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TESTING BYCATCH RELEASE DEVICES FOR VULNERABLE ELASMOBRANCH SPECIES IN TROPICAL TUNA PURSE SEINERS OF THE EASTERN PACIFIC OCEAN

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ABSTRACT

Several regulations on handling and releasing practices have been adopted in the past by IATTC to protect marine megafauna bycatch species such as sea turtles, sharks, mobulid rays, and marine mammals. However, in purse seiners some of these practices, especially regarding elasmobranchs, are mostly manual and still very rudimentary. When large individuals or dangerous species arrive on deck, manual manipulation entails difficulties and risks for crew members, which can deter release actions and delay the release of vulnerable species. This delay negatively affects post-release survival rates of marine megafauna by elevating the animals' stress levels and chances of suffocation. In recent years some bycatch release device (BRD) prototypes have been developed, or redesigned, and tested by the Spanish fleet in the Atlantic and Indian Oceans. In 2021, the IATTC, ISSF and AZTI signed a Memorandum of Understanding to trial novel release equipment on several OPAGAC vessels operating in the eastern Pacific Ocean (EPO) with the goal of examining their efficiency for improving fishers' safety and elasmobranch post-release survival. Several EPO and western and central Pacific Ocean (WCPO) opportunistic research cruises are ongoing with trained scientists and observers onboard to satellite tag and take condition measures (e.g., vitality indexes, blood lactate levels) to estimate post-release mortality of mobulids and sharks released with different devices and methods. These studies can help document survival rates of vulnerable species released with BRDs and provide information for fisheries management on better options to improve current bycatch handling and release practice guidelines in tuna purse seiners.

RESUMEN

Varias regulaciones sobre prácticas de manejo y liberación han sido adoptadas en el pasado por la CIAT para proteger especies de captura incidental de megafauna marina como tortugas marinas, tiburones, mobulas, y mamíferos marinos. Sin embargo, en atuneros de cerco algunas de estas prácticas, especialmente las relacionadas con elasmobranquios, son manuales y todavía muy rudimentarias. Cuando individuos grandes y/o peligrosos llegan a cubierta, la manipulación manual entraña dificultades y riesgos para la tripulación, lo cual puede frenar acciones de liberación y demorar la devolución al agua de las especies

vulnerables. Esta demora afecta negativamente las tasas de supervivencia post-liberación de la megafauna al elevar los niveles de estrés del animal y sus probabilidades de sofoco. En años recientes algunos prototipos de dispositivos de liberación de bycatch han sido desarrollados, o re-diseñados, y testados por la flota española en el océano Atlántico e Índico. En 2021, la CIAT, ISSF y AZTI firmaron un Memorándum de Entendimiento para probar nuevos equipos de liberación a bordo de varios atuneros de OPAGAC operando en el Océano Pacífico oriental (OPO) con el objetivo de examinar su eficiencia para mejorar la seguridad de los pescadores y la supervivencia post-liberación de elasmobranquios. Varias campañas oportunistas de investigación en el OPO y el Océano Paficico central y occidental (OPCO) se están llevando a cabo por científicos y observadores entrenados para colocar marcas satelitales y tomar medidas de condición (p. ej. índices de vitalidad, niveles de lactato en sangre) para estimar la mortalidad post-liberación de móbulas y tiburones liberados con diferentes herramientas y métodos. Estos estudios pueden ayudar a documentar las tasas de supervivencia de especies vulnerables liberadas con dispositivos de liberación y aportar información para la gestión de pesquerías sobre las mejores opciones de prácticas de manejo y liberación de captura incidental en atuneros de cerco.

1. INTRODUCTION

One of the main impacts of fisheries on marine ecosystems is the capture of non-target or incidental catch (i.e., bycatch), with many endangered, threatened and protected (ETP) species showing marked population declines in recent years (Hall and Roman, 2013; Gray and Kennelly, 2018). Due to their life history traits such as slow growth, late maturation, and low fecundity, marine megafauna such as sea turtles, sharks or mobulid rays are among the most vulnerable groups to anthropogenic effects, in which fishing related mortality is regarded as the most impactful (Lewison et al., 2004; Worm et al., 2009; Oliver et al., 2015; Paucoreau et al., 2021, Juan-Jorda et al., 2022). While the total population reductions in these species is attributed to multiple fishing gears (e.g., longline, handline, purse seine, gillnet) and fishery types (e.g., industrial, artisanal, recreational), work should be conducted by each of these segments to minimize their impact.

In tuna purse seining, the rate of bycatch per ton of target species caught is relatively low and mostly is composed of non-endangered finfish such as minor tuna species, mahi mahi, rainbow runner or triggerfish (Murua et al., 2021a). Nevertheless, due to the total annual capture of this gear, the impact on some vulnerable species can still be significant (Clavareau et al., 2020). For some of the megafauna bycatch species in purse seiners there are already well-defined protocols that are effective at releasing alive most of the animals such as methods employed to release dolphins (i.e., the use of the backdown manoeuvre and divers as specified by AIDCP protocols; Hall and Roman, 2013) or whale sharks (e.g., release over the net's corkline, Escalle et al., 2016). Similarly, it is thought that for species like sea turtles the impact of purse seiners is relatively low, especially if fully non-entangling FADs are used, and individuals arriving on deck are released by hand following recommended best practices (IATTC Resolution C-19-04).

However, for elasmobranch species best handling and release protocols required by regulations (e.g., C-15-04) focus on prohibiting poor practices such as the use of gaffs, hooks, pulling with ropes but offer few alternatives to extract and transport heavy and dangerous animals in a safe, rapid, and practical way. Even for recommended procedures such as the use of slings or nets to release large mobulids, based on Poisson et al., (2012), these heavy animals still need to be pulled out of the brail by hand. This is a difficult task, often resulting in animals being poorly held by sensitive organs such as gill slits, cephalofoils, or head spiracles in the case of mobulids and can considerably delay return to the water, in which a few minutes delay might be critical to post-release survival. In general, mortality studies in purse seiners have shown very low post-release survival rates of sharks with only 15% to 20% of individuals surviving (Poisson et al., 2014; Hutchinson et al., 2015) and poor rates for some mobulid ray species as well (Francis and Jones, 2017). Observing that currently recommended handling and release practices of some vulnerable species still show marked room for improvement, it

was decided that work on improving this aspect through an international collaboration between scientists from AZTI, the International Seafood Sustainability Foundation (ISSF) and the Inter-American Tropical Tuna Commission (IATTC) through a Memorandum of Understanding (MoU) must be conducted. This MoU is in line with the Commission's Strategic Science Plan (IATTC 93-06a) and call in several of its resolutions for prioritization of its scientific staff to work in areas such as the mitigation of elasmobranch bycatch and improving handling practices to maximize post-release survival (e.g., C-04-05_Rev2, C-16-04, C-21-06).

Since 2019 AZTI has been collaborating with the Spanish purse seine fleet (and associated flag vessels) operating in various oceans to develop bycatch release device (BRD) prototypes to potentially reduce megafauna mortality and poor practices, which can assist fishers to release large and dangerous animals. These BRD included shark velcros to extract adult sharks from the brail to make possible substituting ropes or nooses previously employed for this action that would injure animals; sorting grids for mobulid rays that avoid any physical interaction with fishers (e.g., no need to pull mobulid rays out of the brail) and speed up releases; ramps to quickly transport bycatch from the brail to the water's edge (e.g., no need for fishers to carry by hand dangerous species); openings or gutters in the lower deck to allow faster release of bycatch accidentally falling down to this area, and hoppers with ramps to sort out the brail's contents from the working deck preventing bycatch going accidentally to the lower deck and quickly release them back into the water (Grande et al., 2020; Murua et al., 2020, 2021b,c; Onandia et al., 2021). Some of these ideas had been first proposed by fishers at participatory workshops with fishers known as ISSF Skippers Workshops (Mandelman et al., 2022; Murua et al., 2023) and later refined through at sea trial and error by scientists and fisheries technicians.

2. BYCATCH RELEASE DEVICE TESTS IN PURSE SEINERS OF THE EASTERN PACIFIC OCEAN

Several OPAGAC vessels operating in the EPO under Ecuadorian, Spanish, and El Salvadorian flags have been equipped with different types of BRDs to potentially improve the bycatch post-release survival rates. All the vessels involved in this initiative are large class-6 vessels (>363 mt). Currently, 6 of these purse seiners have been fitted with selective hoppers with ramps to release sharks and other bycatch. In addition, another vessel has a release ramp in the upper deck and a release opening or gutter in the lower deck, plus two other vessels carry mobulid ray sorting grids onboard (Table 1). In addition, several of these vessels have shark velcros onboard.

Table 1 – List of bycatch release device types and vessels involved in the MoU.

Bycatch Release Device	Vessel	Company
Hopper with ramp	Rosita C	Bolton Foods
	Charo	Bolton Foods
	Aurora B	Bolton Foods
	San Andres	Bolton Foods
	Montelucia	Calvo
	Monterocio	Calvo
Ramp and lower deck gutter	Panama Tuna	Salica
Mobulid sorting grid	Sisargas	Ugavi
	Jane IV	Ugavi

In order to obtain quality data on the use of these BRDs, the scientific staff of IATTC has developed a complementary observer form to collect the necessary extra information for the project during the experimental cruises, such as the release device employed during release, individual vitality indexes, lactate samples of sharks and tagging IDs (Figure 1). This form can be linked to other data collection forms already being used regularly by observers and that can provide relevant information for the project, including the survival analyses (e.g., brail number in which the animal was found, time from sacking to release, total catch of the set, size and sex of the individual released). This information was, or will be, collected during various research trips by AZTI scientists alongside a trained IATTC observer, where blood samples will be taken to measure stress levels and satellite linked archival tags deployed on a number of animals (e.g., Wildlife Computers S-PAT and mini-PAT tags) (Figure 2).

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REGISTRO DE MUESTREO Y MARCACIÓN DE TIBURONES (RMMT)

Formulario diseñado para el proyecto de marcado, supervivencia y fisiología de tiburones

No. de viaje	No. RDT	Longitud total (cm)	Sexo		Zona de detección:	
			Macho	[ ] 1	Enmallado, izando la red	[ ] 1
			Hembra	[ ] 2	Cubierta principal	[ ] 2
			Indeterminado	[ ] 3	Parque de pesca	[ ] 3
			No observado	[ ] 4	Otro	[ ] 4

Hora formación del saco	Hora primer salabardo	No. salabardo	Hora individuo en cubierta	Hora de liberación	Método de liberación	Condición al ser liberado

No. de la marca:	/	Prueba de lactato:	.	mmol/l

Comentarios:

Códigos de métodos de liberación (utilice todos los aplicables)

1. **Sarria:** El buque tiene una red de carga (sarria o chinguillo), en la cual colocan al tiburón y lo liberan al mar con la ayuda de un cabrestante.
2. **Plataforma rígida:** El buque tiene una plataforma rígida en la cual colocan al tiburón y lo liberan al mar con la ayuda de un cabrestante.
3. **Camilla:** El buque tiene una plataforma flexible, normalmente construida de una lona plástica colocada entre dos agarraderos rígidos en la cual colocan al tiburón y lo liberan al mar con la ayuda de un cabrestante o simplemente a mano entre varios tripulantes.
4. **Rampa:** El buque cuenta con una rampa y una escotilla de rescate que es usada, en la cual colocan al tiburón para que se deslice y caiga al mar.
5. **Canaleta (Hopper):** El buque cuenta con bandeja metálica inclinada que recibe la captura del salabardo y la desemboca en la abertura que comunica a la cubierta de bodegas. Marque esta opción si el tiburón fue liberado en este sitio.
6. **Manual:** Uno o más tripulantes cargan al tiburón y lo liberan al mar sin la ayuda de equipos mecánicos u otros aparejos.
7. **Manual, por las branquias o aleta caudal:** Si el animal es cargado manualmente por las aberturas branquiales o por la cola.
8. **Salabardo:** El tiburón fue liberado de un salabardo sin ningún aditamento que facilite su liberación.
9. **Salabardo modificado con rejilla:** Algunos buques han colocado una rejilla flexible a sus salabardos, de manera que el pescado pueda pasar al 'copo' del salabardo y evitar que el tiburón también pase.
10. **Velcros:** Se refiere a una manga acolchonada que se ciñe alrededor del pedúnculo caudal del tiburón y se asegura con velcro. El animal es levantado y regresado al mar por medio de un cabrestante.
11. **Coletera (Shark rope):** Cinta acolchada, sin velcro, envuelta alrededor del pedúnculo caudal del tiburón. El animal es levantado y regresado al mar por medio de un cabrestante.
12. **Estrobo:** Se refiere a una cuerda, chicote, cabo o estrobo que se ciñe alrededor del pedúnculo caudal del tiburón. El animal es levantado y regresado al mar con ayuda de la grúa, o bien es arrastrado por cubierta para su posterior liberación.
13. **Parrilla:** Estructura metálica con cabos formando una rejilla ajustable manualmente, colocada en la abertura que comunica a la cubierta de bodegas, la cual detiene el paso de tiburones o mantas hacia dicha cubierta.
14. **Otra:** Cualquier otro método de rescate que no se incluya en las descripciones anteriores (por ejemplo: el uso de garfios). Describa bajo Comentarios, y en la medida de lo posible, tome fotos o video de este sistema.

Códigos de condición al ser liberado

1. **Buena:** Sin heridas. El organismo se muestra activo y energético al ser rescatado y al regresar al agua, se aleja nadando de una manera normal o que usted considera vigorosamente.
2. **Regular:** El organismo parece desorientado al ser liberado o nada de forma errática o lenta, pero claramente muestra signos de vida. Puede presentar heridas, pero no sangrado profuso.
3. **Mala:** El organismo claramente está herido, o tiene heridas que presentan sangrado profuso y/o está moribundo. Al ser liberado su comportamiento en el agua es sumamente errático, como cuando nada boca arriba o parece sumergirse casi sin movimiento. Aunque vivo, usted considera que es muy probable que muera.
4. **Muerto:** El organismo no presenta signos vitales al ser regresado al agua.
5. **Imposible observar:** La condición del organismo al ser liberado no pudo ser determinada.

FIGURE 1- Adapted shark tag and release form for IATTC observers during research trips

FIGURE 2 – AZTI scientist satellite tagging silky shark released with a hopper and ramp in opportunistic EPO experimental research campaign onboard F/V Charo (Bolton Group).

The experimental trips will also help scientists exchange opinions with captains, deck bosses and other crew to identify strengths and weaknesses of the use of BRDs in relation to the fishing manoeuvre (i.e., if BRDs delay the fishing operation or not, if they are difficult to use, etc.), so that improvements in design can be considered in future prototypes. Several trips with tagging and extra data collection were already conducted, showing promising preliminary results, and additional experimental trips are also planned for 2023. For now, the focus in these tagging cruises has been on hoppers with ramps as other studies (e.g., Murua et al., 2021b) have shown to be one of the most promising BRDs to reduce post-release mortality. However, post-release survival rates with other simpler tools will also be investigated.

Although the current MoU between IATTC-AZTI-ISSF was initially focused on bycatch mitigation research with OPAGAC vessels (project M.1.d, SAC-14-01), as they had these tools already onboard, it is likely that other interested fishing companies operating in the EPO will join our BRD mitigation research efforts, or conduct similar ones, in the near future. In addition to AZTI and ISSF, other organizations such as the Monterey Bay Aquarium and the Manta Trust have offered funding and support with their knowledge for satellite tags to be deployed during BRD research trials. It would be interesting to not only examine the efficiency of BRDs in class-6 vessels but also in smaller class vessels which usually have smaller spaces on deck and other logistical and practical limitations (e.g., no aid of cranes to lift sorting grids) and for which the BRDs employed in larger purse seiners will probably need to be adapted in shape and size. In this regard, the IATTC staff will be collaborating with TUNACONS and MSC on a PRS study for sharks in class 2-5 purse seine vessels (project M.2.e, SAC-14-01), starting in 2023. Results of this project will be shared with the efforts described in this document to provide a more comprehensive understanding of what best handling and releasing practices could be for the whole purse seine fleet.

3. FINAL REMARKS

The most relevant guideline in best handling and release practices in tuna purse seiners, which is the basis for most of today's bycatch release protocols in tRFMOs, was published more than a decade ago by Poisson et al. (2012). Those guidelines which were produced by a collaboration between French scientists and fishers were a relevant step forward from the previous release practices. Nevertheless, closer inspection shows that even when trying to employ those recommended practices, fishers still find some release situations problematic such as handling large or adult elasmobranchs or spotting small sharks within the brail before they end up in the lower deck (Maufroy et al., 2020). Therefore, there is a need to provide better solutions to handling and releasing vulnerable species that are sometimes large and

dangerous onboard commercial purse seine vessels. It is worth noting that fishers have nothing to win from higher elasmobranch bycatch (e.g., shark finning is prohibited in purse seiners in the EPO) and on the contrary have much to lose (e.g., fines for sharks ending up in the wells, captains losing their licenses for bad practices). An important aspect for these BRDs to be accepted voluntarily by the fishing industry is that they must ensure crew safety and also must not interfere negatively with the fishing operation (e.g., must not reduce target catches or reduce fishing efficiency by delaying fish loading onboard).

By conducting BRD trials onboard commercial purse seine vessels under real fishing conditions, scientists will be able to assess the true efficiency of such tools for bycatch post-release survival. Satellite tagging together with collection of survival physiological covariates such as lactate levels and vitality indices will assist in this objective. The battery of BRDs tested reflects the need for different equipment to respond to the variety of handling and release situations that take place at various stages of the net hauling and brailing process with different species and sizes that are encountered. Furthermore, some vessels will only be capable of incorporating some types of BRDs and not others, depending on limiting logistical or practical factors such as reduced deck space or lack of cranes to assist with releases. In general, some of the vessels involved in the research are among the largest class-6 vessels in the EPO and thus, large BRDs such as ramps with hoppers have been able to fit in their working decks. For smaller vessels other simpler release tools such as ramps and sorting grids that can be built in proportion to the size of the deck may be more feasible.

Successful BRD prototypes will assist EPO purse seine companies in their objective of reducing undesirable impacts of their fisheries on the marine ecosystem. Besides being a management goal at international and regional level (IATTC's Antigua Convention), this is one of the main principles required by eco-certification programs (e.g., Principle 2 of the Marine Stewardship Council) in which many tuna industry members are increasingly participating. The involvement of fishers in designing and testing BRDs, with their deep practical knowledge of fishing gears, along with regular consultation in workshops with the fleet and research trips is key to find the best fit-for-purpose tools that will satisfy management organizations and fishers demands (Restrepo et al., 2018; Cronnin et al., 2022; Murua et al., 2023). If fishers are co-owners of BRD solutions, it will promote its implementation across the fleets. The BRD trials in the EPO will provide fisheries managers with science-based results on updated handling and release best practice guidelines for purse seiners which can contribute to a sustainable management of bycatch.

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