently caught sharks in purse seiners showed for example silky sharks, which are the dominant species in this gear type, reaching up to 3.7 m in total length and 345 kg in weight. Other bycatch shark species reported to appear occasionally in purse seiners can reach over 6 m in length and 550 kg (Table 1).

Table 1 – Maximum total length (cm) and weight (kg) for several shark species reported to be caught in tropical tuna purse seine fisheries. Source Fishbase.

Shark species	**Max TL (cm)**	**Max Weight (kg)**
Silky shark (*Carcharhinus falciformis*)	370	345
Oceanic Whitetip shark (*Carcharhinus longimanus*)	400	167
Blue shark (*Prionace glauca*)	400	205
Hammerhead shark (*Sphyrna* sp.)	610	450
Thresher shark (*Alopias sp.*)	610	363
Mako shark (*Isurus sp.*)	450	570

As an illustrative example 6 fishing trips in the Atlantic Ocean prior to the invention of shark velcros and harnesses was examined, the comparison of shark sizes when the rope nooses had been employed clearly showed that this happened almost exclusively with large individuals (i.e., > 95%) and in the few instances used with other sharks these were individuals in the upper percentile of the medium class category (i.e., 1.5 to 1.8 m).

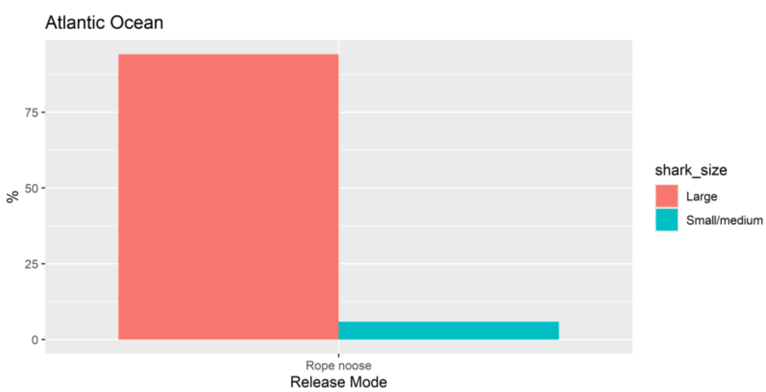

Figure 6. Percentage of large (≥ 180 cm) and small/medium (< 180 cm) sharks in the release mode rope noose from 6 purse seine trips in 4 vessels of the Atlantic prior to shark velcros and harnesses.

Figure 7 – Large shark left on deck until it becomes less active for release to ensure crew safety.

Their size of the individuals tagged was not of very large adults (size at maturity 2.1-2.4 m) but because we wanted to check PRS with velcros and there were no large sharks in these opportunistic trips, we opted to tag these intermediate sized individuals (Fig.8). From the tagging results all individuals released with velcros were females of intermediate size and showed a good vitality index (i.e., active and showed some sign of life on deck and when returned to the water) (Table 2).

Figure 8. Satellite tagged silky shark (*C. falciformis*) released with shark velcro. AZTI ©

Table 2. Tag type, species, length, sex, blood lactate, vitality, and survival of sharks tagged and released with velcros in tropical tuna purse seiners.

Tag Type	Shark species	Length (cm)	Sex	Lactate (mmol/L)	Vitality	Survival (>10 days)
sPAT	Silky	144	Female	7.2	2	Yes
sPAT	Silky	171	Female	4.7	2	Yes
sPAT	Silky	140	Female	4.5	2	Yes
sPAT	Silky	171	Male	4.6	2	Yes

All individuals tagged were selected from the first or second brail, with three individuals showing low blood lactate levels (4.5-4.7 mmol/l) and the other having 7.2 mmol/l, which is still considered within the threshold for surviving individuals (Onandia et al., 2021). All sharks tagged survived more than 10 days after the release (range 15-60 days; programmed automatic tag release at 60 days), which is considered the minimum standard time to indicate that an animal has survived a release event (Hutchinson et al., 2015). Scientists collected data for another three sharks that were released with a velcro but not tagged, for these individuals blood lactate showed low levels and all of them swam away correctly after release in the 2024 trip (Table 3).

Table 3. Species, length, sex, blood lactate, vitality, and behaviour after release of silky sharks (*C. falciformis*) released with shark velcros in tropical tuna purse seiners.

Shark species	**Length (cm)**	**Sex**	**Lactate (mmol/L)**	**Vitality**	**Behaviour after release**
Silky	171	Male	5.6	2	Swim away vigorously
Silky	165	Female	-	3	Swim away slowly
Silky	188	Female	4.6	1	Swim away vigorously

Looking at the daily movement of sharks tagged they displayed normal behavioural patterns, both vertically and horizontally (Fig. 9), which could indicate that there were no apparent injuries to the caudal spine during lifting with velcros.

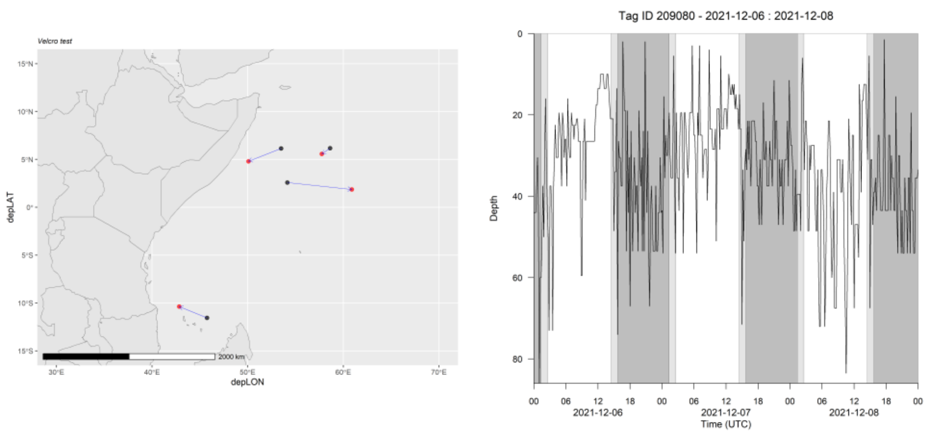

Figure 9. Tag deployment and release locations of sharks released with velcros and tagged in the Indian Ocean (left) and daily vertical movement patterns of one of them (right).

Discussion

Preliminary results from silky sharks released from the deck of purse seiners with specially designed BRDs, such as shark velcros and harnesses, designed to safely lift large active individuals by the caudal peduncle appear to be effective for the objective of returning these animals quickly back to the water to increase survival. We argue that if proven to be non-harmful to the sharks' physiology, lifting by the tail protocols employing these BRDs should be permitted and even supported by regulations. Although we do not discount that better designs than shark velcros or harnesses might be developed in the future to release medium to large sized sharks, at this time there is a technical gap in the availability of BHRP methods to release active adult sharks arriving on deck in the brailer without compromising the wellbeing of the crew.

At present the BHRPs for sharks in Annex 3 of C-25-04 asks to “release the shark as soon as possible. The recommended practice is to remove the shark from the brailer, hopper or ramps by grabbing it, without suspending it, by the caudal peduncle ... This should be done manually whenever possible”. However, even if active large sharks were to be released with stretchers or a ramp, sharks would first need to be grabbed to be extracted from the brailer, which can entail serious risks of being hit or bitten by these powerful animals. Furthermore, we should remember that release operations are taking place in an already complex operational environment (i.e., a size limited, slippery and unstable deck floor with many dangerous moving elements around like winch cables, ropes, netting, etc. simultaneously). Some sharks are just too large to manipulate manually by the crew, with single individuals reaching from 300 to 500 kg, and lifting them with a crane seems like the only solution.

The alternative is to wait for large sharks to become less active and vigorous before proceeding with their extraction from the brailer or the working deck to ensure crew safety, which is considered reasonable as stated in resolution C-24-05. However, this practice will likely result in large sharks becoming moribund or dead by the time it is safe to handle them due prolonged hypoxia from air exposure and internal organ damage from crushing by the tons of fish squeezing them in the brailer. On the other hand, fishers would prefer not having to stop the brailing operation for long, as histamine levels in tunas can quickly rise, especially in warm tropical weather, and can render tuna unsellable. Solutions that enable fast and safe release of bycatch and do not slow down fish loading provide a win-win solution, increasing chances of fishers implementing them. Past information in the Atlantic of sharks released by lifting with loops or nooses, before the invention of velcros, revealed that most sharks released with these poor practices were large individuals. This illustrates the difficulties that fishers experience to safely remove large sharks from the brailer, as otherwise they would use correct manual release methods as they do with smaller sharks.

Currently, we need to collect more PRS information of sharks released with velcros and harnesses, to unequivocally demonstrate these BRDs can increase their survival chances. Release times with these devices are very fast (e.g. < 1 min), as application of the velcro and harness is normally simple and the release mechanism as well. We have an upcoming trip in the Atlantic Ocean in June 2025, where we are hoping to collect more data on sharks released with velcros and harnesses. We encourage other teams of scientists to test these BRDs, or similar ones, under controlled experimental research trips to gather further information. We can share information on design characteristics and manufacturers of these BRDs should any CPC in the EPO be interested in testing these implements, always with the previous approval and in coordination with the IATTC. It would also be interesting to conduct a study to investigate if lifting sharks by the tail, with our BRDs, results in some kind of spinal cord injury. This might be done, for example, by examination of the tail anatomy of sharks before and after lifting events with portable x-ray machines, with the help of veterinarians or other experts.

If these new protocols were to be approved, dissemination of these BRDs among captains, navigators, and crew would be key to familiarize them with these release tools and how to employ them correctly. For example, one important aspect of lifting the sharks with velcros is to make sure that both sides of the velcros (hook side and loop size) are well adhered before lifting and that when starting to pull up with the crane, this should be done in a controlled and gradual way (i.e., not jerking) to make sure the animal is lifted carefully. In addition, fishers can provide ideas to improve the designs of the BRDs and adapt them to their needs, which will result in more willingness to uptake these devices (Murua et al., 2025).

In those purse seiners currently without a deck crane to lift sharks with the velcros or harnesses, other operational alternatives will need to be examined. For example, most purse seiners can adapt the position of the boom to lift heavy weights towards the starboard. Alternatively, other release protocols and BRDs (e.g., suction biodisks) might need to be developed to deal with potentially dangerous situations with highly active and heavy sharks in the absence of mechanical lifting options. In such case, the involvement of fishing companies and fisheries technologists to develop and test new solutions will be instrumental, together with the help of scientists to evaluate their effectiveness to increase survival.

Information sharing and dialogue with ship-owners to convince them to invest in providing these BRDs and others (e.g., ramps, mobulid sorting grids, etc.) to their crew will also be important, so that all vessels have the necessary tools to release bycatch safely from deck. In the case of velcros and harnesses, the price is relatively low, each currently costing below 100 USD, even for the larger sized units (e.g., XL velcros), and having a long use lifetime. We argue that any BRD that minimizes the probability of injury to crew when performing release operations with risky species is money well spent.

In recent times, the auditors of eco-certification programs, such as the Marine Stewardship Council, have become interested in learning more about the different BRDs as they can provide an option to reducing poor practices (i.e., nooses, bind wire) and mitigate post release mortality of elasmobranchs arriving in a correct condition on deck.

Providing fishers with better and safer alternatives that enable them to execute on deck BHRPs is critical to mitigate impacts on bycatch (Swimmer et al., 2020), especially if these are threatened and protected shark species (Dulvy et al., 2021). Given the slow growth and delayed maturity of sharks (i.e., K-selective strategy), maximizing the survival of those individuals that have managed to reach a reproductive stage should be priority to prevent further population declines (Juan-Jordá et al., 2022). Our research group will continue to work on the improvement of BRD prototypes like the velcros and harnesses and conduct experimental trials to measure their efficacy. Future trial results will be shared with the IATTC Ecosystems and Bycatch Working Group and other similar groups in the rest of tuna RFMOs.

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