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Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries

Methodology for data collection

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By

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Preparation of this document

This document was prepared by the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) and finalized with the inputs from partner organizations, namely the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS), the Specially Protected Areas Regional Activity Center (SPA/RAC) of the United Nations Environment Programme/Mediterranean Action Plan (UN Environment/MAP), the International Union for Conservation of Nature – Centre for Mediterranean Cooperation (IUCN-Med), BirdLife Europe and Central Asia (BL ECA) and the Mediterranean Association to Save the Sea Turtles (MEDASSET). This publication is a part of the joint project "Understanding Mediterranean multi-taxa 'bycatch' of vulnerable species and testing mitigation – a collaborative approach", funded by the MAVA Foundation within the framework of its 2016–2022 strategy and specifically one of its expected outcomes, whereby 'by 2022, the impacts of selected fisheries on priority species and habitats are reduced in three marine geographies'. It contributes to meeting the four objectives outlined therein, namely: 'knowledge on fisheries impacts on biodiversity'; 'awareness of fishers and key stakeholders on the impacts of fisheries on biodiversity'; 'capacity of conservation and other involved stakeholders'; 'identification and demonstration of solutions'. It contributes to the fulfilment of the mandates of the partners involved in the project by providing a harmonized framework to increase knowledge on incidental catches of vulnerable species in the Mediterranean and the Black Sea. This publication is a result of regional commitments by riparian countries and organizations in line with the international agenda and within the context of related regional strategies, which include the mid-term strategy towards the sustainability of Mediterranean and Black Sea fisheries, in particular its Target 4, 'Minimize and mitigate unwanted interactions between fisheries and the marine ecosystems and environment'.

Paolo Carpentieri, GFCM Fishery Resources Monitoring Specialist, was responsible for the development of the methodology, general coordination and compilation of this document. He relied on the contribution of external experts, in particular Beatriz Guijarro, who compiled important baseline information and preliminary analysis, which were instrumental in the initial stages of this work. The document was subject to two rounds of consultations with the project partners, which reviewed and improved its content through the assistance of their respective pools of taxon-specific experts, as reported in the list of contributors. The document also benefited from the assessment and contributions of the national focal points involved in the observer programmes of the project, namely Mourad Ben Amor and Mohamed Nejmeddine Bradai (National Institute of Marine Sciences and Technologies of Tunisia), Sana El Arraf (National Institute of Marine Resources of Morocco), and Meltem Ok (Middle East Technical University of Turkey), who reviewed the methodology and provided valuable comments on the templates for data collection, based on their field experience. It was revised by the IUCN Specialist Species Group and the IUCN Fisheries Expert Group, and then submitted to the GFCM Scientific Advisory Committee on Fisheries (SAC), the GFCM Working Group on the Black Sea (WGBS) and the ACCOBAMS Scientific Committee, which provided their endorsement, together with inputs for its finalization.

The editing, graphics, layout and publishing were coordinated by Dominique Bourdenet (GFCM Scientific Editor), with the assistance of Julia Pierraccini (GFCM Language and Communications Specialist) and Lauriane Palopoli (Editing/Communications Intern). Lynn Ball and Barbara Hall served as language editors, and Chorouk Benkabbour managed the graphic design and layout.

Abstract

Healthy and productive marine ecosystems are important means of supporting maximum sustainable yield and blue growth. However, fisheries and other anthropogenic threats (e.g. pollution, habitat pressure, climate change or the introduction of non-indigenous species) can have potentially negative effects on the marine environment and ecosystems. In this context, the incidental catch of vulnerable species (i.e. elasmobranchs, marine mammals, seabirds, sea turtles and macrobenthic invertebrates), hereafter referred to as 'bycatch', is considered one of the main threats to the profitability and sustainability of fisheries, as well as to wider marine biodiversity and the conservation and welfare of marine species (FAO, 2011). As such, bycatch attracts the attention of most regional fisheries management organizations and other fisheries management bodies. It is included in the Code of Conduct for Responsible Fisheries of FAO, the International Guidelines on Bycatch Management and Reduction of Discards, and associated instruments such as the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) and its SPA/BD Protocol, the International Union for Conservation of Nature (IUCN) Red List of Threatened Species and other international plans of action for vulnerable species such as seabirds and sharks.

Necessary measures should be taken to minimize and mitigate the negative impacts of anthropogenic effects on marine biodiversity, especially in relation to vulnerable species and ecosystems, and their adoption requires deep knowledge of the extent of the problem. Robust data collection is therefore crucial to better understand the prevalence of incidental catch events in fisheries. Efficient reporting and monitoring of the incidental catch of vulnerable species allow scientists and managers to obtain a more complete overview of the situation, and on this basis, to set priority areas for management action.

Worldwide, a significant amount of work is being undertaken to quantify, understand and reduce the incidental capture and mortality of vulnerable species. However, there are still large gaps in knowledge of the actual extent of bycatch in the Mediterranean and the Black Sea. Control and surveillance at landing sites are ineffective in recording bycatch, because animals are generally either released alive (with unknown post-release survival) or discarded dead by fishers at sea despite regulations in place, and programmes for monitoring incidental catch using on-board observers with statistically robust sampling designs are not regularly implemented for all fisheries in these areas (Spedicato, 2016; Ligas, 2018).

Adequate regional monitoring programmes are therefore urgently required to obtain representative data on the incidental catch of vulnerable species during sampled fishing operations. This will allow to: (i) determine fleet segments with the highest impact on populations of vulnerable species; (ii) develop mitigation measures to reduce mortality rates in priority fisheries; and (iii) better understand demographic processes shaping species distribution, abundance and survival probabilities. These programmes are a fundamental step towards developing and implementing appropriate conservation and management measures for the protection of the vulnerable species with resident populations in the Mediterranean and the Black Sea, and the concomitant sustainability of the fisheries sector.

The *Monitoring the incidental catch of vulnerable species in the Mediterranean and Black Sea fisheries: methodology for data collection* aims to support regional monitoring programmes and provide a framework for the development and implementation of an efficient, standardized data collection and monitoring system for all vulnerable species encountered in the Mediterranean and the Black Sea, namely elasmobranchs, marine mammals, seabirds, sea turtles and macrobenthic invertebrates. This will be achieved through on-board observations, questionnaires at landing sites and self-sampling activities. This methodology ensures minimum common standards for the collection of data on these species and allows for replicability and comparisons among fisheries across the region, thus offering a harmonized basis of knowledge, information and evidence for decision-making.

The Med bycatch project

The joint project "Understanding Mediterranean multi-taxa 'bycatch' of vulnerable species and testing mitigation – a collaborative approach" (the Med bycatch project) is a partnership between the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS), the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO), the Specially Protected Areas Regional Activity Center (SPA/RAC) of the United Nations Environment Programme/Mediterranean Action Plan (UN Environment/MAP), the International Union for Conservation of Nature – Centre for Mediterranean Cooperation (IUCN-Med), BirdLife Europe and Central Asia (BL ECA) and the Mediterranean Association to Save the Sea Turtles (MEDASSET). Funded by the MAVA Foundation over a three-year period (2017–2020) and building on complementarities of the partners' respective mandates with a view to promote synergies and join resources and expertise, the project aims to address the gaps in knowledge regarding the bycatch of vulnerable species during fishing operations in the Mediterranean, support the potential testing of mitigation measures and eventually provide elements for the formulation of national/regional strategies to reduce incidental catches and support the sustainability of fisheries.

Project implementation involves field observation programmes (on-board, at landing site and through self-sampling) across different fishing gear (i.e. bottom trawls, gillnets and demersal longlines), together with training, awareness raising, and identification and testing of mitigation techniques. Although it is being implemented in three Mediterranean countries (Morocco, Tunisia and Turkey), it also develops tools and builds knowledge applicable to the entire Mediterranean and Black Sea area. In this context, a harmonized data collection on incidental catches of vulnerable species – elasmobranchs, sea turtles, marine mammals, seabirds and macrobenthic invertebrates – is in line with a standard regional multi-taxa data collection methodology, allowing for replication across different areas, eventually leading to appropriate solutions for the whole region. The main project outputs include:

- a regional review on available information on incidental catches of vulnerable species in the Mediterranean;
- standardized regional protocols for multi-taxa data collection, inclusive of methodological annexes for observations on-board and landing sites, as well as self-sampling and questionnaires;
- training and capacity-building activities, including formation of national teams of on-board observers and of fishers on self-sampling methodologies;
- data analysis on the impacts of fleet segments on the incidental catch of vulnerable species, and the spatial and temporal distribution of incidental catches for the selected fleet segments;
- identification of the typology and a quantitative assessment of current fishing practices pertaining to these fisheries that lead to incidental catch (e.g. fishing area, seasonality, carrying capacity of the vessels, market);
- awareness initiatives on the impact of the incidental catch of vulnerable species; and
- testing of mitigation measures, including implementation and monitoring of possible methods and tools in identified fisheries and countries.

A Project Steering Committee oversees a proper and effectively coordinated project implementation, and a Project Scientific Committee provides technical feedback, advice and coherence. The latter is composed of project partners, national focal points, as well as one international expert per taxa (cetaceans, macrobenthic invertebrates, elasmobranchs, seabirds, sea turtles) and one international expert on fisheries aspects (fishing gear, in particular). At the end of its implementation period, the project purports to identify elements for a regional post-2020 strategy on incidental catch of vulnerable species.

Project partners

Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS)

Established under the auspices of the UNEP Convention on Migratory Species of Wild Animals (UNEP/CMS), ACCOBAMS is a regional cooperation agreement, whose mandate is to achieve and maintain a favourable conservation status for cetaceans in the Mediterranean and the Black Sea, and the contiguous Atlantic area. It entered into force in 2001 and includes 24 Contracting Parties. The Agreement is based on a detailed Conservation Plan, which provides specific provisions related to conservation, research and management measures. In particular, it provides that Parties shall assess and manage human-cetaceans interactions, such as the incidental catches in fisheries, which are one of the main threats to cetaceans, recognized as vulnerable species. The ACCOBAMS Permanent Secretariat, hosted by the Principality of Monaco, provides support to the Parties in the implementation of the ACCOBAMS provisions.

Within the Med bycatch project, ACCOBAMS, through its Task Manager on Interactions with Fisheries, provides advice and guidance on the monitoring and management of cetaceans-fisheries interactions, particularly bycatch. ACCOBAMS is also in charge of facilitating the coordination of the activities in Morocco, specifically to ensure a successful implementation of the national monitoring programme of incidental catches of vulnerable species coordinated by the Institut National de Recherche Halieutique (INRH) in collaboration with Groupe de Recherche pour la Protection des Oiseaux au Maroc (GREPOM).

For this publication, the ACCOBAMS Scientific Committee provided inputs on cetaceans, in particular regarding the data to be collected on bycaught or stranded cetaceans. This document was endorsed by the ACCOBAMS Scientific Committee and will be presented to the ACCOBAMS Parties, highlighting the strong collaboration established with the GFCM to regionally address cetacean bycatch in the Mediterranean and the Black Sea.

General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO)

The GFCM is a regional fisheries management organization (RFMO) established under FAO provisions and composed of 24 contracting parties and five cooperating non-contracting parties. Its mandate is to ensure the conservation and the sustainable use of marine living resources, at the biological, social, economic and environmental level, as well as the sustainable development of aquaculture in the Mediterranean and in the Black Sea. In support of FAO objectives, the key function of the GFCM is to adopt binding recommendations and ensure that riparian states meet their national, regional and international commitments on sustainable fisheries and aquaculture development, towards a level-playing field. GFCM policy and activities are implemented through its Secretariat, including in collaboration with multiple partner organizations.

Within the Med bycatch project, the GFCM is responsible for developing the methodology for data collection, recruiting and overseeing the work of the national focal points in the focus countries (ultimately responsible for project implementation at the national level), compiling the regional review on incidental catches of vulnerable species, developing the database hosting the data collected throughout the project, and contributing to data analysis and the post-2020 strategy.

The GFCM Secretariat compiled the baseline information for this document and developed the underlying methodology and the methodological annexes for data collection and reporting. It also oversaw the coordination with project partners to include their knowledge, experience and contributions to the final product, and ensured the alignment with relevant practices and existing instruments at the regional level. The document was endorsed by the GFCM Scientific Advisory Committee on Fisheries (SAC) in June 2018 as a contribution to the mid-term strategy objective on reducing bycatch rates.

Specially Protected Areas Regional Activity Center (SPA/RAC) of the United Nations Environment Programme/Mediterranean Action Plan (UN Environment/MAP)

The SPA/RAC was established in Tunis in 1985 following a decision of the Contracting Parties to the Barcelona Convention. As one of the seven components of the Mediterranean Action Plan, its mission consists in supporting the Contracting Parties in the implementation of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol) of the Barcelona Convention. SPA/RAC works in close collaboration with governmental and non-governmental organizations at both the national and regional levels. The centre contributes to the conservation and sustainable management of threatened species, ecosystems and areas of particular natural and cultural value in the Mediterranean and to the mitigation of impacts of human activities (including fisheries) in the Mediterranean Sea.

The SPA/RAC participates in a range of activities within the project (i.e. the observer programme, the data collection protocol, training sessions, workshops, communication and advocacy activities, coordination at the regional/national level). In Tunisia, the centre is ensuring the smooth running and implementation of the observer programme and the data collection, in coordination with the national partners in Tunisia, i.e. Association Les Amis des Oiseaux (AAO)/BirdLife Tunisia, National Institute of Marine Sciences and Technology (INSTM) and the National Department of Fisheries and Aquaculture (DGPA) and the Ministry of Local Affairs and Environment. The SPA/RAC also ensures that relevant experts analyse the bycatch data and support the identification of mitigation measures. Finally, together with project partners, it contributes to the dissemination of the relevant data collected through the project.

SPA/RAC provided its contribution to this document by reviewing the developed methodologies and the relevant data to be collected (on-board and in port), particularly those related to the endangered species. The SPA/RAC review was based on SPA/RAC documents on the monitoring and handling of vulnerable species, prepared within the implementation of the Regional Action Plans for the conservation of marine turtles, cetaceans, monk seal, marine and coastal birds, cartilaginous fishes and coralligenous and other calcareous bio-concretions in the Mediterranean.

International Union for Conservation of Nature – Centre for Mediterranean Cooperation (IUCN-Med)

IUCN is a membership union composed of both government and civil society organizations. It harnesses the experience, resources and reach of its more than 1 300 member organizations and the input of more than 10 000 experts. IUCN is the global authority on the status of the natural world and the measures needed to safeguard it. The IUCN-Med opened in Malaga, Spain in October 2001 with the core support of the Spanish Ministry of Environment, the Regional Government of Andalucía and the Spanish Agency for International Cooperation and Development (AECID). The Centre's mission is to influence, encourage and assist Mediterranean societies in sustainably conserving and using the natural resources of the region, work with IUCN members and cooperate with all other agencies that share the objectives of IUCN.

IUCN-Med participates in the project with the aim to minimize the negative impacts of fishing practices on marine biodiversity. It complements the activities of the other partners by assisting capacity-building programmes and by covering the strategic elements regarding elasmobranchs as well as sponges and coral taxa, with the support of the IUCN Specialist Species Group, the IUCN Fisheries Expert Group and additional Mediterranean experts. IUCN-Med is also in charge of developing a handbook on the identification of Mediterranean vulnerable species for use by fishing fleets and observers during on-board monitoring programmes. It participates and leads communication and policy activities as well as investigates the potential for minimizing bycatch through its experts groups and Commission members, and through the collaboration of partners and stakeholders.

IUCN-Med provided inputs to this publication in the form of a review of methodologies for monitoring and assessing fishing bycatch across taxa, including particular suggestions and recommendations for assessing vulnerable elasmobranchs and macrobenthic species made in coordination with the IUCN Specialist Species Group and IUCN Fisheries Expert Group and additional Mediterranean experts. Further contributions were made together with all partners in the subsequent reviews of this document.

BirdLife Europe and Central Asia (BL ECA)

BL ECA is a partnership of 48 national conservation organisations that strives to conserve birds, their habitats and biodiversity, working with people towards sustainability in the use of natural resources. It is one of the six regional secretariats that compose BirdLife International, a global partnership of 121 NGOs worldwide – and growing – widely recognised as the world leader in bird conservation. Rigorous science informed by practical feedback from projects on the ground in important sites and habitats enables BL ECA to implement successful conservation programmes for birds and all nature. BL ECA actions are providing both practical and sustainable solutions significantly benefiting nature and people. Driven by the belief that local people – working for nature in their own places but connected nationally and internationally through our global Partnership, are the key to sustaining all life on this planet – this unique local-to-global approach delivers high impact and long-term conservation for the benefit of nature and people.

As the lead organization for the Med bycatch project, BL ECA is in charge of the overall coordination of the project partners and the delivery of the project activities. Its specific responsibilities include organizing the Steering and Scientific Committee meetings, running training workshops for observers on the collection and recording of bycatch data, live release strategies and species identification, as well as developing the project communication and advocacy strategy, and coordinating its implementation.

BL ECA contributed to this publication by supporting the compilation of baseline information, providing inputs on the methodology — focusing in particular on seabird-related knowledge and fishing gear — and providing recommendations on the structure of the methodological annexes for data collection and reporting.

Mediterranean Association to Save the Sea Turtles (MEDASSET)

MEDASSET is an international non-governmental organization (NGO) registered as a non-profit organization in Greece. It plays an active role in the study and conservation of sea turtles and their habitats throughout the Mediterranean by conducting scientific research, providing environmental education, lobbying relevant decision-makers and raising public awareness. The organization is a partner to UN Environment/MAP and, since 1988, has been a permanent observer-member to the Bern Convention, Council of Europe.

MEDASSET's role within the Med bycatch project is to coordinate activities related to sea turtles. In particular, MEDASSET provides insights on sea turtle bycatch and conservation status, and coordinates national partners in Turkey for the programme on-board observations, port surveys and mitigation trials. MEDASSET also actively participates in the training sessions of observers and fishers, and directly supports advocacy and communications activities.

Contributions for this document were provided by MEDASSET in the form of a review of methodologies pertaining to the monitoring of sea turtle bycatch across the Mediterranean. Recommendations were proposed for on-board observations, fishers' questionnaires and self-sampling methods, in addition to essential data to collect. Further contributions were made together with all partners in the subsequent reviews of this document.

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Abbreviations and acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area
CITES	Convention on International Trade in Endangered Species of Fauna and Flora
DCRF	Data Collection Reference Framework (GFCM)
FAO	Food and Agriculture Organization of the United Nations
GFCM	General Fisheries Commission for the Mediterranean
GPS	Global Positioning System
GSA	Geographical subarea (GFCM)
ICCAT	International Commission for the Conservation of Atlantic Tunas
IUCN	International Union for Conservation of Nature
IUCN-MED	IUCN Centre for Mediterranean Cooperation
MAP	Mediterranean Action Plan
MEDASSET	Mediterranean Association to Save the Sea Turtles
REM	Remote Electronic Monitoring
SPA/BD	Specially Protected Areas and Biodiversity
SPA/RAC	Specially Protected Areas Regional Activity Center
UN Environment	United Nations Environment Programme
UN Environment/MAP	UN Environment/Mediterranean Action Plan
VME	vulnerable marine ecosystem
VMS	vessel monitoring system

Definitions

For the purpose of this document, the following definitions have been used (adapted from GFCM, 2018a):

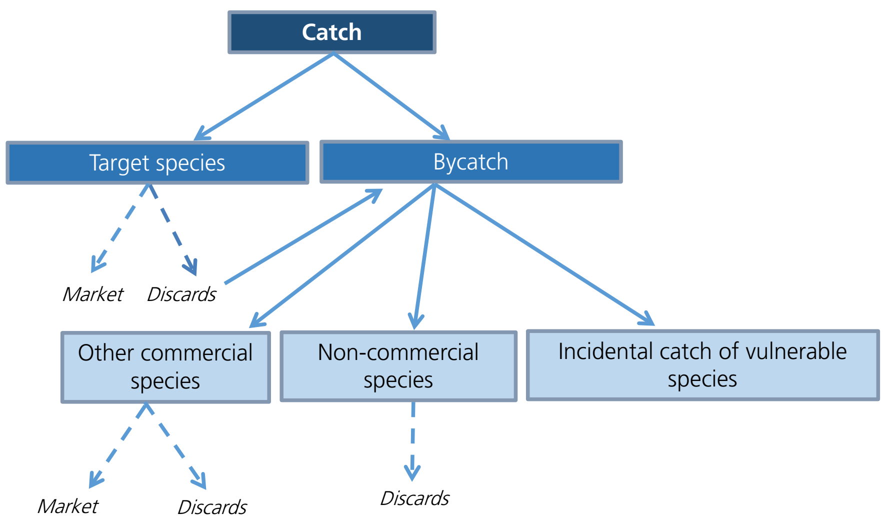
Active vessel:	In terms of its operational status, a vessel is considered active when it executes at least one fishing operation during the reference year in the GFCM area of application.
Bycatch:	The part of the catch that is unintentionally captured during a fishing operation in addition to the target species. It may refer to the catch of other commercial species that are landed, commercial species that cannot be landed (e.g. undersized, damaged individuals), non-commercial species as well as to the incidental catch of endangered, vulnerable or rare species (e.g. sea turtles, sharks, marine mammals).
Catch:	The amount of marine biological resources that are caught by the fishing gear and reach the deck of the fishing vessel. This includes individuals of the target species, which are usually kept on board and retained, as well as bycatch, which refers to species with or without commercial value that are not targeted by the fishery.
Discards:	The part of the catch that is not retained on board and is returned at sea, dead or alive. It may include target species or any other species (both commercial and non-commercial) discarded at sea.
Fishing operation:	Any single action carried out during a fishing trip, whether or not a catch was made; this includes, inter alia, towing a trawl net, setting a line and hauling pots and traps.
Fleet segment:	The combination of a group of fishing vessels of the same size category and using the same gear type for more than 50 percent of the time at sea during a year.
Fishing trip:	In the simplest cases, a fishing vessel leaves the port, steams to the fishing grounds, fishes for a certain time and returns to the port where its catch is landed. The combination of these events is called a ‘fishing trip’ (Sparre, 2000). Generally, in the Mediterranean and the Black Sea, a 24-hour period (i.e. a fishing day), irrespective of the calendar day, is often used as a time unit. During a fishing trip, a fishing vessel may carry out different fishing operations.
Fishing vessel:	Any vessel used or intended to be used for the commercial exploitation of marine living resources.
Landing:	The part of the catch that is retained on board and brought ashore.
Non-indigenous species:	Any species introduced – either intentionally or unintentionally – outside its natural past or present distribution. These species are also known as exotic or alien species. Their establishment can modify ecosystems, biodiversity and fishing behaviour, and can have (negative and/or positive) social and economic impacts.
Vulnerable species:	A taxon is considered vulnerable when facing a high risk of extinction in the wild in the medium-term future. For the purpose of this document, the lists of seabirds, sea turtles, marine mammals and shark species included in Appendix II (endangered or threatened species) and Appendix III (species whose exploitation is regulated) of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (the Barcelona Convention), together with elasmobranch species included in the IUCN Red List of Threatened Species, and benthic species pertaining to vulnerable marine ecosystems (VMEs) have been used.

1. INTRODUCTION

The effects of fisheries on the environment have been abundantly described and reviewed (Garcia *et al*., 2003). Fisheries impact not only target resources (e.g. fish, crustaceans and cephalopods), but many other species relevant to the functioning of the overall ecosystem (Jackson, Kirby and Berger, 2001; Kelleher, 2005), both directly (e.g. discards, vulnerable species, benthic species, etc.) and indirectly (e.g. species occupying higher trophic levels that rely on the target catch). The term 'bycatch' is widely used to refer to that part of the catch unintentionally captured during a fishing operation, in addition to target species, and consisting both of *other commercial species* (which may be secondary targets or may become target species if the market develops), *non-commercial species* (returned to the sea or landed, in the case of a discard ban[1]) and *incidental catches of vulnerable species* (which may include species of commercial value or not, formally declared as 'vulnerable' or 'species at risk' because of their intrinsic properties or severe overfishing). For the purpose of this document, the term 'bycatch' (Figure 1) will be used to refer to incidental catch of endangered, vulnerable or rare species (i.e. seabird, sea turtle, seal, marine mammal, shark and ray species) (GFCM, 2018a), together with species in vulnerable marine ecosystems (VMEs) (GFCM, 2017).

Commercial fishing operations are one of the main causes of human-related injury and mortality for vulnerable species (e.g. some of those species can be hauled up with the catch and then discarded overboard). Some fishing methods (e.g. trawlers) can affect the marine environments where they are employed damaging biogenic structures (e.g. on biogenic structures such as seagrass beds, kelp and other algal beds, sponge reefs, etc.). Most biogenic species considered vulnerable are usually not considered

FIGURE 1
Scheme representing diverse components of the catch as defined by the Data Collection Reference Framework



Source: GFCM, 2018a.

[1] https://ec.europa.eu/fisheries/cfp/fishing_rules/discards_en

bycatch in conventional fishery manuals, and their catch is not regularly monitored (with the exception of some VME indicator species).

Incidental catch of vulnerable species has become a central concern of fishing industries, resource managers, conservation organizations and scientists (Lewison *et al.,* 2004; Soykan *et al*., 2008), representing an important threat to those populations.

Both in the Mediterranean and the Black Sea, bycatch mortality is a particular conservation concern for large marine vertebrates (Tudela, 2004; Sacchi, 2008), including sharks (Ferretti *et al*., 2008; Dulvy *et al*., 2014), cetaceans (Bearzi, 2002), sea turtles (Casale, 2011; Luschi and Casale, 2014), seabirds (Genovart *et al*., 2016; Tarzia *et al*., 2017) and monk seals (Karamanlidis *et al*., 2008). The ecological impact of bycatch varies greatly with the species being taken, depending also on the different life-history characteristics of the taxon concerned. The quantity and nature of catches can also vary greatly among fisheries and regions.

The fishing industry realizes the need to further reduce bycatch of vulnerable species. Some limited mitigation measures do exist, such as technical modification of fishing gear so that fewer non-target species are caught or can escape; shorter soak time to reduce mortality rates; increased deployment depth to avoid vulnerable species; 'scare devices' to keep vulnerable species away; time-area closures and financial incentives/disincentives. However, despite these efforts, bycatch of vulnerable species is still a problem. One of the primary limitations is the absence of both quantitative and qualitative data: studies on incidental catch of vulnerable species are absent for many fishing gear and countries of the Mediterranean and the Black Sea. This means that defining clear management targets for most fisheries is problematic.

Thus the main objective of this document is to develop and implement an efficient, standardized data collection and monitoring system for all vulnerable species encountered in Mediterranean and Black Sea fisheries through:

- providing minimum standards for collection of data on vulnerable species; and
- standardizing data to be collected, including forms to allow repeatability and comparisons among fisheries in the region.

2. VULNERABLE SPECIES

2.1 WHAT ARE VULNERABLE SPECIES?

The definition varies, but the most widely accepted classification for the conservation of species is the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN). The IUCN Red List classifies the species in several categories, such as 'near threatened', 'vulnerable', 'endangered' or 'critically endangered'. A species is categorized as 'vulnerable' according to criteria describing diverse characteristics, such as reduction in population size, reduction in geographic range, or probability of extinction in the wild (IUCN, 2017). Thus vulnerability can be caused by habitat loss or direct mortality as a result of human activities.

Vulnerable species

A taxon is categorized as vulnerable by IUCN when the best available evidence indicates that it is likely to be facing a high risk of extinction in the wild in the medium-term future, unless the circumstances that are threatening its survival and reproduction improve.

(IUCN, 2017)

For the purpose of this document, a wider range of taxa have been considered vulnerable species than just those included in this category in the IUCN Red List:

- vulnerable species listed in the General Fisheries Commission for the Mediterranean (GFCM) – Data Collection Reference Framework (DCRF)[1] (GFCM, 2018a), based on those included in Annex II (endangered or threatened species) and Annex III (species whose exploitation is regulated) of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) (Annex 1.a);
- other species considered protected and threatened (especially some sensitive or rare elasmobranch species – Annex 1.b); and
- benthic species that form vulnerable ecosystems (Annex 1.c).

Marine mammals, sea turtles, seabirds, sharks and rays are the four groups of marine fauna that have received particular attention in studies of the impact of fisheries on vulnerable species (FAO, 2016), and that have been included in Annex 1.a of this document. Some elasmobranch species are of concern owing to their extreme rarity (Ferretti *et al.*, 2008; Bradai, Saidi and Enajjar, 2012). Consequently, it is important to record and report information on these species as well (Annex 1.b).

Moreover, for the purpose of this document, a minimum set of data (e.g. presence and abundance) should be collected for the main benthic species composing VMEs, such as sponges and corals (Annex 1.c). Some of these species (e.g. pertaining to the phyla Porifera, Cnidaria, etc.) are already included in Annexes II and III of the Barcelona Convention, representing an important and integral component of marine ecosystems playing a key role in the marine ecological environment.

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[1] The DCRF is updated on a regular basis, please check the DCRF section on the GFCM website for the latest version.

2.1.1 Marine mammals

Fisheries can impact marine mammals unintentionally or indirectly by reducing their critical habitat and the availability of their prey (Northridge, 1991), or directly by potentially injuring them (e.g. in the case of net depredation). Marine mammals can impact fisheries by removing bait or caught fish from hooks, nets or traps, thus damaging fishing gear, or because their favourite prey are also highly commercial species.

Interactions between marine mammals and fisheries in the Mediterranean and the Black Sea involve mainly coastal fisheries and species such as common bottlenose dolphins (*Tursiops truncatus*), which are typically found on the continental shelf, common dolphins (*Delphinus delphis*), harbour porpoise (*Phocoena phocoena*), Mediterranean monk seals (*Monachus monachus*) and killer whales (*Orcinus orca*) (Guinet *et al.*, 2007; Bearzi *et al.*, 2008; Snape *et al.*, 2018). The striped dolphin (*Stenella coeruleoalba*), by far the most abundant cetacean in the Mediterranean, has a pelagic distribution and largely feeds on non-commercial prey species (Notarbartolo di Sciara and Demma, 1997; Notarbartolo di Sciara, 2002). Thus it rarely represents a problem for coastal fisheries, apart from gear damage or time lost for fishers when the animals are entrapped in fishing gear (Bearzi, 2002).

Most fisheries interact with marine mammals through towed nets (e.g. pelagic and bottom trawl, purse seine, etc.) and static nets (e.g. bottom set gillnet, trammel nets and longline, etc.). Static nets, a mainstay of small-scale Mediterranean and Black Sea fisheries, are prone to interaction with marine mammals, especially when these nets are set too close to critical areas of reproduction (Panou and Panos, 1993; Cebrian, 1998). In particular, common bottlenose dolphins are increasingly interacting with set nets across the region where, as well as being caught, they depredate catch, damage gear and may cause severe economic losses (Snape *et al*., 2018).

2.1.2 Sea turtles

Sea turtles can be affected at all life stages by a range of anthropogenic factors, including fishing operations (FAO, 2009a). As a result, all sea turtle species are considered subjects of conservation concern. The Mediterranean region is an important breeding area for two marine turtle species: the loggerhead turtle (*Caretta caretta*) and the green sea turtle (*Chelonia mydas*) (Luschi and Casale, 2014). Key loggerhead nesting concentrations are in Cyprus, Greece, Libya and Turkey, while green turtle nesting sites are recorded mostly in Cyprus, Syria and Turkey, with low levels of nesting also recorded in Egypt, Israel and Lebanon (Stokes *et al*., 2015). Loggerhead turtles nesting in the Atlantic also enter the Mediterranean and are mostly confined to the western basin. The leatherback turtle (*Dermochelys coriacea*) and the olive ridley turtle (*Lepidochelys olivacea*), also enter the Mediterranean from the Atlantic, without breeding in the basin, and are sparsely distributed.

Sea turtles interact with and are incidentally caught by diverse types of fisheries. Many authors have reported that most incidental catches of sea turtles occur in fisheries using longlines, bottom and pelagic trawlers and gillnets (FAO, 2004; Casale *et al*., 2010; Fortuna *et al*., 2010; Casale, 2011). Coastal bottom gillnets are often set close to shore or laid atop reef flats, a primary sea turtle feeding area. Sea turtles entangled in these nets face a high risk of drowning (FAO, 2009a; Casale, 2011). Sea turtles are also among the most endangered groups of species to be taken incidentally in some trawl fisheries. Fisheries that use bottom trawls in coastal waters and other nearshore areas – particularly coastal shrimp trawl fisheries – may have a high impact on sea turtles (Hall, Alverson and Metuzals, 2000). As well as having a negative conservation impact, bycatch can also cause loss of earnings through damage to nets and longlines.

Several attempts have been made to quantify the number of sea turtles accidentally caught in fishing operations every year. These studies usually apply to specific areas and fisheries and thus are not suitable for extrapolating regional or sub-regional estimates, although one comprehensive Mediterranean review suggests that at least 44 000 sea turtles die annually in the Mediterranean through bycatch (Casale, 2011). A global review suggests that the threat of fisheries bycatch to Mediterranean turtle populations is particularly pronounced, warranting urgent conservation action (Wallace *et al.*, 2010). Catch rate estimates may also be affected by the fact that individual turtles may be captured multiple times. The Demography Working Group of the 5th Mediterranean Conference on Sea Turtles recommends that "a regional bycatch project should be established to update bycatch figures and assess post-release mortality" as part of their 10 priority recommendations.

2.1.3 Seabirds

Seabirds are found in all the world's oceans and seas. There is often a broad match between seabird distribution and the world's most-fished seas: both seabirds and fishing vessels concentrate in areas of high biological productivity (Brothers, Cooper and Løkkeborg, 1999). Some seabird species approach fishing vessels to obtain easy food from discards produced by fisheries; others can dive up to 30 metres below the surface (Meier *et al.*, 2015), often to take the bait from hooks (Aguilar *et al.*, 2003). This extra source of food has benefited some seabird species, leading to changes in foraging behaviour and population dynamics (Bartumeus *et al.*, 2010; Cama *et al.*, 2012). However, fishery/seabird interactions can also result in mortality when seabirds become entangled or hooked in fishing gear, and for some species, particularly the long-lived procellariforms, this is at levels unsustainable for the populations involved (Croxall *et al.*, 1998; Tuck *et al.*, 2001; Arnold, Brault and Croxall, 2006; Barbraud *et al.*, 2009; Thompson, Phillips and Tuck, 2009).

The Mediterranean basin contains a breeding seabird community characterized by a high level of endemism, thus being of special conservation concern (Arcos, Louzao and Oro, 2008). Some Mediterranean fisheries have been found to cause seabird bycatch significant numbers (UNEP/MAP-SPA/RAC, 2009; Menchero, 2010; ICES, 2013), although many data gaps remain (Cooper *et al.*, 2003). Generally, longline, trawl and gillnet are the three types of fisheries most commonly associated with incidental catches of seabirds (Anderson *et al.*, 2011; Žydelis, Small and French, 2013). In the Mediterranean and the Black Sea, incidental catch in longline fisheries is one of the main sources of seabird mortality (FAO, 2016), and it might be driving the decline of some seabird populations, as seems to be the case for the Balearic shearwater (*Puffinus mauretanicus*) and Scopoli's shearwater (Genovart *et al.*, 2016, 2017a). Longlines (and trawls) also pose a threat to Audouin's gull (*Larus audouinii*), a Mediterranean endemic species (UNEP/MAP-SPA/RAC, 2009). Nevertheless, the information available on these fisheries' impacts on seabirds is still limited to a few regions (Dimech *et al.*, 2009; García-Barcelona *et al.*, 2010; Karris *et al.*, 2013; Cortés, Arcos and González-Solís, 2017).

In terms of gillnet fisheries, compared with other regions, the number of seabird species susceptible to bycatch in gillnets is low in the Mediterranean, but includes two of the most threatened seabirds in Europe: the Balearic and Yelkouan shearwaters (*P. yelkouan*) (Žydelis, Small and French, 2013). Louzao and Oro (2004) showed that the Mediterranean shag (*Phalacrocorax aristotelis desmarestii*), a subspecies of the European shag, is caught in gillnets in the Balearic Islands, and it is thought that gillnetting could pose a significant threat to this subspecies (De Juana, 1984; Muntaner, 2004; Genovart *et al.*, 2017b). Thus more data are needed to properly assess their degree of impact.

Incidental catches have also been documented in other gear used in Mediterranean fisheries, such as purse-seiners, traps and driftnets (ICES, 2008; FAO, 2016).

2.1.4 Sharks and rays

Elasmobranchs belonging to the Chondrichthyes class first appeared on the IUCN Red List in 1996, the last assessment of the species living in the European waters is in Nieto *et al*. (2015). Currently, different species of sharks and rays are listed in the appendixes to the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), thus requiring specific permits for exportation. This is particularly relevant because, unlike other taxa addressed here, some members of this taxon have high commercial value in the region. In 2012, GFCM adopted Recommendation GFCM 36/2012/3, which prohibited the landing and commercialization of the shark species included in Annex II of the Specially Protected Areas and Biodiversity (SPA/BD) Protocol. Many species of sharks, skates and rays have been and are currently impacted as bycatch in diverse fishing activities (Ferretti *et al*., 2008; Bräutigam *et al*., 2015; Dulvy *et al*., 2016). This is particularly relevant for the Mediterranean, where many populations have separate and elevated IUCN status assessments (Dulvy *et al*., 2016). This updated assessment means that only some of these endangered species are included in the appendixes of international conventions. Thus fisheries impacting these vulnerable populations of chondrichthyans require careful management.

Historically, fisheries targeting species of chondrichthyans existed in the Mediterranean, but local abundance of the target populations decreased to the point that these could no longer sustain fisheries pressure (Abella and Serena, 2005; Cavanagh and Gibson, 2007; Dulvy *et al*., 2016). Nowadays, few fisheries are directed at one or a small number of species of sharks, but generally, most sharks are taken in multi-species fisheries where fishers tend to target more highly valued teleost fish species (UNEP/MAP-SPA/RAC, 2006). When accidentally caught, they are either discarded at sea or retained and landed to be sold (e.g. for subsistence or bait), depending on the species. Gillnet, trammel net, longline and bottom trawl should be considered the major threats for the survival of shark and ray populations (GFCM, 2014).

2.1.5 Vulnerable benthic species

As previously mentioned, fishing is the most widespread human activity exploiting the marine environment. It has a direct impact not only on commercial fishery resources, but also on the entire marine community, including benthic organisms. The importance of benthic habitats to ecological processes and as providers of key ecosystem services is unquestionable. Diverse studies in the region have shown that mechanical damage by some fishing activities (e.g. trawlers) is highly destructive to benthic communities, including those forming VMEs on geomorphological features such as seamounts and canyons. In addition, it has been documented that other fishing activities (e.g. longlines) also have a considerable effect on vulnerable communities (such as the bamboo coral *Isidella elongata,* sponge fields, black corals and other cold-water corals including gorgonians and scleractinians) (Bo *et al*., 2014; Fabri *et al*., 2014; Mytilineou *et al*., 2014). This document intends to focus also on those species considered VME indicators and key components of VMEs that are being captured accidentally during fishing operations affecting these vulnerable ecosystems (FAO, 2009b). Among them, corals and sponges are known to be the main habitat-forming structures, often with numerous species living within or around their body structures.

Trawling, in particular, has been shown to remobilize surface sediments in canyon rims and plains, generate sediment turbidity far from the specific fishing ground and increase sediment accumulation rates and suspension, altering many vulnerable communities and habitat-forming species (Pusceddu *et al*., 2014).

Consequently, the Working Group on Vulnerable Marine Ecosystems (GFCM, 2017; GFCM, 2018b and 2018c) has identified Mediterranean VME indicator features, habitats and taxa and developed a VME data collection protocol for commercial fisheries.

In many areas of the Mediterranean and the Black Sea, information on these types of marine biotic assemblages is fragmented. Thus it is essential to maximize the use of available resources and to collect data through additional/alternative sources of information (e.g. observers on board) to better understand fishing impacts on vulnerable benthic ecosystems.

2.2 WHY IS BYCATCH OF VULNERABLE SPECIES A PROBLEM?

Interactions between fisheries and all categories of species described above are widespread and are cause for much concern (Garcia *et al*., 2003; Abdulla, 2004; Tudela, 2004; Bradai, ACCOBAMS, 2010; Bradai, Saidi and Enajjar, 2012; FAO, 2016). As described before, unwanted bycatch is in general a threat not only to the profitability of fisheries (owing to the sorting burden), but also to the industry's sustainability (e.g. when it consists of juveniles of valuable target species), and it is especially damaging when we consider vulnerable species. The incidental catch of vulnerable species becomes a threat to their conservation and may endanger their survival. Fisheries impact varies by geography, fishing gear, target catch and bycaught species. This type of interaction is negative both for fisheries and the environment (Garcia *et al*., 2003) and may also represent a significant animal welfare issue.

Indirect impacts of fisheries operations on vulnerable species include competition for prey and damage or destruction of sensitive habitat. Removing a large portion of the biomass of a target fish stock may have severe effects on vulnerable species and other predators if they depend on that stock as prey, reducing the population carrying capacity of the ecosystems on which they depend. For example, marine mammals interact adversely with fishing operations targeting other species, as they feed on fish caught by these fisheries (Gonzalvo *et al*., 2008; Gönener and Özdemir, 2012). Some populations of bottlenose dolphins and killer whales have become quite skilful at removing a variety of fish species from longlines and nets. Depredation can significantly affect the volume and quality of catches and thus profits, leading to fishers taking retaliatory action and increasing the likelihood of entanglement or hooking of marine mammals.

Dolphins and seabirds have been reported to follow trawlers to take advantage of discarded fish or to seize fish from the net, which may increase the risk of bycatch, but may also cause conflict between them and fishers. This interaction has also been reported in other types of fisheries, such as trammel nets and gillnets, with deleterious effects both for the fishers and the species (Snape *et al*., 2018). Removal of fish entangled in nets can reduce total catch and cause significant damage to fishing gear, with costs on the order of thousands to tens of thousands of euro annually. In addition, some types of trawl and dredge fishing have repeatedly been shown to significantly alter the physical and biological structure of sensitive marine habitats (e.g. formed by corals and sponges), potentially affecting vulnerable species (e.g. sharks, marine mammals and sea turtles) that depend on those habitats (Kaiser *et al*., 2002).

'Ghost fishing'

In recent decades, the use of static nets extending to the continental slopes in all coastal fisheries has led to increased risk of loss of these gear and thus to unaccounted catches (i.e. 'ghost fishing') and macro-litter. Ghost fishing first gained global recognition at the Sixteenth Session of the FAO Committee on Fisheries in April 1985. It is an important issue, as a very high proportion of litter consists of net fragments. Fishing gear can be lost accidentally during storms, but it can also be abandoned deliberately. Globally, it is estimated that abandoned, lost or discarded fishing gear in the oceans makes up some 10 percent (640 000 tons) of all marine litter (Macfadyen, Huntington and Cappell, 2009). In the Mediterranean, as well, despite the scarcity and inconsistency of data on derelict fishing gear, it has been recognized as an issue of major concern (Galgani, Souplet and Cadiou, 1996; Galgani *et al.*, 2000; Katsanevakis, 2008; UNEP/MAP, 2015). The main impacts of abandoned or lost fishing gear are: continued catches of fish – and other animals such as turtles, seabirds, and marine mammals – who are trapped and die; alterations of the sea-floor environment; and creation of navigation hazards that can cause accidents at sea and damage boats.

2.3 IMPORTANCE OF COLLECTING INFORMATION ON BYCATCH OF VULNERABLE SPECIES

Collection of data on the incidental catch of vulnerable species (e.g. quantities, sizes, locations, fishing gear and timing of such bycatch) is key in understanding the nature and extent of this problem. It can be considered the first step towards developing and implementing adequate management measures for reducing interaction. Information on bycatch will contribute to understanding the impact of specific fishing activities on the various vulnerable species concerned. Once collected, these data could indicate which fishing gear are most damaging for a given species and whether catch patterns reveal any geographical or seasonal trends. This information may, in turn, be useful in applying adequate targeted measures to reduce the impact of fisheries on these species, while minimizing the impact on industry. Effective scientific management of marine fishery resources depends on the availability of detailed and reliable catch records, information on fishing effort and biological data. To better understand to what extent incidental catch of vulnerable species occurs in fisheries, it is necessary to develop a robust data collection monitoring programme. It should include efficient reporting and monitoring of incidental catches to obtain a complete picture of the situation across the region and, based on that, set priority areas for management actions.

The collection of biological information on the vulnerable species caught (e.g. length, sex and maturity) can also help improve knowledge of these species, which would be difficult to sample in any other way. Thus collecting data on vulnerable bycaught species can not only help assess the extent of the problem, but also help analyse the population-level effect on the species and better understand their ecology. Information should be collected through increased collaboration between countries, which can also help support implementation of the consistent application of bycatch mitigation measures across the total range of the population. Instruments such as agreements made under the Convention on the Conservation of Migratory Species of Wild Animals may support multinational efforts.

Collected information could not only facilitate identification of spatial and temporal mitigation measures to reduce bycatch, but also allow fishing gear engineers to develop modifications that reduce bycatch while maintaining catches of the targeted species (Kennelly, 1999), as well as other management measures such as time-area closures and fishing effort management.

3. DATA SOURCES

Methods for collecting useful information to assess the status of vulnerable species can be derived from the following categories (adapted from FAO, 2016):

- *Fishery-dependent data*: data are obtained from commercial fisheries. There are a variety of approaches to obtaining fishery-dependent data. Information on incidental catch of vulnerable species, with some biological information as well, can be obtained through the use of on-board observers, self-reporting, logbooks, telephone surveys and/or other sources (e.g. remote electronic video monitoring systems; information collected by recovery centres, etc.).
- *Fishery-independent data*: data are obtained from scientific surveys and ad hoc monitoring programmes, depending on the vulnerable species. Surveys are designed to develop unbiased estimates (e.g. indices of presence, trends in abundance, population size, structure, etc.) that are independent of commercial fisheries.

The collection and accurate interpretation of both fishery-dependent and -independent data are of fundamental importance in understanding the status of bycaught species. Several methods are available to quantify the bycatch of vulnerable species, each of them with positive and negative aspects (Table 1).

TABLE 1

Summary of main characteristics of common monitoring strategies[a]

Category	Source of data	Costs	Inconvenience to industry	Accuracy/ reliability	Representation of normal fishing[b]
Fishery-dependent data	Observers on board	Medium	Medium	High	High
	Interviews	Low	Medium	Low	High
	Self-sampling	Low	High	Low	High
	Stranding data	Low	None	Medium	Low
Fishery-independent data	Surveys with research vessels or chartered vessels	High	None	Medium	Low

[a] In terms of: cost inconvenience to industry; accuracy, reliability and representation of normal fishing practice; and common monitoring strategies used to identify and quantify bycatch of vulnerable species.

[b] How the identified source of data matches the existing commercial fishing behaviour (i.e. low, medium, high).

Source: Adapted from Kennelly, 1999; ACCOBAMS, 2010.

One favourable methodology is the use of *observers on board*. Although observer programmes are included here as a fishery-dependent source of data, they can be viewed as a combination of both dependent and independent, because they involve fishery-independent observers (generally with a scientific background) working on fishing vessels during normal operations, recording data on catches, bycatch and fishing operations (Kennelly, 1999). Other typical fishery-dependent methods used to quantify bycatch include *interviews* with fishers and *self-sampling* by fishers. The main advantage of both these methods is that they are relatively inexpensive to execute, because fishers gather most of the data. However, there may be substantial inconvenience to fishers in terms of on-board and/or dockside processing. Moreover, the data gathered can be inaccurate and biased, particularly when the bycatches of vulnerable species to be reported by fishers are perceived to be the subject of controversy, potentially leading to increased regulation.

In addition, in the case of observer programmes, there may be some inconvenience to fishers because these activities involve an extra person (or persons) on board the vessel, occupying deck space (in some artisanal vessels, there is no space for an on-board observer) and conducting activities outside normal fishing practices (e.g. measuring, weighing and recording information). Because observer programmes usually cannot monitor 100 percent of all fishing trips in a fishery, questions arise on how to set the level of observer coverage and how to interpret the resulting data (Hilborn and Mangel, 1997).

Beside these methods, some additional sources of data can be helpful, such as stranding data and specific scientific surveys. Data from stranded individuals might not be representative of the whole problem in the fisheries, but in some cases it may be helpful in providing valuable information on mortality involving fishing gear. It can also increase knowledge of the biology (e.g. data on sex and maturity) of the species impacted by bycatch at a relatively low cost. Stranding data may give an indication of an underlying seasonal or temporal trend in mortality, providing data that can be matched to seasonally and temporally variable fishing activities to build an evidence base.

In the case of fishery-independent surveys (e.g. using research vessels), high cost is a problem, but so is lack of representativeness of the real problem in fisheries. However, they may be a source of additional useful information. For instance, surveyed animals may tend to occur in areas where bycatch is low, since they are fished out of important bycatch hotspots.

It is clear that there is no single correct methodology for adequate recording of the bycatch of vulnerable species. The combination of several methods could give a more-complete and more-robust image of the bycatch situation. Thus multiple types of methods should be combined to gain a more-accurate picture of the status of resources and the magnitude of bycatch (FAO, 2016).

When designing a monitoring programme, one needs to apply accepted survey design standards to ensure that all samples and subsamples are appropriately randomized, stratified across all fleet, spatial and temporal scales, and sufficiently replicated for reasonable levels of precision. By incorporating these design factors into bycatch programmes, the extrapolation of results from, for example, relatively small numbers of observed trips to statistically reliable bycatch estimates of whole fisheries becomes straightforward. In addition, owing to the stochastic nature of events such as the incidental catch of vulnerable species – and because these records are rarely kept in logbooks (often despite existing regulations) – it is recognized that only the presence of observers on vessels, sampling the fleets in a representative manner, would allow robust estimates of the actual mortality of vulnerable species caused by fishing operations. On the other hand, precisely because of the great irregularity of these catches, extrapolations using limited observer survey data might lead to high biases, usually underestimating bycatch. Owing to the life histories of some vulnerable species (e.g. high longevity and low reproduction rates), even very infrequent bycatch events can have profound effects on populations. Thus many observations are required to detect mortality and potential 'mass-mortality' events, which may be relatively rare but very important.

Independently of the selected data source(s), design of a monitoring programme should take into account spatial (e.g. aiming to cover the main ports within GFCM geographical subareas [GSAs] as in Annex 2) and temporal (e.g. quarter of the year) variability to detect seasonal and geographical differences in the incidental catch of vulnerable species for different fleet segments (Annex 10).

In this sense, the selection of an adequate methodology and a statistically robust sampling design are essential to a better understanding of the problem of incidental catches and the size of the bycatch issue. The level of monitoring will ultimately be determined by the financial and human resources available to address the task and the collaboration offered by fisheries stakeholders.

3.1 FISHERY-DEPENDENT DATA

Sampling based on the commercial fleet covers a wide variety of options, with a range of costs and efficiency (Table 1). It goes from the option of lowest costs, but high inconvenience to the industry (as it requires their collaboration) – with low accuracy and reliability, and dependence on the confidence of this collaboration – to intermediate costs and high reliability. One of the benefits is that this sampling method has a high representation of normal fishing. In any case, when a collaboration with the fishing industry is necessary, it is important to include an ethics statement detailing how the data is to be used and the policy on confidentiality (Moore *et al*., 2010). Three main sampling strategies can be included here: observer programmes, interviews, and self-sampling, plus an additional source of information from stranded data.

3.1.1 Observer programmes

Incidental bycatches should be recorded according to standard data collection procedures by on-board fishery observers. Independent observations made by trained observers are the most reliable and useful means of collecting data. Wherever feasible, bycaught specimens should be sampled at sea (or, whenever possible, at the landing place, in the lab, etc.).

The following aims have been established for observers on board fishing trips:

- Obtain reliable information on the interaction of vulnerable species with specific fishing gear.
- Record the number and weight (or estimate) of each species bycaught during each fishing operation/set and, whenever possible, the position of the bycatch event.
- Gather biological information (length, sex, etc.) on the vulnerable species caught (e.g. some seabird species could be dissected, on board or at the landing place, to assess age and sex).
- Gather data on the amount of gear deployed and set parameters (e.g. size and length of net, mesh size, net type, number of hooks, bait, soak time, etc.).

Once on board, observers should also gather the general information, by fishing trip, needed for correct interpretation of results:

- features of the vessel (e.g. information on fishing gear and fishing trip, as in Annex 3.a);
- weight (or estimate in kilograms) and specific composition of the catch, with indication of the main target species (as in Annex 3.b);
- percentage of discards in the total catch, with indication of the main discarded species (as in Annex 3.b); and
- percentage of marine litter in the total catch, with indication of the composition (as in Annex 3.b and Annex 13).

All bycatches of vulnerable species should be recorded according to standard data collection procedures by trained and experienced on-board observers. As far as possible, observers should be placed on randomly selected vessels conducting typical fishing trips from the main ports in the investigated area. For smaller vessels, there may be strict space limitations and the use of on-board observers may not be logistically possible. Moreover, the use of on-board observers is usually self-selecting. Only vessels willing to collaborate should allow observers on board, unless regulations dictate that hosting an on-board observer is mandatory (often the case for larger vessels in some areas). Ideally, days at sea should be proportionally allocated by quarter of the year (to cover seasonality) and all fishing operations should be observed on all trips (although this is not always possible, owing, for example, to bad weather conditions or safety considerations). In addition, all main fishing ports in the investigated area should be covered by the monitoring programme. Templates for observers on board, including vessel characteristics, fishing trip and bycatch information, are presented in Annex 3.

Depending on various factors (e.g. condition of the species caught, accessibility of the species, etc.), and whenever possible, on-board observers should also report biological information (e.g. length, weight and sex) as in Annex 4. These programmes can be quite expensive, but costs can sometimes be defrayed by coordinating observations (e.g. discards or biological monitoring programmes in place) to meet several objectives at once, for example to provide data that may be useful for fish stock assessment (e.g. discards) or fishery effort quantification or validation. Moreover, if on-board monitoring is already in place, data obtained from it may provide an initial insight into its potential usefulness for vulnerable bycatch with certain gear or in certain areas.

Although this methodology brings valuable information on bycatch, it can also be combined with other methodologies to obtain more-reliable results. Integration of self-reporting tools with observer programmes allows for cross-checking and review of self-reported data.

3.1.2 Interviews

Interviews can be of great use in gathering quantitative information if the correct methodology is used. Informal contacts with the industry may be made, building early relationships with targeted fishers to foster trust and credibility, achieve compliance and good results, and promote awareness-raising of the bycatch problem. And while it is possible to establish such informal contacts, in order to gain an impression of the scale of bycatch of vulnerable species adequate sampling should be carried out formally, with standardized questionnaires conducted in the ports or wherever fishers can best be gathered and approached (Annex 7). However, it has been shown that fishers, like all humans, are likely to forget or miss-report specific details, such as numbers, over time (Lien *et al*., 1994). Moreover, there may be strong incentives in some areas for the scale of bycatch to be misrepresented. The possibility of economic compensation for damage may also lead to inflated reports of depredation or net damage. Thus this methodology should be considered in those areas where information on bycatch is scarce – as a first step to discovering which fishing gear are more likely to catch vulnerable species – and in those fisheries in which the use of other methodologies cannot be applied (e.g. small vessels that cannot take an observer on board or vessels operating in remote areas of difficult access). They can also be used to prioritize the fisheries for broader studies, and as a complementary tool to some of the other sampling methodologies proposed (e.g. participatory self-reporting and direct observer schemes), which would then be used to provide statistically robust estimates of catch and mortality rates in target areas.

Illustration cards (but also videos, photos, etc.) of vulnerable species known or expected to occur in the study areas can be used to help fishers identify species caught. Interviewers could also take appropriate maps into the field to help fishers describe the locations of their fishing areas. Standard questionnaire forms for interviews are included in Annex 7.

Telephone surveys are a specific category of interview useful in follow-up – for example, to confirm anomalous data or to follow up surveys with on-board observations and self-monitoring. One of the limitations of telephone surveys compared with personal interviews is that, in the latter, interviews can be complemented with visual information to help in identification of the species, which may provide better information on the bycatch of vulnerable species. For this reason, and whenever possible, fishers should be encouraged to photograph their bycatch of vulnerable taxa using a mobile device so that species can be identified post hoc.

3.1.3 Self-sampling

The basic self-sampling methodology involves the use of ad hoc logbooks (or data sheets). The logbook methodology is low cost but requires a high degree of cooperation from the industry. In this sense, fishers often have too many forms to complete on a daily basis and their voluntary collaboration may suffer from the obligation of reporting different data. Additionally, fishers also need to be properly trained in collecting this information, as there could be many cases in which questions can be interpreted differently and doubts arise.

This methodology is based on fishers completing logbooks while at sea (Annex 8). There is the danger that fishers may not always record accurate data, underreport their catch or identify species incorrectly. Correct species identification is a major issue, because fishers are not scientifically trained in proper identification techniques. Thus the reporting form should be accompanied by a clear, easy identification guide. As in the previous case, this methodology can be an alternative to others, but can also be used as a complementary tool to some of the other sampling methodologies proposed. This is particularly valuable where self-reporting fishers are also hosting on-board observers, thus providing for basic training in species identification. Self-reporting fishers can be trained by observers to take descriptive photographs, so that species identification can be validated by trained observers and specialists.

One support to this monitoring system is the use of mobile devices (e.g. smartphones). Most fishers use mobile phones with built-in photographic and Global Positioning System (GPS) technologies. These can complement self-monitoring sampling to verify identification and the position of capture. This would require further collaboration from the industry, as they are asked to photograph each individual of any of the vulnerable species caught. To help estimate individual size from photographs, it is advisable to have some reference on board, such as including in the photo an object of known size. The limitation of this methodology, used alone, is that it doesn't indicate total effort of the vessel, and the absence of pictures is considered zero catch, so the level of collaboration of fishers will determine the quality of results. In this sense, a complementary interview or logbook is necessary to have a realistic picture of the situation, although logbooks should be regarded with the same degree of caution, as there is no guarantee that logbooks are completed on every trip and some specimens may not be remembered, logged or photographed. Project personnel can retrieve images from fishers when they visit them at ports to collate logbook data, or the images can be shared by the fisher. Fishers may feel rewarded when they are able to show that they are doing their best for threatened species and may readily share images/videos of vulnerable species being handled and released at sea (most fishers are already equipped with smartphones – available and easily used by stakeholders). However, coverage can be very uncertain, because the technology is land-based, not sea-based.

There may be a temptation to use self-sampling as a cheap alternative to on-board observation. The benefit of self-sampling is that the cost-per-vessel is relatively low, so a much greater sample can be achieved for the same budget. However, self-sampling is innately associated with warnings that limit the statistical power of its results. Not every fisher will photograph or note down the details of every vulnerable species, and they may be more likely to report live than dead specimens. Regardless, bycatch occurrence and absence data are very useful in flagging bycatch hotspots, which could be missed by a limited number of on-board observations. This is particularly true because bycatch rates may be very low and thus missed by a low number of on-board observations – although the cumulative impact of thousands of sets may still yield benefits at the population level. Self-sampling can also be used to provide positional data and information on fleet segments that could not be provided with the same precision through, for example, interviews alone.

3.1.4 Stranding data

Information obtained from the presence of stranded animals onshore can be considered additional data. It cannot be considered quantitative, but only qualitative. The presence of stranded animals on the shore (e.g. beaches) may help determine that some bycatch is occurring in a region, but as a quantitative measure such observations cannot be of much use, because the number of stranded animals may not be directly related to the number of animals bycaught in any given region.

However, these are valuable data and may reflect bycatch in an area where little information is available, especially if the cause of death can be detected (for instance, entanglement in gear or strangulation marks).

Stranded individuals are also a valuable source of information on the demography (e.g. length) of the species potentially impacted by bycatch and can be useful in inferring reproductive values of individuals impacted by fishing operations. Care must be taken not to overinterpret data from stranded animals, and protocols for establishing cause of death must be followed. Necropsy can be useful in providing further details, such as the presence or absence of hooks or line in the gastro-intestinal tract of sea turtles or larynx strangulation from consuming sections of net during depredation in dolphins. Stranding data and biological information (e.g. sex, maturity and weight) of stranded species could be reported using the templates in Annexes 4 and 9.

3.1.5 Remote electronic monitoring (REM)

Recently, new monitoring tools have been developed for a variety of biomes (Bartholomew *et al*., 2018). Some vessel monitoring system (VMS) technologies have been developed as an alternative to or to supplement on-board observers. VMS is most commonly associated with GPS, but also incorporates other monitoring technologies. It is capable of providing data at high spatial and temporal resolution and has been installed in numerous fisheries (Gerritsen and Lordan, 2010), although, to date, VMS has been mostly deployed in industrial fisheries, where it is sometimes mandatory (Bertrand *et al*., 2008).

One increasingly popular VMS tool, discussed here but not further elaborated on in the document, is remote electronic monitoring (REM), which represents one of the many applications of cameras in marine environmental research (Rist *et al*., 2010; Bicknell *et al*., 2016).

REM could be another cost-efficient and reliable way to monitor bycatch on fishing vessels, in particular where there are practical limitations on using dedicated at-sea observers on board (e.g. small-scale vessels). This system has had moderate success in using recorded video to monitor the volumes of non-target fish bycatch as fish are sorted on board. Studies have been carried out to measure the effectiveness of REM systems in monitoring industrial fishing activities, including target catch (Hold *et al*., 2015), bycatch (Kindt-Larsen *et al*., 2012) and the use of bycatch mitigation technologies (Ames, Williams and Fitzgerald, 2005). In some cases, different methods have been applied simultaneously, such as observers and REM systems, as the data collected could be of complementary value. Researchers have demonstrated the potential benefits of REM systems in the context of small-scale fisheries (Bartholomew *et al*., 2018), as they could improve understanding of these large, vastly understudied fleets by supplementing or reducing the need for extensive, costly and sometimes impractical on-board observer programmes, and can be used to overcome some deficiencies in observer reports. Eventually, trials could be conducted to test REM ability to record incidental catch of vulnerable species on board commercial vessels. Such trials could increase monitoring levels and possibly reduce the cost of observations.

3.2 FISHERY-INDEPENDENT DATA

The use of specific ad hoc surveys (e.g. ship surveys, tracking and aerial sea surveys, etc.) designed to cover the various groups of vulnerable species can provide information on habitat use, hotspots of abundance and diversity. In recent decades, for example, the use of satellite systems and manned aircraft surveys for remote data collection has been shown to be transformative for vulnerable species conservation (e.g. sea turtles and cetaceans) and research by enabling collection of data on species and their habitats over larger areas (Rees *et al*., 2018). Remote sensing data are becoming increasingly important in understanding the spatial ecology of marine systems and, when used in tandem with tracking data, can provide important insights into the specific environmental niches and spatial distribution of target species (seabirds: Afán *et al*., 2014; fish: Druon *et al*., 2015; cetaceans: do Amaral *et al*., 2015; seals: Nachtsheim *et al*., 2017; sea turtles: Thums *et al*., 2017). Accurate species distribution data is of clear relevance in identifying potential bycatch hotspots.

A limitation in using these surveys could be misrepresentation of the real problem of interaction of vulnerable species with commercial fleets and, in some cases, the high costs of the survey.

Another possibility is to use existing scientific surveys (e.g. demersal and/or pelagic acoustic surveys already being implemented) to monitor the abundance of commercial species, in order to have an approximate idea of the issue of bycatch of vulnerable species. This may be especially useful in the case of the catch of elasmobranchs, rays and chimaeras, as some of the vulnerable species may be caught regularly in some scientific surveys such as bottom trawl surveys. Data from those surveys should not be used to extrapolate bycatch estimates for a target population of fishers. Their data cannot be considered representative, because this is not a probabilistic sampling, but an opportunistic (or convenience) sampling, and thus the estimations are not statistically valid and cannot be generalized to the target population. This methodology may be useful, however, in analysing temporal trends of the abundance of vulnerable species caught during scientific surveys, as well as some aspects of their biology and population dynamics. For this reason, collection of this information, although considered supplemental to other methodologies, is valuable. The same templates in Annex 3 can be used to report information from ad hoc surveys.

4. SAMPLING SCHEME

4.1 DESIGNING AN OBSERVER PROGRAMME

The idea of designing a perfect bycatch monitoring programme covering all fisheries in all countries is not realistic: fishing behaviour, catch composition, nature of the fleet and the availability and capacities of human resources vary among countries. Monitoring programmes are needed that are designed to meet existing needs on a case-by-case basis. However, common information is always necessary before designing any monitoring programme, and, in general, sampling cannot be planned without sufficient knowledge of the nature and scale of the fisheries concerned. So the first step is to have an in-depth knowledge of the fisheries of the area to be studied, including:

- total number of fishing vessels operating in each country and in different GSAs (see Annex 2);
- identified fleet segments operating in the country (based on the GFCM DCRF – Annex 10); and
- number of vessels by fleet segment and GSA, together with:
  - o fishing techniques (e.g. types of gear; see gear codes in Annex 11); and
  - o fishing effort (e.g. total number of fishing days by fleet segment).

Monitoring schemes should be designed on an annual basis and established to monitor bycatch in a representative manner. Schemes should be made sufficiently representative by adequately spreading observer coverage over the fleets, time and fishing areas.

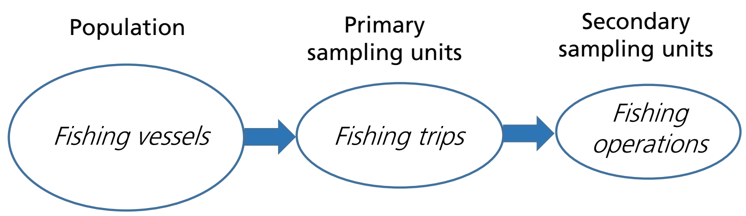
It is also important to consider previous information on the bycatch of vulnerable species for the diverse gear in the study area. If no information is available, the first approach would be to start a large survey of interviews (in ports or by telephone) to establish relationships with fishers and to have a first estimation of the problem, trying to cover all fishing gear employed in a certain area (see subsection 3.1.b).

4.2 SAMPLING STRATIFICATION AND ALLOCATION SCHEME

Before designing a sampling strategy, whatever the sampling procedure, it is important to identify the target population (as a whole), the subset to be measured (i.e. the sample) and the nature of its individual members – the sampling units (GFCM, 2018a). The target population, the observable subset (sample) and the assumed link between them should be clearly identified.

For example, taking into account the specificities of each country/GSA, the population of interest may comprise all the vessels in a certain fleet segment (Figure 2).

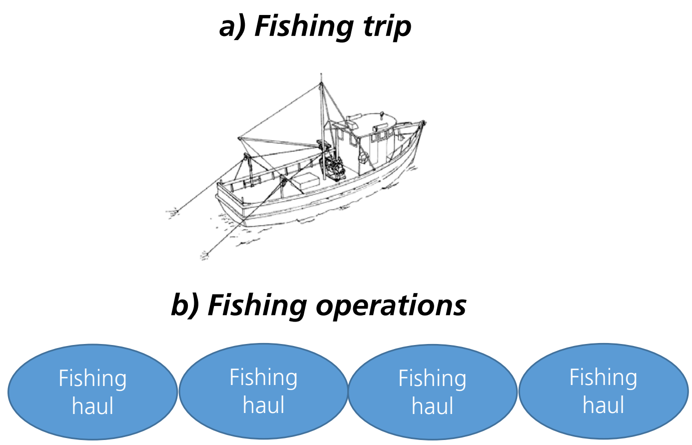
FIGURE 2
Sampling population, primary and secondary sampling units



The identified target population (i.e. fishing vessels) should be sampled using ad hoc sampling units covering the whole population without overlap (Cochran, 1977; Jessen, 1978). The sampling units should then be defined according to the hierarchical nature of the population. For example, each fleet segment consists of a number of vessels, each of which carries out a variable number of fishing trips throughout the year, and each trip consists of a variable number of fishing operations (e.g. fishing hauls, pulling traps).

The sample size – the number *n* of sampling units to be included in a sample – must be estimated according to several criteria (e.g. cost, precision level, confidence level, variability within the population and availability of resources). However, as a rule of thumb, the sample size should be as large as possible, given the staff and resources available. In the case of a fishing fleet, the target population would comprise all vessels in the fleet, but the observable population might only consist of those vessels that, for example, are accessible in nearby ports. Assuming that the unobserved part of the fleet behaves in the same way as the observed part, it would require a raising factor to convert sample estimates to the population of interest (Figure 3).

FIGURE 3
Trawler performing several fishing hauls (b) during a fishing trip (a)



Note: A sample of those hauls (e.g. 2 out of 4) could beextrapolated to represent the whole fishing trip.

Ideally, sampling days at sea should be proportional to the previous year(s) effort (number of days at sea for each fleet segment) and allocated by monthly or quarterly period covering at least the main fishing ports in the investigated area.

Generally, trips (as a combination of fishing vessel and time at sea) should be sampled randomly. The fishing trip duration is the time elapsed from the moment the vessel leaves port until the moment it returns to port. In the Mediterranean and the Black Sea, the fishing trip is equivalent in most cases to a fishing day (one fishing trip = one fishing day). For the purpose of this document, the basic assumption is that, when a fishing trip includes more than one fishing day, it should be broken down into fishing days (Table 2). This practice makes possible harmonization of data and results over fleet segments, countries and years (GFCM, 2018a).

TABLE 2
Example of conversion of fishing trips into fishing days for a given vessel

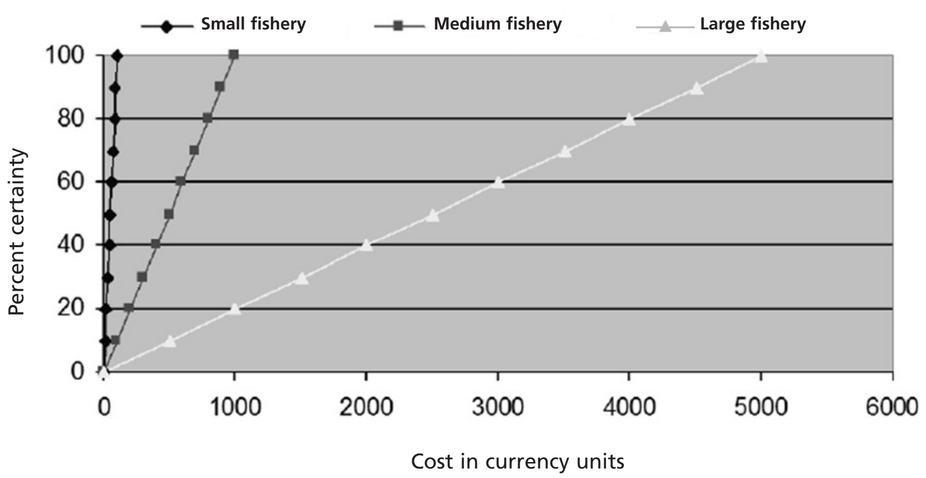
	Country 1	Country 2	Country 3
Number of fishing trips per year	60	125	50
Number of fishing days per fishing trip	2	1	3
Total number of fishing days during year	120	125	150

There is no single prescription for the optimum design of a data collection scheme. As mentioned previously, it is generally not feasible to design a perfect sampling strategy for all fisheries because the underlying conditions may vary from place to place and among fisheries. In light of this, some degree of flexibility (e.g. adoption of alternative approaches) must be a key component of any strategy. The availability and capacities of human resources may vary, and the data collection schemes should thus be designed to meet existing needs.

4.3 ASSESSING HOW MUCH MONITORING IS REQUIRED

Several factors can determine the number of fishing trips to be sampled, although the sampling should be cost efficient. The number of trips should be high enough to be representative and to achieve an adequate level of certainty, but not so much that the cost is unattainable. The extreme situations are from 'zero cost – zero precision' (no information) to 'certainty' (with a 100-percent level of observation). Thus an optimal level of sampling, for all taxa as presented in this document, is a trade-off between the extremes. But the larger the fishery and the greater the gap between the two extremes, the higher is the cost of the operation for the same level of precision (Figure 4). However, the relationship between increasing cost and increasing precision is not linear, and in reality, precision increases rapidly at lower levels of sampling, but increases less rapidly as sampling approaches 100 percent. In some cases and depending on the vulnerable species, it is considered that, typically, coverage should range from 2 percent to 7 percent (FAO, 2009b; ACCOBAMS, 2010), although a minimum level of 0.5 percent is often accepted (MARE/2014/19, 2016). Sampling intensities above 10 percent will do little to decrease uncertainty (ACCOBAMS, 2010). A target of 0.5 percent is what is achieved in some large fisheries monitored under the bycatch monitoring programmes carried out within Regulation (EC) No. 812/2004 (European Union, 2004; Northridge, Kingston and Thomas, 2015). Certainly, the required level of coverage could be much higher or lower for a particular fishery, depending on its size, distribution of catch and bycatch, and spatial stratification.

FIGURE 4
Relationship between cost of sampling programme, fishery size and precision of estimate



Source: ACCOBAMS, 2010.

However, as the cost of a sampling programme is a limitation, it is possible to combine different methodologies to achieve a high-enough percentage of coverage without exceeding the cost of the programme.

4.4 EXAMPLES OF SAMPLING SCHEME

Two examples are reported of organizing a sampling activity for hypothetical fleet segments: (a) trawlers 12–24 m and (b) small-scale fishing vessels 6–12 m.

Case (a): Trawlers 12–24 m

In this example, we consider vessels in which the presence of an observer on board is possible and permitted by the fishery: a trawl fleet composed of 100 vessels, 12–24 m length overall, in a certain geographical area. Each vessel usually makes a fishing trip lasting one day. Depending on the diverse situations that can occur during a year (e.g. weather conditions, vessel and gear maintenance, temporal fishing bans, etc.), we can assume that each vessel performs a total of 130 fishing trips (i.e. days) per year. Thus total effort by the whole fleet will be estimated at 13 000 fishing trips (Table 3).

Based on subsection 4.3, if we consider the proposed 0.5 percent as a minimum level of coverage and the 2–7 percent as optimal, this should result in allocating 65 and 260–910 sampling fishing trips per year respectively (Table 3).

TABLE 3
Example of sampling scheme for a fleet composed of fishing vessels of 12–24 m

Fleet description			
Trawlers 12–24 m	**Number of vessels**	**Estimated annual effort (fishing days) by single vessel**	**Total annual effort (vessels x fishing days)**
2016	**100**	**130**	**13 000**
Sampling			
	Sampling trips[a]		
Minimum coverage (0.5%)	65		
Optimal coverage (2–7%)	260–910		

[a] Number of sampling trips estimated to ensure an optimal and a minimum coverage of the entire fleet.

However, these numbers can be divided into the different sampling methodologies, combining them, and so obtaining the optimal coverage. They could be divided as follows:

- **Interviews.** Considering either of the two possibilities explained above (interviews at port or by telephone), one person, conducting interviews once per week with five different vessels (see Annexes 7.a and 7.b) and asking about the vulnerable species caught during the last fishing trip, may obtain information on the entire year of those vessels, 650 fishing trips per year (5 vessels x 130 annual fishing days per vessel = 650 trips). That represents, in our example, a coverage of 5 percent, which is inside the optimal coverage, but may finally be lower, as not all the fishers contacted would necessarily collaborate, or some weeks it might not be possible to carry out the interview owing to closing periods of the fishery or bad weather conditions that did not allow the vessels to operate.
- **Self-sampling with logbooks**. This method allows good coverage if the industry involved responds positively. For instance, if 10 percent of the fleet agrees to collaborate (in this case, it would be 10 vessels from the entire fleet) and does so correctly, coverage would be up to 10 percent. In this example, information would be collected on 1 300 fishing trips (10 vessels x 130 annual fishing days by vessel = 1 300 trips). Such high coverage may not be realistic, as in some cases vessels might not use the logbooks or might do so partially. In any case, if we consider that half the fleet that receives logbooks collaborates, coverage would be 5 percent, which is still in the optimal range. It is also possible to alternate vessels (for instance, change which vessels use logbooks monthly), so that the effort of

sampling is not as high for the same selected fishing vessels. Ideally, the vessels should be selected randomly, but in this case, selecting those vessels willing to collaborate is a key point for the success of the sampling.

- **Observers on board.** This is the most-costly method, particularly for large fleets. Thus it is very important to combine it with any of the previously described methods to ensure optimal coverage. In this case, if we consider a minimum coverage of 0.5 percent, it represents a total of 65 fishing trips per year, which is 5–6 fishing trips per month. This number may seem high, but two considerations should be taken into account: first, these fishing trips could be combined with other observer programmes already carried out by the country (for instance, monitoring of discards), and second, if this method is combined with any of the previous ones, the number of fishing trips required to be covered by observers on board may be lower, especially if collaboration with the industry is high and there is high confidence that the logbook and/or self-sampling methodologies are reliable. Sampling programmes may start with a high number of fishing trips covered by observers on board. Once they have been validated in relation to the other methodologies, the number of fishing trips covered by observers on board may be reduced.

Table 4 summarizes the number of fishing trips to be sampled under this example for a single year for each method. If the fishery operates all year round, this sampling effort should be divided equally by quarter. However, if the fleet does not operate for a certain period, the total number of trips should be distributed throughout the year according to the fishing effort in each quarter. The table also shows the coverage for each of the sampling methods.

TABLE 4
Example of number of fishing trips to sample by year and coverage (%) for a fleet composed of fishing vessels of 12–24 m

Method	Annual fishing trips to sample	Coverage	Comments
Interviews	650	5%	5 vessels interviewed weekly (information of the entire week)
Self-sampling with logbooks	1 300	10%	10 vessels filling logbooks
Observers	65	0.5%	

Case (b): Small-scale fishing vessels 6–12 m

In this example, we consider small vessels in which the presence of an observer on board is not logistically possible (e.g. for security reasons). Let's suppose a fleet of 250 small-scale vessels, 6–12 m length overall, with engine, using passive gear in a certain geographical area.

Depending on the diverse situations that can occur during a year (e.g. weather conditions, vessel and gear maintenance, temporary fishing closures, etc.), we could assume that each vessel would perform a total of approximately 110 fishing trips (i.e. days) per year. Thus total effort by the whole fleet will be estimated at 27 500 fishing trips (Table 5).

TABLE 5
Example of sampling scheme for a fleet composed of small-scale vessels

Fleet description			
Small scale 6–12 m	**Number of vessels**	**Estimated annual effort (fishing days) by single vessel**	**Total annual effort (vessels x fishing days)**
2016	250	110	27 500
Sampling			
		Sampling trips[a]	
Minimum coverage (0.5%)		138	
Optimal coverage (2–7%)		550–1925	

[a] Number of sampling trips estimated to ensure an optimal and a minimum coverage of the entire fleet.

In this case, the optimal range would be from 550 to 1 925 fishing trips, and the minimum coverage would be 138 trips. This latter allocation should allow covering about 0.5 percent of fishing days at sea carried out by small-scale vessels in the area. However, these numbers can be divided into the different sampling methodologies, combining them and so obtaining the optimal coverage, taking into account that the option of an on-board observer programme is not always feasible for small boats (e.g. mainly owing to security considerations). In this case, as the vessels are small, the self-sampling methodology will involve greater inconvenience for the industry, so the importance of interviews should be emphasized. Thus the number of trips to be sampled could be divided as follows:

- **Interviews.** Considering either of the two possibilities (interviews at port or by telephone), one person conducting interviews once a week (or two people, or a single person on two different days), with 10 different vessels, and asking about the vulnerable species caught during the last fishing trip may obtain information on a total of 1 100 fishing trips per year (10 vessels x 110 annual fishing days per vessel = 1 100 trips). That represents a coverage of 4 percent, which may be lower, as not all fishers contacted would necessarily collaborate.
- **Self-sampling with logbooks**. This method allows good coverage if the industry involved responds positively. For instance, if 5 percent of the fleet agrees to collaborate (in this case, it would be 13 vessels from the entire fleet) and does so correctly, coverage would be up to 5 percent. In this example, information would be collected on 1 430 fishing trips (13 vessels x 110 annual fishing days per vessel = 1 430 trips). Such high coverage may not be realistic, as in some cases vessels might not use the logbooks or might do so partially, especially owing to the constraints of working on small vessels. In any case, if we consider that half the fleet that receives logbooks collaborates, coverage would be 2.5 percent, which is in the lower part of the optimal range. It is also possible to alternate vessels (for instance, change which vessels use logbooks monthly), so that the effort of sampling is not as high for the same selected fishing vessels. Ideally, the vessels should be selected randomly, but in this case, selecting those vessels willing to collaborate is a key point for the success of the sampling.

Table 6 summarizes the number of fishing trips to sample under this example for a single year for each method. If the fishery operates all year round, this sampling effort should be divided equally by quarter. However, if for a certain period the fleet does not operate, the total number of trips should be distributed across the year according to the fishing effort in each quarter. The table also shows the coverage for each of the sampling methods.

In any case, it is important to note that if fleets from different countries exploit the same areas, the sampling effort may have to be proportionally distributed among countries.

TABLE 6
Example of number of fishing trips to sample by year and coverage (%) for a fleet composed of small-scale fishing vessels

Method	Annual fishing trips to sample	Coverage	Comments
Interviews	1 100	4%	10 vessels interviewed weekly (information of entire week)
Self-sampling with logbooks	1 430	5.2%	13 vessels filling logbooks

4.5 TRAINING AND IDENTIFICATION GUIDES

To ensure correct identification of the species encountered, a handbook with species identification guidelines should be made available to observers on board, interviewers and fishers participating in the sampling (Serena, 2007; Iglésias, 2013; Domingo *et al*., 2014; Barone, Serena and Dimech, 2018). Training on species identification, safe handling, and knowledge of local species names is also highly recommended. Similarly, the completion of data templates may require some training to help observers and fishers fill in the information correctly and consistently. Periodically, practical sessions with observers to clarify what should be entered will be hugely beneficial in ensuring more accurate data.

5. VULNERABLE SPECIES INCIDENTAL CATCH ESTIMATION

The final objective of a bycatch monitoring programme is to know the extent of the problem in each specific fishery, and then to be able to mitigate negative impacts on vulnerable species. For this reason, an estimate of the total number of individuals of vulnerable species caught by the fishing fleets is necessary. The key point in obtaining a correct estimation of the total bycatch of vulnerable species is to have a robust sampling programme, with adequate coverage and reliable information. The information needed for the estimation is summarized in Table 7.

TABLE 7
Variables needed for estimation of total number of vulnerable specimens caught

Variable	Description
N	Sum of number of individuals of each vulnerable species caught in each sampled fishing trip (ni) ($N = \sum_i n_i$)
D	Number of sampled fishing trips
F	Total number of fishing trips carried out during reference year by analysed fleet segment (or an estimate)

[a] For each of the methodologies applied and each species caught for a specific fleet segment.
Note: For benthic species (see chapter 6), total biomass in kg should be used, instead of the sum of individuals.

From the two first variables in Table 7, we can compute the bycatch rate (T), per species and fleet segment, as:

$$T = \frac{N}{D}$$

From the bycatch rate, we can compute the estimation of individuals caught (I) by that fleet as:

$$I = T \cdot F$$

We can also calculate some dispersion measures, such as standard deviation (SD), as:

$$SD = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$$

Where n is the number of measurements for computing the mean (in this case, it would be the number of sampling methodologies used, as we compute the mean based on a value for each methodology).

Or we can compute the standard error (SE) as:

$$SE = \frac{SD}{\sqrt{n}}$$

Where n is as above.

Table 8 shows an example of the raising procedure based on data from Tables 3 and 4 (subsection 4.4).

In this case, we obtain three different bycatch rates, from 0.8 percent (through interviews) to 1.7 percent (through on-board observers), and three different values of total number of individuals of a species caught for this fleet segment, from 103 (through interviews) to 217 (through on-board observers) individuals caught by year. If we trust equally in all the methodologies applied, we can compute a single average of the three estimates (*I*), which will result in 148 individuals, with a standard deviation of 60.2 or a standard error of 34.8. This means that the probability (*I*) of catching a vulnerable species is 148 (*T*)/13 000 (*F*) = 0.011, which represents 1.1 percent.

TABLE 8
Vulnerable species estimation

	Methods		
	Interviews	*Self-sampling with logbooks*	*Observers*
Planned fishing trips to sample by year	650	1 300	65
N	5	12	1
D	630	1 250	60
T	0.008	0.010	0.017
F	13 000	13 000	13 000
I	103	125	217

Notes: N – sum of number of individuals of each vulnerable species caught/recorded during a single sampled fishing trip; D – number of sampled fishing trips by methodology; T – bycatch rate (T=N/D); F – total number of fishing trips (= fishing days) of analysed fleet segment; and I – estimation of individuals caught (I=T*F).

As the estimation procedure is carried out for each of the methodologies used in the sampling, it is possible to validate the results among methodologies. In this case, the results from the interviews and self-sampling are more similar than when compared with on-board observers. It will be necessary to assess the reasons for this difference, which could be related to bad reporting from fishers or to an inadequate number of sampled trips. For instance, in the case of on-board observers, only one individual was caught in the entire year, which probably reflects the low number of sampling trips and thus the results are overestimated. In this case, as the results from the interviews and self-sampling are more robust, it would be possible to redirect the effort of these methodologies to increase the sampling from on-board observers. Data from scientific surveys and stranding data should not be used to extrapolate bycatch estimates for a target population, as they are not representative of the commercial fishing bycatch, although they may be used to complement the study.

Once the information is raised to the total fishing trips of the specific fleet segment, data should be reported using the reporting file included in Annex 12.

6. BENTHIC SPECIES

Benthic species are the components of an invertebrate community that spend the majority of their lifecycle living in close association with the surface of the sea floor. Depending on the area, habitat type and fishing practice, they can constitute an important part of the catch. Some benthic species are the key element of the food web and serve as the primary food source for fish and other higher organisms, playing a major role also in the maintenance, well-being and dynamics of the ecosystem. Some national laboratories already record this benthic component, although no agreed protocols exist for the collection and submission of data. The collection of such data (e.g. presence and abundance of different macrobenthic species) through on-board observations would provide a unique opportunity to increase knowledge of benthic assemblages and to produce basic information on their distribution within the region.

However, owing to the difficulty of collecting information on all benthic species (Figure 5), attention should focus mainly on vulnerable benthic species that may form vulnerable marine ecosystems as defined by FAO (FAO 2009c; FAO 2017a, 2017b; GFCM 2018b, 2018c). VMEs are characterized by slow resistance and resilience from environmental short-term or chronic disturbance. They are easily disturbed and very slow to recover, or may never recover from such disturbance. VMEs are therefore highly susceptible to the impact of bottom fishing gear (i.e. significant adverse impact of fisheries) (FAO 2009c). It is important to underline that the presence of individuals of vulnerable benthic species does not necessarily imply the occurrence of a VME but specific communities, habitats and sea-bottom features may display characteristics consistent with the possible occurrence of VMEs.

FIGURE 5
Benthic macroinvertebrates in the catch composition

Among VME indicator taxa, corals (phylum Cnidaria) and sponges (phylum Porifera) are known to be the main habitat-forming structures, often with numerous species living within or around their body structures (Figure 6 and Annex 1.c).

The GFCM has defined a series of VME indicators such as features, habitats and taxa for the Mediterranean Sea (Box 1) which, whenever possible should be recorded and reported in Annex 1.c.

BOX 1

Mediterranean VME indicator: features (a), habitats (b) and taxa (c)

(a) Mediterranean VME indicator features

The following features potentially support VMEs:

- Seamounts and volcanic ridges
- Canyons and trenches
- Steep slopes
- Submarine reliefs (slumped blocks, ridges, cobble fields, etc.)
- Cold seeps (pockmarks, mud volcanoes, reducing sediment, anoxic pools, methanogenetic hard bottoms)
- Hydrothermal vents

(b) Mediterranean VME indicator habitats

The following habitats potentially support VMEs:

- Cold-water coral reefs
- Coral gardens
  - Hard-bottom coral garden
  - Soft-bottom coral gardens
- Sea pen fields
- Deep-sea sponge aggregations
  - "Ostur" sponge aggregations
  - Hard-bottom sponge gardens
  - Glass sponge communities
  - Soft-bottom sponge gardens
- Tube-dwelling anemone patches
- Crinoid fields
- Oyster reefs and other giant bivalves
- Seep and vent communities
- Other dense emergent fauna

(c) Mediterranean VME indicator taxa

Phylum	Class	Subclass (Order)
Cnidaria	Anthozoa	Hexacorallia (Antipatharia, Scleractinia)
		Octocorallia (Alcyonacea, Pennatulacea)
		Ceriantharia
	Hydrozoa	Hydroidolina
Porifera (sponges)	Demospongiae	
	Hexactinellida	Amphidiscophora
		Hexasterophora
Bryozoa	Gymnolaemata	
	Stenolaemata	
Echinodermata	Crinoidea	Articulata
Mollusca	Bivalvia	Gryphaeidae (*Neopycnodonte cochlear, N. zibrowii*)
		Heterodonta* (Lucinoida) (e.g. *Lucinoma kazani*)
		Pteriomorphia* (Mytiloida) (e.g. *Idas modiolaeformis*)
Annelida*	Polychaeta	Sedentaria (Canalipalpata) (e.g. *Lamellibrachia anaximandri, Siboglinum* spp.)
Arthropoda*	Malacostraca	Eumalacostraca (Amphipoda) (e.g. *Haploops* spp.)

*only chemosynthetic species that indicate the presence.

On-board observers can routinely identify and report data on the vulnerable indicator taxa and provide useful information on VMEs. Ideally, once the catch has been sorted, macrobenthic individuals should be identified to the minimum taxonomic level – and species is obviously the basic taxonomic level of reference. Many species are difficult to identify owing to scarcity of taxonomic expertise (e.g. levels of taxonomic expertise on board vessels can be variable) and consequently a high risk of misclassification; or to the fact that some species still await formal scientific description. In these cases, aggregation of species to higher taxonomic levels (e.g. family or genus) and/or their assignment to morphological groups according to their growth form (e.g. massive, tubular, globular, arborescent, stalked, fan-shaped, lollipop-shaped, cup-shaped, etc. – see Annex 1.c) could be recorded. In some cases, for correct identification of the species, biological samples should be collected and brought to the laboratory and/or photographic documentation should be made. Coupled with photographic documentation, it is also highly recommended to report on the colour, consistency (e.g. hard, soft, cartilaginous) and form of benthic species. For each identified species (or family/genus), a minimum set of parameters, such as the total number of individuals caught per fishing haul and weight, should be reported (see Annex 6). Once collected, data could serve to produce information regarding the possible occurrence of VMEs and species richness (i.e. number of species), abundance and biomass (i.e. weight).

FIGURE 6
Benthic species of sponges and corals

Note: Some benthic species of sponges (e.g. *Suberites* spp.; *Geodia barreti*) and corals (e.g. *Desmophyllum dianthus*; *Pennatula rubra*) forming VMEs and that are frequently present in the catch composition.
Suberites sp. ©Maurizio Pansini; *Geodia barretti* ©Joana Xavier; *Desmophyllum dianthus* ©Marzia Bo; *Pennatula rubra* ©Marzia Bo

Depending on various aspects (e.g. time availability, resources, expertise, space, etc.), information on other benthic species – such as Bryozoa, Echinodermata (e.g. sea stars, sea urchins, sea cucumbers), Crustacea, Mollusca (e.g. bivalves and gastropods), Annelida (e.g. polychaetes), Tunicata (e.g. ascidians) – could also be recorded on board (Figure 7) and reported in Annex 6.

FIGURE 7
Species of macroinvertebrates present in the catch

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7. MARINE LITTER

Litter in the marine environment not only has negative environmental effects, but could also have negative economic and social impacts on fisheries (UNEP/MAP, 2015). So far, data collection on marine litter has been inconsistent and geographically restricted to some areas in the Mediterranean and the Black Sea, which is why understanding of these impacts is still limited (Fiorentino *et al*., 2013). Standardized research data on the problem of litter in the whole region are still necessary for statistical purposes and, in this case, observer programmes could be a source of information. Even if assessment of marine litter is beyond the scope of this document, during each fishing observation it would be important to give a rough estimate of the quantity (weight) and quality (type) of any macro-litter material that may be brought up by fishing operations (e.g. plastics, wood, metals, glass, rubber, clothing, fishing gear, petrochemicals, etc.). An indicative list of relevant data to be provided is reported in Annex 13.

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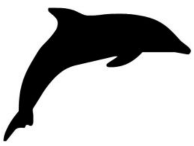
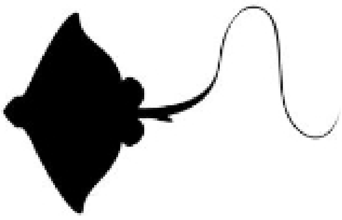
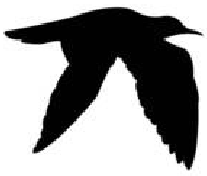
ANNEX 1. Vulnerable species

ANNEX 1.a. VULNERABLE SPECIES

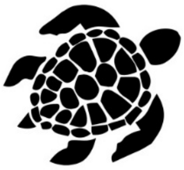
The list of vulnerable species is included in Annex II (endangered or threatened species) and Annex III (species whose exploitation is regulated) to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention). The list also contains the amendments to Annexes II and III to the Protocol Concerning Specially Protected Areas and Biological Diversity (SPA/BD) in the Mediterranean (2012/510/EU: Council Decision of 10 July 2012 establishing the position to be adopted on behalf of the European Union with regard to the amendments to Annexes II and III to the SPA/BD in the Mediterranean, of the Barcelona Convention, adopted by the Seventeenth Meeting of the Contracting Parties, Paris, France, 8–10 February 2012).

Group of vulnerable species	Family	Species	Common name
Cetaceans 	Balaenopteridae	*Balaenoptera acutorostrata*	Common minke whale
		Balaenoptera borealis	Sei whale
		Balaenoptera physalus	Fin whale
		Megaptera novaeangliae	Humpback whale
	Balaenidae	*Eubalaena glacialis*	North Atlantic right whale
	Physeteridae	*Physeter macrocephalus*	Sperm whale
		Kogia sima	Dwarf sperm whale
	Phocoenidae	*Phocoena phocoena*	Harbour porpoise
	Delphinidae	*Steno bredanensis*	Rough-toothed dolphin
		Grampus griseus	Risso's dolphin
		Tursiops truncatus	Common bottlenose dolphin
		Stenella coeruleoalba	Striped dolphin
		Delphinus delphis	Common dolphin
		Pseudorca crassidens	False killer whale
		Globicephala melas	Long-finned pilot whale
		Orcinus orca	Killer whale
	Ziphiidae	*Ziphius cavirostris*	Cuvier's beaked whale
		Mesoplodon densirostris	Blainville's beaked whale
Seals	Phocidae	*Monachus monachus*	Mediterranean monk seal

Group of vulnerable species	Family	Species	Common name
Sharks, Rays, Chimaeras 	Alopiidae	*Alopias vulpinus*	Common thresher
	Carcharhinidae	*Carcharhinus plumbeus*	Sandbar shark
		Carcharodon carcharias	Great white shark
		Prionace glauca	Blue shark
	Centrophoridae	*Centrophorus granulosus*	Gulper shark
	Cetorhinidae	*Cetorhinus maximus*	Basking shark
	Gymnuridae	*Gymnura altavela*	Spiny butterfly ray
	Hexanchidae	*Heptranchias perlo*	Sharpnose sevengill shark
	Lamnidae	*Isurus oxyrinchus*	Shortfin mako
		Lamna nasus	Porbeagle
	Myliobatidae	*Mobula mobular*	Devil fish
	Odontaspididae	*Carcharias taurus*	Sand tiger
		Odontaspis ferox	Small-tooth sand tiger shark
	Oxynotidae	*Oxynotus centrina*	Angular rough shark
	Pristidae	*Pristis pectinata*	Smalltooth sawfish
		Pristis pristis	Common sawfish
	Rajidae	*Dipturus batis*	Blue skate
		Leucoraja circularis	Sandy ray
		Leucoraja melitensis	Maltese skate
		Rostroraja alba	White skate
	Rhinobatidae	*Rhinobatos cemiculus*	Blackchin guitarfish
		Rhinobatos rhinobatos	Common guitarfish
	Sphyrnidae	*Sphyrna lewini*	Scalloped hammerhead
		Sphyrna mokarran	Great hammerhead
		Sphyrna zygaena	Smooth hammerhead
	Squatinidae	*Squatina aculeata*	Sawback angelshark
		Squatina oculata	Smoothback angelshark
		Squatina squatina	Angelshark
	Triakidae	*Galeorhinus galeus*	School/Tope shark

Group of vulnerable species	Family	Species	Common name
Seabirds 	Falconidae	*Falco eleonorae*	Eleonora's falcon
	Alcedinidae	*Ceryle rudis*	Pied kingfisher
		Halcyon smyrnensis	White-throated kingfisher
	Charadriidae	*Charadrius alexandrinus*	Kentish plover
		Charadrius leschenaultii columbinus	Greater sand plover
	Hydrobatidae	*Hydrobates pelagicus melitensis**	European storm-petrel (Mediterranean)
		*Hydrobates pelagicus**	European storm-petrel
	Laridae	*Larus audouinii**	Audouin's gull
		*Larus armenicus**	Armenian gull
		*Larus genei**	Slender-billed gull
		*Larus melanocephalus**	Mediterranean gull
		*Sternula albifrons**	Little tern
		*Thalasseus bengalensis**	Lesser crested tern
		*Thalasseus sandvicensis**	Sandwich tern
		*Hydroprogne caspia**	Caspian tern
		*Gelochelidon nilotica**	Common Gull-billed tern
	Pandionidae	*Pandion haliaetus*	Osprey
	Pelecanidae	*Pelecanus crispus*	Dalmatian pelican
		Pelecanus onocrotalus	Great white pelican
	Phalacrocoracidae	*Gulosus aristotelis desmarestii*	European shag (Mediterranean)
		Microcarbo pygmaeus	Pygmy cormorant
	Phoenicopteridae	*Phoenicopterus roseus*	Greater flamingo
	Procellariidae	*Calonectris diomedea**	Scopoli’s shearwater
		*Calonectris borealis**	Cory’s shearwater
		*Puffinus yelkouan**	Yelkouan shearwater
		*Puffinus mauretanicus**	Balearic shearwater
	Scolopacidae	*Numenius tenuirostris*	Slender-billed curlew

*The only birds which can be considered as seabirds. The other species in the table are mentioned as “aves” in Annex II of the Barcelona Convention. Some of them belong to the so-called water-bird or aquatic bird (e.g. birds that inhabit or depend on bodies of water or wetland areas).

Group of vulnerable species	Family	Species	Common name
Sea turtles 	Cheloniidae	*Caretta caretta*	Loggerhead turtle
		Chelonia mydas	Green turtle
		Eretmochelys imbricata	Hawksbill Turtle
		Lepidochelys kempii	Kemp's ridley sea turtle
		Lepidochelys olivacea	Olive ridley sea turtle
	Dermochelyidae	*Dermochelys coriacea*	Leatherback sea turtle
	Trionychidae	*Trionyx triunguis*	African softshell turtle

ANNEX 1.b. RARE ELASMOBRANCH SPECIES

This list reports elasmobranch species included in the IUCN Red List of Threatened Species www.iucnredlist.orgwww.iucnredlist.org (www.iucnredlist.org) or that are considered rare in the Mediterranean and the Black Sea (Bradai, Saidi and Enajjar, 2012). www.iucn.org/sites/dev/files/content/documents/brochure_medredlist_sharks.pdf

Group of rare species	Family	Species	Common name
Sharks, Rays, Chimaeras 	Alopiidae	*Alopias superciliosus*	Bigeye thresher
	Hexanchidae	*Hexanchus nakamurai*	Bigeyed sixgill shark
	Echinorhinidae	*Echinorhinus brucus*	Bramble shark
	Squalidae	*Squalus megalops*	Shortnose spurdog
	Centrophoridae	*Centrophorus uyato*	Little gulper shark
	Somniosidae	*Centroscymnus coelolepis*	Portugese dogfish
		Somniosus rostratus	Little sleeper shark
	Lamnidae	*Isurus paucus*	Longfin mako
	Scyliorhinidae	*Galeus atlanticus*	Atlantic sawtail catshark
	Carcharhinidae	*Carcharhinus altimus*	Bignose shark
		Carcharhinus brachyurus	Bronze whaler shark
		Carcharhinus brevipinna	Spinner shark
		Carcharhinus falciformis	Silky shark
		Carcharhinus limbatus	Blacktip shark
		Carcharhinus melanopterus	Blacktip reef shark
		Carcharhinus obscurus	Dusky shark
		Galeocerdo cuvier	Tiger shark
		Rhizoprionodon acutus	Milk shark
	Torpedinidae	*Tetronarce nobiliana*	Great torpedo ray
		Torpedo sinuspersici	Variable torpedo ray
	Rajidae	*Dipturus nidarosiensis*	Norwegian skate
		Leucoraja fullonica	Shagreen skate
		Leucoraja naevus	Cuckoo skate
		Raja brachyura	Blonde skate
		Raja montagui	Spotted skate
		Raja polystigma	Speckled skate
		Raja radula	Rough skate
		Raja undulata	Undulate skate
	Dasyatidae	*Bathytoshia centroura*	Roughtail stingray
		Dasyatis marmorata	Marbled stingray
		Dasyatis pastinaca	Common stingray
		Dasyatis tortonesei	Tortonese's stingray
		Himantura uarnak	Honeycomb whipray
		Taeniurops grabata	Round stingray
	Myliobatidae	*Aetomylaeus bovinus*	Bullray
	Rhinopteridae	*Rhinoptera marginata*	Lusitanian cownose ray
	Sphyrnidae	*Sphyrna tudes*	Smalleye hammerhead

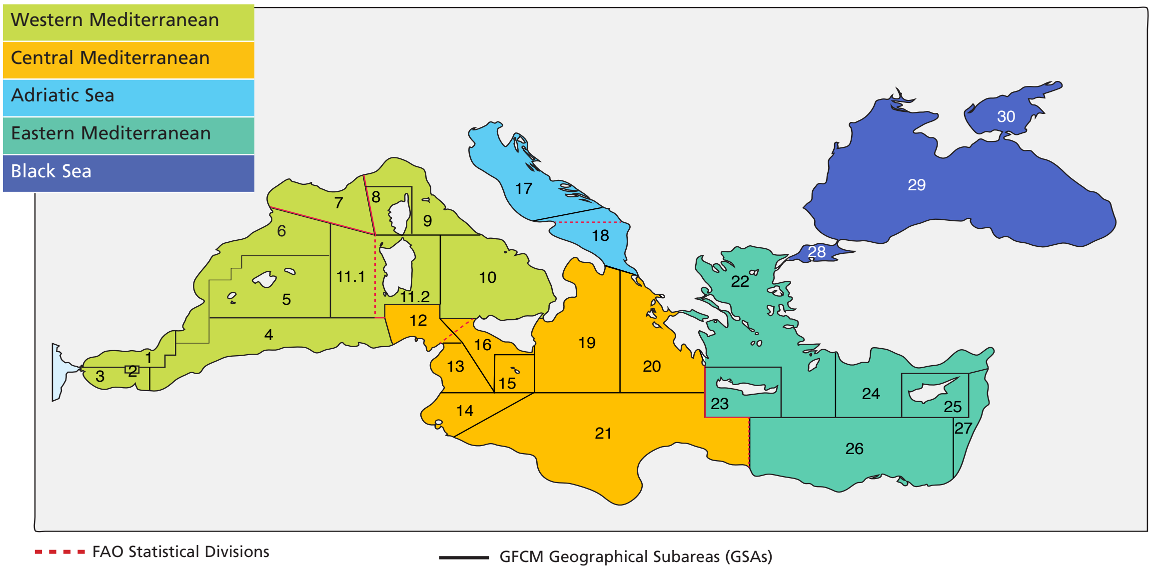
ANNEX 1.c. VULNERABLE BENTHIC SPECIES

Source: Identification of vulnerable deep-sea sponges by fishers and fishery observers (FAO, 2017a).The figure is available in high resolution online (www.fao.org/3/a-i6945e.pdf).

Source: Identification of vulnerable deep-sea corals by fishers and fishery observers (FAO, 2017b). The figure is available in high resolution online (www.fao.org/3/a-i7256e.pdf).

ANNEX 2. GFCM geographical subareas (GSAs) and subregions

GFCM subregions



GFCM GSAs

01 - Northern Alboran Sea	07 - Gulf of Lion	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus
02 - Alboran Island	08 - Corsica	14 - Gulf of Gabès	20 - Eastern Ionian Sea	26 - South Levant
03 - Southern Alboran Sea	09 - Ligurian Sea and Northern Tyrrhenian Sea	15 - Malta	21 - Southern Ionian Sea	27 - Eastern Levant Sea
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - South of Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Islands	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic Sea	23 - Crete	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant Sea	30 - Azov Sea

Source: GFCM 2018a.

ANNEX 3. Templates for observers on board

Annex 3.a. On-board observation – vessel characteristics					
Name of data collector(s)					
Date					
ID. Fishing trip					
Country					
GSA					
					Notes
Vessel name*					
Fleet segment					
Total length of the vessel					
Power (kW)					
Gross tonnage (GT)					
Port of departure					
Port of arrival					
Gear specifications					
	1st gear	2nd gear	3rd gear	4th gear	**Notes**
Gear type					
Net length (m)					
Mesh size (cod-end – mm)					
Number of hooks					
Bait					
Number of lines					
Number of pots/traps					
Soak time (time during which fishing gear is actively in the water)					
Other					

*if available.

Instructions:

- ID fishing trip: identification code assigned to each fishing trip (unique).
- GSA: insert code of GSA as in Annex 2.
- Fleet segment: insert fleet segment code (i.e. vessel group + length class) as in Annex 10.
- Gear type: insert code of fishing gear, as reported in Annex 11 (e.g. set gillnets [GNS]). If, during a fishing trip, different gear have been used, insert each code separately in the respective columns. Then, based on type of gear, provide the different measures of effort (e.g. mesh size, number of hooks, etc.) in the corresponding column and row.

Annex 3.b. On-board observation – general information by fishing trip			
Date			
ID. Fishing trip			
			Notes
Total number of fishing operations			
Fishing hours			
Bycatch of vulnerable species (Y/N)			
Number of fishing operations with zero catch of vulnerable species			
General information on catch composition			**Notes**
Total landing (kg)			
Main commercial species in landing fraction			
Discard (kg and percentage) in catch composition	kg	%	**Notes**
Main species in discarded fraction			
Marine litter (Y/N)			

Instructions:

- ID fishing trip: identification code assigned to each fishing trip (as in Annex 3.a).
- Total number of fishing operations: insert total number of fishing operations carried out during same fishing trip.
- Fishing hours: insert total number of fishing hours carried out during that fishing trip (i.e. summing the hours of all fishing operations).
- Bycatch of vulnerable species (Y/N): insert 'yes' if during the fishing trip there has been incidental catch of vulnerable species and/or vulnerable marine benthic species (in this case, detailed information, by groups of species, should be reported in Annex 3.c, Annex 4 and Annex 6); otherwise insert 'no'. If, during a fishing operation, the presence of vulnerable species around the vessel has also been recorded, this should be reported in Annex 3.c.
- Fishing operations with zero catches: insert total number of fishing operations carried out during same fishing trip with zero catches of vulnerable species.
- Total landing: insert total landing in kilograms (kg) (or estimate) of commercial species caught during same fishing trip.
- Main commercial species in landing fraction: insert name (preferably scientific name, otherwise the common one) of main commercial species present in landed fraction.
- Discard in catch composition: insert total, cumulative discarded fraction (or estimate) during that fishing trip in kg and percentage (%).
- Main species in discarded fraction: insert name (preferably scientific name, otherwise the common one) of main species discarded.
- Marine litter (Y/N): insert 'yes' if marine litter has been recorded, otherwise insert 'no'. If 'yes', detailed data, by fishing trip, should be reported in the ad hoc template (see Annex 13).

Annex 3.c. On-board observation – general information on vulnerable species				
Date				
ID. Fishing trip				
ID. Fishing operation				
				Notes
Time of starting operation				
Time of ending operation				
Latitude (start and end) of fishing operation*				
Longitude (start and end) of fishing operation*				
Gear type				
Some details of gear configuration				
Depth (in metres)				
Environmental variables*				Notes
Cloud*				
Wind direction*				
Visibility*				
Light condition*				
Sea state*				
Vulnerable species caught				
	Species 1	Species 2	Species 3	Notes
Group of vulnerable species				
Family*				
Genus*				
Species				
Photo (Y/N)*				
Total number of individual(s) caught				
Total weight of individual(s) caught (kg)				
Condition at capture*				
Alive				
Dead				
Almost dead				
Not known				
Condition at release*				
Alive				
Dead				
Almost dead				
Not known				
Biological data collected (Y/N)				
Presence of vulnerable benthic species (Y/N)				
Presence of specimens around the vessel during fishing operations*				
Species/family/genus	**Number***		**Behaviour**	**Notes**

* if available.

Instructions:

- ID fishing trip: identification code assigned to each fishing trip (as in Annex 3.a).
- ID fishing operation: identification code assigned to each fishing observation during fishing trip (following a progressive numbering).
- Latitude (start and end) of fishing operation: insert latitude at beginning and end of each fishing operation (e.g. fishing hauls). This information is mandatory for ad hoc scientific monitoring surveys. Data should be inserted in degree, minutes and seconds (e.g. 40°51’59”N).
- Longitude (start and end) of fishing operation: insert longitude at beginning and end of each fishing operation (e.g. fishing hauls). This information is mandatory for ad hoc scientific monitoring surveys. Data should be inserted in degree, minutes and seconds (e.g. 124°4’58”W).
- Gear type: insert code of fishing gear as reported in Annex 11 (e.g. GNS).
- Some details of gear configuration: if needed, more information on gear could be reported here (e.g. distribution of weights, floats, signals. etc.) that could be relevant to assessing bycatch.
- Depth (in metres): mean depth or depth range (from xx m to xx m), in metres, of the fishing operation carried out during that fishing trip.
- Environmental variables: whenever possible insert the condition of requested environmental variables, using codes in Annex 14.
- Photo (Y/N): insert ‘yes’ or ‘no’ to indicate if specimen has been photographed and, if so, assign an identification code to photo.
- Total weight of individual(s) caught (kg): whenever possible, report precise value, otherwise insert estimate.
- Condition at capture and at release: for each species, indicate number of individuals caught and released alive, dead, almost dead or in a state not known.
- Biological data collected (Y/N): insert ‘yes’ if biological data have also been recorded for the reported vulnerable species, such as length, weight, sex and age (those data should then be reported by groups of species, as requested in Annex 4. Templates for biological data), otherwise insert ‘no’.
- Presence of vulnerable benthic species (Y/N): insert ‘yes’ if vulnerable benthic species (see Annex 1.c) have been caught, otherwise insert ‘no’. If ‘yes’, detailed data should be reported in the ad hoc template (see Annex 6).
- Presence of specimens around vessel during fishing operation: if during a single fishing operation, there are sightings of vulnerable specimens, insert name of the species (or the genus/family) with a short description of behaviour (e.g. feeding, playing, etc.).

ANNEX 4. Templates for biological data

Annex 4.a. Data on marine mammals

Source	On-board observers (Y/N)		**ID fishing trip**		**ID self-sampling operation**		
	Self-sampling operation (Y/N)		**ID fishing operation**		**ID stranding observation**		
	Stranding observation (Y/N)		**Date**				

Species	**ID specimen**	**Total body length (TBL cm)***	**Girth in front of the dorsal fin (GFD cm)***	**Other body measures (cm)***			**Weight (kg)***	**Sex***	**Photo (yes/ no)***	**Position of specimen in gear***	**Notes**
Comments											

* If available.

Note: Data should be reported by species. Name of genus or family can be inserted only if detailed information by species is not available.

Instructions:

- Source: indicate source of data and then report code for:
  - ID fishing trip: identification code assigned to each fishing trip (as in Annex 3.a).
  - ID fishing operation: identification code assigned to each fishing observation during a fishing trip (as in Annex 3.c).
  - ID self-sampling operation: identification code assigned to self-sampling operation (as in Annex 8.b).
  - ID stranding observation: identification code assigned to stranding observation (as in Annex 9).
- ID specimen: identification code assigned to each single individual caught.
- Total body length (TBL in cm): insert requested length measure as detailed in Annex 5 (Figure A).
- Girth in front of dorsal fin (GFD in cm): insert requested length measure as detailed in Annex 5 (Figure A1).
- Other body measurements: whenever possible, insert other length measures as detailed in Annex 5 (Figure A2).
- Weight (kg): whenever possible, and for each specimen caught, report total weight, otherwise insert estimate.
- Sex: when available, insert code for sex of individual(s) – M (male), F (female), U (undetermined), ND (not determined).
- Photo (Y/N): insert 'yes' or 'no' to indicate if specimen has been photographed and, if so, assign an identification code to photo. For cetaceans, detail photos of dorsal fin or any remarkable sign would also be useful, facilitating identification of the animal in existing photo–identification catalogue(s) for the area (where available).
- Position of specimen in gear: whenever possible, please specify position of specimen in gear at the moment of capture (e.g. near float or lead lines, in middle of net, etc.).
- Notes: any additional information.

Annex 4.b. Data on sharks, rays and chimaeras							
Source	**On-board observers (Y/N)**			**ID fishing trip**		**ID self-sampling operation**	
	Self-sampling operation (Y/N)			**ID fishing operation**		**ID stranding observation**	
	Stranding observation (Y/N)			**Date**			
Species	**ID specimen**	**Total body length (cm)***	**Disc width (cm)***	**Weight (kg)***	**Sex***	**Photo (yes/no)***	**Notes**
Comments							

* If available.

Note: Data should be reported by species. Name of genus or family can be inserted only if detailed information by species is not available.

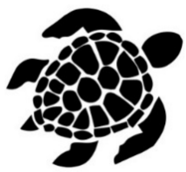
Instructions:

- Source: indicate source of data and then report code of:
  - ID fishing trip: identification code assigned to each fishing trip (as in Annex 3.a).
  - ID fishing operation: identification code assigned to each fishing observation during a fishing trip (as in Annex 3.c).
  - ID self–sampling operation: identification code assigned to self–sampling operation (as in Annex 8.b).
  - ID stranding observation: identification code assigned to stranding observation (as in Annex 9).
- ID specimen: identification code assigned to each single individual caught.
- Total body length (cm): insert length measure as detailed in Annex 5 (Figure A3).
- Disc width (cm): insert width of disc in rays as detailed in Annex 5 (Figure A3).
- Weight (kg): whenever possible, and for each specimen caught, report total weight, otherwise insert estimate.
- Sex: when available, insert code for sex of individual(s) – M (male), F (female), U (undetermined), ND (not determined) (Figure A4).
- Photo (Y/N): insert ‘yes’ or ‘no’ to indicate if specimen has been photographed and, if so, assign an identification code to photo.
- Notes: any additional information.

Annex 4.c. Data on sea turtles						
Source	**On-board observers (Y/N)**		**ID fishing trip**		**ID self-sampling operation**	
	Self-sampling operation (Y/N)		**ID fishing operation**		**ID stranding observation**	
	Stranding observation (Y/N)		**Date**			

Species	**ID specimen**	**Curved carapace length (cm)***	**Curved carapace width (cm)***	**Tail measurements***			**Weight (kg)***	**Sex***	**Photo (yes/no)***	**Notes**
				a)	**b)**	**c)**				

Comments



* If available.

Note: Data should be reported by species. Name of genus or family can be inserted only if detailed information by species is not available.

Instructions:

- Source: indicate the source of the data and then report the code of:
  - ID fishing trip: identification code assigned to each fishing trip (as in Annex 3.a).
  - ID fishing operation: identification code assigned to each fishing observation during a fishing trip (as in Annex 3.c).
  - ID self–sampling operation: identification code assigned to self–sampling operation (as in Annex 8.b).
  - ID stranding observation: identification code which has been assigned to stranding observation (as in Annex 9).
- ID specimen: identification code assigned to each single individual caught.
- Curved carapace length (cm): insert curved carapace length as detailed in Annex 5 (Figure A6b).
- Curved carapace width (cm): insert curved carapace width as detailed in Annex 5 (Figure A6a).
- Tail measurements (cm): whenever possible, and for each specimen caught, insert carapace tip to tail measurement as detailed in Annex 5 (Figure A6c).
- Weight (kg): whenever possible, and for each specimen caught, report total weight, otherwise insert estimate.
- Sex: when available, insert the code for the sex of individual(s) – M (male), F (female) U (undetermined), ND (not determined).
- Photo (Y/N): insert 'yes' or 'no' to indicate if specimen has been photographed and, if so, assign an identification code to photo.
- Notes: any additional information.

Annex 4.d. Data on seabirds

Source	**On-board observers (Y/N)**		**ID fishing trip**		**ID self-sampling operation**	
	Self-sampling operation (Y/N)		**ID fishing operation**		**ID stranding observation**	
	Stranding observation (Y/N)		**Date**			

Species	**ID specimen**	**Body measures (mm)**				**Position of specimen in gear***	**Step of the fishing operation***	**Breeding status***	**Sex***	**Photo (yes/ no)***	**Notes**
		Bill length*	**Wing length***	**Tarsus length***	**other***						

Comments

* If available.

Note: Data should be reported by species. Name of genus or family can be inserted only if detailed information by species is not available.

Instructions:

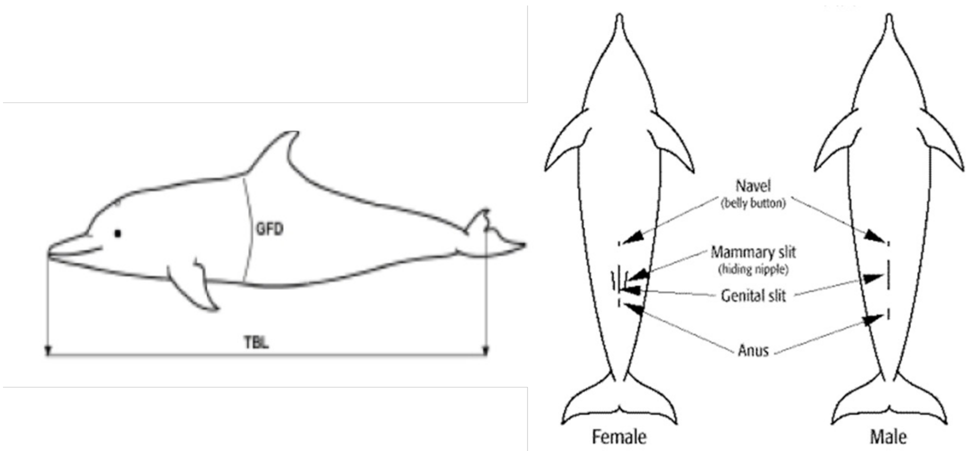
- Source: indicate source of data and then report code of:
- ID fishing trip: identification code assigned to each fishing trip (as in Annex 3.a).
  - ID fishing operation: identification code assigned to each fishing observation during a fishing trip (as in Annex 3.c).
  - ID self–sampling operation: identification code assigned to self–sampling operation (as in Annex 8.b).
  - ID stranding observation: identification code assigned to stranding observation (as in Annex 9).
- ID specimen: identification code assigned to each single individual caught.
- Body measures (mm): insert, if available, bill length, wing length and tarsus length and any other important measures (as detailed in Annex 5, Figure A5).
- Position of specimen in gear: whenever possible, please specify position of seabird in gear at the moment of capture (e.g. near float or lead lines, in middle of net, etc.)
- Step of fishing operation: describe during which stage of fishing operation (e.g. setting, hauling. etc.) seabird has been captured.
- Breeding status: whenever possible, report if seabird caught was immature, juvenile or adult.
- Sex: when available, insert code for sex of individual(s) – M (male), F (female), U (undetermined), ND (not determined).
- Photo (Y/N): insert 'yes' or 'no' to indicate if specimen has been photographed and, if so, assign an identification code to photo.
- Notes: any additional information.

ANNEX 5. Length measurements

ANNEX 5.a. CETACEANS

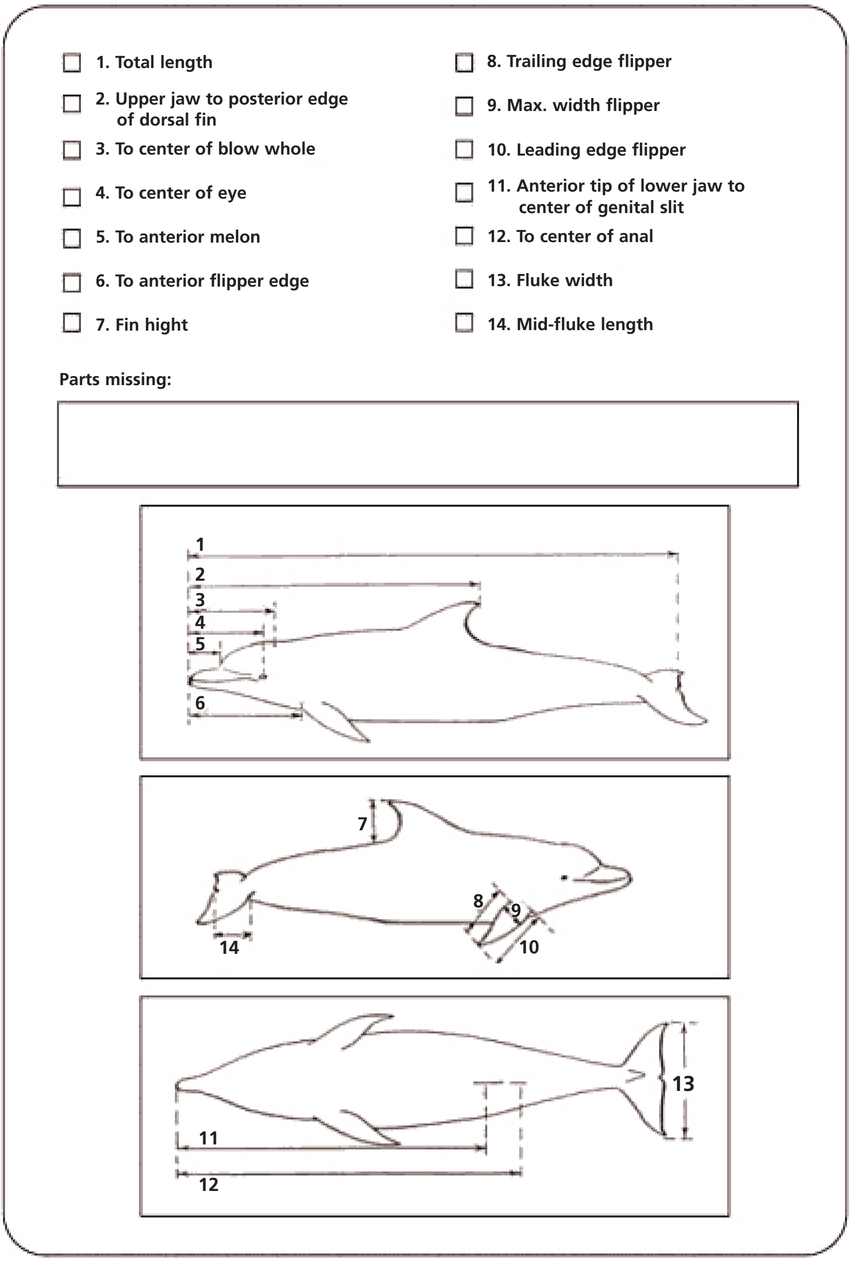
– Total body length (TBL, in cm, see Figure A1): from tip of snout to tip of caudal fin.
– Girth in front of dorsal fin (GFD, in cm, see Figure A1): girth measured in front of frontal fin.

FIGURE A1
Details of biological information (i.e. length and sex) for cetaceans



Source: MARE/2014/19, 2016.

FIGURE A2
Other body measures that could be collected for cetaceans



- ☐ 1. Total length
- ☐ 2. Upper jaw to posterior edge of dorsal fin
- ☐ 3. To center of blow whole
- ☐ 4. To center of eye
- ☐ 5. To anterior melon
- ☐ 6. To anterior flipper edge
- ☐ 7. Fin hight
- ☐ 8. Trailing edge flipper
- ☐ 9. Max. width flipper
- ☐ 10. Leading edge flipper
- ☐ 11. Anterior tip of lower jaw to center of genital slit
- ☐ 12. To center of anal
- ☐ 13. Fluke width
- ☐ 14. Mid-fluke length

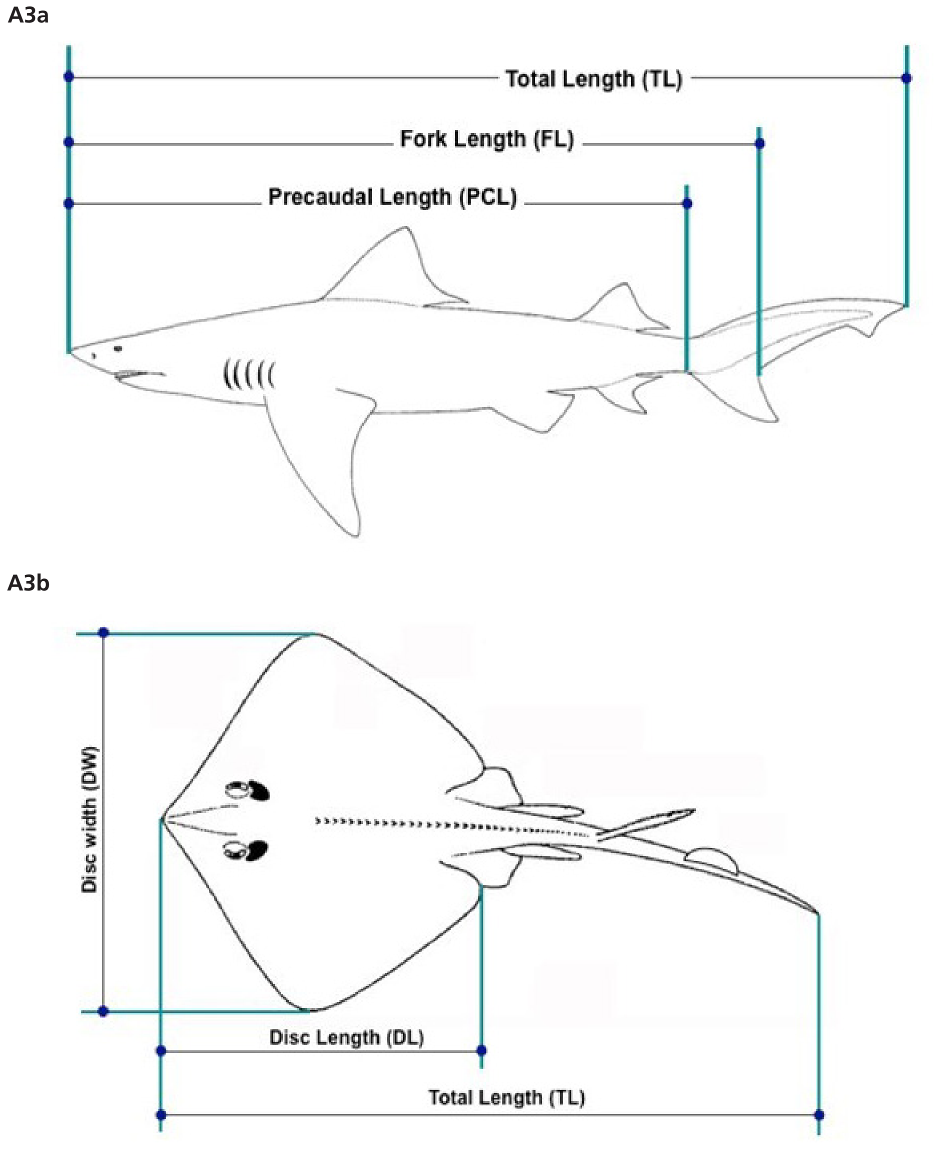
Parts missing:

Source: UN Environment/MAP, 2008.

ANNEX 5.b. SHARKS, RAYS AND CHIMAERAS

– Total length (cm, see Figure A3a): total body length (from the tip of the snout to the tip of the caudal fin) for sharks and rays, and anal length (from the tip of the snout to the anus) for chimaeras.
– Disc width (cm, see Figure A3b): width of the disc in rays.

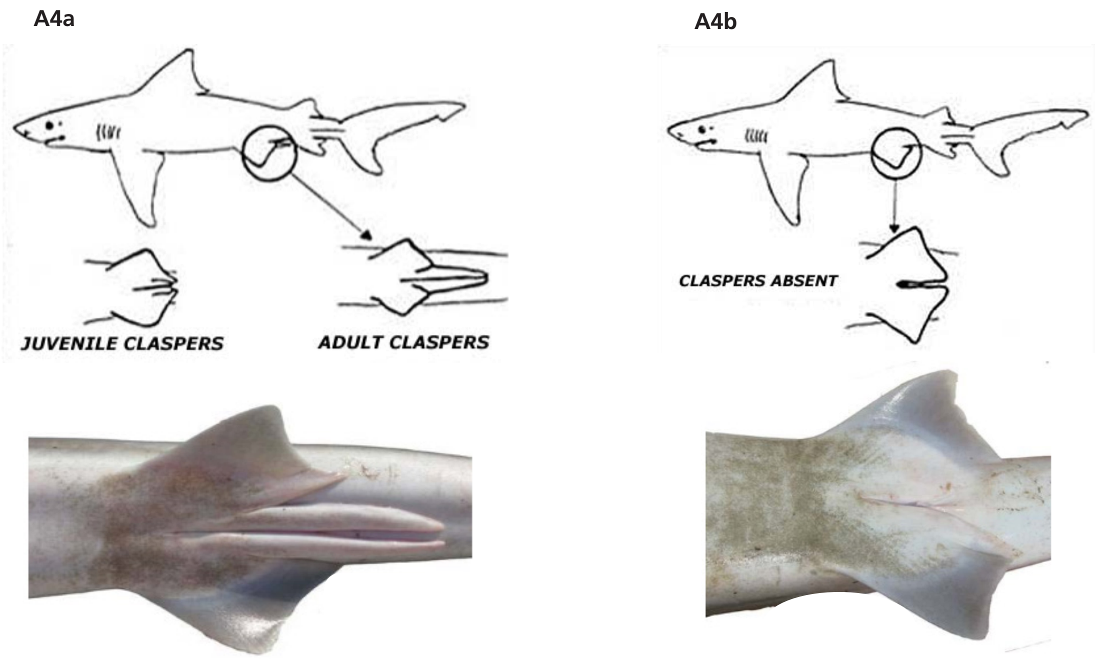
FIGURE A3
Details of measuring sharks and rays



Source: UN Environment/MAP-SPA/RAC, 2012.

For sharks, rays and skates, sex can be determined by the naked eye: pterygopods are organs found on male elasmobranchs (Figure A4). Each male has two pterygopods (or claspers), located along the inner side of the shark or the ray's pelvic fin, which are used in reproduction. All elasmobranchs have internal fertilization.

FIGURE A4
llustrations showing the sexual macroscopic determination of sex in elasmobranchs: A4a male, A4b female

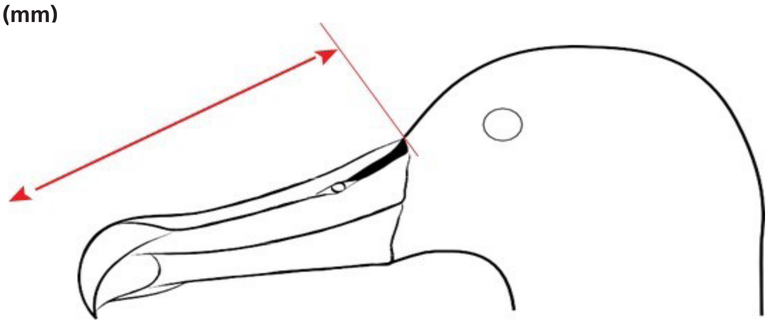


Source: Northeast Fisheries Science Center, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce.

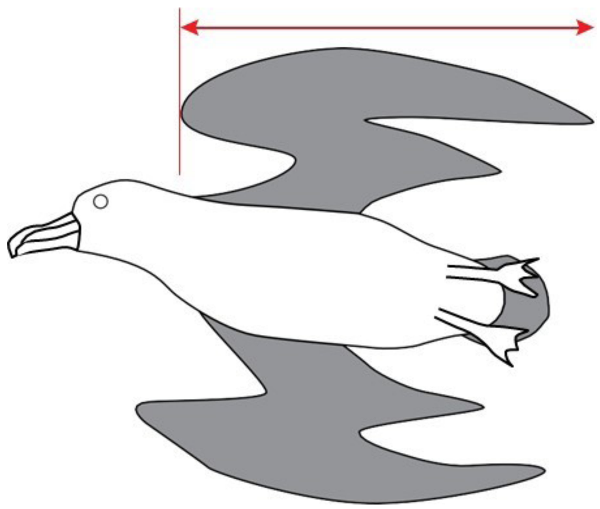
ANNEX 5.c. SEABIRDS

FIGURE A5
Details of measuring seabirds

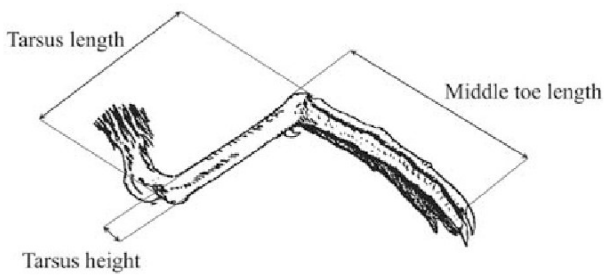
A5a – Bill length (mm)



A5b – Wing length (mm)



A5c – Tarsus length (mm)



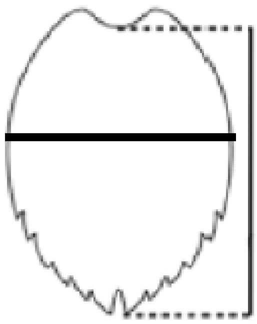
Note: Bill, wing and tarsus length measurements (in mm) may help identify the species.

ANNEX 5.d. SEA TURTLES

– Curved carapace width measured across widest span of carapace (cm).
– Curved carapace length (cm): carapace length measured from anterior point at midline (nuchal scute) to posterior tip of the supra-caudal, using a flexible tape (cm).

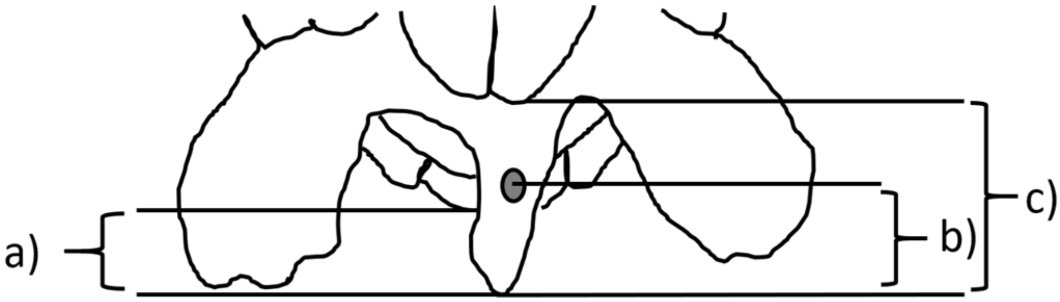
FIGURE A6
Curved carapace width and length measurements (A6a and A6b) and tail measurements (A6c) for sea turtles

A6a – Curved carapace width



A6b – Curved carapace length

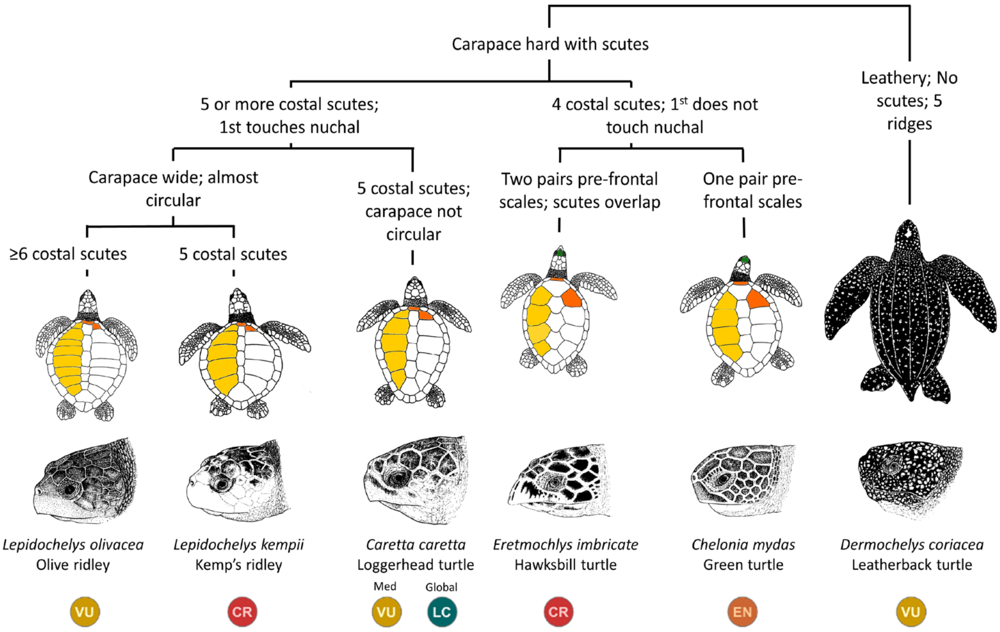
A6c – Tail measurements



Note: In figure A6c: a) carapace tip to tail tip; b) centre of cloaca to tail tip; and c) plastron tip to tail tip.
Source: MARE/2014/19, 2016; UNEP, 2011; tail measurement diagram modified from Casale *et al.*, 2005.

FIGURE A7

Details of measuring sea turtles and some details of the carapace 'scheme' for diverse species



Note: MARE/2014/19, 2016; UNEP, 2011; Snape, 2017.

ANNEX 6. Vulnerable benthic species

<table>
<tr><th colspan="6">Annex 6. Data on marine vulnerable benthic species</th></tr>
<tr><td>Date</td><td colspan="5"></td></tr>
<tr><td>Source</td><td colspan="5"></td></tr>
<tr><td>ID fishing trip</td><td colspan="5"></td></tr>
<tr><td>ID fishing operation</td><td colspan="5"></td></tr>
<tr><td></td><td colspan="2">Total live weight (kg)</td><td colspan="2">Percentage (%)</td><td>Notes</td></tr>
<tr><td>Sponges in the catch*</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>Corals in the catch*</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>Other benthic species in the catch*</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td colspan="2">Feature*</td><td colspan="2">Habitat*</td><td>Taxa*</td></tr>
<tr><td rowspan="5">VME Indicator*</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
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<tr><th colspan="6">Composition by species*</th></tr>
<tr><th>Species*</th><th>Family/genus/order/taxa/ morphological group</th><th>Total weight (kg)</th><th>Total number</th><th>Photo* (Y/N)</th><th>Notes</th></tr>
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<tr><td colspan="6">Comments</td></tr>
</table>

* If available.
- Don’t leave blank; report zero catches also.
- Refers to FAO Corals and Sponges Guidelines as in Annex 1.c (FAO, 2017a, 2017b).

Instructions:

– Source: indicate source of data (e.g. on-board observation; self-sampling operation, etc.)
– ID fishing trip: identification code assigned to each fishing trip (unique) (as in Annex 3.a).
– ID fishing operation: identification code assigned to each fishing operation during fishing trip (as in Annex 3.c).
– Total live weight (kg): insert total live weight (or estimate) of sponges, corals and all other vulnerable benthic species caught during a single fishing operation.
– Percentage (%): insert total vulnerable benthic fraction, by identified groups of species, caught during a single fishing operation.
– VME Indicator (Feature, Habitat, Taxa): If possible, record this information for each fishing trip and/or fishing operation (please refer to Box 1 – Chapter 6. Benthic Species).
– Composition by species: whenever possible, insert name of species. When specimens cannot be identified at species level, genus, family, order or taxa should be indicated. In cases where species identification is not possible (especially for sessile taxa), assign organisms to morphological groups according to their growth form (e.g. massive, tubular, globular, arborescent, stalked, fan-shaped, lollipop-shaped, cup-shaped – see Annex 1.c), coupled with information on their colour, consistency (e.g. hard/soft) and photographic documentation.
– Total weight (kg): insert total weight (or estimate) for each identified species of benthic marine macroinvertebrates caught during a single fishing operation.
– Total number: insert total number (or estimate) for each identified species of benthic marine macroinvertebrates caught during a single fishing operation.
– Photo (Y/N): insert ‘yes’ or ‘no’ to indicate if specimen has been photographed and, if so, assign an identification code to photo.

ANNEX 7. Questionnaire forms

Annex 7.a. Questionnaire on fishing vessel characteristics			
Interviewer			
Date of interview			
Port			
ID questionnaire			
Vessel name			
Vessel length			
Main gear			
Does vessel use any other gear during year? If so, explain which and indicate frequency of each fishing gear by year.			
Gear			
Gillnet		*Longlines*	
mesh size:		hook size:	
number of gillnets:		number of hooks per day:	
total net length:		distance between branch lines:	
net width:		number of lines per day:	
soak time (time during which fishing gear is actively in water):		soak time (time during which fishing gear is actively in water):	
depth range/position:		depth range/position:	
frequency:		frequency:	
fishing period:		fishing period:	
Trammel net		*Beach seine*	
external mesh size:		mesh size:	
internal mesh size:		total net length:	
number of trammel nets:		net width:	
total net length:		distance from shore:	
net width:		depth range/position:	
soak time (time during which fishing gear is actively in water):		frequency/period:	
depth range/position:		frequency:	
frequency:		fishing period:	
fishing period:			
Purse/surrounding seine		*Trawl or towed nets*	
mesh size:		mesh size (cod-end):	
total net length:		opening size:	
net width:		average speed during fishing operation:	
depth range:		depth range:	
frequency:		frequency:	
fishing period:		fishing period:	
Other gear information (e.g. average setting speed, use of floats and weights, distance and weight of consecutive weights, etc.):			

Number of fishing trips/days per month (average):	0–5	
	6–10	
	11–15	
	16–20	
	21–25	
	26–30	
Duration of a single fishing trip:	0–10 hours	
	10–24 hours	
	1–2 days	
	3–5 days	
	>5 days	
Number of fishing trips/days during year (average):		
Month(s) fished:		
In what season do you have the most fishing effort?		
Main target species of your fishing activity		
How many fishing vessels are there in port with same characteristics?		

Annex 7.b. Questionnaire by fishing trip						
Date of interview						
ID questionnaire						
Date of fishing trip						
Port of departure						
Port of arrival						
Total number of fishing operations						
Bycatch of vulnerable species (Y/N)						
Number of fishing operations with zero catch of vulnerable species						
Information on fishing area (e.g. depth range, position, sea bottom, etc.)						
Gear specifications						
	1st gear	**2nd gear**	**3rd gear**	**4th gear**	**Notes**	
Gear type						
Net length (m)						
Mesh size (codend - mm)						
Number of hooks						
Bait						
Number of lines						
Number of pots/traps						
Soak time (time during which fishing gear is actively in water)						
Other gear information						
General information on catch composition during fishing trip						
Total landing (kg)						
Main target species in catch						
Discard (kg and percentage) in catch composition	kg			%		
Main species in discard fraction						
Marine litter (kg and percentage) in catch composition	kg			%		
Benthic species (kg and percentage) in catch composition	kg			%		
Did you catch any of the following group of vulnerable species during your fishing trip?		Yes/No	Species			
Dolphins and whales						
Seals						
Sharks and rays						
Seabirds						
Sea turtles						
If yes, on average, how many individuals have been caught?		0	1 to 10	10 to 50	50 to 100	> 100
Dolphins and whales						
Seals						
Sharks and rays						
Seabirds						
Sea turtles						

<table>
<tr><th colspan="2">Condition at capture and at release</th><th colspan="2">Capture</th><th>Release</th><th>Notes</th></tr>
<tr><td colspan="2">Dolphins and whales</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2">Seals</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2">Sharks and rays</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2">Seabirds</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2">Sea turtles</td><td colspan="2"></td><td></td><td></td></tr>
<tr><th colspan="6">Benthic species composition</th></tr>
<tr><td>Species or family/genus/order/taxa</td><td>Total weight (kg)</td><td>Total number</td><td colspan="3">Notes/description</td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td></tr>
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<tr><td colspan="6">Additional comments</td></tr>
</table>

<table>
<tr><th colspan="7">Annex 7.c. Questionnaire on general information on bycatch of vulnerable species</th></tr>
<tr><td colspan="2">Date of interview</td><td colspan="5"></td></tr>
<tr><td colspan="2">ID questionnaire</td><td colspan="5"></td></tr>
<tr><td colspan="7">Reference period</td></tr>
<tr><td>Last week</td><td></td><td>Last month</td><td colspan="2"></td><td>Last year</td><td></td></tr>
<tr><td colspan="2">Did you catch any of the following group of vulnerable species? (Y/N)</td><td>Yes/No</td><td colspan="4">Species</td></tr>
<tr><td colspan="2">Dolphins and whales</td><td></td><td colspan="4"></td></tr>
<tr><td colspan="2">Seals</td><td></td><td colspan="4"></td></tr>
<tr><td colspan="2">Sharks and rays</td><td></td><td colspan="4"></td></tr>
<tr><td colspan="2">Seabirds</td><td></td><td colspan="4"></td></tr>
<tr><td colspan="2">Sea turtles</td><td></td><td colspan="4"></td></tr>
<tr><td colspan="2">If yes, on average, how many individuals have been caught?</td><td>0</td><td>1 to 10</td><td>10 to 50</td><td>50 to 100</td><td>> 100</td></tr>
<tr><td colspan="2">Dolphins and whales</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Seals</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Sharks and rays</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Seabirds</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Sea turtles</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">When more than one gear is used, please report name of gear</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">How many are released alive? (insert a number or a percentage)</td></tr>
<tr><td colspan="2">Dolphins and whales</td><td colspan="5"></td></tr>
<tr><td colspan="2">Seals</td><td colspan="5"></td></tr>
<tr><td colspan="2">Sharks and rays</td><td colspan="5"></td></tr>
<tr><td colspan="2">Seabirds</td><td colspan="5"></td></tr>
<tr><td colspan="2">Sea turtles</td><td colspan="5"></td></tr>
<tr><td colspan="2">In which months or seasons do you most commonly catch vulnerable species?</td><td colspan="5"></td></tr>
<tr><td colspan="2">In general, in which location/area do you catch them (including distance offshore)?</td><td colspan="5"></td></tr>
<tr><td colspan="2">In general, when you do catch a vulnerable species, what do you do with it?</td><td colspan="5"></td></tr>
<tr><td colspan="2">What is your opinion on factors influencing bycatch and on how to mitigate interactions (if any)?</td><td colspan="5"></td></tr>
<tr><td colspan="7">Additional comments</td></tr>
</table>

With the help of the accompanying illustrations, try to identify species of each group caught. Include information on number and if they were released dead or alive.

ANNEX 8. Self-sampling

Annex 8.a. Self-sampling – logbook for vessel characteristics and catch data					
Country					
GSA					
Date					
ID fishing trip					
Fleet segment					
					Notes
Vessel name*					
Port of departure					
Port of arrival					
Total length of vessel					
Power (kW)					
Gross tonnage					
Total number of fishing operations					
Bycatch of vulnerable species (Y/N)					
Number of fishing operations with zero catch of vulnerable species					
Gear specifications					**Notes**
	1st gear	**2nd gear**	**3rd gear**	**4th gear**	
Gear type					
Net length (m)					
Mesh size (cod-end – mm)					
Number of hooks					
Bait					
Number of lines					
Number of pots/traps					
Time during which fishing gear is actively in water (i.e. from setting to hauling time)					
Others					
General information on catch composition					**Notes**
Total landing (kg)					
Main commercial species in landing fraction					
Discard (kg and percentage), in catch composition	kg		%		**Notes**
Main species in discarded fraction					
Marine litter (kg and percentage)\ in catch composition	kg		%		Notes

* If available.

Instructions:

- GSA: insert code of GSA as in Annex 2.
- ID fishing trip: identification code assigned to each self–sampled fishing trip (unique).
- Fleet segment: insert fleet segment code (i.e. vessel group + length class) as in Annex 10.
- Total number of fishing operations: insert total number of fishing operations carried out during same fishing trip.
- Bycatch of vulnerable species (Y/N): insert 'yes' if there has been bycatch of vulnerable species during the fishing trip (in this case, information, by group of species, should be reported in Annex 8.b), otherwise insert 'no'.
- Number of fishing operations with zero catches: insert total number of fishing operations carried out during same fishing trip with zero catches.
- Gear type: insert code of fishing gear, as reported in Annex 11 (e.g. GNS). If, during a fishing trip, different gear have been used, insert each code separately in the respective columns. Then, based on type of gear, provide the different measures of effort (e.g. mesh size, number of hooks, etc.) in the corresponding column.
- Total landing (kg): insert total landing (or estimate) of commercial species caught during same fishing trip.
- Main commercial species in landing fraction: insert name (preferably scientific name, otherwise the common one) of main commercial species present in catch.
- Discard (kg and percentage) in catch composition: insert total, cumulative discarded fraction (or estimate) during that fishing trip.
- Main species in discarded fraction: insert name (preferably scientific name, otherwise the common one) of main species discarded.
- Marine litter (kg and percentage) in catch composition: insert total, cumulative marine litter fraction (or estimate) during that fishing trip.

Annex 8.b. Self-sampling – logbook for data on vulnerable species					
Date				**Notes**	
ID fishing trip					
ID self-sampling operation					
Fishing gear					
Latitude (start and end) of fishing operation*					
Longitude (start and end) of fishing operation*					
Group of vulnerable species					
	Marine mammals	Sea turtles	Seabirds	Sharks, rays	Benthic species
Family*					
Genus*					
Species*					
Photo (Y/N)*					
Total number of individual(s) caught*					
Total weight of individual(s) caught (kg)*					
Biological data collected (Y/N)					
Condition at capture					
Species*	Alive (Y/N)	Dead (Y/N)	Almost dead (Y/N)	Unknown (Y/N)	Notes
Condition at release*					
Species*	Alive (Y/N)	Dead (Y/N)	Almost dead (Y/N)	Unknown (Y/N)	Notes
Comments					

* If available.

Notes:

- Data should be reported by species, or by genus and/or family if detailed information by species is not available.
- This template should be duplicated as needed if, during a single self-sampling fishing operation, diverse vulnerable species have been caught.

Instructions

- – ID fishing trip: identification code assigned to each fishing trip (as in Annex 8.a).
- – ID self-sampling operation: identification code assigned to each single self-sampled fishing operation (unique).
- – Gear type: insert code of fishing gear as reported in Annex 11 (e.g. GNS).
- – Latitude (start and end) of fishing operation: insert latitude at beginning and end of each fishing operation (e.g. fishing hauls). Data should be inserted in degree, minutes and seconds (e.g. 40°51′59″N).
- – Longitude (start and end) of fishing operation: insert longitude at beginning and end of each fishing operation (e.g. fishing hauls). Data should be inserted in degree, minutes and seconds (e.g. 124°4′58″W).
- – Group of vulnerable species: indicate (with 'yes') the group of vulnerable species caught.
- – Benthic species: whenever possible, insert name of species. When specimens cannot be identified at species level, genus, family, order or taxa should be indicated. In cases where species identification is not possible (especially for sessile taxa), assign organisms to groups according to their growth form (e.g. massive, tubular, globular, arborescent, stalked, fan-shaped, lollipop-shaped, cup-shaped – see Annex 1.c), coupled with information on their colour, consistency (e.g. hard/soft) and photographic documentation.
- – Photo (Y/N): insert 'yes' or 'no' to indicate if specimen has been photographed and, if so, assign an identification code to photo.
- – Weight (kg): whenever possible, and for each group of species, report total weight of individual(s) caught, otherwise insert estimate.
- – Biological data collected (Y/N): indicate if biological data have been collected for the reported vulnerable species, such as length, weight, sex and maturity (those data should then be reported in Annex 4, Templates for biological data).
- – Condition at capture and at release: whenever possible, indicate condition at capture of individual(s) caught (e.g. alive, dead, almost dead or state unknown) and, if possible, also condition at release.

ANNEX 9. Stranding data

Annex 9. Stranding data		
Country		
GSA		
Date		
ID stranding observation		
		Notes
Family*		
Genus*		
Species		
Total number of individual(s) stranded		
Total weight of individual(s) stranded		
Photo (Y/N)*		
Biological data collected (Y/N)		
Notes on area		
Latitude*		
Longitude*		
State of stranded specimen(s)*		**Notes**
Alive		
Fresh dead		
Moderately decomposed		
Severely decomposed		
Skeleton/keratinized remains		
Cause of death*		
Comments		

* If available.
Note: Data should be reported by species, or by genus and/or family if detailed information by species is not available.

Instructions:

- GSA: insert code of GSA as in Annex 2.
- ID stranding observation: identification code assigned to each stranding observation (unique).
- Total weight of individual(s) stranded (kg): insert weight recorded for stranded individual(s) (or estimate).
- Photo (Y/N): insert 'yes' or 'no' to indicate if specimen has been photographed and, if so, assign an identification code to photo.
- Biological data collected (Y/N): insert 'yes' for stranded vulnerable specimen(s) if biological data have been collected and reported (e.g. length, weight, age), otherwise insert 'no'. Collected data, for different groups of vulnerable species, should then be reported in Annex 4 (Templates for biological data).
- Latitude: if available, insert latitude of stranding observation. Data should be inserted in degree, minutes and seconds (e.g. 40°51′59″N).
- Longitude: if available, insert longitude of stranding observation. Data should be inserted in degree, minutes and seconds (e.g. 124°4′58″W).
- State of stranded specimen(s): indicate state of decomposition of stranded individual(s). If, for the same species, more individuals have been observed, report number in the corresponding column (e.g. 2 individuals of that species were alive, 3 were severely decomposed, etc.).
- Cause of death: when specimen is found dead, describe (if possible) the cause of death (e.g. evidence of net entanglement, disease and natural causes, etc.).

ANNEX 10. Fleet segments

Annex 10. Fleet segments				
Vessel groups	**Length classes (LOA)**			
Small-scale vessels without engine using passive gear	< 6 m	6–12 m	12–24 m	> 24 m
Small-scale vessels with engine using passive gear	< 6 m	6–12 m	12–24 m	> 24 m
Polyvalent vessels	< 6 m	6–12 m	12–24 m	> 24 m
Purse seiners	< 6 m	6–12 m	12–24 m	> 24 m
Tuna seiners	< 6 m	6–12 m	12–24 m	> 24 m
Dredgers	< 6 m	6–12 m	12–24 m	> 24 m
Beam trawlers	< 6 m	6–12 m	12–24 m	> 24 m
Pelagic trawlers	< 6 m	6–12 m	12–24 m	> 24 m
Trawlers	< 6 m	6–12 m	12–24 m	> 24 m
Longliners	< 6 m	6–12 m	12–24 m	> 24 m

Source: Combination of vessel groups and length classes – modified from GFCM, 2018a.

Notes:

– A vessel is assigned to a group on the basis of the dominant gear used in terms of percentage of time: more than 50 percent of the time at sea using the same fishing gear during the year.

– 'Polyvalent vessels' are defined as all vessels using more than one gear, with a combination of passive and active gear, none of which exceed more than 50 percent of the time at sea during the year.

– A vessel is considered 'active' when it executes at least one fishing operation during the reference year in the GFCM area of application.

ANNEX 11. Fishing gear

Annex 11. Fishing gear	
Gear name	**Code**
Purse seine without purse lines (lampara)	LA
Purse seine with purse lines (purse seine)	PS
One boat-operated purse seines	PS1
Two boat-operated purse seines	PS2
Beach seines	SB
Danish seines	SDN
Pair seines	SPR
Scottish seines	SSC
Boat or vessel seines	SV
Seine nets (not specified)	SX
Otter trawls (not specified)	OT
Bottom otter trawls	OTB
Midwater otter trawls	OTM
Otter twin trawls	OTT
Pair trawls (not specified)	PT
Bottom pair trawls	PTB
Midwater pair trawls	PTM
Bottom trawls	TB
Bottom beam trawls	TBB
Bottom nephrops trawls	TBN
Bottom shrimp trawls	TBS
Midwater trawls	TM
Midwater shrimp trawls	TMS
Other trawls (not specified)	TX
Boat dredges	DRB
Hand dredges	DRH
Lift nets (not specified)	LN
Boat-operated lift nets	LNB
Portable lift nets	LNP
Shore-operated stationary lift nets	LNS
Cast nets	FCN
Falling gear (not specified)	FG
Gillnets and entangling nets (not specified)	GEN
Gillnets (not specified)	GN
Encircling gillnets	GNC
Driftnets	GND
Fixed gillnets (on stakes)	GNF
Set gillnets (anchored)	GNS
Combined gillnets-trammel nets	GTN
Trammel nets	GTR
Aerial traps	FAR
Traps (not specified)	FIX

Annex 11. Fishing gear	
Gear name	**Code**
Stationary uncovered pound nets	FPN
Pots	FPO
Stow nets	FSN
Barriers, fences, weirs, etc.	FWR
Fyke nets	FYK
Handlines and pole-lines (mechanized)	LHM
Handlines and pole-lines (hand operated)	LHP
Longlines (not specified)	LL
Drifting longlines	LLD
Set longlines	LLS
Trolling lines	LTL
Hooks and lines (not specified)	LX
Harpoons	HAR
Pumps	HMP
Mechanized dredges	HMD
Harvesting machines (not specified)	HMX
Miscellaneous gear	MIS
Recreational fishing gear	RG
Gear not known or not specified	NK

ANNEX 12. Vulnerable species rate and estimation

Annex 12. Incidental catch of vulnerable species rate and estimation (by fleet segment)	
Country	
GSA	
Reference year	
ID fleet segment	
Total number of vessels operating during reference year (by fleet segment)	
Total number of fishing trips of analysed fleet segment during reference year **(F)**	
Total number of fishing trips sampled (combining all methodologies) in reference year **(D)**	
Coverage (%) of fishing trips in reference year by fleet segment	Coverage (%) = D*100/F
Family	
Species	
Sum of number of individuals of each vulnerable species caught/recorded during reference year by fleet segment **(N)**	
Total weight of individuals caught by species	
Number of individuals released alive	
Number of dead individuals	
Number of individuals released in unknown status	
Bycatch of vulnerable species rate **(T)**	T = N/D
Estimation of individuals caught by analysed fleet segment during reference year **(I)**	I = T*F

ANNEX 13. Template for marine macro-litter

Annex 13. Data on marine macro-litter		
Date		
Source		
ID fishing trip		**Notes**
Total quantity of marine litter (kg)		
Percentage (%) of marine litter in catch		
Marine litter composition*	**Kg**	**Notes**
Plastic		
Rubber		
Fishing gear		
Metal		
Glass		
Ceramic		
Cloth		
Wood processed		
Other (please specify)		
Comments		

* If available.

Instructions

- Source: indicate source of data (e.g. on-board observation; self-sampling operation, etc.)
- ID fishing trip: identification code assigned to each fishing trip (unique) (as in Annex 3.a).
- Total quantity of marine litter (kg): insert total weight (or estimate) of marine litter taken during fishing trip.
- Percentage (%) of marine litter in the catch: insert total, cumulative marine litter fraction during fishing trip.
- Marine litter composition: whenever possible, insert weight (or estimate) in kg, and percentage of different items contributing to marine litter during fishing trip.

ANNEX 14. Weather conditions

Annex 14. Weather conditions		
Variable	**Code**	**Description**
Cloud	0	0% of sky covered
	25	25% of sky covered
	50	50% of sky covered
	100	100% of sky covered
Wind direction	N	north
	E	east
	S	south
	W	west
	NE	northeast
	SE	southeast
	SW	southwest
	NW	northwest
Visibility	A	< 2 km
	B	2–5 km
	C	6–9 km
	D	≥ 10 km
Light condition	0	dawn
	1	dusk
	2	day
	3	night
Sea state	0	sea like a mirror
	1	small ripples
	2	small wavelets
	3	crest break
	4	numerous white caps
	5	moderate waves, some spray
	6	larger waves, more spray

ANNEX 15. Equipment for on-board observations

– Copies of necessary templates for data recording
– Board, pencils, eraser and sharpener
– GPS data recording
– Measurement tools: flexible tape, calliper and measuring board
– Dynamometer
– Voice recorder with microphone and earphones, batteries
– Identification guides
– Digital camera
– Gloves and rubber boots
– Slates for labelling the haul when taking photographs
– Medical first aid kit

SHEET FOR REPORTING SINGLE FISHING OPERATION DATA

Date	ID fishing trip	ID fishing operation	Gear type	Total landing (kg)	Total discards (kg)	Marine litter (kg)	Bycatch (Y/N)

Bycatch – a term widely used to refer to the part of catch unintentionally captured during a fishing operation, in addition to target species, and consisting of discards and incidental catches of vulnerable species – is considered one of the most important threats to the profitability and sustainability of fisheries, as well as to the conservation of the marine environment and ecosystems. In the Mediterranean, studies on the incidental catch of vulnerable species cover only a small portion of the total fishing activity. In addition, there are several important knowledge gaps for many types of fishing gear, and several countries and/or subregions, as well as on temporal scales, and only a few measures are in place that address the protection of vulnerable species. Monitoring programmes and surveys on incidental catches, which follow a harmonized methodology allowing for results to be compared across subregions, are necessary to improve knowledge on the issue and to subsequently support the identification of potential mitigation methods and tools, and relevant management measures. This publication and the methodology contained herein aim to provide a framework for the development and implementation of an efficient, standardized data collection and monitoring system for all vulnerable species encountered in the Mediterranean and the Black Sea, namely elasmobranchs, marine mammals, seabirds, sea turtles, and macrobenthic invertebrates. This is achieved through on-board observations, questionnaires at landing place and self-sampling activities. It ensures minimum common standards for the collection of data on these species and allows for replicability and comparisons among fisheries across the region, thus providing a harmonized basis of knowledge, information and evidence for decision-making.

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