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Best practices for reducing negative impacts on endangered elasmobranchs and seabirds

In October 2021, the SeaBOS Endangered Species Strategy was published along with a set of time-bound goals to substantially reduce negative impacts on endangered elasmobranch (sharks and rays) and seabird species from seafood operations. To support the achievement of these goals, this document presents a set of science-based and operational best practices for reducing negative impacts on endangered species, while also emphasizing the importance of advancing monitoring, control and surveillance to demonstrate compliance, as well as critical knowledge gaps in this space and means to address these.

1 Background

Seafood Business for Ocean Stewardship (SeaBOS) is a coalition of ten of the largest seafood producers in the world, working together and with science, *to lead a global transformation towards sustainable seafood production and a healthy ocean*. In October 2021, SeaBOS members agreed on an "Endangered Species Strategy".[*,**] This document is based on available science, best practices used by the seafood industry (including SeaBOS members), existing regulations, and guidance from expert organizations. It provides operational guidance and support for making the first phase of the SeaBOS strategy for endangered species operational; which placed its taxonomic focus on elasmobranchs[***] and seabirds.

Optimal mitigation strategies will vary by production system and the taxa at risk, and the available information is substantially larger for wild capture fisheries than for aquaculture. The studies reviewed in this document and the recommendations derived from them serve as a starting point for further research, piloting and innovation. We describe the identified best practices according to the following main sections: reducing **interactions in aquaculture** (Section 2.1), reducing **interactions in wild capture fisheries** (Section 2.2), improving **handling of animals** when interactions occur (Section 3), **minimizing indirect risks** (Section 4), **using monitoring, control and surveillance (MCS)** to demonstrate compliance (Section 5), and **critical knowledge gaps** – along with best practices on how they can be filled (Section 6).

Many elasmobranch and seabird species have life-history strategies that make them vulnerable to excess mortality due to overexploitation, bycatch[****] and forage fish depletion, respectively (Cury et al., 2011; Field et al., 2009; Richards et al., 2021). In general, both species groups have delayed sexual maturation (they do not start breeding until several years old) and only produce one or a few offspring each year. Populations can only grow and recover slowly and even a small increase in mortality (particularly of adults) can be detrimental for the survival of populations and the species. Both groups also include species with generally predictable migratory and foraging behavior – they migrate seasonally to distinct feeding or breeding areas along predictable migratory routes, which can be used as a basis for designing appropriate means to reduce risks (if such information is available). Several seabird species are central place foragers during the breeding season, which means that they return to the same nesting site every year, during the same time period, for reproduction. This is one of many examples where additional collection and sharing of scientific information (e.g. on spatial and temporal overlap between endangered species and seafood production) would enable development of more precise best practices. Section 6 in this document identifies knowledge gaps, and potential for collaborative learning and innovation, which would benefit from strengthened collaborations between scientists and the seafood industry.

* https://seabos.org/wp-content/uploads/2021/10/Endangered-Species-Strategy.pdf

** For the purposes of SeaBOS, we define "Endangered Species" as the list of species identified as Vulnerable, Endangered or Critically Endangered by the IUCN, refined as appropriate with more recent or detailed scientific assessments, as well as those species designated as endangered, threatened or protected by relevant governmental or intergovernmental bodies.

*** Elasmobranchs include sharks, skates, rays, guitarfishes, and chimeras.

**** The FAO defines bycatch as discarded catch of any living marine resource plus retained incidental catch and unobserved mortality due to a direct encounter with fishing gear.

2 Best practice for reducing direct interactions

2.1 Reducing interactions in aquaculture

The environmental impacts of aquaculture production on endangered elasmobranchs and seabirds may include incidental capture of such animals in aquaculture cages and/or ponds as well as associated equipment. Both sharks and birds may attempt to predate farmed species, or to eat the feed administered in aquaculture operations. Additional negative and primarily indirect effects from aquaculture on endangered species include the loss of coastal habitats, unintended introduction of invasive species to coastal ecosystems, disease, or bycatch during the capture operations of species for fish feed (Primavera, 2006). Sustainable production of feed – including from well-managed populations of small pelagic species is an important starting point for ensuring that endangered species maintain access to their prey species (Belghit et al., 2018; Cury et al., 2011) and is further developed below (indirect effects Section 4).

Aquaculture pens and ponds can be an attractor for endangered species for multiple reasons (Sagar, 2013; Surman et al., 2015):

Predation of farmed fish by seabirds – seabirds may seek to enter cages to eat fish (or other farmed species), potentially resulting in their entanglement or capture. (*Mitigation measures*: cover pens with taut bird mesh nets (less than 6 cm); or submerge pens).

Predation of farmed fish by sharks – aquaculture has been known to attract sharks, which can bite through conventional containment nets and in some cases subsequently become entangled. (*Mitigation measure*: transition to nets developed to withstand shark bites (Gümpel et al., 2019)).

Consumption of fish feed – seabirds may be attracted to the feeds used in fish farming, particularly in the case of whole fish, resulting in some instances in entanglement or capture. Most tropical open-pond aquaculture also distribute feed on pond surfaces that attract seabirds that can be hunted to decrease avian feed consumption. (*Mitigation measures*: transition from using whole fish as feed to using pellets; use submerged pens with slow-release feeders).

Lighting can disorient seabirds active at night – seabirds active at night can be disoriented by bright lights, resulting in collision. (*Mitigation measures*: reduce use of lighting; develop a light management plan and adjust seasonally to account for migratory birds; transition to downward-pointing and shaded light sources).

Perching on aquaculture pens and associated equipment – if seabirds are attracted to aquaculture facilities, their feces can lower water quality, increase parasite and pathogen levels and foul gear (*Mitigation measures*: cover pens with bird mesh; design other above-water materials to reduce attractiveness as bird perches; use visual, physical (e.g. Bird B Gone) audio deterrents or biological deterrents, such as birds of prey).

Aquaculture infrastructure as de facto Fish Aggregation Devices (FADs) – residues from feeds and attraction of larval fish and other organisms to artificial marine structures can attract fish and both seabird and elasmobranch predators that can become entangled in gear (*Mitigation measures*: reduce oil content in feeds; remove dead fish from pens / cages).

Proximity of aquaculture pens to known colonies of endangered seabirds, aggregations of sharks and rays, critical breeding/spawning sites, foraging sites or migratory routes increases the risk of negative direct interactions (e.g. entanglement) as well as negative indirect interactions. This second category can include, for instance, changes to ecological conditions that result in altered behavior of local seabird populations and increased populations of species like gulls and cormorants that can crowd out endangered species. (*Avoidance measure*: Locate pens as far away as feasible from known colonies of endangered species.)

2.2 Reducing interactions in capture fisheries

Wild capture fisheries can result in direct and indirect negative effects on elasmobranchs and seabird species. Direct effects may result from bycatch and entanglements or collisions with fishing equipment. Mortality of endangered species - particularly elasmobranchs - is also associated with illegal, unreported or unregulated (IUU) fisheries that directly target sharks and rays. Hence, a retention ban (or no retention policies) on such species and improved enforcement by governments represent complementary approaches for reducing negative impacts on such endangered species, in addition to those described in the following. Indirect effects from wild capture fisheries include competition (between fisheries and marine predators) for prey resources (see Section 4).

Negative direct interactions can be reduced by minimizing the (horizontal or vertical) spatial or temporal overlap between fishing operations and endangered species (**avoidance measures**) and by reducing the likelihood of bycatch events of endangered species which are in the vicinity of a fishing operation (**mitigation measures**).

2.2.1 Purse seine

The FAO defines a purse seine as "a wall of netting designed to encircle a school of pelagic fish near the surface and use a purse line to close the bottom of the net." In the context of marine fisheries catch volumes, it is the world's most important fishing gear, accounting for roughly one-third of global catch. The FAO notes the importance of purse seine fishing in anchoveta fisheries (Peru / Chile), Atlantic herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*) fisheries (Northeast Atlantic), and in Skipjack tuna (*Katsuwonus pelamis*) fisheries around the world.

Purse seines frequently make use of fish aggregating devices (FADs), particularly in the case of tropical tuna purse seiners, and artificial lights at night, both of which are associated with negative interactions with endangered species, primarily elasmobranchs and sea turtles. FADs are a type of floating equipment that is often used to aggregate tunas and, therefore, facilitate capture at a particular location.

The main interactions between purse seining and endangered species include entanglements of dolphins, turtles, sharks, mantas and birds caught as bycatch (Justel-Rubio and Restrepo, 2015). According to the Marine Stewardship Council, tropical tuna purse seining can be a selective form of fishing with low levels of bycatch, especially when such operations take place around a 'free school' of target fish, which is not associated with a pod of dolphins or FADs (Lezama-Ochoa et al., 2019).

Most knowledge about bycatch in purse seining is related to tuna and tuna-like species, in particular operations that rely on FADs, which account for ~40% of tuna catches worldwide (ISSF, 2021). FAD bycatch rates are higher than those of "free school" sets and certain FAD structures, when their subsurface structure is made of netting (these are known as entangling FADs). Such FADs are known to entangle sharks and other marine animals, but alternative non-entangling FADs are increasingly being used.* They also pollute the ocean when lost or discarded. While there is also bycatch in non-tuna purse seine operations, we are not aware of any associated best practices to mitigate such effects.

* https://www.iss-foundation.org/fishery-goals-and-resources/our-best-practices-resources/non-entangling-and-biodegradable-fads-guide/download-info/non-entangling-and-biodegradable-fads-guide-english/

Elasmobranchs

Make fewer fish aggregation device (FAD) sets and shift effort to free-school sets. Sharks are more commonly found in FAD sets than they are on free swimming schools. According to an ISSF report, for a given amount of fishing effort, a shift to more free-swimming school sets will reduce overall catch of sharks,** but may result in higher catches of mantas per unit of effort (Justel-Rubio and Restrepo, 2015; Lezama-Ochoa et al., 2019).

Avoid setting on small schools of fish. Avoiding sets on schools of tuna less than 10 tons would reduce the amount of bycatch of some shark species (e.g. silky sharks by 21-41%) depending on the region, without compromising tuna catches*** (Dagorn et al., 2012).

Use biodegradable and non-entangling FADs. Such FADs are made from natural and/or biodegradable materials (cotton ropes, canvas, manila hemp, sisal, coconut fiber) and do not continue to cause further entanglement/bycatch or result in other negative ecosystem impacts if they are lost.

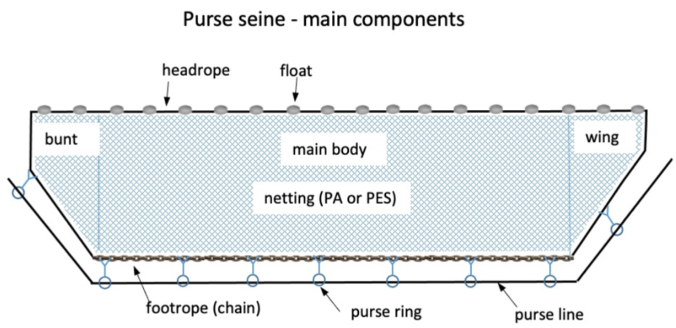
Identify shark bycatch hotspots and avoid these areas. Areas of high shark bycatch and relatively lower tuna catches have been identified in regions such as the Eastern Tropical Pacific and findings suggest that, if avoided, shark bycatch would decrease, while not jeopardizing tuna catch rates (Watson et al., 2009).

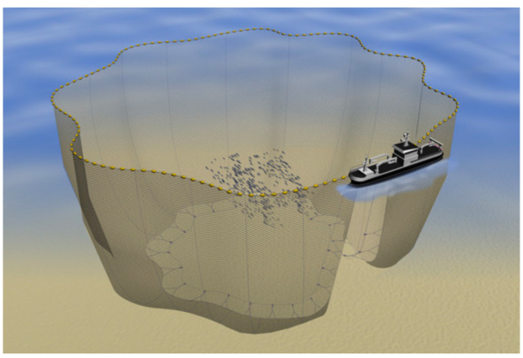
Seabirds

Purse seine fishing operations are not the main source of industry-related seabird mortality globally, although some species may be more susceptible to bycatch in specific fisheries. This is particularly true for tuna purse seine operations, although there is evidence that localized purse seine fisheries across various size classes (e.g. in Chile for small pelagics), can result in notable bycatch rates (Suazo et al., 2014). Seabird bycatch in purse seine fishing operations primarily results from the entanglement of animals in different parts of the fishing gear (Suazo et al., 2016) and is most likely in operations which target forage fish.

** http://iss-foundation.org/knowledge-tools/publications-presentations/infographics/download-info/protecting-sharks-reducing-shark-bycatch-in-purse-seine-fisheries/

*** https://meetings.wcpfc.int/node/11305





Illustrations: He et al. 2021

The Modified Purse Seine (MPS) consists of a package of gear adjustments to non-tuna purse seine nets that include two primary measures: buoy mounting to reduce surface entanglements and reducing the mesh size.* These modifications show promise in reducing seabird bycatch and improving catch success in the fishery they were tested on in Chile (Suazo et al., 2017).

2.2.2 Longline

The FAO defines longlines as a "type of hook-and-line gear where hooks are connected to branch lines which are then attached to a long horizontal mainline at certain intervals which are usually baited and set in open water untended for a period of time". Large-scale pelagic and demersal longlines are known to range in length from several hundred meters to over 100 kilometers (Sacchi, 2021).

Surface longline gears are primarily used to catch tuna, billfishes and sharks (pelagic longlines), as well as bottom-dwelling species (with demersal longlines) such as Atlantic cod (*Gadus morhua*), Atlantic halibut (*Hippoglossus hippoglossus*), and haddock (*Melanogrammus aeglefinus*) in the North Atlantic, snappers and groupers in East / Southeast Asia, and Patagonian toothfish (*Dissostichus eleginoides*) in the Southern Ocean (Sacchi, 2021). These gears can generate substantial bycatch of elasmobranchs and seabirds, if proper avoidance and mitigation methods are not used. Pelagic longlines have been estimated to kill at least 160,000 seabirds annually (Anderson et al., 2011; Clarke et al., 2014). Longline fishing also has some of the highest elasmobranch catch and bycatch rates, when comparing across fishing gears (Oliver et al., 2015). However, multiple best practices are available and have been put to extensive use, with resulting positive effects (reduction of bycatch rates and associated recoveries of depleted animal populations (Robertson et al., 2017)).

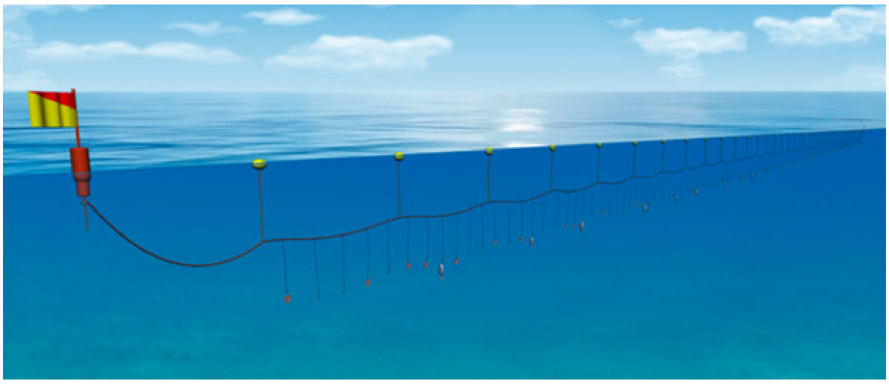
<u>Elasmobranchs</u>

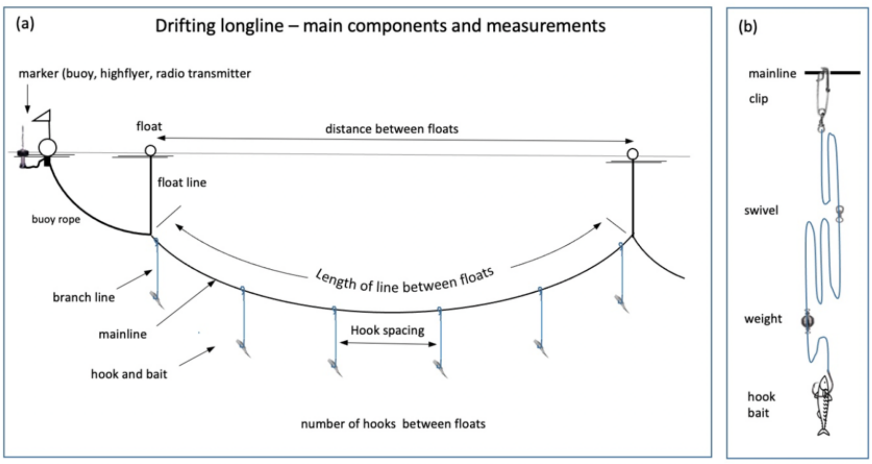
Use Circle hooks. Circle hooks on pelagic longlines have been found not to have a major effect on shark catch rates, but they do reduce at-vessel mortality of sharks compared to the more frequently used J-hooks, as J-hooks tend to be more deeply hooked inside the animal (Godin et al., 2012). Other studies suggest that catch rates of some bycatch species may increase, but mortality rates decrease (Reinhardt et al., 2018), since these are linked to where in the shark the hook engages. Sharks captured on circle hooks were more frequently hooked in the mouth or jaw rather than internally in the esophagus or gut as when caught by J-hooks, which cause more substantial damage to the animal (Godin et al., 2012; Serafy et al., 2012).

Use nylon (monofilament) leaders. The portion of the longline that stems from the main line and suspends the baited hook is called the leader. Compared to the traditional use of wire leaders, monofilament leaders allow bite-off and escape of pelagic sharks and decrease unwanted bycatch mortality when compared to wire leaders (Ward et al., 2008). Monofilament leaders have been found to lead to either no changes in target species catch rates (Santos et al., 2017) or to moderate increases (Ward et al., 2008).

Reduce longline soak times. Another way to effectively reduce bycatch mortality of sharks in longlines is to reduce the soak time (the time that longlines are in the water) (Carruthers et al., 2011). Elasmobranchs removed more quickly from longlines have a higher chance of survival since their breathing depends on the capacity to continue swimming.

If sharks are still caught with longlines (hooked or entangled) it is recommended to use long-handled line cutters and de-hookers while the animal remains in the water. For further instructions on shark handling if interactions are inevitable, see Section 3.





Illustrations: He et al. 2021

* https://www.acap.aq/working-groups/seabird-bycatch-working-group/sbwg-10/sbwg10-meeting-documents/3796-sbwg10-doc-19-toolbox-for-seabird-bycatch-mitigation-in-purse-seine-fisheries/file

Seabirds

Seabird mortality from pelagic longlines is a source of serious concern, in particular for threatened albatrosses and petrels (ACAP, 2021a). Mortality occurs primarily when birds become hooked or entangled and drowned while foraging for baits as the line sinks, or sometimes as the gear is hauled. Several fisheries management organizations, including the five tuna Regional Fisheries Management Organizations (RFMOs), require that all of their longline vessels use a combination of seabird mitigation measures, including, but not limited to, night setting, branch line weighting and bird-scaring lines, in areas that overlap with albatross distributions (Clarke et al., 2014). Seasonal closures or fisheries around seabird breeding areas also represent a prevalent method for reducing negative interactions.

Night setting. Setting longlines at night is highly effective at reducing incidental mortality of seabirds because the majority of vulnerable seabirds are inactive at night. However, night setting is not as effective for birds that forage in the dawn/dusk or night (e.g. White-chinned Petrels, *Procellaria aequinoctialis*). The effectiveness of night setting may also be reduced during bright moonlight and when using intense deck lights, and is less practical in high latitudes (with very short nights) during summer.

Avoid fishing in proximity of nesting grounds. These are areas where seabirds are predominately feeding (for themselves and their offspring) and they should be seasonally avoided to reduce negative impacts on birds. Effective reduction of seabird mortality often requires detailed knowledge of spatial and temporal overlap between seabird foraging and fisheries operations.

The Agreement for the Conservation of Albatrosses and Petrels (ACAP) has produced a substantial "Review of mitigation measures and Best Practice Advice for Reducing the Impact of Pelagic Longline Fisheries on Seabirds". Fact sheets with detailed recommendations are available in English, Japanese, Korean and other languages* and a short summary of these measures is provided below.

Use weighted branch lines. Branch lines should be weighted to sink the baited hooks rapidly out of the diving range of feeding seabirds. Studies have demonstrated that branch line weighting where there is more mass closer to the hooks, results in hooks sinking most rapidly and consistently (Gianuca et al. 2011; Robertson et al. 2010; 2013; Barrington et al. 2016), reducing bird attacks on bait (Gianuca et al. 2011; Ochi et al. 2013, Jiménez et al. 2019) and seabird mortality (Jiménez et al. 2017; 2019: Santos et al. 2019). The methods are easy to implement and easy to monitor for compliance (see Box 1).

Box 1: Weighted branch line specifications.

Current recommended minimum standards for branch line weighting configurations include the following:

(a) 40 g or greater attached within 0.5 m of the hook; or

(b) 60 g or greater attached within 1 m of the hook; or

(c) 80 g or greater attached within 2 m of the hook.

Lines should be attached to the vessel with a barrel swivel to minimise rotation of the line from torque created as it is dragged behind the vessel. Long streamers should be attached with a swivel to prevent them from rolling up onto the bird scaring lines(Clarke et al., 2014).

Use bird-scaring lines (a.k.a. tori lines) to deter birds from sinking baits. Brightly colored streamers hanging from a rope connected to a buoy which drags behind the vessel have been identified as particularly effective. Lines should be attached to the vessel with a barrel swivel to minimise rotation of the line from torque created as it is dragged behind the vessel. Long streamers should be attached with a swivel to prevent them from rolling up onto the bird scaring lines (Clarke et al., 2014) (see Box 2).

Hook shielding device. Hook-shielding devices encase the point and barb of baited hooks to prevent seabirds being hooked during line setting until a prescribed depth is reached (10 metres), or until a minimum period of immersion has occurred (10 minutes) ensuring baited hooks are released beyond the foraging depth of most seabirds (see Box 3).

Use underwater bait setting devices. These devices deploy baited hooks at a predetermined depth immediately at the stern of the vessel enclosed in a capsule or similar device to eliminate any visual stimulus for seabirds. Analogous devices may also be referred to as 'underwater setting chutes' (Gilman et al. 2003). The device should deploy encapsulated hooks in a vertical manner at the stern of the vessel until a minimum prescribed depth of 5 meters is reached. Branch lines should meet recommended minimum standards for branch line weighting described above.

Bird Exclusion Devices (BEDs). Seabirds are also vulnerable to bycatch as longlines are hauled in. Using BEDs, such as 'brickle chains', prevents seabirds from getting to the longline, thus avoiding bycatch. Other devices used in the hauling process include 'moonpools'), which also reduce bycatch rates.

* https://www.acap.aq/resources/bycatch-mitigation/mitigation-fact-sheets

Box 2: Bird-scaring Line specifications

Recommendations for vessels greater than 35 meters differ from those smaller than 35 meters (streamers should be brightly colored regardless of vessel size):

>35m: Bird scaring lines should be attached to the vessel such that they are suspended from a point a minimum of 8 m above the water at the stern. Streamers should be placed at intervals of no more than 5 m. Baited hooks should be deployed within the area bounded by the two bird scaring lines.*

<35m: mix of long and short streamers, that includes long streamers placed at 5 m intervals over at least the first 55 m of the bird scaring lines. The alternative are short streamers (1 meter) placed at 1m intervals. The aerial extent should be >75m for vessels in this size class by suspending the scaring line at least 6m above the waterline on the stern of the vessel.**

* https://www.acap.aq/resources/bycatch-mitigation/mitigation-advice/3956-acap-2021-pelagic-longlines-mitigation-review-bpa/file

** https://www.acap.aq/resources/bycatch-mitigation/mitigation-advice/3956-acap-2021-pelagic-longlines-mitigation-review-bpa/file

Box 3: Hook shielding device specifications

The following devices have been assessed as meeting these performance requirements and are therefore considered to represent best practice:

i. 'Hookpod-LED' – 68 g minimum weight that is positioned at the hook, encapsulating the barb and point of the hook during setting, and remains attached until it reaches 10 m in depth, when the hook is released (Barrington 2016, Sullivan et al. 2018).

ii. 'Hookpod-mini' – 48 g minimum weight that is positioned at the hook, encapsulating the barb and point of the hook during setting, and remains attached until it reaches 10 m in depth, when the hook is released (Goad et al. 2019, Gianuca et al. 2021, Sullivan & Barrington 2021).

2.2.3 Trawl

The FAO describes a trawl as a "cone-shaped body of netting, usually with one codend, towed behind one or two boats to catch fish through herding and sieving." A variety of trawls exist, adapted for use to be towed along the seabed (bottom trawls) or in the water column (midwater trawls). Trawls are a versatile fishing gear, with mesh size in the codend largely determining which species, and of which size, are caught.

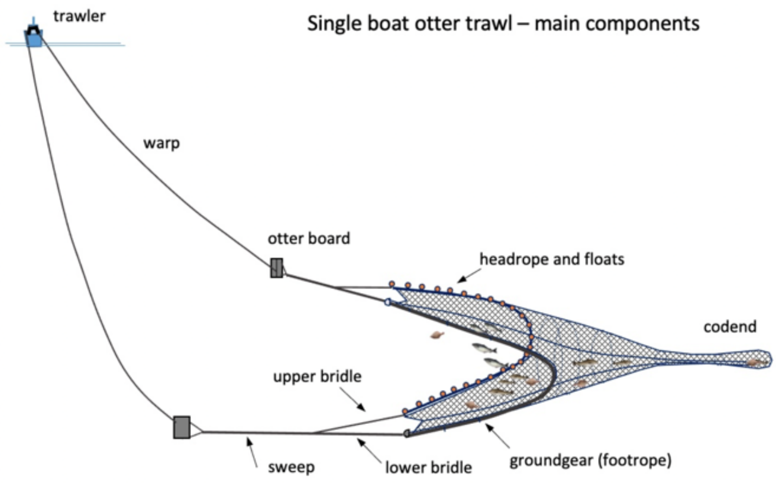
Pelagic and benthic/bottom trawls sets are known to result in the unintended bycatch of several non-target species groups, including seabirds and elasmobranchs (Sacchi, 2021). These interactions tend to be fishery-specific, but seabirds most commonly are affected during the setting and hauling processes, while interactions with elasmobranchs happen primarily throughout the fishing transect (Sacchi, 2021). While trawlers for small pelagic fishes may catch species, such as mako (*Isurus spp.*) and thresher (*Alopias spp.*) sharks, benthic trawls targeting deep water crustaceans and finfish may catch large quantities of demersal sharks, such as catsharks (*Galeus spp.*) or houndsharks (*Mustelus spp.*) and Orectolobiform and Carcharhiniform skates.

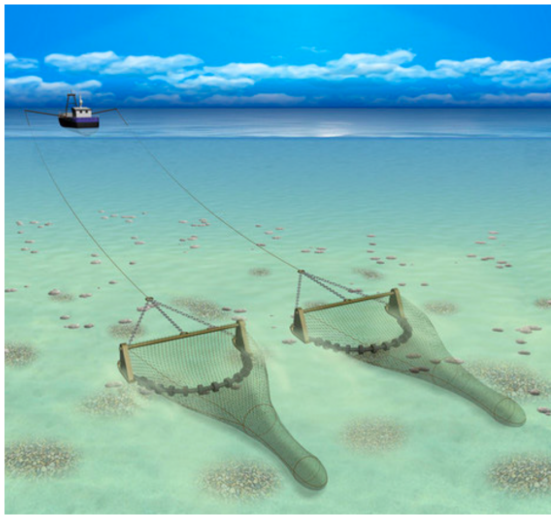
Within the International Council for the Exploration of the Sea (ICES) region, bottom trawling was the fishing gear with the highest incidence of caught elasmobranch species. Elasmobranch bycatch was particularly high in the Greater North Sea, Western Mediterranean Sea, and Barents Sea ecoregions (ICES 2020). The ICES working group on bycatch of protected species requested a zero total allowable catch (TAC) for elasmobranchs and protected fish species and an increase in the resolution of bycatch information to the fishing trip level (ICES, 2020). In principle, benthic trawl operations should aim to confine the impact of their operations to previously disturbed areas (McConnaughey et al., 2020).

<u>Elasmobranchs</u>

In addition to restrictions on access to spawning and nursery areas, there are other spatial preventive measures that would enable shark and ray capture by trawls to be avoided (Sacchi, 2021). Potential forms of avoidance could include empirical move-on rules, which would have to be designed for specific fisheries (Dunn et al., 2014).

Use of bycatch reduction devices (BRDs, also referred to as 'filter grids') in demersal fish trawls is an effective bycatch mitigation strategy for the large majority of megafauna species, with the associated loss of target species being negligible (Cosandey-Godin, 2015; Wakefield et al., 2017). BRD configurations may vary depending on the specific gear characteristics. Wakefield et al. (2017) found that the most effective (+20-30% effectiveness) configuration for reducing elasmobranch bycatch was the upward BRD.





Illustrations: He et al. 2021

Modification of bottom trawls. The catch rate of sharks and rays can be significantly lowered by removing the tickler chains in benthic trawls (Kynoch et al., 2015).

It is uncommon for bycaught elasmobranchs (unable to exit the net) to survive during long hauls (Ellis et al., 2017). If individuals are hauled back onto the deck alive, their survival rates can increase by applying the best practices described in Section 3.

Seabirds

Seabird mortality in trawl fisheries occurs when birds collide with cables as they feed on fish processing waste (offal and discards) or are entangled in trawl nets as they attempt to forage on captured fish or fish parts. Cable strikes, including collisions with net-monitoring cables, warp cables and paravanes are associated with the fish waste discharged by vessels that catch and process fish on-board (catcher-processors).

Avoid fishing in proximity of nesting grounds. These are areas where seabirds are predominately feeding (for themselves and their offspring) and they should be seasonally avoided to reduce negative impacts on birds.

Practice responsible handling of offal and discards. Mitigation measures should focus on reducing the general attractiveness of trawling operations to seabirds. The discharge of offal and discards is the most important factor attracting seabirds to the stern of trawl vessels, where they are at risk of cable and net interactions (ACAP, 2021b). The following offal and discard management measures have been identified as effective:

- Avoid discharging waste during fishing trips. If discharging must happen, avoid discharging before or during fishing operations (when cables or net are in the water);
- "Mealing waste – Where retention of waste is impracticable, converting offal into fish meal, and retaining all waste material with any discharge restricted to liquid discharge / sump water;
- Batching waste – Where meal production and retention of offal and discards are impracticable, waste should be stored temporarily for two hours or longer before strategically discharging it in batches;
- Mincing of waste – Where retention, mealing or batching is impracticable, reduce waste to smaller particles (currently only recommended as a mitigation for bycatch of large Albatross *Diomedea spp.*)" (ACAP, 2021b).
- Cleaning the nets of dead fish from previous hauls would reduce the attractiveness of the net in subsequent sets.

Use paired bird-scaring lines (BSL) which are proven and recommended as a mitigation measure to deter birds away from warp cables, and net monitoring cables where their use cannot be avoided, for pelagic and demersal trawl fisheries., e.g. to reduce the risk of seabirds striking fishing gear associated with trawling (e.g., warp cables and net-sonder cables) and accessing the net. Brightly colored streamers hanging from a rope connected to a buoy/drag device which drags behind the vessel has been identified as particularly effective. Attachment of a BSL to both the port and starboard sides of a vessel, above and outside of the warp blocks, greatly reduces the access of birds to the danger zone where warps enter the water (Melvin et al., 2010; Reid and Edwards, 2005). An offsetting towed device has been demonstrated to improve BSL performance (Tamini et al., 2015) (see Box 2).

Use Rory lines, which are designed to be used in conjunction with bird-scaring lines, to reduce warp strikes by placing a physical barrier between the scupper (where factory discards are released) and the danger zone (where the trawl warps enter the water) at the stern of the vessel. They have been proved highly effective at reducing the number of seabirds that drifted alongside the vessel into the danger zone (Rice, 2012).

2.2.4 Gillnet

The FAO groups gillnets and entangling nets together, characterized by their "long rectangular walls of netting that catch fish by gilling, wedging, snagging, entangling or entrapping them in pockets". Such nets are maintained in a vertical alignment by a combination of floats and weights, and can be used either singly, or in long strings of nets that can extend across several kilometers (He et al., 2021). Gillnets are a widely applied fishing method and are used by both small-scale, artisanal coastal fisheries and in large-scale, industrial fishing operations. Gillnets account for roughly 3% of reconstructed global fish landings, but are generally untended and particularly prone to become abandoned, lost or discarded.*

Set gillnets are used around the world and primarily for catching species found on or near the seabed (He et al., 2021). Large-scale gillnet operations primarily target coastal species like salmon, and large-scale driftnets have been internationally banned on the high seas since 1991, primarily due to their substantial and negative impacts on non-target species. Bycatch in gillnets is considered one of the principal sources of mortality across various non-target species groups, including seabirds, with mortality estimates upwards of 400,000 seabirds caught per year (Žydelis et al., 2013). Capture and mortality rates for elasmobranchs in gillnets are also high, although there is variability across species (Molina et al., 2020; Oliver et al., 2015).

Gear transitioning. Given the negative impacts of gillnets and limited opportunities for mitigation, it is advisable to switch to alternative fishing gear-types if possible. Fish traps, pots and hook & line gears have been the center of attention for gear replacement in recent years (Birdlife, 2021) . Fish traps emerge as a promising alternative to gillnets, as they have comparable catch per unit of effort of certain target species, and significantly lower bycatch rate of birds and other non-target species groups. Traps do, however, require more time and effort for deployment and might not be able to target as broad an array of species as gillnets.

Interesting alternatives to gear transitioning may also be developing, since recent studies have identified substantial promise from attaching **Light Emitting Diodes (LED)** on gillnets. This has proven to be effective in the reduction of seabird and sea turtle bycatch, without reducing target catch (Mangel et al., 2018). Seabird bycatch rates have dropped by over 80% using this method (Bielli et al., 2020; Mangel et al., 2018)). More recent findings have also identified how LEDs substantially reduce the bycatch of sharks, turtles and squid, without negative effects on catch rates of target species (Senko et al., 2022).

Elasmobranchs

Avoid nursery areas. These are areas used by elasmobranchs for giving birth and where juveniles of many species spend the first few years of their life.

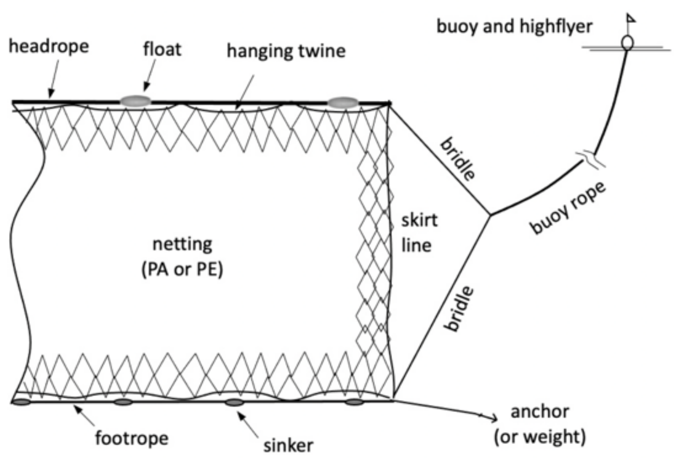
Reducing the soaktime of gillnets and driftnets (i.e. the length of time the gear is in the water) is the most promising measure to reducing elasmobranch bycatch mortality after becoming entangled in driftnets or gillnets (Northridge et al., 2017).

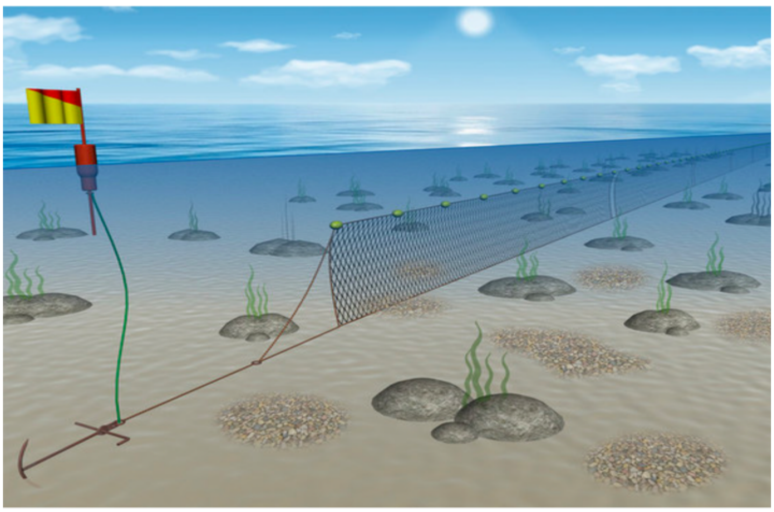
Increasing the tension of gillnets by using larger floats on the head-rope and increasing the lead-core lead-line weight has proven to be useful in reducing bycatch rates of sharks, while not impacting target catches (Thorpe and Frierson, 2009).

Seabirds

Avoid fishing in proximity of nesting grounds. These are areas where seabirds are predominately feeding (for themselves and their offspring) and they should be seasonally avoided to reduce negative impacts on birds.

Set gillnet – main components





Illustrations: He et al. 2021

* https://www.seaaroundus.org/data/#/global?chart=catch-chart&dimension=gear&measure=tonnage&limit=10

According to various studies, **regulating the depth** at which the gillnets (and other fishing gears) are set may significantly reduce seabird bycatch (Bull, 2007). While the depth will depend on the diving range of specific species, submerging the driftnets two meters below the surface was proven to already lead to reductions in seabird bycatch in the northern Pacific (Hayase and Yatsu, 1993); while a ban on gillnets shallower than 60 meters in California almost completely stopped bycatch of common guillemots.

"**Pearl" nets** include small acrylic spheres that float on the water surface, with the objective of visually deterring seabirds. Other deterrents that show promise include looming eyes buoys and predator shaped kites (Birdlife, 2021).

3 Best practice for reducing mortality when interactions occur

The above best practices (Section 2) aim to avoid and mitigate interactions with endangered species, but it is likely that such interactions will sometimes occur. Should that be the case, there are a number of best practices that can be employed in order to reduce negative impacts. The primary focus is to ensure that endangered species survive the interaction, and many methods for correct handling are available to improve the survival rate of elasmobranchs and seabirds and keeping the crews safe.

3.1 Increasing the post-release survival rates of sharks and rays

Elasmobranchs, in particular mobulid rays, are susceptible to stress and injury, which can reduce their chances of post-release survival. Sharks lifted by the head or tail can suffer damage as a result. A shark's head also holds a number of sensitive and fragile organs used to detect prey, and if damaged, the shark— once released— may not be able to locate their prey. If sharks are brought on deck, the following procedures should be applied to increase their survival rate. Responsible handling (and avoidance of traumatic handling practice) of rays after capture significantly reduces rates of post-release mortality (Carlson et al., 2019).

In the case of purse seine operations, it is recommended, if possible, to release elasmobranchs from the purse seine net at sea, rather than after being brought on-board (Hutchinson et al., 2019). Shark mortality can fall to 0% if the shark is fished within the net and released, while mortality rates if the shark is first on deck are far higher (Hutchinson et al., 2019). Fishing sharks from the net with handlines and baited hooks is a promising technique.*

If brought on deck, **medium or large elasmobranchs** should be transferred directly from the brailer to sea; to a purpose-built large-mesh cargo net or canvas sling, and then to sea; or to a metal ramp that connects to an opening on the top deck railing (Figure 2 of Justel-Rubio et al., 2019)**.

* https://meetings.wcpfc.int/node/11305

** https://meetings.wcpfc.int/node/11305

Box 4: Proper handling and release of sharks and rays

Practices to avoid when handling sharks and rays:

- Do not cut off the tail.
- Do not lift the animal by the gills or the cephalic lobes (the protruding body parts next to the mouth on manta rays).
- Do not lift the animal by its head or tail, as this can severely damage the spinal cord
- Do not throw, hit, yank, push or squeeze the animal. Prevent it from battering itself against the deck or other hard objects.
- Do not insert a gaff, hook, or other pointed object to drag or lift the animal.
- Do not insert hands or objects in gill openings
- Do not rip a hook out of the animal.
- Do not leave the animal in the sun. If possible, handle it in the shade or otherwise reduce exposure to the sun.
- Do not drag the animal on the deck and/or tow it
- Hold stingrays away from the body to avoid lashes and risk with the barbs.

Best practice when handling sharks and rays:

- Attempt to release the animal as soon as possible.
- Drape a cool, wet cloth over the animals head (this can calm an energetic shark)
- Place a seawater hose in its mouth if the shark cannot be released right away (this is likely to improve its chance of survival).
- For crew safety, avoid the animal's jaws (some suggest placing a fish in its mouth to prevent bites), and regardless of the animal's state (live or moribund) be cautious at all times.

When handling small sharks:

- Place One hand on the dorsal (top) fin and the other holding the body from below
- Use both hands to hold the body.
- Place one hand on the pectoral (side) fin and the other holding the tail.
- Release the fish by pointing its head down toward the water and dropping it in.

When handling medium-large sized sharks:

- One or two people should hold the dorsal and pectoral fins, with the other person holding the tail. Release over the side by dropping, not throwing, the animal.

These best practices are compiled directly from the following publications (Carlson et al., 2019; Justel-Rubio et al, 2019; Poisson et al., 2014)

A **Small or medium-sized elasmobranch** can be transported safely on deck by two crew members using a stretcher bed (Figure 2 on Swimmer and Hutchinson, 2019)*; preferably by using a specialized cradle/ stretcher (Justel-Rubio et al., 2019).

- Responsible handling of rays after capture significantly reduces rates of post-release mortality. Proper handling techniques should be observed (see Box 4).
- Stingrays should be held at a safe distance from the body to avoid lashes from contact with the barbs on the tail. Do not cut off the tail (Hutchinson et al., 2017).

The ISSF Longline Skipper's Guidebook provides substantial advice for elasmobranch handling.** Additional graphics for safe handling are also available (Justel-Rubio et al, 2019).

3.2 Increasing the survival rates of birds

Seabirds are particularly vulnerable to damage of their wings, and such damage will substantially impair the animal to forage for prey, making them likely to die. If a bird is caught in fishing gear, it is important to ensure that the bird is grabbed by the bill - never by the wing.

Restrain the bird and hold it securely - Carefully fold the wings and wrap the bird in a towel or blanket, cover the eyes if possible and keep it away from oil on deck. Do not cover nostrils and loosen hold if the bird vomits to avoid suffocation.

Dehooking bycaught birds

If a bird is still caught during hauling despite the use of these preventive measures, slow or stop hauling to release line tension, use a landing net if possible, to lift the bird. If the hook is visible: use pliers/bolt cutters to cut through the hook and pull it . If the hook is swallowed and removable: a second person should find the hook position externally by feeling the neck. If you can get a good grip on the hook, push the tip of the hook though the skin and remove. If hook removal is not possible: cut the line as close to the hook as possible and leave the hook in the bird.

If the bird is exhausted or waterlogged - If possible, place it in a ventilated box or bin in a quiet, dry, shaded place to recover for an hour or two. Otherwise, contain bird in a quiet dry area, away from oil. Release when the bird is dry, alert and able to stand.

Release the bird - If the bird is strong and mostly dry, release it onto the water. Having again first grabbed the bill, lift and slowly lower the bird onto the water letting go of the bill last. Where birds cannot be lowered directly onto water, lift and release the bird from the side of the vessel into the wind letting go of the bill at the same time.

* https://meetings.wcpfc.int/node/11305

** http://www.issfguidebooks.org/downloadable-guides/skippers-guide-longline-english

4 Best practice for reducing indirect risks for endangered species

In addition to direct incidental capture or collision with fishing or aquaculture equipment, seafood production may present indirect threats to endangered species, primarily through interference with important habitats or their ability to feed.

4.1 Prey availability and feeding grounds

A key indirect impact is caused by competition between fishing operators and endangered species for their prey. This competition is accentuated in areas of known importance as feeding grounds. While governments have traditionally regulated the protection of such areas, industry actors and groups have the capacity to take voluntary action that can outpace the sometimes slow pace of regulatory reform.

One such example is found in Voluntary Restricted Zones (VRZs), a voluntary measure established by The Association of Responsible Krill Harvesting Companies (ARK) in Antarctica to protect foraging habitats for krill-dependent penguin colonies during the breeding season. The measure includes 12 out of 13 active vessels in the fishery. The buffer zones around penguin colonies established by the measures cover critical incubation and chick-rearing periods which take place during the Antarctic summer months. Penguins belong to one of the most threatened groups of seabirds and today populations of 11 of the 18 species are decreasing (Ropert-Coudert et al., 2019). There is already evidence that penguin populations in particular are at risk from overexploitation of resources and climate change (Handley et al., 2021). Like many top marine predators, penguins are considered a sentinel or an indicator species as their population trends can provide valuable insights into the overall health of the marine environment (Hazen et al., 2019). Since the establishment of the VRZs in 2018, ARK members have been fully complying with the measure and members provide haul-by-haul data or maps of fishing locations to verify their compliance. The initiative and compliance are reviewed yearly in a joint effort by the industry, scientists and NGOs, and results are published on the ARK website.*

A similar (legislated) example can be found in the North Sea, where mandatory closures of lesser sandeel (*Ammodytes marinus*) fishing areas to protect seabirds showed promise for increasing the breeding success for black-legged kittiwake (*Rissa tridactyla*), a species that has declined in recent decades (Daunt et al., 2008). In addition to the spatial overlap between important fishing and feeding grounds, the overall abundance of important prey species for seabirds (which includes both fish and krill) has been found to be very important for driving the productivity of different seabird populations.

An empirical study determined that maintaining forage fish biomass above 1/3 of the carrying capacity is important for ensuring seabird breeding success (Cury et al., 2011). In this regard, an unequivocal element of ocean stewardship is ensuring that harvest rates of forage fish species do not drive populations below thresholds that may interfere with breeding success, although other research suggests that more precautionary limits are required (Pikitch et al., 2012).

4.2 Healthy and unpolluted habitats

In addition to forming the foundation of multiple ecosystem types, certain habitats play important roles as spawning and nursery grounds (Sheaves, 2017). While some species spawn over large parts of the open ocean, where their larvae are transported by ocean currents, a large proportion of species of cultural, nutritional and economic importance rely on coastal habitats for reproduction and protection in their early life; these include mangrove forests, seagrass meadows and coral reefs. The recently initiated UN Decade of Ecosystem Restoration (2021-2030) aims to realize a global effort to reverse the decline of important ecosystems for biodiversity and human livelihoods.

Seafood operations can result in habitat degradation, including bottom trawling (impacting benthic environments) and aquaculture production (degradation or conversion of coastal habitats). While annual mangrove loss rates have slowed, negative trends have not yet been reversed, and recent remote sensing estimates annual losses still range between 0.2-0.7% (Hamilton and Casey, 2016).

Ensuring that seafood operations (1) do not result in habitat destruction (e.g. mangrove deforestation) and (2) transitioning gear-types from bottom-contact gears (e.g. bottom trawls) to less harmful alternatives would be in line with international efforts to preserve habitats and biodiversity and represent a long-term investment for all actors in the seafood production sector.

* https://www.ark-krill.org/ark-voluntary-measures

5 Using monitoring, control and surveillance (MCS) to demonstrate compliance

Reliable and verifiable MCS of seafood production operations is not only important for ensuring compliance with best practices, but also helps generate actionable information for decision-makers. All of the elements of MCS, as described by an FAO Expert Consultation,* are important for demonstrating the implementation and effectiveness of best practice measures for reducing negative impacts on endangered species. FAO defines these as:

(i) **monitoring** - the continuous requirement for the measurement of fishing effort characteristics and resource yields;

(ii) **control** - the regulatory conditions under which the exploitation of the resource may be conducted; and

(iii) **surveillance** - the degree and types of observations required to maintain compliance with the regulatory controls imposed on fishing activities.

Key MCS approaches include **inspections** of aquaculture operations and wild capture fisheries (e.g. port inspections), use of **independent observers on board**, the use of **electronic monitoring** systems (cameras), consistent and uninterrupted use of automatic identification system (AIS) and/or vessel monitoring system (VMS) transponders, and advancements in **Electronic Automated Reporting** (a.k.a. e-logbooks).

Private and public electronic monitoring coverage standards and ambition have grown in recent years, primarily driven by three principal advantages of these systems: "(a) cost-efficiency, (b) the potential to provide more representative coverage of the fleet than any observer programme and (c) the enhanced registration of fishing activity and location" (van Helmond et al., 2020). These are resulting in improved data about fisheries operations and catch, and have attracted the attention of financial institutions, which are now linking observer coverage and electronic monitoring coverage as key performance indicators for financial packages such as sustainability-linked loans.**

* https://www.fao.org/3/y3427e/y3427e0a.htm

** https://asia.nikkei.com/Business/Finance/Seafood-giant-Thai-Union-secures-400m-in-first-sustainability-loan

6 Critical knowledge gaps and means to address them

Robust bycatch avoidance and mitigation actions rely on the availability of data on specific animal populations, their breeding, feeding and migration habitats, and associated temporal and spatial dynamics. The scientific community does not have sufficient information on all these important aspects, although synthesis of available information can provide some guidance (see e.g., Beal et al., 2021). The seafood industry can play an important role in increasing such knowledge generation, through sharing of information on catch and mortality rates of target and non-target species, the location and times of the year of the fishing operations, as well as basic information on gear configuration and fishing effort. In summary, it is important that fishing operations document interactions that answer the questions – when, where, how, and what species? Improving knowledge exchange between science and industry therefore has the potential to e.g., develop effective "move on rules" (Dunn et al., 2014) and other means to reduce spatial and temporal overlap. One way to increase knowledge generation from seafood production is through increased data collection on fishing vessels. Although several fisheries have very limited observer coverage (Debski et al., 2016; Gilman et al., 2012) and increased observer coverage could be enabled both by human observers and novel technologies.

Civil society groups, consumers, governments and the seafood industry share the interest in reducing or eliminating negative impacts on endangered species, triggering the development of not only the best practices identified in Sections 2 and 4, but also a growing number of novel and emerging policies, technologies and practices. Examples include regulations by governments or RFMOs that stipulate trade bans for sharks and shark products, bans on shark finning, and bans on shark retention. Bans represent important mechanism for reducing negative impacts on sharks and have also been advocated for by individual companies. Although different forms of bans can be effective, they can also have negative side effects and need to be complemented by adequate mitigation measures and handling practice (Tolotti et al., 2015, Booth et al., 2019, Young and Carlson, 2020). There is also a need to identify the most effective approaches and measures and incentives to ensure compliance. Science, industry, policy makers and NGOs can and should therefore work together to create a comprehensive understanding from the perspective of endangered species, ecosystems, deck crews, vessel owners, legislators, and companies on how to best develop effective policies. Whereas government policy making may represent a relatively time-consuming approach, company policies (on e.g., a retention ban) can be developed relatively quickly.

Additional knowledge gaps are related to how novel technologies can be better used to reduce negative impacts on endangered species. A number of studies cited in this document describe how novel and emerging technologies and gear improvements are having a positive impact, and multiple additional technologies are in development. While these have not yet achieved broad-scale uptake in operations, they may be of relevance or useful opportunities for pilot projects for commercial fisheries. Promising examples include:

Novel tuna purse-seine bycatch reduction measures Novel equipment for the safe release of elasmobranchs in purse seine operations is being successfully tested in various purse seine fisheries and include methods such as: deck release ramps, shark velcro to safely lift large sharks from the caudal fin, hoppers with ramps and manta sorting grids.*

Close-Kin Mark Recapture (CKMR) Abundance estimates of target and non-target species in wild-capture fisheries currently are largely dependent on traditional fisheries stock assessments, which are costly and heavily reliant on the quality of the fisheries reporting information. New genomic-based fisheries-independent abundance estimation techniques, such as Close-Kin Mark Recapture (CKMR; Bravington et al., 2016), can complement traditional fisheries stock assessments by providing fisheries-independent abundance estimates. Corporations with a large throughput of wild-caught species are in a unique position to facilitate CKMR sampling.

Observations aggregating behavior under FADs. Echo sounders can be fitted to floating FADs to gain a better understanding of the biomass and species composition below the FAD (Poisson et al., 2021). Since there is evidence that setting on larger fish aggregations can reduce bycatch, having access to instantaneous biomass estimates may allow vessels to avoid setting on FADs with higher bycatch likelihood.

It is our ambition that this document, along with associated actions taken by SeaBOS members to reduce negative impacts on endangered species, will help generate exchange of information, new knowledge, partnerships, and pilot projects, that will help to generate new practices that contribute to reaching the goals set out in the SeaBOS endangered species strategy.

* https://www.iotc.org/documents/developing-solutions-increase-survival-rates-vulnerable-bycatch-species-tuna-purse-seine

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