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Review Article

An overview on elasmobranch release as a bycatch mitigation strategy

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Sharks and rays are among the most threatened vertebrates, mostly due to commercial fisheries. Data on incidental capture is sparse, but it is estimated that about 50% of reported global catches of elasmobranchs are from bycatch. Elasmobranchs are captured in a variety of fishing gear throughout the world. One promising strategy to minimize incidental catches is the release of live sharks and rays. However, so far, no critical analysis had been carried out to assess the importance of release as a measure to mitigate the impacts of bycatch. Results indicated that despite onboard releases being cited in Plans of Action (along ZEEs) and recommendations/regulations of Regional Fisheries Management Commissions (in international waters), this measure is treated as secondary and has voluntary adherence, which can significantly reduce its efficiency. Moreover, among the Best Fishing Practice Manuals currently available, although release is cited as a priority, most of them do not consider the dynamics of the location/fishing modality for which it was developed. A change on how release is perceived is needed to prioritize this conservation strategy, as well as its potential as a social tool to reduce the impacts of bycatch on sharks and rays.

Keywords: commercial fisheries, conservation, elasmobranch, incidental capture.

Introduction

The incidental capture of elasmobranchs poses a significant challenge for their management and conservation, with 99.6% of species threatened by overfishing mainly due to bycatch (Dulvy *et al.*, 2021). There is a deficit in documenting the historical and recent estimates of non-targeted species catches (James *et al.*, 2016). Recently, more attention has been dedicated to elasmobranch incidental captures, with regional surveys available for a wide range of commercial fleets and fishery gears (Duffy *et al.*, 2019; Ferrete *et al.*, 2019; White *et al.*, 2019; Clavareau *et al.*, 2020; Jannot *et al.*, 2021). For this taxonomic group, a consensus regarding bycatch definition seems difficult to be agreed upon. While for mammals, turtles, and seabirds the term bycatch usually refers to an accidental/unintentional capture (Soykan *et al.*, 2008), for sharks and rays the definitions are many. There is now a growing interest in the retention and trade of non-targeted elasmobranchs. This is partially due to the overexploitation of other marine resources (Ward-Paige *et al.*, 2012). Furthermore, the exponential increase on elasmobranch meat demand, especially in low and low-middle income countries (Karnad *et al.*, 2020) seems to contribute to the observed shift in bycatch fate, as well as the market demand for shark fins in Asian countries (Lam and Sadovy de Mitcheson, 2011).

There is a growing interest in evaluating the impacts of bycatch on elasmobranchs. Pelagic longline fisheries are the main source of sharks' incidental captures (Oliver *et al.*, 2015), but some fleets are known for targeting blue sharks (*Prionace glauca*) (Aires-da-Silva *et al.*, 2008; IOTC, 2014; Hiraoka *et al.*, 2016). Furthermore, there are situations difficult to account for, such as "cryptic bycatch," which consists of entangled or hooked specimens that escape but with serious injuries that can be deadly (Reeves *et al.*, 2013). This kind of bycatch is of great concern since it directly impacts marine megafauna and the mortality driven by it remains unrecorded in statistics (Reeves *et al.*, 2013; Mustika *et al.*, 2021). In addition to that, coastal fisheries and incidental captures on gillnets are also considered a significant source of population declines (Jackson *et al.*, 2001; Molina and Cooke, 2012). Although scarcer, data on rays' bycatch has indicated that most captures are from deep-sea and coastal trawl fisheries (Oliver *et al.*, 2015; Clarke *et al.*, 2016; White *et al.*, 2019). Despite having fisheries targeting rays pointed as rare (except for guitarfish, "manta rays"—*Mobula* spp.—and skates–Quiroz *et al.*, 2011; Moore, 2017; Booth *et al.*, 2021a), bycatch poses the main threat for most species. Incidental capture management is very difficult to perform, due to the lack of historical data (James *et al.*, 2016) and to present challenges in collecting information. Furthermore, bycatch estimates are mainly based on fisher's logbooks or independent observer programmes (Lewison *et al.*, 2004), and legal measures are mostly restricted to high-income countries where elasmobranch commercial fisheries are relatively well managed (Oliver *et al.*, 2015). Moreover, whereas bycatch has a strong relationship with the low selectivity

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of most commercial fisheries (Soykan *et al.*, 2008), the currently proposed measures aim to reduce incidental catches through gear modification, exclusion devices, or seasonal closures (Valdemarsen and Suuronen, 2003; Molina and Cooke, 2012; Sacchi, 2021). For some taxonomic groups, these measures may be promising, however, given the representativeness of elasmobranch incidental catches, and the increasing (and poorly regulated) retention and trade of non-target species, such measures tend to be ignored by the fishing industry even when legal measures are in force (e.g. Graham *et al.*, 2010; Arias *et al.*, 2016; Wosnick *et al.*, 2019; Giovos *et al.*, 2020).

The release of live animals is a bycatch mitigation measure commonly used for marine animals that have a more positive public perception (i.e. dolphins, whales, sea turtles, and other marine mammals), with very promising results (Zeeberg *et al.*, 2006; ISSF, 2016a; Hamilton and Baker, 2019). Release measures often exhibit higher success rates when human dimensions are taken into account, such as financial compensation in a pay-to-release model (Leduc and Hussey, 2019; Wosnick *et al.*, 2020). Release can also be a result of fisher's ethics, or mandatory measures for threatened species (IOTC, 2014; Leduc and Hussey, 2019). Nevertheless, it is considered a positive conservation intervention that is encouraged for species which capture is difficult to avoid, either as a result of sympatric occurrence with species with very high commercial value (e.g. guitarfish, and flatfish in the southwest Atlantic), or the lack of technologies to increase fishing gear selectivity (Cliff and Dudley, 2011; Wosnick *et al.*, 2018; Gupta *et al.*, 2020). Release is also a promising strategy in a context where there is growing evidence that seasonal closures and the establishment of no-take zones are very difficult to implement and enforce (Gupta *et al.*, 2020). Animal fate can be divided into two main categories: fishing mortality, characterized by the death of the animal while trapped in the fishing gear due to extensive injuries or physiological depletion, or post-release mortality, characterized by the release of an animal after interacting with fishing gear/handling followed by delayed death, that can occur hours or even days later (Dapp *et al.*, 2016; Musyl and Gilman, 2019). The first category is the main source of bycatch mortality estimation for most species that interact with commercial fisheries (Davis, 2002), as it does not depend on mid- to long-term monitoring schemes, such as telemetry data (Bowlby *et al.*, 2021). Studies on post-release mortality are mainly from high-income countries as current methods for investigating survival rates are costly (Dapp *et al.*, 2016). Moreover, most data on bycatch survival rates are from industrial fisheries, followed by recreational captures, and data from artisanal fisheries configure a huge knowledge gap (Oliver *et al.*, 2015).

Although mortality rates are very species-specific and gear-type related, there is evidence that the improvement of handling practices can significantly increase the chances of post-release survival (Poisson *et al.*, 2014). In addition, even when immediate mortality is high, release should be encouraged, since most elasmobranchs are K-strategists and can benefit from this practice even when only a small portion of individuals caught have a chance of survival (Ellis *et al.*, 2017). To date, most sharks' release (and to a lesser extent, rays) reports are from industrial fleets (Musyl and Gilman, 2019), and little is known about the involvement of artisanal fishers in release activities, with only a few reports found in the literature (Leite *et al.*, 2020; Wosnick *et al.*, 2020).

In times when elasmobranch fisheries information was limited worldwide and only a few countries had specific management plans for their populations, the International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks) was created by the Food and Agriculture Organization (FAO) (FAO, 2000; Fischer *et al.*, 2012). A Plan of Action is a tool in social planning defined as an organizational strategy to identify necessary steps toward a goal (Groves *et al.*, 2002). It is widely used to direct strategies for biodiversity conservation, and is usually designed with the aid of specialists and then forwarded to government agencies responsible for implementation. Plans of Action are also versatile as they can inform stakeholders, decision-makers, researchers, and civil society members (e.g. NGOs) about the need to establish regulatory measures, priority topics for investigation, management, and conservation initiatives (Kizhakudan *et al.*, 2015). Plans of Action may even help guide the productive sector on strategies for the sustainable use of a target resource, such as with the implementation of eco-labelling (Kaiser *et al.*, 2006; Kirby *et al.*, 2014). Developed in 1999, the IPOA-Sharks was the first document to mention release as a conservation strategy for elasmobranchs in its aim of ensuring the conservation and management of elasmobranchs and their long-term sustainable use (FAO, 2000; Fischer *et al.*, 2012). The release of sharks and rays incidentally caught regardless of their physical state was later replicated in several Regional and National Plans of Action (RPOA-Sharks and NPOA-Sharks, respectively) and domestic legislations. Nevertheless, no diagnosis on the extent of release practices as a suggested measure was performed to date, and detailed information on elasmobranch release is limited or unavailable.

This study aimed to answer specific questions, such as: how many official/mandatory documents (i.e. Regional Fisheries Management Organizations—RFMOs) include elasmobranch release to mitigate bycatch? How many documents that are not necessarily mandatory but are recommended by governments, organizations, and research groups (i.e. Plans of Action and Best Fishing Practices manuals) bring release as a strategy to compensate for incidental capture? What is the priority given to this action by the documents mentioned above? Are there compensation schemes or other mechanisms to operationalize the releases in the analyzed documents? Is elasmobranch release prioritized, or at least mentioned, in the Plans of Action of the top ten elasmobranch fishing nations? Finally, is the release proposed considering the diversity of fishing gear, stakeholders involved, and the real chances of survival of the species?

Methods

An online search was initially performed on the IPOA-Sharks of the FAO of the United Nations database. The database is divided by country and includes all Plans of Action (i.e. regional and national, shared—binational, trinational, etc.) available. All Plans available (both currently adopted and drafted but not yet officially adopted) were compiled and organized according to the corresponding country/region, year of publication, name of the Plan, recommendations for bycatch release—such as onboard release (i.e. considering releases performed from inside or beside the boat) and other mitigation measures. The NPOAs from Taiwan and Papua New Guinea were added manually, as they were not available at the FAO database in the search phase. RPOAs were coded and analyzed separately,

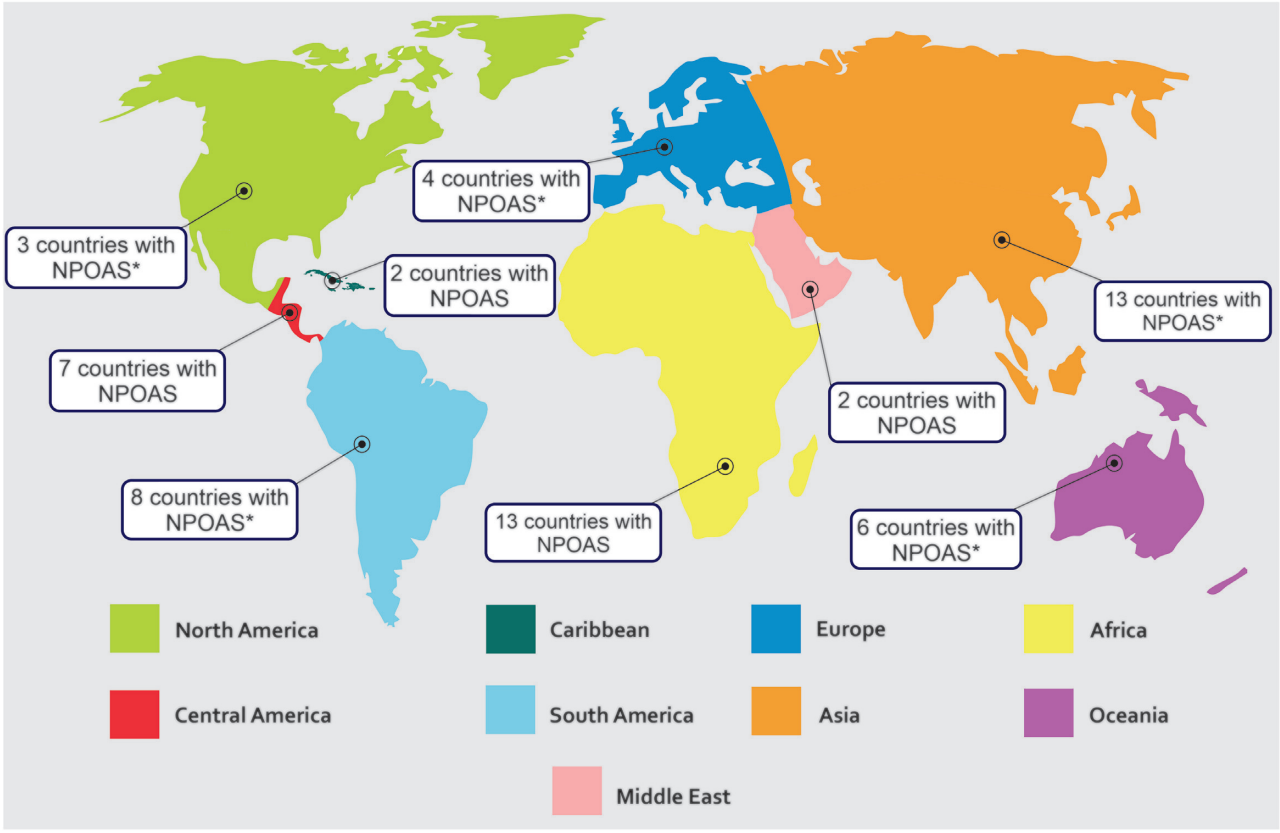

Figure 1. The number of NPOAs focusing on elasmobranchs for each continent or region.

considering the detailed information/guidelines and signatory countries. Whenever there was doubt in defining the number of NPOAs/RPOAs regarding updates or versions, the criteria adopted by FAO were followed. Additionally, to evaluate how the current top ten elasmobranch fishing nations (Fischer *et al.*, 2012; FAO, 2022) are dealing with commercial fisheries bycatch, a more detailed evaluation of their NPOAs was performed, aiming to identify the priority given to release, and if these nations are signatories of RPOAs that encourage the release of individuals captured alive.

A second search was conducted on online databases of the main RFMOs focusing on measures that cited release as a strategy to mitigate the negative impacts of bycatch. Information recovered was compiled in a data spreadsheet, including RFMO name and acronym, spatial range, action type (i.e. resolution, recommendation), and document official identification number, release details, and species. A structured Boolean search (AND, OR, +) to access currently available Best Fishing Practices Manuals (hereafter referred to as BFPM) focused on sharks and rays was then performed using the following search terms: "handling practices," "handling guidelines," "best handling practice guidelines," "safely handle and release," "elasmobranch release," "elasmobranch," "shark," and "ray." In the case of manuals that were not found using these search terms, a manual entry search was performed by the authors. The following topics were analyzed when considering the BFPMs structure, regarding the presence or absence of the following aspects: (A) handling and release methodology illustrations; (B) handling and release photographs exemplifying the methodologies; (C) handling and release step-by-step descriptions; (D) specific section with the "don'ts" (do not do, or actions to be avoided for handlers' safety and or animal welfare) of handling and release. All information obtained was compiled in a data spreadsheet, including objectives/target audience, contemplated species, location, and if release occurred. User guides and protocols on how to safely release an elasmobranch were also included in the spreadsheet. To avoid any bias in the recovery process, two authors examined each content independently. Only BFPMs published in English, Spanish, and French were considered in the present study.

Results

Two categories of Plans of Action were identified, based on geopolitical reach: National Plan of Actions (NPOAs), which are usually developed by governments along with civil society members and have jurisdiction throughout a county's national territory or Exclusive Economic Zone (EEZ); and RPOAs characterized by strategic plans that include the jurisdictions of regional associations of local authorities, countries clusters, or any other combination other than a single country unit. Plans of Action (both NPOAs and RPOAs) focused on elasmobranchs were identified for 130 countries, with most of them from Asia ($n = 20$), Africa ($n = 17$), and South America ($n = 15$). When considering the total number of NPOAs, most plans were from Asia ($n = 18$), followed by Africa ($n = 13$), South America ($n = 12$), Oceania ($n = 8$), Central America ($n = 7$), North America ($n = 4$), Europe ($n = 2$), Middle East ($n = 2$), and Caribe ($n = 2$). Most countries had only one NPOA, except for Brazil ($n = 3$), Japan ($n = 3$), Uruguay ($n = 2$), Argentina ($n = 2$), United

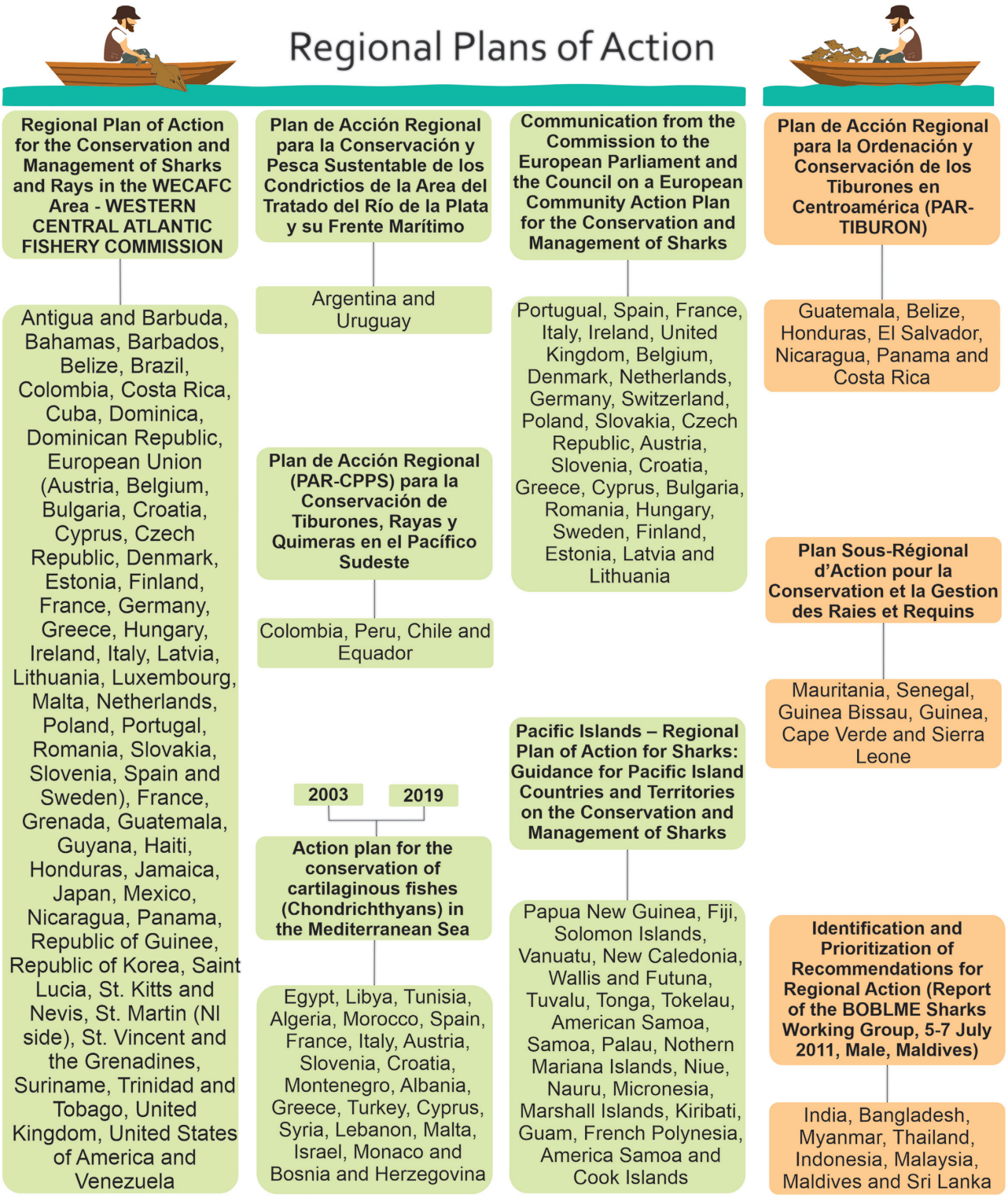

Figure 2. RPOAs with (green) and without release measures (orange) and the countries that have adopted them.

Kingdom ($n = 2$), Canada ($n = 2$), Thailand ($n = 2$), Indonesia ($n = 2$), Malaysia ($n = 2$), Australia ($n = 2$), and New Zealand ($n = 2$). According to each region, the number of countries with NPOAs was shown (Figure 1). Interestingly, many countries are only Parties to RPOAs and in some cases, more than one Regional Plan is in place even though no NPOAs has been drafted.

Ten shared RPOAs were identified, mainly between European countries or countries within the Americas. More specifically, Europe ($n = 4$) and Africa ($n = 4$) stand out, followed by South America ($n = 3$), Central America ($n = 2$), Middle East ($n = 2$), Asia ($n = 2$), North America ($n = 1$), and the Caribbean ($n = 1$) (Figure 2). Among these, seven present releases as a mitigation measure, and three have no mention of

bycatch release for any elasmobranch species (Figure 2). Regions that comprise several countries with a historical relationship of fishing traditions are the ones that had the least NPOAs, relying only on RPOAs to guide their actions. Although RPOAs have a significant weight, some intrinsic peculiarities of each country may be left out when clustered proposed measures are applied, thus perpetuating the problems arising from elasmobranch bycatch. For example, of the 14 countries listed in the IPOA-Shark database that make up the Caribbean, only two (Antigua and Barbuda, and Cuba) have their own NPOA. This fact is even more pronounced in Europe, whereof the 35 countries listed, only the ones belonging to the United Kingdom had an NPOA. Asia (13 countries = 13 NPOAs), Central America (7 countries = 7 NPOAs), and North America (3 countries = 4 NPOAs) were the most advanced regions in terms of NPOAs numbers since all countries there had at least one NPOA, the only exception in these regions is Canada having two National Plans.

In general, both NPOAs and RPOAs follow the criteria recommended by the IPOA-Sharks Code of Conduct. The recommended actions to mitigate the impacts of incidental captures rely on incentives for the adoption of new technologies to avoid the capture of threatened elasmobranchs or reduce mortality. When accounting for release, 48.53% of the NPOAs and 70=5% of the RPOAs encouraged this measure; however, the recommendations indicated varied between countries and regions. More specifically, some Plans bring release as a priority mitigation measure to be adopted for all species captured as bycatch, regardless of the animal's physical condition. Other Plans suggest releasing species with low commercial value, or when there are additional legal measures in place, such as the mandatory release of threatened species. Finally, there are Plans that encourage release only in cases where the animals are responsive and have a chance of surviving, however, no additional information regarding proxies to assess survival chances are cited. The adoption of appropriate handling protocols is also encouraged, as well as the creation and implementation of BFPMs, and fishers training for proper species identification. Furthermore, studies on capture mortality and post-release survival rates are also encouraged. Some countries, such as Guatemala, Brazil, Argentina, Uruguay, India, Bangladesh, Indonesia, Papua-New-Guinea, and New Zealand have specific domestic regulations cited in their Plans concerning permitted species (i.e. ban for species listed on National Red Lists), minimum capture size and life stages (i.e. neonates and pregnant females are prohibited from being captured and if captured incidentally, need to be immediately returned to the water). Although NPOA-Sharks from Mozambique, Mauritius, Kenya, Oman, Pakistan, and Thailand are cited in FAO's IPOA database, these Plans were not available online for open consultation, preventing further analysis of their content. Saint Martin Island was counted as belonging to the Western Central Atlantic Fishery Commission (WECAFC) RPOA since the northern part of this island is a signatory and has adopted this RPOA; however, Saint Martin could not be found on FAO's IPOA-Shark website. Aruba and Curacao are also part of WECAFC, but have not adopted its RPOA's.

As for the top ten elasmobranch fishing nations, eight have their NPOAs officially adopted (of which two are currently under review and one was already reviewed), one has a non-official NPOA, and for one nation its NPOA status is unknown (FAO, 2022) (Figure 3). Regarding mitigation measures recommended by these ten nations: Indonesia (top 1 elasmobranch fishing nation), in its first NPOA (2010), did not mention shark and ray release. Later, when their NPOA was updated (2017), release recommendations were included, emphasizing *Alopias* spp. Indonesia is also a signatory of an in-progress RPOA (2011) where elasmobranch release has not been included. Spain (top 2 nation) does not have an NPOA, but is a signatory to three adopted RPOAs (2003, 2009, and 2019) that include release and also to a drafted RPOA (2018), which also cites release as a recommended mitigation measure. –India (top 3) has a non-official NPOA (2015) in which release is cited as a recommendation and is a signatory to an in-progress RPOA that does not mention release. –Mexico (top 4) has an adopted NPOA (2004) where release is not indicated as a mitigation measure, and is a signatory to an RPOA draft (2018) where release is cited. The United States of America (top 5) has an adopted NPOA (2001), where release is recommended, and is a signatory to an RPOA draft (2018) that also recommends release as a mitigation measure. Taiwan (top 6) has an NPOA (2006) adopted, in which release is not mentioned, but whale shark (*Rhincodon typus*) bycatch reduction is encouraged with no further details. It is not a signatory of any RPOA, following only some recommendations from RFMOs (FA, 2012; FAO, 2022). Argentina (top 7) has two NPOAs adopted (2009 and 2015), in which release is recommended, and is a signatory of an RPOA adopted (2018) that also cites release. Top 8–Malaysia (top 8) has two NPOAs adopted (2006 and 2014), and, in both, release is not brought as a mitigation measure. It is also a signatory to an in-progress RPOA (2011), which also does not mention release. Brazil (top 9) has two adopted NPOAs (2005 and 2014) that cite release and one NPOA adopted (2011) that does not cite release as a mitigation measure. It is also a signatory to an RPOA draft (2018), where release is cited. Lastly, for –Nigeria (top 10), no information is available (FAO, 2022) (Figure 3).

Concerning RFMOs, a total of 39 documents citing bycatch release were found. Of these, ten are from the International Commission for the Conservation of Atlantic Tunas (ICCAT), nine from the Inter-American Tropical Tuna Commission (IATTC), six from the Indian Ocean Tuna Commission (IOTC), four from the North East Atlantic Fisheries Commission (NEAFC), three from the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), two from the General Fisheries Commission for the Mediterranean (GFCM) and from the Western and Central Pacific Fisheries Commission (WCPFC), and one from the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), from the Northwest Atlantic Fisheries Organization (NAFO), and from the Southeast Atlantic Fisheries Organization (SEAFO) (Figure 4). Except for the Arctic, there are release recommendations for all oceans, with a predominance of measures for fisheries carried out in the Atlantic Ocean, followed by the Indian Ocean. Eight recommendations/resolutions (20.5%) covered the release of rays, and half of them focus exclusively on Mobulid rays. As for sharks, 24 recommendations/resolutions were directed at the species level (with three of them citing other species, or "non-targeted sharks"), with a predominance of measures for *Carcharhinus falciformis*, *C. longimanus*, *Alopias* spp., and *R. typus*. Most recommendations/resolutions only encouraged releases. Even when releases were indicated as mandatory, it was mentioned that they should be done to the best extent but only whenever possible.

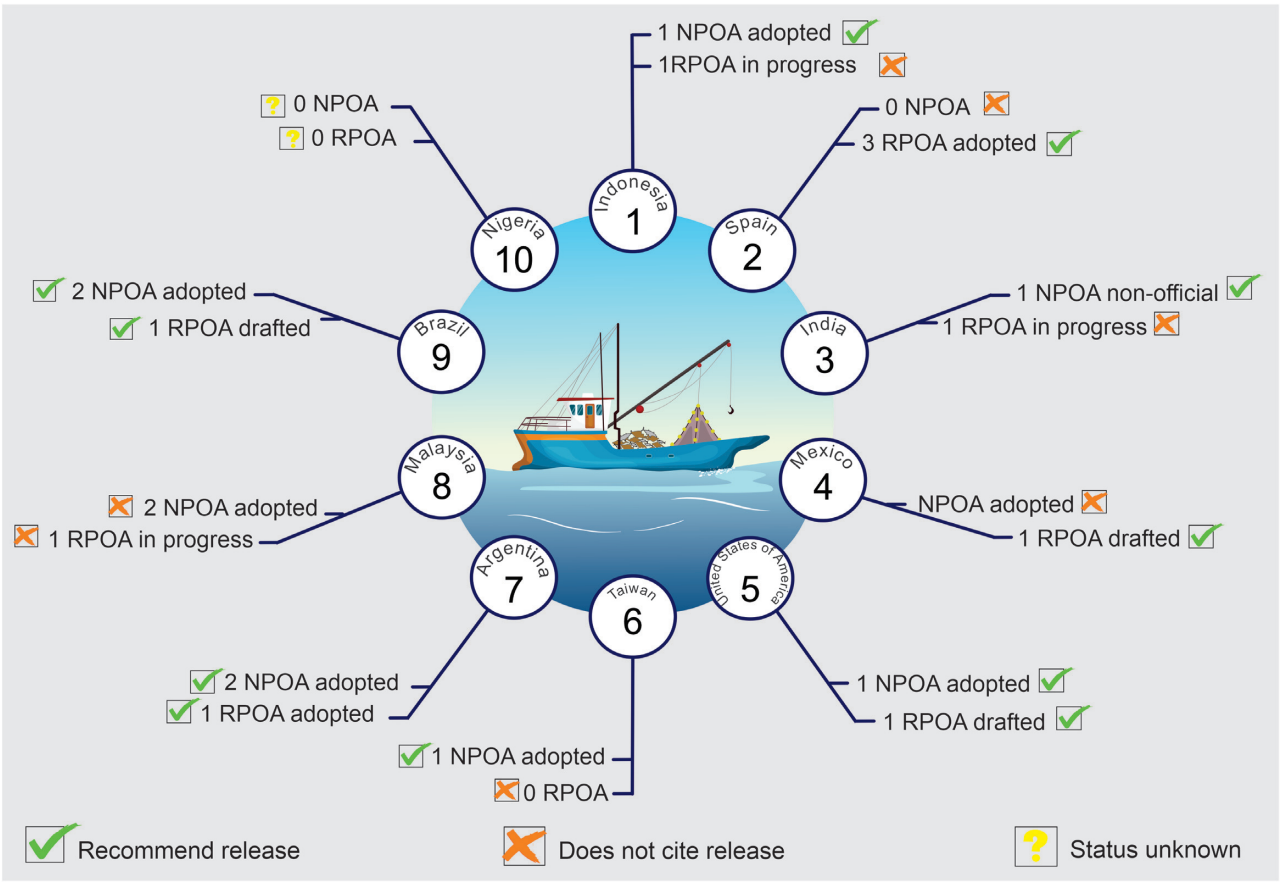

Figure 3. Top ten elasmobranch fishing nations (FAO, 2022): number and status (adopted, drafted, unknown) of their NPOAs and RPOAs to which they are signatories. Plans of Action that cite release are represented by a green check mark (✓); Plans of Action that do not cite release are represented by orange (X), and Plans for which this information is not available are represented by a yellow question mark (?).

As for BFPMs, 24 documents were found. Among these, only two were scientific papers, and the rest were guides and reports developed by private companies, governments, and NGOs. The first BFPM made available dates from 2009, and the most recent from 2021. The main objective of the BFPMs is to encourage the release of live animals and to reduce injuries that might compromise their chances of survival. All manuals highlighted handlers' safety and were designed for onboard release. Although protocols for release were very detailed, the practice was only encouraged with voluntary adherence. There were some recommendations on the need to properly identify species that are caught as bycatch, along with guidelines to avoid unwanted captures through the improvement and implementation of fishing exclusion devices and specific handling protocols to increase the chances of post-release survival. As for the target audience, eight BFPMs focused on both longline and purse seine fisheries, five exclusively on purse seine, and three exclusively on longlines. Two were directed to gillnetting, one was designed exclusively for commercial fishers, one for both commercial and recreational fisheries, and one directed to artisanal/coastal small-scale fisheries that use longlines, purse seine, and gillnets. Of the total, 18 were specifically for elasmobranchs and six also considered other animals, such as sea turtles, seabirds, and billfish. Thirteen used generalized categories such as "Sharks and Rays" or "Elasmobranchs," 1 was focused on "Chondrichthyans," and 10 were directed to a specific species or group of species. Mobulids and whale sharks were highlighted in four BFPMs, Angel sharks and sawfish had two targeted BFPMs and stingrays were cited in only one BFPM.

The BFPMs content analysis showed that most manuals were illustrated (58%) or had photographs (33%) and that a great part of the illustrations were extracted (50%) from Poisson *et al.* (2012), according to each manual's objective. Some manuals (25%) included photographs exemplifying the handling and release procedures. Only 12% of the manuals were restricted to shark handling photographs but did not use photographs to show how the release should be done. Many manuals (63%) only had species' photographs. The vast majority of manuals had a step-by-step section describing thoroughly the handling and release methodology (83%), while others simply mentioned "release" but provided no further details regarding best practices. Many had a "dont's" section (88%) (Figure 5).

Discussion

Currently, the most recommended measures to reduce the impacts of bycatch are the creation of no-take zones and the implementation of fishing exclusion devices. While both measures are promising, conflicts with the fishing sector are reported, mainly due to the financial loss inflicted on fishers (Gupta *et al.*, 2020). While no-take zones are difficult to implement, fishing exclusion devices demand study, technology,

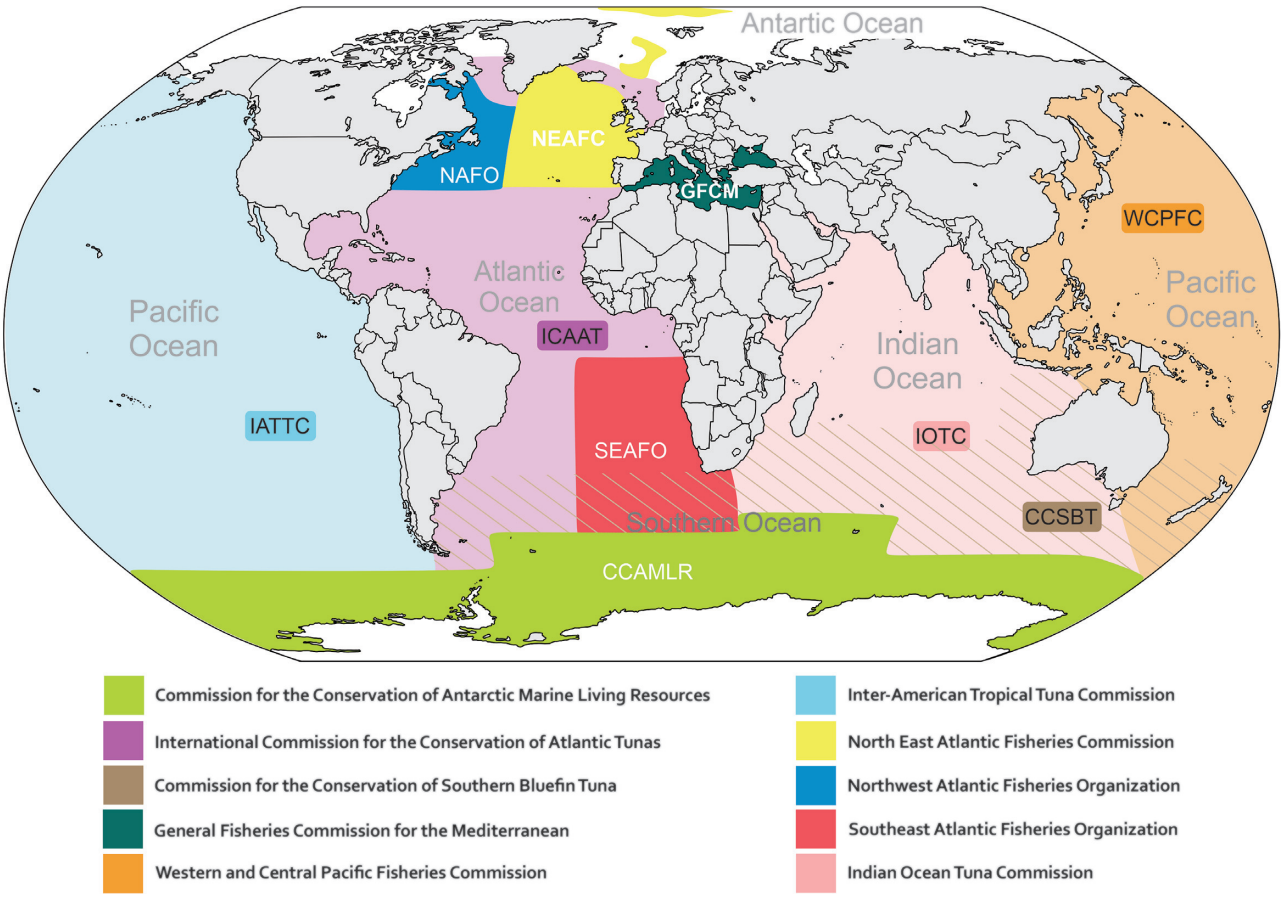

Figure 4. RFMOs that have at least one recommendation/regulation on bycatch onboard release focused on sharks and rays.

Figure 5. Percentages of the content analysis in BFPMs.

financial resources, and time, resulting in a significantly reduced applicability (Favaro and Cote, 2015). In this context, these recommendations in Plans of Action and other documents may seem promising, but who is actually working on them? What is the real effectiveness and chances of a long-term commitment by the fisheries industry? Considering the great impacts of bycatch on elasmobranch populations, it is imperative to propose measures that are simple, easy to implement, and likely to be truly adopted by fishers, even if their effectiveness is not considered as high as estimated for other

measures based on bycatch avoidance. Onboard releases were cited in all types of documents evaluated in the present study and have been adopted by many countries through their Plans of Action. Releases have also been adopted as a mitigation measure for oceanic sharks and rays that are protected by international agreements and monitored by RMFOs, being considered an additional strategy to the prohibition of target fishing.

Despite significant efforts to improve release measures over time, three points still need attention: the fact that releases are only encouraged, the absence of qualitative and quantitative reports on species released, and the lack of distinction between "discard" and "release" observed in several documents. When releases are only encouraged, their importance might become secondary, and crew commitment tends to reduce considerably. The act of removing a live elasmobranch from the fishing apparatus can be done by cutting the line as close to the animal as possible, therefore avoiding its handling and concurrently reducing handling risks for the crew. Often hooks fall off in a few days and wounds heal over a short period of time, allowing a higher survival chance for the animals (Poisson *et al.*, 2019). In some cases, handling the animal onboard is needed and releasing it carefully requires training and a commitment to animal's welfare (Diggles *et al.*, 2011). Furthermore, the entire process must be done in the shortest time possible, which further reduces the chances of compliance if measures are not mandatory since fishing operations usually are long and very tiring for fishers. Elasmobranch release would greatly benefit if professionals trained for release were incorporated to the fishing crew, taking this obligation off the hands of fishers who already have several other duties and heavy workloads. Such an initiative could be implemented with the support of governments through taxes that could cover the costs of keeping professionals dedicated to onboard releases.

Moreover, all fisheries management tools should focus on the improvement of release measures, as well as require the detailed report on how many animals were released alive and how many died and were not retained. In order to achieve this objective, it is imperative that remote monitoring and observer programmes are implemented in as many fleets as possible (especially industrial ones). In artisanal fleets, fishers could be trained to promptly identify the condition of specimens captured (live, moribund, or dead) through reflex action mortality predictors (RAMPs) and condition scores. These reports would favour bycatch data collection and also provide subsidies for the improvement of release protocols based on the peculiarities of each species and fishing modality. That said, recommendations should be revised aiming to obligate release, especially for threatened with extinction shark and ray species, as well as studies aiming to improve the release protocols based on the experience and difficulties faced by fishing crews and/or skippers. As for lack of distinction, considering the definitions for each term (i.e. discard—to throw something away or get rid of it because you no longer want or need it; release—to give freedom or free movement to someone or something) (Cambridge Dictionary, 2021a, 2021b), there seems to be room for interpretation, since "discarding" gives the idea of getting rid of something already dead, while the term "release" conveys the idea of returning a live being to the place where it belongs. The lack of a clear distinction between the terms may not seem problematic at first, however, by not differentiating both it is possible that the commitment to the release of live animals becomes lower. More specifically, when an official document encourages the disposal of a species with no commercial value, the owner of the vessel or fishing crew may not prioritize the removal of the animal from the fishing apparatus still alive, precisely because of an error in interpreting the proposed measures. Thus, it is suggested that when updating Plans of Actions, RMFOs recommendations, and BFPMs the term "discard live animals" be replaced with "release," or even cite both terms, but with clear distinction on what each one means.

Plans of action

Plans of Action are important tools to guide governments, the third sector, stakeholders, and research groups on what species and environments should be prioritized in management and conservation planning. Along with the Red Lists of threatened species, the objectives and actions determined in a Plan will set the entire agenda for a taxonomic group (Hoffmann *et al.*, 2008). Although these documents are sometimes (and in some countries) not mandatory, the Plans have great potential for guiding decision-making, and for this reason, they should be designed considering all possible ways to reduce anthropogenic and environmental impacts on bycatch species. There is now a consensus that for a Plan to be effective, it should follow guidelines based on Conservation Standards, in which implementing, measuring success, and adapting when necessary is as important as the planning itself (Grantham *et al.*, 2010; Conservation Standards, 2021). A point of concern is that only 48.53% of NPOAs adopted onboard release as a bycatch mitigation strategy. The situation is a bit better for RPOAs (75%) but still far from the ideal considering how simple and practical such a measure can be, with few potentially challenging exceptions concerning extremely large specimens (i.e. adult whale sharks). The reasons why release was left out of these Plans are unclear. Nonetheless, the adoption of onboard release on NPOAs and RPOAs needs to be discussed as soon as possible, and have the consensus reached that bycatch release should be recommended in all Plans. Another point of concern is that in none of the Plans focusing on elasmobranchs release was brought up as a priority, being only mentioned as a complementary measure to reduce the impacts of bycatch. Furthermore, the Plans rarely distinguish between small-scale and industrial fisheries. In some countries, along with the industrial captures, the artisanal sector poses an extra challenge for elasmobranch management and conservation, once small-sized vessels might not be considered as impactful as medium- to large-sized fleets but still capture a significant number of elasmobranchs as bycatch, including individuals in critical life stages (i.e. pregnant females, neonates, and juveniles) (Klippel *et al.*, 2005; Vooren *et al.*, 2005). The main issue concerning artisanal fisheries is that not only catch volumes of targeted species are often lacking, but also data on bycatch is virtually unknown for most sharks and rays that interact with small-sized fishing vessels (Molina and Cooke, 2012). In addition, several elasmobranchs caught as bycatch are landed and consumed internally due to socioeconomic and cultural aspects of many traditional communities, further hindering annual catch volume estimates (Hoq, 2011; Jabado *et al.*, 2018; Ismail *et al.*, 2019). The expressive differences between artisanal and industrial fishing profiles are an indication that bycatch cannot be treated the same way, as well as mitigation measures and success rates of conservation interventions as a whole (Booth *et al.*, 2021b). Another concern is that, in all

Plans, release was treated only as a measure, rather than as a social tool. The inclusion of fishers in conservation interventions is an imperative component for elasmobranch bycatch mitigation (Campbell and Cornwell, 2008). When human dimensions are left aside and fishers' opinions are not taken into account, the chances of success drop considerably. Although gear modification and seasonal closures are considered the most promising measures to reduce the impacts of bycatch on sharks and rays (Molina and Cooke, 2012), both measures are rarely implemented. In fact, gear modification and fishing exclusion devices are the most cited mitigation measures; however, little progress has been made in this regard so far. Measures adopted to benefit other animals, such as turtles (e.g. hook modification) may bring good results for elasmobranchs (Zeeberg *et al*., 2006); however, adaptations directed to sharks and rays might have little or no acceptability by the fishing industry (Campbell and Cornwell, 2008). Even when imposed by law, gear adaptations and their use are often ignored, as onboard inspections are rare, if not non-existent for most fishing fleets. A promising way to engage traditional communities on elasmobranch conservation is through the implementation of release programmes focused on species with low commercial value (Wosnick *et al*., 2020).

It was noted that release programmes with traditional communities can be built based on two main models that tend to evolve organically and follow different directions depending on the attitude and commitment of those involved. The first scenario includes programmes that rely on releases already performed by a fishing community (e.g. fishers ethics, low/no commercial value) and serve as a catalyst (i.e. more releases) and promoter (i.e. raising public interest), aggregating research activities, society engagement, and empowering fishers as conservation ambassadors. The second scenario relies on programmes that were built from scratch, and release activities were first performed by members of research groups, or NGOs, in parallel to building a trusting relationship with the fishing community, so that releases were then presented to fishers, aiming at long-term releases based on changing the behaviour of community members. Research activities, society engagement, and fishers' empowerment are also foreseen in this model.

Both models have been developed in southern Brazil. The first model has been carried out in Balneário Camboriú (Santa Catarina State). A co-participative release programme started in May 2020, focusing on low commercial value elasmobranchs bycatch. In less than two years, over 750 cownose rays (*Rhinoptera brasiliensis* and *Rhinoptera bonasus*) were released, along with less frequent releases of longnose stingrays (*Hypanus guttatus*), spiny butterfly rays (*Gymnura altavela*) and neonate scalloped hammerheads (*Sphyrna lewini*) (videos and photos of releases can be seen on the Instagram page @projetotubarão). The second model has been carried out in Paraná State since 2010, focusing on threatened with extinction guitarfish (i.e. *Zapteryx brevirostris*; *Pseudobatos percellens*; *Pseudobatos horkelii*) (Wosnick *et al*., 2020). To date, almost 3000 individuals were rescued in a pay to release approach. While some members of the fishing community sell the animals to be released for low-price, others now donate it. Civil society has been included in both programmes' activities, focusing mainly on children in Paraná State. Although these release programmes were not foreseen in the Brazilian NPOA ("Pan-Tubarões") and are not a measure officially supported by the environmental agencies, hundreds of individuals were rescued and returned to nature, providing strong evidence of the success of such strategies. This way, it is suggested that release programmes should be prioritized, or at least encouraged when both NPOAs and RPOAs are updated.

RFMOs

A point of attention regarding elasmobranch management in international waters was the non-retention recommendation of prohibited species without a direct recommendation for release of these species, which would then mean a voluntary adherence to releases. In cases where the recommendations/resolutions for non-retention are not species-specific, release is encouraged with focus on the incidental capture of juveniles and pregnant females, but also for any elasmobranch that is not of commercial interest. This observation is considered problematic since it overlooks the release of live threatened species individuals, for example. In other words, releases get mixed to compulsory discards and are considered a non-retention consequence. Furthermore, mandatory release was not foreseen for all species protected by international agreements (e.g. CITES, CMS), which can compromise management and create loopholes for retention onboard and subsequent illegal trade. Based on RMFOs' jurisdiction, only oceanic and/or migratory species were considered, while the recommendations for coastal species were in general set by the NPOAs. For this reason, the release of rays was mostly focused on Mobulids, and more specifically on "Manta rays" (*Mobula* spp.). The exception was the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), which provides for the release of skates as part of Antarctica's Wildlife Monitoring Programme. In the case of sharks, most RMFOs focused on oceanic whitetip sharks (*C. longimanus*), whale sharks, silky sharks (*C. falciformis*), and thresher sharks (*Alopias* spp.), all listed under CITES Appendices, and for these species release was encouraged along with detailed reports of number of individuals returned to the sea and their physical state.

Despite existing recommendations for voluntary adherence, RMFOs are the bodies responsible for fisheries management in international waters—where countries have no jurisdiction. For this reason, release should be treated with higher priority in the resolutions published by RMFOs, once there is no additional legislation that can ensure fishers' compliance, not even for species at great risk of extinction or CITES-listed species. Thus, it becomes extremely necessary that RMFOs optimize their onboard release recommendations, as well as the creation/constant update of BFPMs and promote release training for fishing crews. In this regard, the Western and Central Pacific Fisheries Commission (WCPFC) stood out in its efforts to develop manuals for the safe release of elasmobranchs. The topic was first presented at the Twelfth Regular Session and focused on whale sharks (WCPFC, 2015). Over the years, new guidelines for sharks and rays have been developed (WCPFC, 2015, 2017, 2018; Clarke, 2018). The first drafts were composed of texts, with little visual content, and for that reason, allowed room for interpretation. In 2018, Clarke *et al*. proposed a draft using the illustrations of Poisson *et al*. (2012) and Gilman (2014). All documents culminated in the "WCPFC Shark and Ray Handling Guidelines for Purse-seiner and Longline Crew," with the objective of creating routine processes for the safe release of sharks and rays, aiming to increase their survival through the reduction of stress

and injuries. The guide was presented in a didactic way with previously unpublished illustrations and some based on Poisson *et al.* (2012).

BFPMs

The release of incidentally captured animals is a positive action for bycatch mitigation, but it should reduce as much as possible the stress and injuries inflicted on captured individuals for it to be successful (Hall, 1996; Ellis *et al.*, 2017). The establishment and improvement of species-specific handling protocols have the potential to significantly improve the chances of post-capture survival (Zollett and Swimmer, 2019). Nonetheless, when it comes to sharks and rays, fishers do not always release their catches due to fear of bites and stings and when they do so, the release is performed without considering the animal's welfare and often causes their death (Carruthers and Neis, 2011). Therefore, as important as establishing handling protocols is the development and communication of simple, but practical manuals that take into consideration all the challenges involved in elasmobranch handling and release (Patterson and Tudman, 2009). Moreover, the development of effective handling protocols requires extensive research on capture stress and post-capture survival rates (Patterson and Tudman, 2009; WCPFC, 2015). Also, only with the careful evaluation of the methods used by fishing crews, it can be considered possible to corroborate the efficiency of the proposed/suggested protocols (WCPFC, 2015). Despite the need for close collaboration between the developers (i.e. researchers, specialists) and fishers, few BFPMs have been designed in this way (Poisson *et al.*, 2012, 2014; Grande *et al.*, 2019; Razzaque *et al.*, 2020). Even when protocols were developed based on onboard observations and crew experience, fishers complained that actions consumed a lot of time, and were still risky (Grande *et al.*, 2019). Thus, it is necessary to further invest in crew training and in individual protection equipment in order to increase the chances of commitment (FAO and ACCOBAMS, 2018). Fortunately, some unprecedented measures have been elaborated to facilitate onboard release, including shark velcros, manta sorting grids, release ramps, hoppers with ramps, double conveyor belt, and waste chute so that sharks and rays can be more safely (for both crew and animal) released. Some of these measures have already even been adopted by French commercial purse-seiners, while others are being developed and tested (Poisson *et al.*, 2014; Hall *et al.*, 2017; Murua *et al.*, 2021). Manuals focused on artisanal fisheries still need to be developed and implemented. For example, while onboard release (i.e. considering releases performed from inside or beside the boat) seems to be relatively well covered, releases of elasmobranchs landed alive (i.e. beach seine captures or species brought alive to fishing landing sites) are still categorically neglected. For fisheries carried out in small vessels, or from the shore, adaptations are needed, but somehow have not yet been foreseen either in NPOAs or in any other fisheries management tool.

Among the available BFPMs, all were of voluntary adherence and aimed to teach methods and strategies to facilitate release, reduce animal mortality and avoid accidents with fisheries crews. Although in some cases BFPMs had a target audience/fishing modality, most explanations and illustrations seemed very intuitive. Among the manuals published so far, Poisson *et al.* (2012), Gilman (2014), and Reina *et al.* (2014) are the most recognized and have inspired many others, with language adaptations and overall presentation, according to the target audience (IOTC, 2013; ISSF, 2016a, 2016b; Clarke, 2018; WCPFC, 2019; Grande *et al.*, 2019). These corresponded to extremely didactic manuals, with step-by-step instructions and several figures to illustrate the protocols. Furthermore, all illustrations had a detailed description, to avoid misinterpretation. In addition to explaining what should be done, these manuals also highlight what should not be done in a specific "dont's" section. There were some variations in their composition, such as a brief introduction when the target audience was academic (e.g. Patterson and Tudman, 2009; Poisson *et al.*, 2014; Fowler, 2016), or when it was necessary to inform the need to protect the species (e.g. Peverell, 2010 for sawfish; Angel Shark Project, 2018, 2021). Some manuals also contain sections aimed at species ID (e.g. Poisson *et al.*, 2012; Reina *et al.*, 2014; ISSF, 2016a, 2016b; Carlson *et al.*, 2019), as well as relevant information that should be reported to local research groups (e.g. Peverell, 2010; NOAA, 2018; Angel Shark Project, 2018, 2021).

Although not cited in most BFPMs, the vulnerability of elasmobranchs to injuries and physical trauma should be addressed in future updates (Poisson *et al.*, 2012), with illustrations/photos of elasmobranch internal and external anatomy along with types of injuries caused by capture and inadequate handling (e.g. tail fracture, eye perforation). Moreover, manuals should be developed at the local level whenever possible. Particularly in the case of underdeveloped and developing countries, research groups/NGOs should work in synergy to create, or at least translate/adapt BFPMs to provide fishers and vessel owners/captains/skippers with the information needed to safely carry out releases. In addition, BFPMs should emphasize to governments and fisheries management organizations the importance of training fishers for release, thus boosting the efficiency and relevance of this conservation strategy. Lastly, it is important to mention that several elasmobranchs are extremely sensitive to capture, and are rarely brought onboard alive or in conditions to be released with chances of survival. That said, release measures are, unfortunately, not possible for many species that are caught by commercial vessels. Therefore, such limitation might partially help explain why release is not a priority in most documents, and further studies are needed to better evaluate for which species onboard (or land) release would be beneficial, focusing on cost-effective studies to assess post-capture mortality and develop appropriate handling and release protocols.

Conclusions

In summary, although releases were somehow approached in all types of documents analyzed in the present study, this conservation strategy was mostly underestimated and treated as secondary in fisheries management tools. BFPMs presented release as the main strategy, however, significant data is lacking for the improvement of manuals, and most of them merely reproduced what had been previously presented in other manuals, with no studies being carried out on their applicability, adherence and success rates. If manuals are not being tested with scientific rigour, all protocols seem to be just theories, without any proven efficiency. Thus, future studies should focus on testing the efficacy of proposed release protocols, as well as on generating species-specific handling methods, along with a physiological evaluation to create BFPMs that can effectively reduce the impacts of bycatch on populations. As for Plans of

Action and RMFOs recommendations/resolutions, significant improvements are needed, especially in directing decision-making and prioritizing actions and goals. It is becoming increasingly unacceptable to base all conservation planning directed at elasmobranchs solely on prohibitive and punitive measures. Resource users must be involved, their demands should be heard, and co-participatory management ought to be considered (Mason *et al*., 2020). Moreover, new forms of mitigation based on financial compensation should be discussed (Booth *et al*., 2021c), such as eco-labelling as an incentive to elasmobranch release. In fact, there is recent evidence of growing consumer interest in eco-labeled products specifically designed for shark conservation (Mulazzani *et al*., 2021), creating new possibilities for elasmobranch bycatch management. Thus, for both Plans of Action and RMFOs future updates, it is essential that the suggested measures are based on the human dimensions of elasmobranch fisheries, and take advantage of socio-psychological approaches to overcome the challenges associated with bycatch management (Booth *et al*., 2021b).

Release should also be encouraged in commercial shore fisheries or those carried out on small to medium (mostly non-motorized) vessels, even if there are new challenges associated with the creation of specific protocols for these fishing modalities. In addition, release programmes ought to be disseminated and treated as social tools, since they allow those involved to become conservation ambassadors and feel a sense of belonging or acknowledgment for their role in elasmobranch conservation. Showing society the importance of release as compensation for the impacts of bycatch is also necessary, mainly because popular mobilization can be a powerful tool for attitude changes towards elasmobranch conservation. Furthermore, it is necessary that financial compensation to fishers, which is still frowned upon by funding agencies and conservationists, be valued for what it is: gateways to participatory management and real chances of reducing bycatch mortality. Also, as governments sometimes do not have the tools or specialists to carry out fishers' training or invest in release programmes, it is critical to involve NGOs, research groups, and even private companies to coordinate these activities, even if only on a local scale. Lastly, national and international collaboration networks are necessary, aiming to constantly improve release strategies, in order to inform fisheries responsible bodies on which measures should be taken and how to engage more and more people on this simple, but effective conservation strategy.

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The authors have no conflict of interest to declare.

Author contribution

Conceptualization—NW; data curation—NW, EPG, RDL, IH, and PC; methodology—NW, EPG, RDL, IH, and PC; writing—original draft—NW, EPG, RDL, IH, and PC; writing—review and editing—NW, EPG, RDL, IH, and PC.

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