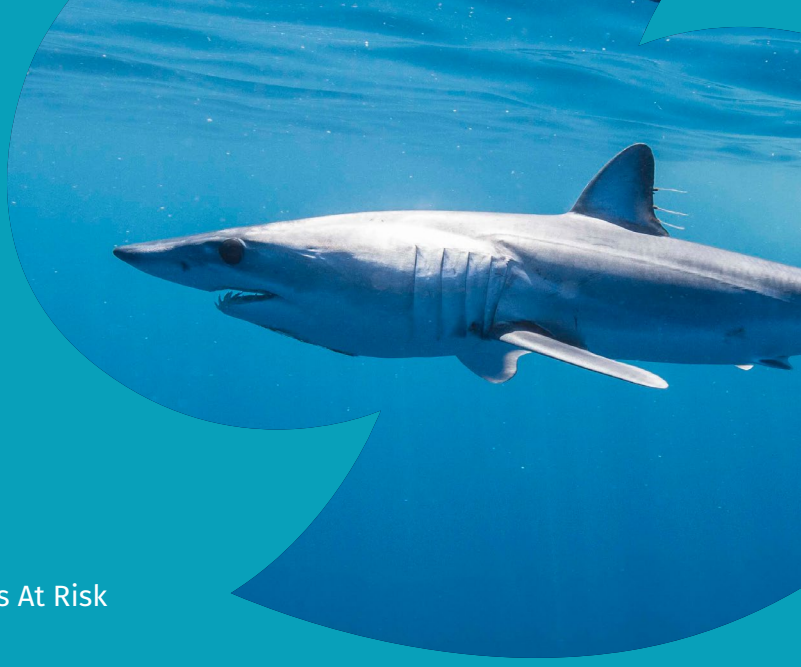
Bycatch guide

Summary and regional dynamics

SEAS AT RISK



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Recommended citation

Seas At Risk (2025). Bycatch guide - Understanding and addressing bycatch of sensitive species in EU fisheries.

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Acknowledgements

Expert interviews informed parts of this study and experts were consulted through two feedback rounds for information accuracy.
The authors would like to thank the following experts :

Bianca Cisternino (Whale and Dolphin Conservation - WDC), Susannah Calderan (Scottish Association for Marine Science & WDC), Camille Richer (BlueSeeds & BlueMove), Russel Leaper (International Fund for Animal Welfare - IFAW), Sarah Dolman (Environmental Investigation Agency), Ida Carlén (Swedish Society for Nature Conservation), Iris Ziegler (Deutsche Stiftung Meeresschutz), Brendan Godley (University of Exeter), Jeffrey Mangel (ProDelphinus)
& Daniel Mitchell (BirdLife International).

The authors would also like to thank the following colleagues and partners for their advice and feedback :

Gonçalo Carvalho and Nicolas Blanc (Sciaena), Cecilia del Castillo Moro (Ecologistas en Acción), Rémi Cossetti & Andrea Ripol (Seas At Risk) as well as John Condon & Ioannis Agapakis (ClientEarth).

SEAS AT RISK BUND SCIAENA ecologistas en acción

Contents

Executive summary

Bycatch, which will here refer in this guide to the incidental catch of marine mammals, seabirds, sea turtles and sharks, is one of the main if not the main threat to all these species groups. Their bycatch in fishing gear can either lead to mortalities or long-term welfare consequences, putting pressure on species or populations that can already be at breaking point. The Baltic proper harbour porpoise is a sad example, with only a few hundred individuals left. Preserving this unique population demands immediate and effective action.

The aim of this guide is to provide a contextual overview of bycatch in its many aspects, providing an accessible baseline to stakeholders and policymakers interested in understanding and addressing bycatch issues. It compiles information from a variety of scientific literature and published reports.

The main takeaway is that there is no silver bullet solution for bycatch. What might work in one setting might be ineffective or worse, detrimental, in another. It is a complex topic with many moving parts, be it the involved fishing métiers, the local marine ecosystem or the dynamic between the target species and the bycatch-sensitive species.

Furthermore, certain mitigation measures can have detrimental side effects, such as widespread pinger use displacing populations out of key habitats. These side effects should be considered and mitigated through synergies with other measures. As such, the most effective solutions to reduce and eventually end/eliminate bycatch are:

- **an overall reduction in fishing effort, with effort actually decreasing overall rather than simply being geographically displaced.**
- **a combination of mitigation measures that are adapted to the local context and that consider bycatch as an issue across all species groups, rather than focusing on one at the detriment of the others.**
- **thorough training in best handling and release practices, maximising the survival of bycaught animals upon release.**

As a main player of fisheries in its own waters and worldwide, the EU has the legal responsibility and the need to drastically reduce or fully eliminate bycatch in all of its fisheries.

Key recommendations

Fully implement the Technical Measures Regulation (TMR - EU/2019/1241) and include sensitive species in its evaluation
The Regulation should be fully implemented as some measures remain unimplemented, such as the mitigation measures for seabirds in Annex XIII. The Commission should also require the STECF to consider sensitive marine species in its evaluations of the TMR implementation, as the last evaluation considering sensitive species dates back to 2020.

Expand protections for elasmobranchs under EU regulations
To meet the 2024 targets set in the Marine Action Plan for reducing fisheries impacts on sharks and rays, the Council and Parliament should include protection measures for all critically endangered and endangered elasmobranch species. This would trigger corresponding obligations for bycatch monitoring and avoidance measures to reduce and remediate mortality in fisheries, regardless of whether they are retained and commercialised or discarded.

Leverage Article 17 of the Common Fisheries Policy (CFP)
Article 17 should be actively applied as a tool to encourage bycatch reduction by preferentially allocating fishing opportunities to operators without bycatch and those who demonstrate effective bycatch mitigation and monitoring practices.

Recommendations on monitoring and mitigation measures

Revise the ICES advice request to support Ecosystem-Based Fisheries Management (EBFM)
ICES advice should include bycatch mitigation strategies being evaluated as part of a set of complementary tools, assessed for their combined effectiveness across species groups and overall ecosystem health.

Improve bycatch monitoring and reporting requirements
The Commission should expand bycatch monitoring and reporting requirements under the Data Collection Framework (DCF) while requiring Member States to report fishing effort using standardized, gear-specific metrics (e.g., number of hooks, net size, soak time, trawl duration etc...).

Combine technical measures with spatio-temporal management measures in key habitats
While technical measures can be appropriate for mitigating bycatch of endangered species, their deployment should be accompanied by further protection of key habitats such as fishing closures. For example, pingers should not be used broadly at the fleet levels without being complemented by the creation of MPAs or closures areas designed for marine mammal protection, in which pinger bans would apply.

Recommendations on funding

Facilitate access to EMFAF funds through bridging capital
Member States and national financial institutions should ensure that fishers awarded EMFAF support have access to the initial capital needed to activate their projects as EMFAF operates on a reimbursement basis.

Secure dedicated funding for bycatch mitigation and just transition in the next EU budget
The EU must ensure that the next Multiannual Financial Framework (MFF) includes strictly ring-fenced funding for marine biodiversity restoration and a fair transition within the fisheries sector, which include funding for effective bycatch mitigation strategies.

Embed socio-economic considerations and conditionality in mitigation funding
All funding for bycatch mitigation should be guided by socio-economic impact assessments and include

conditional financial mechanisms, with priority given to small
structured to incentivise the adoption of sustainable practices

Introduction

Fisheries bycatch refers overall to the catch of species or age and size classes that were not originally targeted by a fishing operation[1–3]. The scope of this best practice guide will be the incidental catch of sensitive species, namely marine mammals, seabirds and sea turtles found in EU waters or in non-EU waters fished by EU fleets. These species are considered "sensitive marine species" and are protected multiple EU regulations (Habitats Directive;92/43/EEC and Birds Directive;2009/147/EC. The bycatch of elasmobranchs (sharks and rays) has a different dynamic, because they are one of the most endangered group of species[5], but have much lower levels of protection compared to the other species groups considered in this report[6].

Bycatch is a major issue for almost all sensitive marine species, but their vulnerability depends on the species group and between species of the same group[3,7]. They however all have some similar characteristics in common that make them especially sensitive to bycatch. They are long lived and produce relatively little offspring, with slow growth and late sexual maturity[8–11]. Bycatch is the main threat to their populations, which are already under stress from climate change, habitat degradation and land-based threats[3,6,7,12,13]. To illustrate, it is estimated 146,000 seabirds are killed annually by bycatch in EU waters[13].

Bycatch monitoring and assessment

All fisheries have different levels of bycatch, but this depends on a variety of factors, including involved fishing métiers, bycatch species, location, season, as well as environmental conditions. As an example, pots can cause mortal entanglements for turtles and larger whales while posing a very limited threat to seabirds. Common dolphins migrate to the Bay of Biscay during the winter, a time of the year that overlaps with the fishing season, explaining the high bycatch peak in pelagic trawlers and gillnets[14]. It is therefore essential to have strong monitoring programs that produce accurate data about where and how bycatch happens. This data is then used a basis to take effective bycatch management measures.

Bycatch can be robustly estimated through multiple methods, such as data collection with on-board observers, Remote Electronic Monitoring (REM)[a] or investigation of stranding records[15–17]. Preliminary assessment of bycatch rates can also be completed through surveys and direct interviews with fishers, so called rapid assessment surveys[18,19]. Other data sources like logbooks or vessel positioning data through AIS/VMS are essential to estimate fishing effort, which in turn is a key component of bycatch estimation[15]. Fishing effort is currently measured with the number of days at sea but there is scientific consensus that in order to have accurate data, each main gear type should have its own fishing effort metric[20,21].

A big caveat of some bycatch estimates is that the reporting requirements for fishing vessels under 15 metres are minimal or non-existent[17,20]. As over 76 % of the fishing fleet in the European Union is made of coastal small-scale vessels below 12 metres, this bycatch reporting and monitoring gap could lead to inaccurate estimation of bycatch mortalities and thereby to inappropriate or ineffective management measures[20,22]. Reporting and monitoring requirements for smaller vessels will change with the enforcement of the newer Control Regulation

a According to 2019 guidelines published by the European Fisheries Control Agency , the REM system is a system that acquires data and video footage using GPS, sensors and CCTV.

(EU/2023/2842) but at the time of writing, there is no clarity about the possible evolution of bycatch monitoring and reporting requirements.

Assessing the impact of bycatch on a population

The bycatch mortality of a population is an important value in itself but its conservation impact can only be assessed by considering the status and dynamics of the impacted population[23]. There are a variety of methods and models for doing this, and certain models might be more appropriate than others depending on the situation, including the species and the chosen area amongst other factors.

One of the simplest and most commonly used reference points for bycatch mortality is the Potential Biological Removal, also known as PBR. In Europe, it is used by scientific advisory bodies and conventions such as ICES and OSPAR, as well as multiple Member States[17,24,25]. PBR is an estimate of the maximum number of individuals that can be removed each year from a population by human activities while meeting specified conservation objectives[26,27]. PBR should not be considered as the number of acceptable deaths, but an absolute red line. Even if the bycatch mortality for a given species in a given fishery is within the PBR, bycatch in other fisheries and other human impacts such as ship collision and sonar strandings can still be major threats to the population.

With these objectives in mind, there are multiple fisheries in which the estimated bycatch mortality reaches or exceeds the PBR. The full report provides a table comparing the bycatch mortalities and the PBR for a certain number of species. For the Baltic proper harbour porpoise, the PBR was estimated at 0.7, meaning there should not be a single human-induced harbour porpoise death.

Measures to avoid and mitigate bycatch

Bycatch mitigation aiming to either completely avoid or at least minimise bycatch can be distinguished in two main categories:

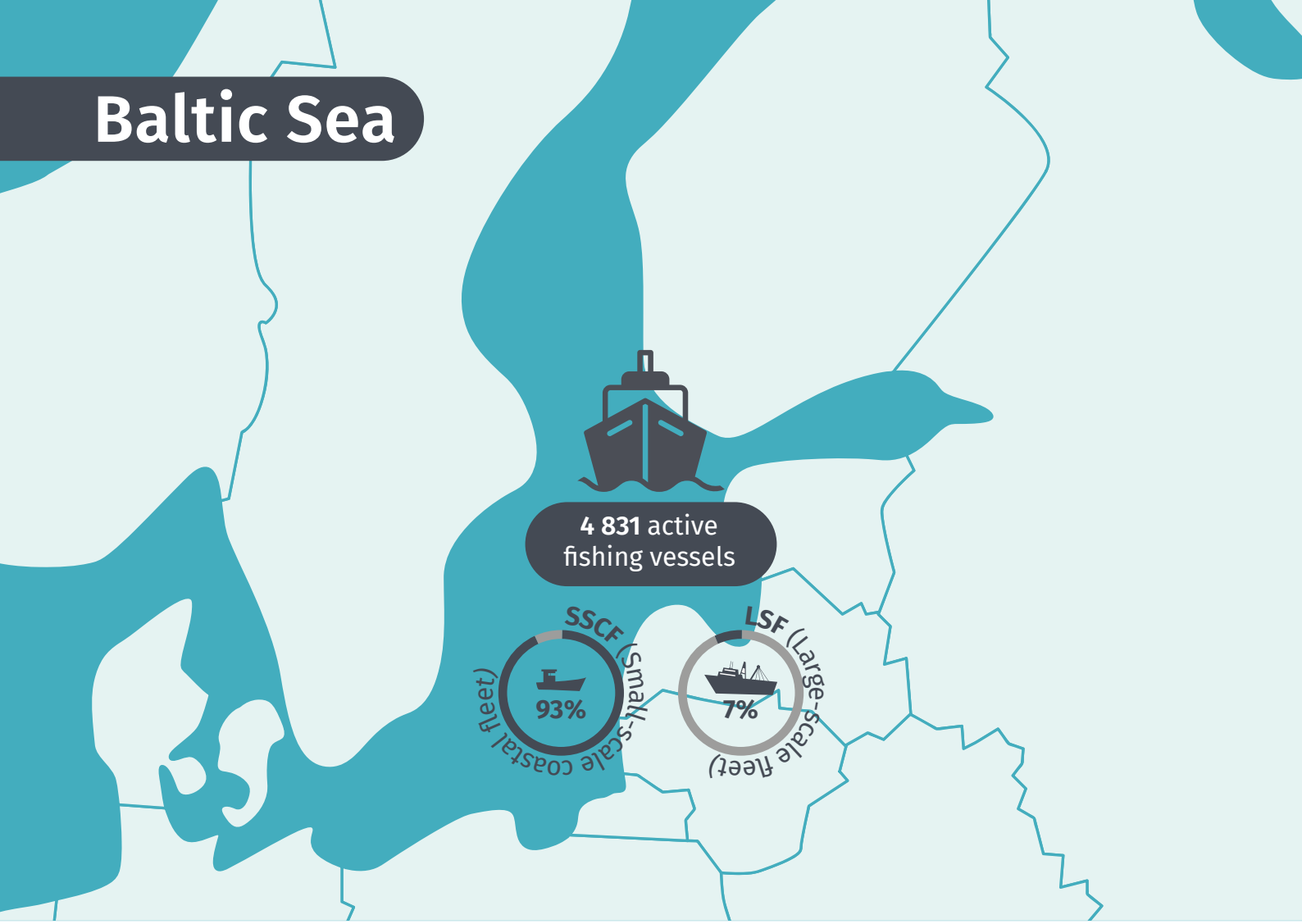
- Technical mitigation measures: They tend to focus on the actual gear itself and how it operates. These can include pingers, setting times, mesh sizes. Changing gear can also be considered a type of technical measure

- Fishing effort measures: They tend to focus on the intensity of the fishing activity and where it is taking place. Measures include fishing closures, reduction of fishing opportunities for vessels with high bycatch or support for diversification to encourage effort reduction.

This guide focuses on the major mitigation measures considered in the bycatch debate, namely acoustic deterrent devices (pingers), fishing closures and use of alternative gears. It focuses on these measures because as useful as they can be, they do come with important sets of considerations that should be fully understood. Additionally, there are two overarching mitigation measures that are not showcased in the overview Table 1 for redundancy as they are always effective:

- Guidelines for good handling and release practices **for all species groups as this minimises on board mortality, addresses animal welfare impacts and can minimise post-release mortality.** Multiple guides have been produced to train fishers and are valuable resources that should be used[28–32].

- Reductions in fishing effort, meaning overall reduction and not just geographical displacement, lead to reductions in bycatch. **Less fishing effort means less bycatch.**



Examples of **Affected Populations**

Baltic proper Harbour Porpoise
Phocoena phocoena

Critically Endangered
IUCN status

Gillnets

Ringed seal
Pusa huspida

Vulnerable
Europe IUCN status

Endangered
Lake Saimaa IUCN status

Gillnets

Common eider
Somateria mollissima

Endangered
European IUCN status

Gillnets

Potential bycatch **mitigation measures**

Marine Mammals:
- Expansion of fixed fishing closures based on ICES advice
- Pinger use only combined with fixed closures in key habitats

Seabirds:
- Limit gillnet to deeper waters, as it reduces mortality
- Visual repellent measures are an option but very case dependent

1. Case study: The Baltic Sea

4831 active fishing vessels of which[22]:

- 93 % small-scale coastal fleet (SSCF)
  - Gillnets for flatfish and herring
  - Fixed coastal traps for salmonids
- 7% large-scale fleet (LSF)
  - Pelagic trawlers for herring and sprat

Although multiple fleet segments are present in the Baltic Sea, the majority métier is the gillnet, which has the most bycatch impact at the sea basin level[38].

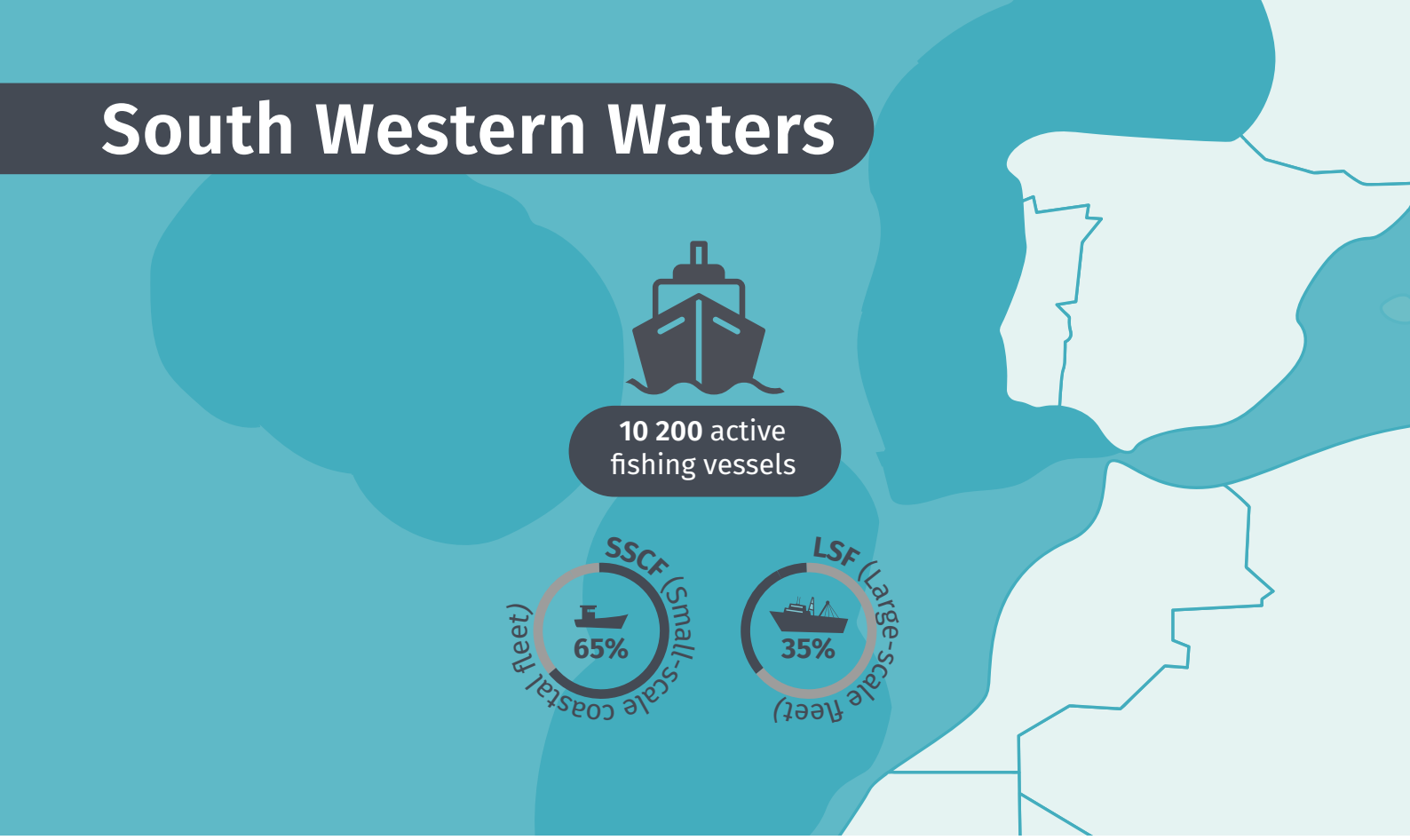
Existing bycatch mitigation measures legally required under EU law:

- General: Driftnets are currently banned in the Baltic Sea per article 9.3 of the Technical Measures Regulations (EU/2019/1241)
- Marine mammals: Gillnets are not allowed to operate in specific areas of the Baltic Sea without pingers, as required under the Annex XIII of the TMR[40]. This requirement is however incompatible with military objectives and is not currently enforced. There are also active fishing closures for bottom static nets as laid out in the delegated act on preserving the Baltic harbour porpoise (EU/2022/303).
- Seabirds: There is a conditional mitigation measures under Annex XIII of the TMR but it has no clear trigger and is therefore not implemented.

Potential bycatch mitigation measures:

- Marine mammals: Fixed closures urgently need to be expanded based on existing ICES advice[41] as the bycatch should approach 0 to save the population from extinction. As pingers are incompatible with military objectives in the Baltic, mitigation measures for gillnets should be focused on fixed fishing closures[42]. Dynamic fishing closures should not be used for the Baltic harbour porpoise, as it is a critically endangered population and porpoises are naturally shy, making them very hard to spot. In effect, dynamic fishing closures would very rarely come into effect, negating their bycatch mitigation effects[42].
- Seabirds: Usual bird scaring and visual deterrent measures have not been found to be consistently effective in reducing seabird bycatch in gillnets. One promising measure would be to limit gillnet fishing to deeper waters has been shown to reduce bycatch mortalities[43,44].

South Western Waters



Examples of **Affected Populations**

Iberian Porpoise
Phocoena phocoena

Critically Endangered — Spanish and Portuguese data

Gillnets

Common dolphin
Delphinus delphis

Least concern — European IUCN status

Gillnets and Pelagic Trawls

Leatherback turtle
Dermochelys coriacea

Poor status — OSPAR assessment

Pelagic Longlines

Gulper Shark
Centrophorus granulosus

Critically Endangered — European IUCN status

Bottom Trawls

Shortfin mako
Isurus oxyrinchus

Data Defficient — European IUCN status

Pelagic Longlines

Potential bycatch **mitigation measures**

Marine Mammals:
Enforcement of the bird scaring line requirements in longliners and trawlers

Sea turtles:
Modifying longlines by using wider circle hooks and changing bait from squid to fish

Elasmobranchs:
Wider circle hooks on longlines and exclusion grids for bottom trawlers

Seabirds:
Enforcement of the TMR requirements for bird scaring lines (longlines and trawlers)

2. Case study: South Western Waters

10 200 active fishing vessels of which[22]:

- 65 % small-scale coastal fleet (SSCF)

  - Common octopus traps
  - Mixed demersal gillnet fishery
  - Mixed handline

- 35 % large-scale fleet (LSF)

  - Mixed bottom trawling
  - Pelagic trawling targeting blue whiting or mackerels
  - Purse seine for small pelagics (sardines, pilchard…)
  - Mixed demersal and pelagic longlines

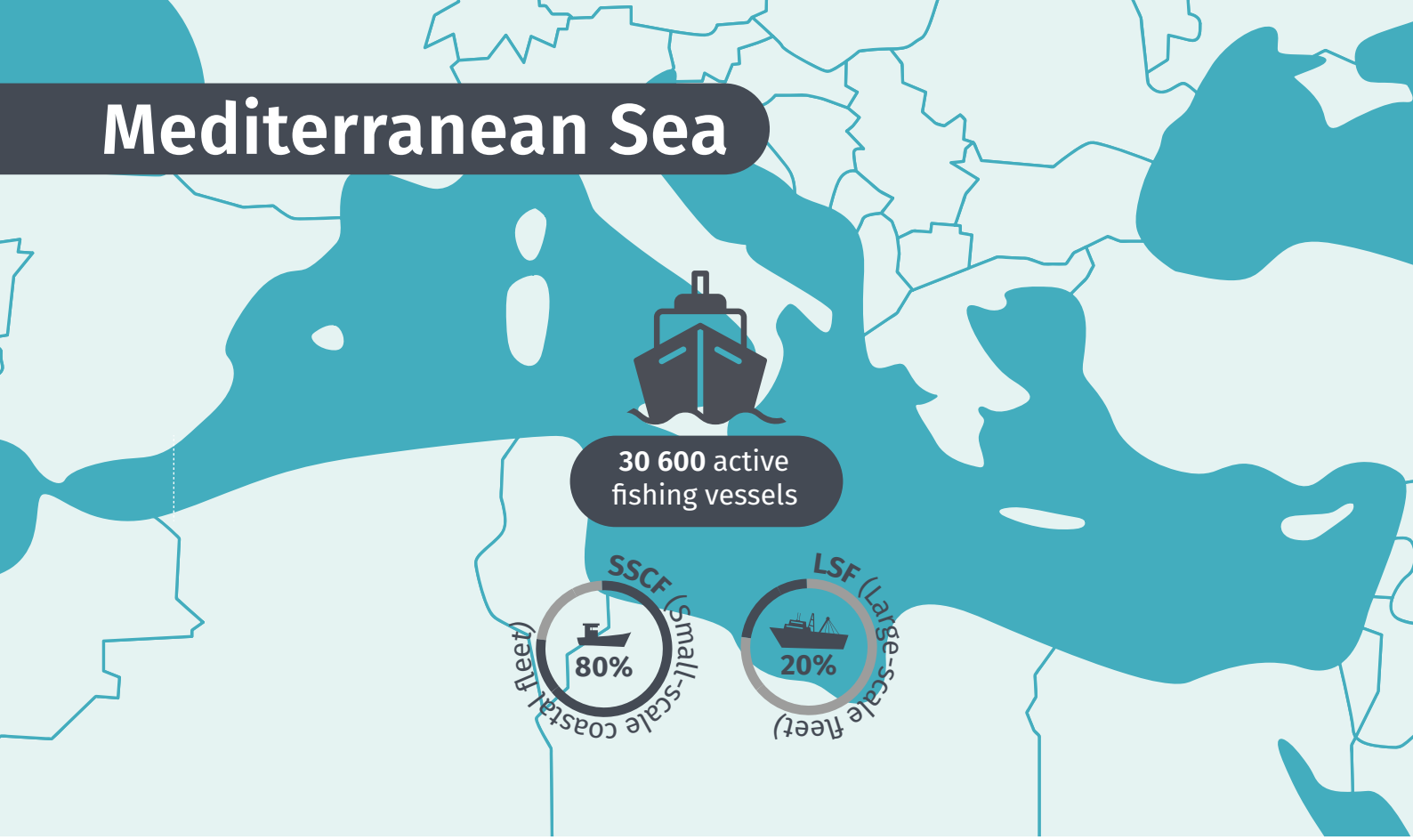
Existing bycatch mitigation measures required under EU law:

- Marine mammals: Temporary fishing closure in the Bay of Biscay from January to February until 2026 to minimise bycatch of common dolphins. No clarity on said closures past 2026.
- Seabirds: There is a conditional mitigation measures under Annex XIII of the TMR but it has no clear trigger and is therefore not implemented
- Sea turtles: None
- Elasmobranchs: Full protection only for species mentioned in Annex I of the TMR

Potential bycatch mitigation measures:

- Marine mammals: Based on evaluation results, possible extension of the fishing closures in the Bay of Biscay. If appropriate and only in areas with high bycatch levels , pingers adapted to harbour porpoises and common dolphins can be used on gillnets and pelagic trawlers, along with implementation of fishing closures to protect key habitats[24]. Pingers are a tool that should be used with great caution and only when strictly necessary when other mitigation measures are not applicable.
- Seabirds: Enforcement of the TMR requirements for bird scaring lines on longlines and trawlers.
- Sea turtles: Modifying longlines by using wider circle hooks and change bait from squid to fish. The importance of more monitoring and data for leatherback turtles[12,48].
- Elasmobranchs: Wider circle hooks on longlines and exclusion grids for bottom trawlers[37].

Mediterranean Sea



Examples of **Affected Populations**

Mediterranean Monk Seal
Monachus monachus

Critically Endangered
Mediterranean IUCN status

Gears (especially with gillnets)

Loggerhead turtle
Caretta caretta

Least concern
Mediterranean IUCN status

Pelagic and Bottom Trawling, Gillnets and Pelagic Longline

Green turtle
Chelonia mydas

Near threatened
Mediterranean IUCN status

Pelagic and Bottom Trawling, Gillnets and Pelagic Longline

Shortfin mako, Blue shark
Isurus oxyrinchus, Prionace glauca

Critically Endangered
Mediterranean IUCN status

Pelagic Longline

Spiny butterfly ray
Gymnura altavela

Critically Endangered
Mediterranean IUCN status

Bottom Trawling

Balearic shearwater
Puffinus mauretanicus

Critically Endangered
Mediterranean IUCN status

Gillnets, Longline and Purse Seine

Potential bycatch **mitigation measures**

Sea turtles:
Turtle excluder grids for bottom trawlers as well as lower setting depth and wider circle hooks for longlines

Elasmobranchs:
Full protection regime for the blue shark, as well as wide circle hooks and monofilament for longlines

Seabirds:
Setting gillnets to deeper waters and bird scaring lines for longliners, trawlers and purse seiners

Marine Mammals:
Seal-appropriate pingers and fishing closures

3. Case study: The Mediterranean

30 006 active fishing vessels of which[22]:

- 80% small-scale coastal fleet (SSCF)

  - Mixed gillnet fishery
  - Line fishery for bluefin tuna
  - Traps for common octopus

- 20% large-scale fleet (LSF)

  - Mixed bottom trawling
  - Purse seiners for European pilchard or anchovy
  - Purse seine for bluefin tuna
  - Pelagic longlines targeting swordfish

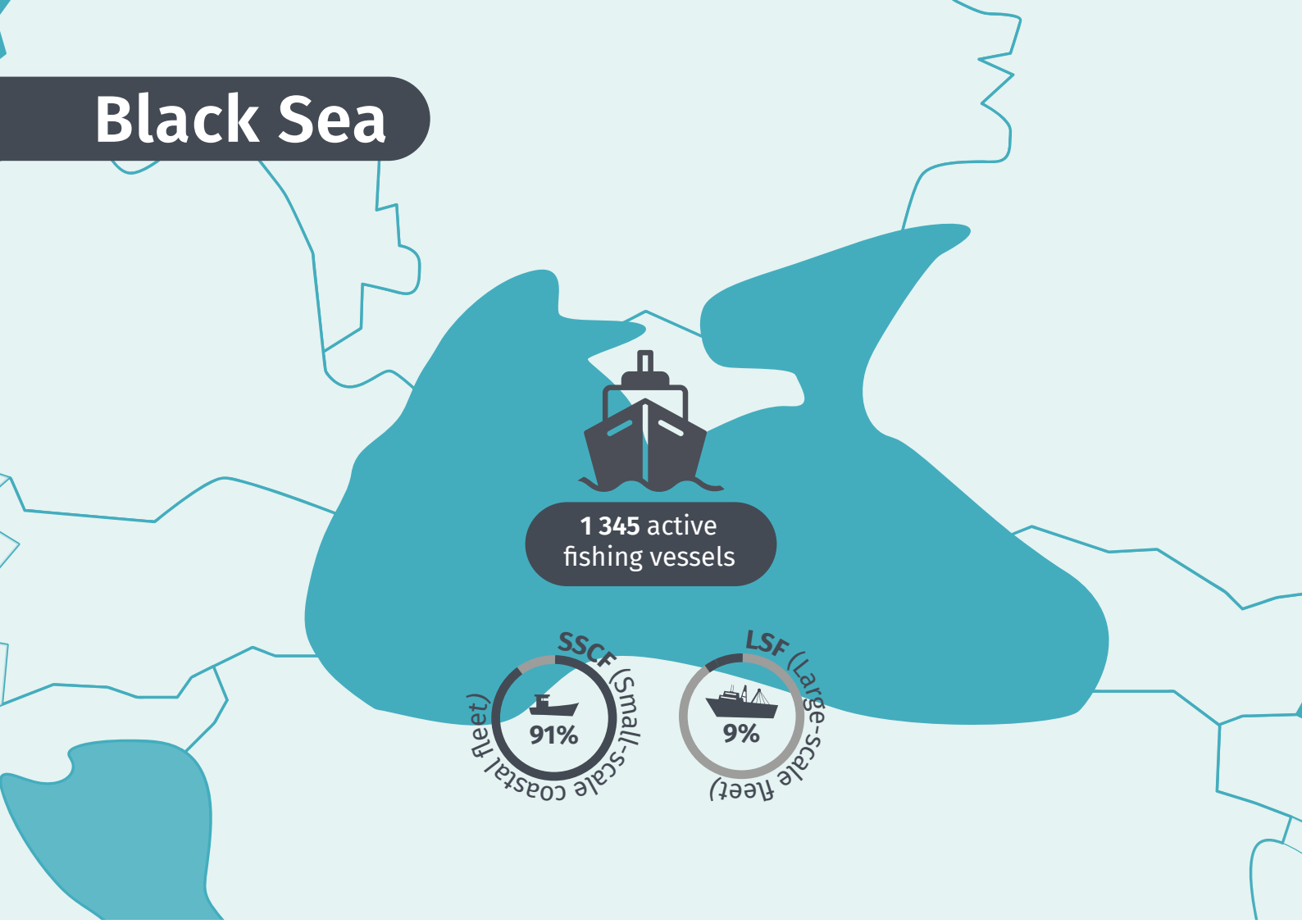
Existing bycatch mitigation measures required under EU law:

- Marine mammals: Mediterranean monk seals have active fisheries closures in multiple countries but they are national measures[37].
- Seabirds: There is a conditional mitigation measures under Annex XIII of the TMR but it has no clear trigger and is therefore not implemented.
- Sea turtles: Under EU/2023/2124, purse seines should not encircle turtles, while longline and bottom gillnet vessels should carry on-board equipment for safe handling, disentanglement and release of turtles.
- Elasmobranchs: Shortfin mako and the spiny butterfly ray are in theory fully protected from fishing activity under EU/2023/2124, as they belong to Annex II of the Barcelona Convention but in practice, no mitigation measures are in place to either avoid or at least minimise mortality. Species listed under Annex III, such as the blue shark, are not protected.

Potential bycatch mitigation measures:

- General: Due to the multi-gear nature of the Mediterranean fisheries, it is a region where trials for alternative gears could be very beneficial, i.e changing gillnets for pots. These gear changes come with considerations regarding shifting fishing effort and conflicts with historical users but can be very efficient at reducing bycatch if executed properly.
- Marine mammals: Seal appropriate pingers and closures.
- Seabirds: Bird scaring lines for longlines and trawlers, while setting gillnets to deeper waters[37,43,44].
- Sea turtles: Turtle excluder grids for bottom trawlers, with a lower setting depth for longlines along with a wider circle hook and a change of bait from squid to fish[37,48,49].
- Elasmobranchs: Inclusion of the blue shark *Prionace glauca* under full protection regime, as its exploitation is currently still authorised. Replacing buoy lines and wire leaders in longlines with monofilament reduces shark mortality to increase survivability through easier self-release[50–52] and mandatory use of large circle hooks to reduce gut hooking and associated mortality[48]. New hookless gear modification called “traplines” in swordfish longlines fisheries are promising for bycatch reduction but need further studies before widespread implementation[53,54].

Black Sea



Examples of **Affected Populations**

Black Sea Harbour Porpoise
Phocoena phocoena ssp. relicta

Endangered — Black Sea IUCN status

Gillnets

Black Sea bottlenose dolphin
Tursiops truncatus ssp. ponticus

Endangered — Black Sea IUCN status

Gillnets

Black Sea common dolphin
Delphinus delphis ssp. ponticus

Vulnerable — Black Sea IUCN status

Gillnets

Spiny/piked dogfish
Squalus acanthias

Endangered — Global and European IUCN status

Target catch for the Bulgarian fleet

Potential bycatch **mitigation measures**

Marine Mammals:
Implementation of appropriate pingers along with fixed fishing closure areas to protect key habitats

Elasmobranchs:
Increasing the protection of piked dogfish and implementing the associated management and conservation measures.

4. Case study: The Black Sea

1345 active fishing vessels of which[22]:

- 91 % small-scale coastal fleet (SSCF)

  - Turbot gillnetters
  - Divers for rapa whelk

- 9 % large-scale fleet (LSF)

  - Purse seiners and pelagic trawls for sprat or anchovy
  - Beam trawling for rapa whelk or piked dogfish
  - Gillnets for turbot

Existing bycatch mitigation measures required under EU law:

- Marine mammals: None
- Seabirds: None
- Elasmobranchs: Under the GFCM 2021 44-10 recommendation, there are management measures for the spiny/piked dogfish, which is currently target catch by the Bulgarian fleet. Indeed, there is a broad restriction on fishing effort but the biological reference points and management strategy are still in development. There are no current binding bycatch mitigation measures in bottom trawling.

Potential bycatch mitigation measure:

- General: The Black Sea is extremely data-poor and there is a severe and urgent need for more extensive assessment and monitoring schemes[6].
- Marine mammals: Implementation of appropriate pingers along with fixed fishing closure areas to protect key habitats.
- Seabirds: There are no existing records of seabird bycatch in the Black Sea[6]. This extreme situation does not allow for an assessment, even less for mitigation measures.
- Elasmobranchs: Increasing the protection of piked dogfish and implementing the associated management and conservation measures once they are developed. Piked dogfish should be subject to Total Allowable Catches (TACs), which should follow the precautionary principle and fall below MSY. Once the TAC has been reached, the target fishery should be closed for the year and bycatch mitigation measures should be activated in fisheries that have picked dogfish as bycatch.

North East Atlantic

(excluding SWW)

Examples of **Affected Populations**

Leatherback turtle
Dermochelys coriacea

Poor status

OSPAR assessment

Common skate
Dipturus batis

Critically Endangered

Global IUCN status

Bottom Trawling

Angel shark
Squatina squatina

Critically Endangered

Global IUCN status

Bottom Trawling

Common Murre, Northern Gannet
Uria aalge, Morus Bassanus

Least concern

European IUCN status

Gillnets and Longlines

Northern Fulma
Fulmarus glacialis

Vulnerable

Europe IUCN status

Gillnets and Longlines

Harbour Porpoise
Phocoena phocoena

Gillnets

Potential bycatch **mitigation measures**

Sea turtles:
Using wider circle hooks, replacing squid bait with fish and setting in deeper waters

Elasmobranchs:
Removing tickler chains and adding escape hatches for bottom trawlers

Seabirds:
Bird scaring and weighted lines for longlines, while setting gillnets to deeper waters

Marine Mammals:
Fixed fishing closures in key habitats and selected pinger use on gillnets and pelagic trawlers

5. Case study: North East Atlantic (excluding SWW)

4510 active fishing vessels[22] of which:

- 49% small-scale coastal fleet (SSCF)

  - Pots for European and Norway lobsters, crab or whelk
  - Mixed demersal gillnet fishery

- 51% large-scale fleet (LSF)

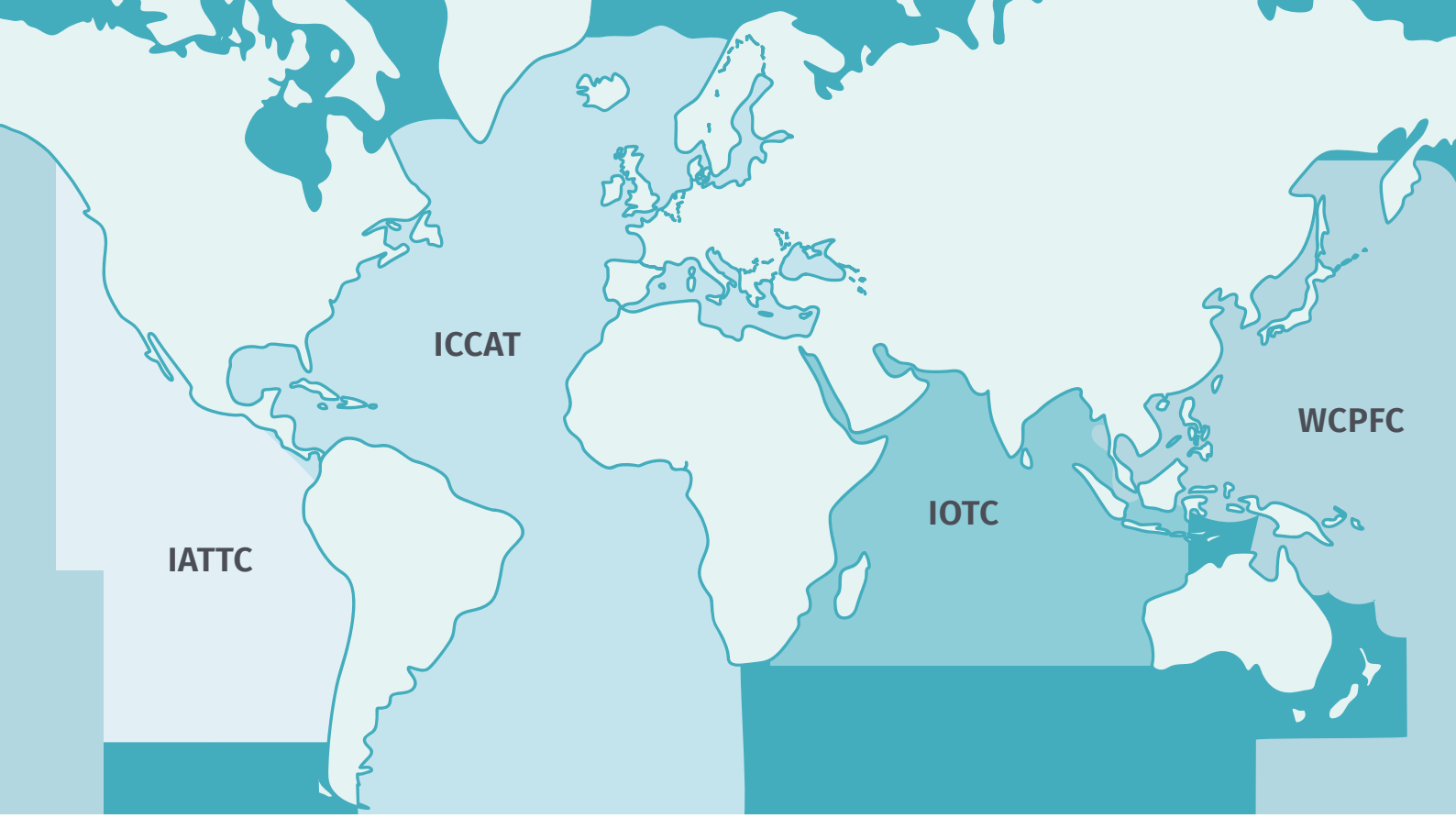
  - Pelagic trawling for mackerel, herring or sand eel
  - Mixed bottom trawling for shrimp, sole, thorny skate or dogfish

Existing bycatch mitigation measures required under EU law:

- Marine mammals: None
- Seabirds: None
- Sea turtles: None
- Elasmobranchs: The common skate and angel shark are in theory fully protected from fishing activity under EU/2023/2124, as they belong to Annex II of the Barcelona Convention but in practice, no mitigation measures are put in place to avoid their catch or reduce mortality; Picked dogfish are subject to a TAC quota and individuals of over 100 cm should be released when caught incidentally

Potential bycatch mitigation measures:

- Marine mammals: Pingers (if applicable for bycatch species) and closures in key habitats
- Seabirds: Bird scaring lines and weighted lines for longlines, while setting gillnets in deeper waters[37,43,44].
- Sea turtles: Using wider circle hooks, replacing squid bait with fish and setting in deeper waters[48,49]
- Elasmobranchs: Removing tickler chains and adding escape hatches for bottom trawlers[37] while banning bottom trawling in VMEs and at seamounts that are known to be important elasmobranch habitats.



Tuna RFMOs and Outermost Regions

Northern royal albatross
Diomedea sanfordi

Endangered
Global IUCN status

Pelagic Longline

White chinnel petrel
Procellaria aequinoctialis

Vulnerable
Global IUCN status

Pelagic Longline

Blue shark, Shortfin mako
Prionace glauca, Isurus oxyrinchus

Appendix II
CITES

Pelagic Longline

Oceanic Whitetip Shark, Whale Shark
Carcharhinus longimanus, Rhincodon typus

Appendix I
CMS

Purse seine

Silky Shark , Mobulid Rays, Hammerhead Shark
Carcharhinus falciformis, Family Mobulidae, Family Sphyrnidae

Appendix II
CITES

Purse seine

Potential bycatch **mitigation measures**

Marine Mammals:
Enforcement of non-entangling FADs and prohibition on encircling a tuna school if marine mammals are present

Sea turtles:
Wider circle hooks and changing squid bait for fish in longlines, while releasing turtles from the purse seine net as early as possible.

Elasmobranchs:
Restriction of dFADs, mandatory release materials and training for purse seiners as well as monofilament wire and wider circle hooks for longliners

6. Case study: Tuna RFMOs and outermost regions

Outermost regions (OMR)[a]

- 2587 active fishing vessels[22]
    - 93% under 12 meters
    - 7% over 12 meters

- EU-flagged vessels fishing in Regional Fisheries Management Organisations (RFMOs):
    - 221 fishing outside of EU waters in the International Convention for the Conservation of Atlantic Tuna (ICCAT) area[22]
    - 35 in the Indian Ocean Tuna Commission (IOTC) area[22]
    - 79 in the Inter-American Tropical Tuna Commission (IATTC) area[b],[57]
    - 28 in the Western and Central Pacific Fisheries Commission (WCPFC) area[58]

Sample of affected populations:

- Marine mammals: Certain dolphin species and larger baleen whale species can get encircled in seine nets as they can overlap with tuna schools. While manoeuvres usually allow the cetaceans to be released alive, this encirclement can cause strong welfare issues, including miscarriages, calf separation and death.
- Seabirds: Albatross and petrels, such as the Northern Royal albatross – Diomedea sanfordi and the white chinned petrel – Procellaria aequinoctalis
    - Global IUCN assessment: Endangered and vulnerable
    - Bycatch is a major issue to these species and occurs mostly in longlines.
- Elasmobranchs: Almost all shark species/families cited in this case study are on the appendix II of the CITES convention, meaning they might become in danger of extinction if their exploitation and trade is not closely controlled[59]. Some of the species listed, such as the oceanic whitetip and the whale shark, are on Appendix I of the Convention of Migratory Species (CMS), meaning they are in danger of extinction[60].
  Elasmobranchs can be either a targeted species and/or a bycatch species depending on the RFMO but they are still treated as "bycatch" in all tuna RFMOs. ICCAT and IOTC have committed to developing managements plans and establishing TAC for blue sharks and shortfin mako.
    - Shortfin mako Isurus oxyrinchus and blue shark Prionace glauca are mainly caught in longlines
    - Oceanic whitetip shark, mantas and devil rays, hammerhead sharks and mostly juvenile silky sharks in purse seines setting on dFADs
    - Rays, silky sharks and hammerheads sharks are caught in driftnets or bottom gillnets

a Fleets from outermost regions are not described in detail due to their heterogeneity but the term includes fleet operating in the EEZ of EU countries, meaning they are subjected to EU regulations and to the CFP. The outermost regions are the following: Portugal (Azores and Madeira), Spain (Canary Islands) and France (French Guinea, Martinique, Guadeloupe, La Réunion and Mayotte). Part of the OMR fleets fish for species covered by ICCAT and IOTC and are therefore subject to their regulations.

b French Polynesia also has a registered fleet of 94 active vessels fishing in the WCPFC area, but French Polynesia is not subjected to EU regulations and to the CFP.

Sample of existing bycatch mitigation measures that are binding in ICCAT and IOTC:

- General

  - ICCAT and IOTC have both developed or are in the process of developing best handling and release practices for bycatch species[61,62].

- Marine mammals:

  - ICCAT has no legally binding recommendation for marine mammal bycatch mitigation[61].
  - IOTC requires their purse seines to not encircle marine mammals and requires drifting Fish aggregating devices (dFADs) to be made with designs and materials to reduce entanglements[63].

- Seabirds:

  - ICCAT requires bird scaring lines on any longline vessels operating in the South Atlantic, unless they set their lines at night[64].
  - IOTC requires longlines vessels in IOTC fisheries to implement two of the following (night setting, bird scaring lines or line weighting) or alternatively, the use of hook-shielding devices[65].

- Sea turtles:

  - ICCAT requires longlines vessels in ICCAT fisheries to implement one of the following (wider circle hook, switching squid bait for fish bait) or other proven effective bycatch mitigation measures while flag states are required to implement fishing closures or mitigation measures required, along with training for safe handling and release[66].
  - IOTC requires vessels operating in IOTC to carry dehooking equipment and do their reasonable best to assist the recovery of sea turtles. Contracting parties are also required to test and trial bycatch mitigation measures, such as wider circle hooks, swapping squid bait for fish[67].

- Elasmobranchs:

  - ICCAT sets catch quotas for blue shark[68,69] and requires the release of bycatch species such as the porbeagle[70] and has an active retention ban for other bycatch species, namely the silky shark[71], the oceanic whitetip shark[72], bigeye thresher shark[73], hammerhead sharks[74], manta and devil rays[75] as well as the whale shark[76]. There is a temporary retention ban on shortfin mako caught in the North Atlantic[77] and a catch quota for dead shortfin mako caught in South Atlantic[78].
  - IOTC is planning to set catch quotas for the blue shark in 2026 and has active retention bans for thresher sharks[79], mantas and devil rays[80], oceanic whitetip sharks[81] and a retention ban for whale sharks coming into effect in 2026[81]. The shortfin mako will be subject to a retention ban for live animals starting in 2026 but there is no limit or quota allocation for dead sharks other than having either an observer or an EMS on board[61].

Potential bycatch mitigation measures :

- Marine mammals:

  - ICCAT suggests through a non-binding resolution that purse seiners should not encircle marine mammals[82], whereas it should be a binding recommendation.

- Sea turtles:

  - IOTC should explicitly require vessels operating in their area of competence to implement bycatch mitigation measures, with the ICCAT requirements being a good example.

- Elasmobranchs

  - ICCAT should reduce the longline TACs for blue shark in the North Atlantic and for shortfin mako in the South Atlantic, continue developing their management strategy and implement bycatch mitigation measures for longlines (banning wire tracers and buoy lines as well, requiring the use of large circle hooks, fishing closures in areas with high bycatch) for. ICCAT should also improve the best handling and release guidelines for elasmobranchs caught in purse seine fisheries, including mandatory material (double conveyer belts, release ramps, manta sorting grids).
  - IOTC should set low quotas for blue shark and shortfin mako in longline fisheries, including a precautionary approach and with the objective of rebuilding the population. Quotas should be complemented by a coherent management strategy, as well as a retention ban on live sharks and bycatch mitigation measures for longlines (similar to those mentioned above for ICCAT). IOTC should also restrict the use of DFADs in its purse seine fisheries as well as require vessels to use appropriate release material (double conveyer belts, release ramps, manta sorting grids

While this section focused on bycatch mitigation measures in ICCAT and IOTC, as they are the RFMOs with the largest EU fleets and highest fishing efforts, the takeaways are easily comparable to the IATTC and the WCPFCv

Table 3: Condensed overview table of fishing gears, associated bycatch risk per species group and mitigation measures

All mitigation measures listed in this table are associated with one or more sources supporting its use, which might be a scientific study, research body advice or government report. **Not one bycatch mitigation measure is a silver bullet and multiple measures should be taken in complementarity to properly address a bycatch issue. Measures should also be taken while considering the local context (fishing métier, sensitive species, local ecosystem etc...), as not all measures are appropriate for every situation.**

The bycatch risk column is colour-coded using the following scale:

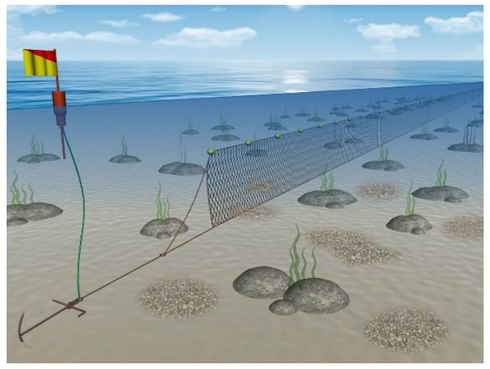
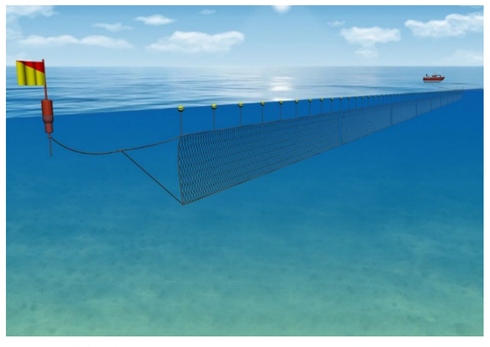
Non-existent to low bycatch risk – No specific actions needed

Low to intermediate bycatch risk – Preventive mitigation measures should be applied to avoid escalation of the issue and protect vulnerable populations

Intermediate to high bycatch risk – Mitigation measures needed to reduce the bycatch risk, which can threaten the long-term viability of populations

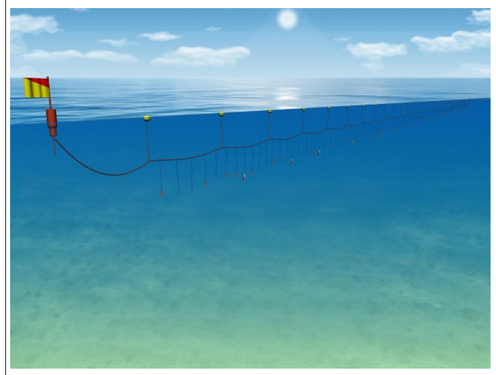
High bycatch risk – Urgent need for a mix of mitigation measures to curb bycatch risk, which can otherwise lead to population collapse if not addressed

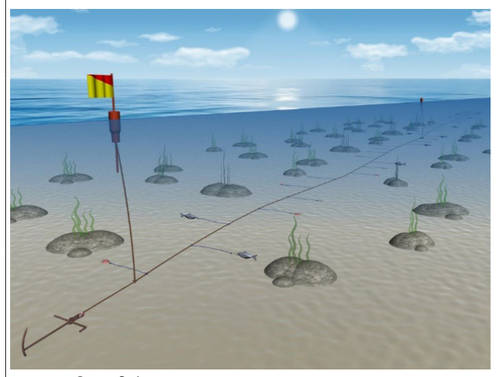
Important consideration for bycatch risk: The bycatch risk scale used in this guide is simplified and is meant to compare the bycatch rates of gears relative to each other, to identify priorities for implementation and funding. This table is not meant to be not read in absolute. **Even gears with low bycatch risk can be problematic for endangered and critically populations in general or to stable populations if fishing effort is very high**.

Gear	Target species, métiers and area of use	Advantages	Disadvantages	Bycatch risk	Examples of successful mitigation measure
Passive gears: The fish and animals get caught in the gears by their own movement					
Entangling nets, which includes gillnets & trammel nets: long net mesh that relies on catch entangling itself in the net, being left to soak for a certain period, before being hoisted up.   Images ©Seafish	Gillnets can either be anchored at the bottom or left drifting at the surface (drift nets[a]) Used commonly in a various number of fisheries. **Métiers examples include:** - Cod bottom gillnets in the Baltic and North Sea - Mixed gillnet fishery in the Mediterranean **Elements to consider when measuring gillnet fishing effort :** - Net length and if available, multiply it by net height to get net surface. Net surface, as well as the number of nets set in a time span (usually a day) give a good estimate of what surface is exposed to species for them to get caught in. - Soaking time : This is a measure of how long a gillnet is left to soak in the water. It tends to be a minimum of 6 hours, lasting up to a few days.	- High fuel efficiency - Relatively cheap for the fishers, easy to replace and store - Low impact on benthic habitats	- Low selectivity in terms of catch - Ropes can break and lead to ghost nets - High levels of marine mammals, seabird, sea turtle and elasmobranch bycatch	**Marine mammals** - Get entangled in the net during swimming due to low echolocation visibility and drown[113–116]	- Pingers[b] generate noise, driving marine mammals from the net[113,114,117–119]” - Closure[c] of areas to gillnets[118,120] - Setting driftnets lower than the surfa[ce121]
				Seabirds - Get entangled and drown[12,122–124]	- Closures[k] of areas to gillnets[123,125,126] - Setting bottom gillnets in areas of deeper waters[123,127]
				Marine turtles[18] - Entangled while swimming and drown[122,128,129]	- Gillnet illumination with LEDs[128–130] - Closures[k] of areas to gillnets[131] - Increasing gillnet tension[61]
				Elasmobranchs[132,133], [d] - Entangled while swimming	- Increasing bottom tension[132] - Gillnet illumination with LEDs[134]

a Driftnets are limited to a length of 2.5 kilometres and under per the Technical Measures Regulation (EU) 2019/1241. The TMR implements a blanket ban on driftnets in the Baltic Sea and for fishing in the species mentioned in Annex I of the TMR, which are tuna-like species, sharks and a few others.
b As touched upon in the dedicated section, pingers do come with an important set of considerations. They are not efficient for every species and if coverage is minimal, pingers might increase bycatch rather than reduce it. Noise pollution is also an important issue and therefore why pingers should be complemented by static closures for gillnets.
c Fishing closures also come with an important set of consideration, which is touched upon in more detail in the dedicated section. If poorly designed, closures can have no reduction on bycatch rates, or worse increase them, if effort is displaced and intensified in other areas.
d Elasmobranchs, meaning sharks and rays, have different dynamics to other sensitive species, which is discussed in the dedicated box in the guide. They can be target bycatch and even when they are true bycatch, existing measures are oriented at reducing mortality. Almost all researched on bycatch mitigation measures for elasmobranchs are related to longlines.

Longlines: Extensive main line, with suspended thinner lines for individual baited hooks, up to thousands of hooks for one set.





Images ©Seafish

Longlines can either be anchored at the bottom to target cod, halibut and flatfish. They can also be left at the surface to target pelagic fish, such as tuna or swordfish. The hooks are usually baited with squid, mackerel or sardines and the leader material connecting hooks to the main line differs depending on target species and fleet.

Métiers examples include:

- Demersal seabass longlines off the coast of Britanny, France
- Tropical tuna longlines in the South East Atlantic
- Pelagic longlines for swordfish in the Mediterranean
- Swordfish and blue shark fisheries in the Atlantic, Pacific and Indian oceans

Appropriate metrics for fishing effort :

- Number of hooks, with one measure of fishing effort being 1000 hooks e.g bycatch rate /1000 hooks. Hooks are exclusive and one hook will in vast majority have only one individual animal caught on it.
- Soak time : While it has not been found to be a major factor for all target catch and bycatch rate, it is a factor for survival rates of bycaught species.

- High fuel efficiency and can be done with very small vessels
- High selectivity for target catches, including size
- No noise pollution

- High levels of bycatch for seabirds, sharks , rays, and turtles
- Depredation and gear damage by seals and marine mammals

Marine mammals

- Seals and baleen whales can get entangled[135]

Toothed whales, including dolphins

- Depredate on the bait or target catch and get hooked[60,135,138]

- Catch protecting gear, which are physical or visual barriers to deter marine mammals from depredating on the target catch[136–140] purse seine, longline, gillnet and pot/trap fisheries.
- Move-on rules and changing fishing area to avoid overlap with pods of marine mammals[135,141]
- Fishing closures[k] which need to consider the high mobility of mammals[135,138]
- Pingers have been found to be inefficient or detrimental in the case of longlines[135,138,142,e;f]

Seabirds

- Get hooked while diving for the bait and drown or suffer internal damage[12,125,143]

- Tori lines or bird scaring lines[124,125,143–145]
- Weighted longlines or line shooters for rapid sinking[124,125,143,144,146]”
- Night setting[124,125,144,147]
- Fully retaining discards and offal and if not possible, discarding during non-fishing operations[147–149]
- Devices that cover the hook until it reaches fishing depth[147,150,151]

Marine turtles

- Get hooked while predating on the bait and drown or suffer internal damage[152,153]

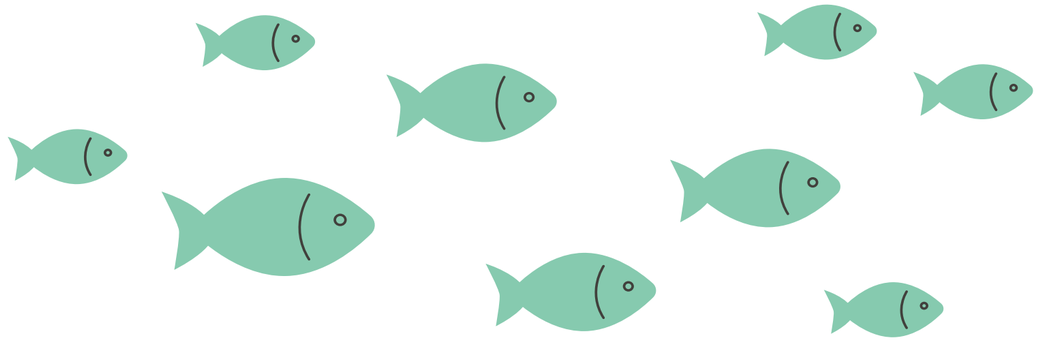
For marine turtles:

- Wider circle hooks reduce the bycatch rate and the rate of internal injury through swallowing[88,152,153]
- Using fish instead of squid for bait[152,153]

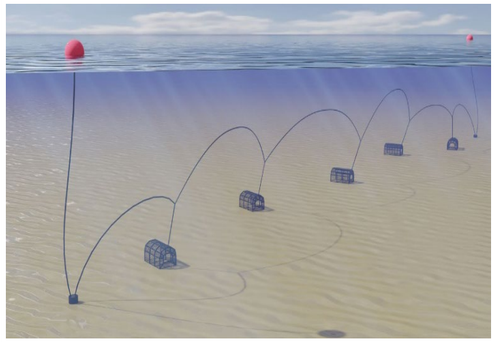
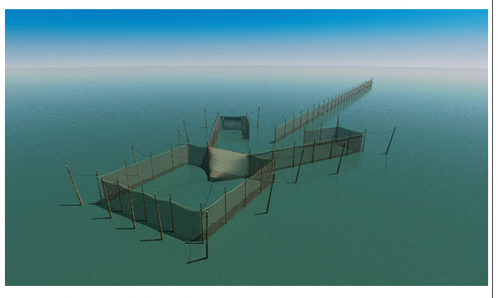
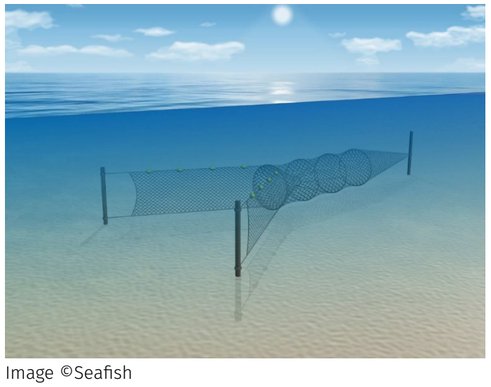
Elasmobranchs[74,154]

- Elasmobranchs have extremely high bycatch rates in longlines and mitigation measures are focused on reducing mortality rather than catch rate

- Banning buoys lines, which are hooks at a shallower depth than the main hook lines[94,95]
- “Banning the use of wire leaders with reinforced hook lines[94,95] and instead requiring the use of monofilament leaders reduce bycatch and increase survival[93]
- Several other gear configurations and setting practices can reduce elasmobranch bycatch and increase chances of survival (set time, set depth, bait, hook type, spacing of hooks, soak time) but effectiveness varies for different elasmobranchs and regions[96–98]



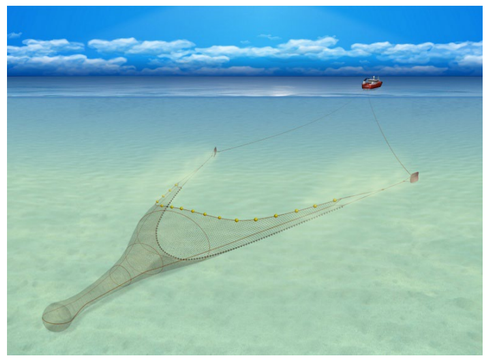
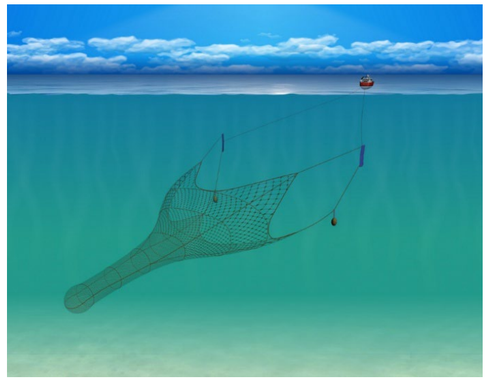
e In the case of pingers for longlines, the noise discomfort to toothed whales is minor compared to the food supply offered by the target catch hanging on the longline. Whales can get habituated to the pinger noise and they may use it to trace it the longlines vessel and depredate even more.

Pots: Box-like container with bait inside to draw in the catch. The entrance mechanism works only one way and leaves the catch trapped in the post. Tens of pots are connected through a groundline, which can span hundreds of meters  Image ©Leaper et al. (2022)	Pots are left to soak on the bottom, usually up to a few days. It is mostly used for invertebrates, including crabs, lobsters and octopus but can also be used for fish species. The bait will change on the target species but can include crab, fish, molluscs, a mix or no bait at all. **Métiers examples include:** - Crustacean (lobster, langoustine, crab) pots in the Irish coast - Octopus pots in the Spanish, Italian and Greek Mediterranean **Appropriate metrics for fishing effort:** - Number of pots : Pots will usually be rigged into fleets of 10 or more pots and multiple fleets will be hauled and shot during one fishing trip. - Soak time : Fleets of pots can be on the seabed for a few hours to a few days.	- High catch quality and size selective - Low impact and fuel efficient - No noise pollution	- Plastic pollution - Not suitable for open sea conditions	**Marine mammals:** - Smaller marine mammals might try and predate inside the pot[60,155]	Marine mammals: - Replacing floating groundline with sinking groundline close to the seafloor[156] - Ropeless mooring, using on-demand flotation system[157,158] - Fishing closures for pots[159] - Devices excluding entrance for marine mammals inside the pot[60]
				Larger marine mammals such as humpback, minke and right whales - Get tangled in the groundline or buoy line[107,159]	
				Seabirds: - Little to no risk of depredation since pots are semi-enclosed and rest on the seafloor.	Seabirds: - Not applicable
				Marine turtles[106] - Entangled in the buoy line[106]	Marine turtles: - Ropeless mooring, using on-demand flotation system[61,106] - Fishing closure for pots[106]
				Elasmobranchs - Low entanglements rates but problematic for vulnerable species. Some species may enter the pot[105,160]	- Ropeless mooring, using on-demand flotation system[106] - Fishing closure for pots[106] - Adding magnetic elements to pots[61,160]
Traps: Stationary structure composed of multiple net chambers, guiding target catch towards a one-way entrance to a chamber that may or may not have bait.  Image ©He et al. (2021)  Image ©Seafish	Traps, such as a pound nets, pontoon traps and fyke nets, rely on the movement of fish through currents and through bait to attract them in the chambers. Due to their stationary nature, traps can only be used in relatively calm and shallow waters. - Fyke net for targeting eels in Swedish coastal waters - Herring pound net in German coastal waters **Appropriate metric for fishing effort :** Volume of trap/net and surface of the net on which species can get entangled : Traps tend to be composed of multiple chambers and sides that species animals can get entangled in. Traps are stationary and soaking time is therefore unlimited.	- Fuel and labour efficient - Low cetacean bycatch outside of harbour porpoises - Bycaught animals can be released alive if they are able to breathe	- Very dependent on fish behaviour, leading to low target species pool - Not suitable for open water conditions - Expensive to set up and maintain	**Marine mammals:** - Other marine mammals do not interact with traps but may get entangled[61]	- Pingers[g,h] generate noise, driving marine mammals from the traps[61,161] - Exclusion device[140]purse seine, longline, gillnet and pot/trap fisheries. Successfully implemented mitigation measures include acoustic deterrent devices (pingers) - Mechanisms that allow surface breathing[162] - Using pontoon traps[163,164] - Modifying trap design[162,163]
				Seals - Follow into the trap to predate on fish[161,162]	
				Seabirds - Seabirds dive to predate on the fish and get stuck[61]	- Escape windows[61] - Increase mesh size on top of the trap[61]
				Marine turtles - Follow into the trap to predate on fish[165]	- Open roof traps to reduce mortality[165] - Exclusion devices[165]
				Elasmobranchs[166,167] - Can swim into the trap	- Adding magnetic elements to traps[166]

f As touched upon in the dedicated section, pingers do come with an important set of considerations. They are not efficient for every species and if coverage is minimal, pingers might increase bycatch rather than reduce it. Noise pollution is also an important issue. This is why pingers should be complemented by static closures for gillnets or replaced by alternative mitigation measures if bycatch risk is intermediary to low.

g If pingers are used to deter seals, they should be used at a higher volume which classifies them as Acoustic Harassment Devices. It is therefore not recommended to use them for pinnipeds, as other efficient mitigation measures are much less harmful.

Active gears: The fish and animals get caught by the movement of the gear

Trawl: Cone-shaped net being dragged behind one or two boats  Image ©Seafish  Images ©Seafish	The trawl can either be targeting species on the seafloor, such as flatfish, cods, shrimp in the case of bottom trawl, with the net being in contact with the seafloor. The pelagic trawl will instead target species in open water, such as mackerel, sardines, herring or whiting. - Shrimp *Nephrops* bottom trawling in the North Sea and Celtic Sea - Pelagic trawling for herring and mackerels in the English Channel - Mixed demersal trawling in the Mediterranean **Appropriate metrics for fishing effort:** - Number of trawls per day and trawl duration : the duration for one trawling operation is dependent on the level of catch but can last 3 – 8 hours. - Net dimensions : Trawls can be vastly different sizes depending on the power and size of the trawling vessel. Pelagic trawls also tend to be much larger than bottom trawls.	- High volumes of fishing - Large range of target species	- Low species and size selectivity - High fuel consumption - Damage to the seafloor in case of bottom trawl	**Larger cetaceans:** - Bycatch bas been known to occur but at low rates compared to other species groups[75,76]. Vessels should also be mindful of collisions[168,169]. **Smaller cetaceans (dolphins, porpoises, pilot whales) and seals:** - Caught during trawling or while they depredate on the catch[83,84,87] **Seabirds:** - Get tangled while depredating during the setting or hauling of the trawl net and drown or get gravely injured[147,178] - Collisions with warp cables and that cause drowning or grave injuries[147,179,180] **Marine turtles:** - Caught during trawling[5,130,175] **Elasmobranchs:** - Caught during trawling[92]	- Exclusion grids complemented by escape hatches adapted to the species' behaviour[61,170–174] - Avoiding sharp turns or using systems that prevent collapse of the trawl entrance due to lower speed[174,175] - Pingers[j],[176] can help in reducing dolphin interactions but this is very case dependant[140,174,176]purse seine, longline, gillnet and pot/trap fisheries. Successfully implemented mitigation measures include acoustic deterrent devices (pingers) - Trawling in deeper waters[177] - Fully retaining discards and offal and if not possible, discarding during non-fishing operations[147,179,181] - Cleaning the net between fishing operations to reduce depredation[147,178] - Bird scaring lines[147,180] - Minimising the surface time of the trawl net during setting and hauling[147,178] - Exclusion grids complemented by escape hatches adapted to the species behaviour[130,175] - Avoiding sharp turns or using systems that prevent collapse of the trawl entrance due to lower speed[174,175] - Removing tickler chains, which hang ahead of the trawl mouth and stir the seafloor[182] - Exclusion grids complemented by escape hatches adapted to the species behaviour[61,92,175]

Purse seine: wall of netting that will encircle the fish and slowly close out the bottom, forming an enclosed purse that can then be hauled onboard.

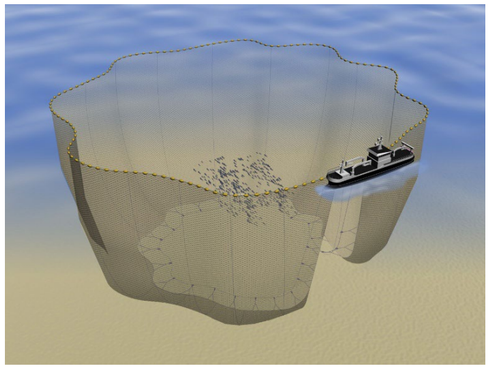


Image ©Seafish

- Purse seiners target exclusively pelagic species, such as tuna, mackerel, herring and others. They can rely on setting on free schools of fish or drifting Fish Aggregating Devices (dFADs), which are small floating wooden or plastic structures with a submerged appendage and a buoy. The submerged appendage can be composed of old netting materials, buoys, ropes and reach up to 50 – 80 meters in depth[95]. dFADs help concentrate fish schools, especially tuna and have therefore become very widespread in tropical tuna fisheries, being the main fishing method used by EU long distance fleet vessels[96].

- The purse seine is in use in a variety of fisheries but is most known for its use in tropical tuna fisheries in non-EU waters.

Example métiers include:

- Yellowfin and skipjack tuna purse seiners in the Indian Ocean, Atlantic, Eastern and Western Central Pacific
- Northeast Atlantic mackerel purse seiners"

Appropriate metrics for fishing effort:

- Number of sets : One set is considered to be the full deployment of a purse seine net. Even sets with no target catch can still cause bycatch
- Net dimensions : Purse seines can range from "smaller" nets of a few hundred meters and depths of 10-20 meters up to larger tuna seines that can be kilometres in length and up to 250 m in depth.
- Number of dFADs deployed per day : dFADs are a massively used tool in tropical tuna fisheries to cause schooling. They are associated with high levels of juvenile bycatch and entangling.

- Extremely high volume of catch
- Little to no damage to the seafloor while floating but massive damage to coral reefs and other VME habitats when dFADs are lost or abandoned, which happens on a regular basis

- Low selectivity in terms of size and target species
- High levels of bycatch, especially juvenile silky sharks, juvenile oceanic whitetip sharks but devil rays

Marine mammals

- Some larger marine mammals can be encircled but with low immediate mortality[183,184]. Welfare issues and post-release survival should be considered.
- Dolphin pods tend to overlap with tuna schools and their presence might be used to trigger a set by purse seiners. They may then get encircled with low immediate mortality but this can cause long term welfare issues, such calf separation and death or miscarriages due to stress[185–187]

- No purse seining when marine mammals are present in the tuna schools[61,187]. But if they are encircled by accident, the "backdown" procedure and Medina panels can help marine mammals safely escape[98,184,187]. Priority should go not to encircling in the first place.
- Pingers generate noise to draw common dolphins away from the purse seine[188]
- Restricting FAD use or optimising FAD design to reduce entanglement[98,184,189]

Seabirds

- Seabirds can get entangled and trapped in the net. Problematic for vulnerable species, notably the Balearic Shearwater[41,187,190,191]

- Avoid setting under whale sharks[61]
- Bird scaring kite[192]
- Using a modified purse seine (MPS)[147]

Marine turtles

- Turtles can get entangled in the FADs. If encircled in the net, they are usually found and released alive[98,184,187]

- Restricting FAD use or optimising FAD design to reduce entanglement[98,187]
- Deploying boats to spot and release entangled turtles[98,184,187]
- Night fishing[98]

Elasmobranchs

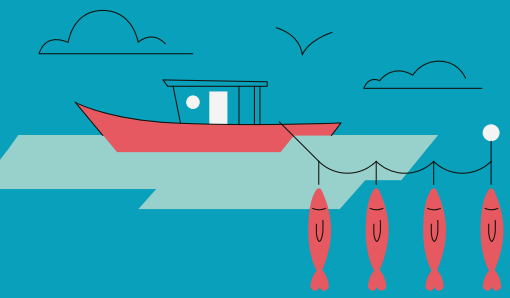
- Sharks, especially juvenile silky sharks and oceanic whitetip sharks, are often present in tuna schools and FAD associated sets[92,98,184]
- Whale sharks might be presents in "free schools" that are not associated with dFADs and might be encircled if they were not spotted.
-

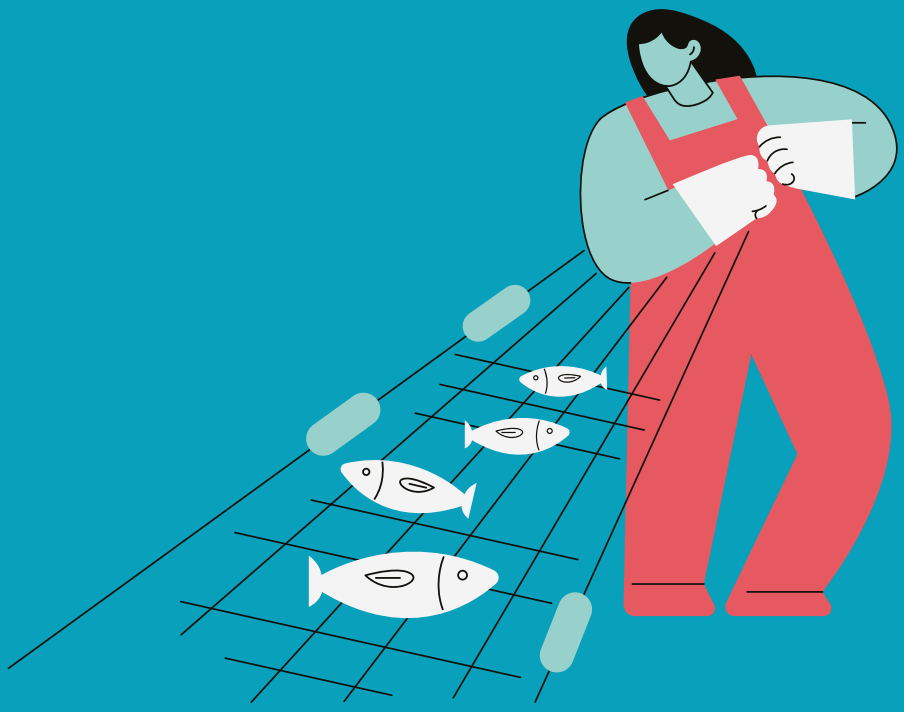
- Banning setting purse seines around tuna school associated with whale sharks[98]
- Restricting FAD use or optimising FAD design to prevent entanglement[92,98,184]
- Releasing before hauling onboard, proper handling technique onboard and optimising release through separate conveyor belts and ramps[193,194]
- Closures of high-density areas, such as nurseries[184]

Conclusion

As a main player of fisheries in its own waters and worldwide, the EU has the responsibility and the potential to drastically reduce or fully eliminate bycatch of sensitive marine species in many of its fisheries. Now is the time to act as many EU bycatch-focused projects have recently started and will be able to provide many useful inputs. As a last reminder of the leitmotiv throughout this document: bycatch monitoring and mitigation is a long and arduous process, as no single solution will work for all species, places and fisheries. It is a matrix of measures that always come with a set of considerations and trade-offs, which must be adapted to the local context. Solutions should include all stakeholders in the spirit of co-management and work mainly through incentives, but enforcement, penalties and monitoring remain essential. Bycatch mitigation and elimination is an essential process, not only to protect sensitive species and populations as a whole, but also to reduce welfare impacts to the maximum extent. The best bycatch is no bycatch at all.

The bibliography can be found in the extended version of the Bycatch Guide, available for download here:





Report design: Iris Maertens
Infographic design: Joana Coelho

Seas At Risk gratefully acknowledges EU funding support. The content of this paper is the sole responsibility of Seas At Risk. It should not be regarded as reflecting the position of the funder.

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Transparency Register: 625261439488-38.
Published in October 2025